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Soybean in the farming system: double cropping strategies and grower case studies

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Summary:

- A number of growers in the Murrumbidgee Irrigation Area (MIA) and Coleambally Irrigation Area (CIA) are very successfully growing new varieties of soybeans in back-to-back double cropping rotations, with up to seven grain crops in three and a half years.
- New soybean varieties are higher yielding, higher value and can be sown from mid November, which is the ideal sowing time in southern NSW.
- Recent research by NSW DPI and James Cook University has shown that new soybean varieties can be sown as late as Christmas, with very little yield penalty, increasing the flexibility and creating new opportunities for double cropping.
- The gross margins per megalitre and per hectare are far higher when double cropping with soybeans, compared with a single summer or winter crop.
- A larger area of soybeans and winter cereals can be sown than rice, with the same amount of water, contributing to whole-farm profitability.

2006-07 season overview

The 2006-07 season proved to many growers the value of soybeans in their irrigated cropping system. While the overall soybean cropped area was down due to severe drought and consequently significant water allocations restrictions, the production per hectare was highest of all soybean growing regions in Australia (AOF Crop Report, May 2007). The average grain yield was estimated to be just over 4 t/ha, with the range varying between 3.5 and 4.75 t/ha.

Grain quality was of a high standard, with growers following current recommendations for final irrigations late in the season to ensure large seed size and high grain yields. The protein content was satisfactory in 2006-07, with no reports of low protein content.

Benefits of double cropping with new soybean varieties

Many growers in the MIA and CIA have found double cropping to have a very positive impact on their whole farming system. Most of last season's soybean crops were double cropped this year into winter cereal, mainly barley, but also biscuit wheat. This allows any remaining moisture and possible residual nitrogen from the irrigated soybean crop to be fully utilised.

Soybeans complement all other crops and provide greater flexibility in many aspects:

- Soybeans are sown later then rice and maize which spreads the workload of sowing over a wider window.
- Soybean are sown from mid-November until the mid December, and, unlike other summer crops, can be sown immediately after a cereal.
- Soybeans also allow growers to capitalise on any late water allocation increases.

Sowing time with double cropping

New and on-going research has shown that soybeans can be sown in southern NSW as late as Christmas, with only minor yield penalties. This research was conducted by New South Wales Department of Primary Industries and James Cook University, Townsville as part of Luke Gaynor's Master's degree, and will soon be published. Growers are, however, reminded not to delay sowing any longer than absolutely necessary. Maximum yields are still only achieved by sowing at the start of the sowing window. The soybean sowing window in southern NSW is from mid-November until late December.

The new, shorter-season human consumption soybean varieties like Djakal and Snowy are faster growing and higher yielding than older soybean varieties. This, coupled with good crop management helps

maximise yields in late sown crops and/or double cropping situations. *This opens more opportunities for double cropping with soybeans.*

Agronomic management of soybeans in double cropping.

In the case of double cropping, increasing plant establishment by 5-10 plants/m2, pre-watering and sowing on raised beds into an ideal seed bed will help guarantee and maximise yields. Research and grower experience has shown that the preferred option for double cropping is to pre-water, rather than water-up. This creates an ideal seed bed for planting and helps promote the survival of *Rhizobium.* However pre-watering may not always be possible due to timing with double cropping. If the beds are in good condition, watering-up is also very effective. The preceding winter crop and its harvest can govern the timing of sowing the soybean crop.

Recent surveys of growers undertaking double cropping have shown that significant cash-flow improvements and increases in water productivity can be achieved by double cropping soybeans with winter cereals. Soybean uses approximately 7 ML/ha of water per season, and because they are a legume, require no nitrogen fertiliser and may even contribute nitrogen to the following cereal crop, reducing its fertiliser requirements.

Profitability of double cropping

Gross margins have been developed with information provided by growers to compare farming systems and their profitability (Table 2). The costings are for inputs, machinery, contractors, insurance etc. It does not include the cost of labour on any crops.

Higher yields of soybeans and barley could be expected if grown as single crops. The returns possible with a high yielding single/fallow crop of soybeans are shown in the brackets in Table 2. This yield of 4.2 t/ha is very achievable. Water use is increased slightly to 8.5 ML/ha to allow for filling of profile.

Table 1: Gross margins of double crop rotation of soybeans and barley for CIA and MIA compared with rice as a single crop. Single crop figures for high-yielding soybeans are shown in brackets.

	Soybeans	Barley	Combined soybeans-barley	Rice (medium grain aerial sown)
YIELD (t/ha)	**3.25 (4.2)**	5.5		10
PRICE ($/t)	**$550**	$150		$250 ($300)
INCOME ($/ha)	**$1,788 ($2,310)**	**$825**	**$2,760**	**$2,500 ($3,000)**
COSTS ($/ha)				
Operations	$156	$123		$264
Seed	$115	$40		$34
Fertiliser Phosphorus	$87	$107		$38
Fertiliser Nitrogen	$0	$78		$237
Chemicals	$100	$4		$177
Water use (ML/ha)	**7.5 (8.5)**	**3.5**	**10.5**	**14**
Irrigation ($28/ML)	$210 ($238)	$98		$392
Insurance	$20 ($26)	$9		$22
TOTAL VARIABLE COSTS ($/ha)	$688 ($722)	$459	$1,147	$1,164
GROSS MARGIN/ HA ($/ha)	**$1,100 ($1,588)**	**$366**	**$1,466**	**$1,336 ($1,664)**
Gross margin/ML ($/ML)	**$147 ($187)**	**$105**	**$251**	**$95 ($119)**

What can I do with 966ML?

Not only is the gross margin per hectare better with double cropping, the higher water use efficiency of soybeans and winter cereals compared with medium grain aerial-sown rice means that more land can be cropped for the same amount of water, contributing more to whole-farm profitability. This is critical in low allocation years. (Table 3). When double cropping soy and barley, an extra 33% land can be sown for the same amount of water, in our example.

Table 2: Example of area of cropping in one year, per 966 ML irrigation allocation and profitability of different rotations. (Costing for labour not included.). 966 ML is sufficient for 69 ha rice (at 14 ML/ha). This is the upper area limit for rice on a single farm in the CIA.

	High yielding soybeans (single crop)	Combined soybean-barley rotation	Rice
Area (ha) using 966 ML	114	92	69
% increase in area sown compared with rice	65%	33%	-
Profit from 966 ML = Gross margin/ha x area sown	$1,588/ha x 114 ha = **$180,472**	$1,466/ha x 92 ha = **$134,872**	$1336/ha x 69 ha = **$92,184**

With the increased adoption of beds-in-bays layouts (where raised beds are created in water-holding bays), the cost of land-forming from a rice/pasture layout can be reduced. Levees do not require removal, saving significant time and labour. This also facilitates speedy irrigations and improves drainage efficiency. This allows the grower to be more flexible with his crop rotations and to grow crops on raised bed layout with significant labour savings.

Double cropping case studies

In June, three case studies were undertaken of growers from the CIA and MIA who have very successfully grown soybeans in continuous double cropping – and are reaping the rewards. Double cropped soybeans provide increased cash-flow, greater flexibility in rotations and provide very high dollar returns per megalitre used.

The following is a summary of key comments (in italics) and common threads from the growers in the case studies:

Management

- When double cropping, a typical rotation is soybean, barley, soybeans, barley, soybean, fallow, maize and barley.
- Soybeans are the only main summer grain crop that can be sown late enough to allow growers in the region to immediately follow a winter crop. *"Soybeans are ideal for double cropping. They're the only summer crop where you can go double cropping year-in year-out."*
- *"Soybeans are the most flexible of the lot. To sow maize, you have to have everything spot-on. Soybeans are the total opposite. You can just direct drill and spray."*
- Unlike rice and maize, soybeans are sown from mid November and harvested in late March to mid April. In some years the seeder has immediately followed the harvester to sow a winter cereal.
- Soybean paddocks are normally pre-watered, sprayed with a knockdown, sown and watered up between mid November to late December, at the very latest. Normally 7-8 ML/ha of water is used on the soybeans, which are normally harvested between late March and early April.

- *"It doesn't take a lot of expensive preparation to double crop. We just burn or bale the cereal stubble, pre-water, knockdown spray and sow. If the soybeans are sown following fallow we also band single super and shape the beds earlier in the year."*
- The only limitation to double cropping is the risk of a wet harvest for both the winter and summer crops. This can delay harvest and planting of the next crop. That's why maintaining a flexible crop rotation is so important.
- Soybeans are usually sown between 20 November and 7 December, when double cropping.
- Growers commented that virtually no paddock preparation was required with double cropping, which is a major advantage: *"We just burn stubbles and put down fertiliser. Pre-irrigation is essential to germinate weeds to kill with glyphosate. Plus, the soil temperature is higher at sowing time with pre-irrigation compared with watering up."*
- *"We then sow our winter crops as soon as possible. We don't get delayed by double cropping with soybeans. It's cost and water efficient to double crop. Barley crops have not required watering up in three out of the last four years thanks to the residual moisture from the soybean crop."*
- Use of the cultivator and shielded sprayer allows one grower to handle weeds like Bathurst burr and blackberry nightshade, which can otherwise cause quality problems with soybeans. This significantly reduces the herbicide costs.
- *"We rarely have weed problems in the winter cereals when double cropping, and don't need a post-emergent spray."*
- *"There are time constraints when sowing soybeans after barley. However, the soybeans can be sown straight into the burnt barley stubble and watered up without any fertilisers, relying on residual phosphorus from the barley crop."*

Varieties

- *"With (the variety) Djakal, we've never had a crop under four tonne per hectare."*
- *"The length of the growing season of Djakal's great. It's given us another week to play with."*
- New shorter season human consumption varieties have proven to be consistently high yielder and early enough to allow double cropping. They also attract the premium prices.

Profitability and cash flow

- The main benefit of the double cropping system to the surveyed growers is the added cash flow it generates. Although yields of soybeans following a cereal are slightly lower than when following fallow, the income from two crops well and truly compensates for this.
- *"Soybeans are lower risk as they have low up-front costs, compared with maize. Maize costs a fortune to sow. With soybeans, it only costs the seed, and if you've got the water, you can go on with them."*
- A grower said that the soybean-barley rotation works well in the drought and is very profitable. "We aim for a minimum $120 per megalitre profit for soybeans. In 2006-07, it was $150 per meg."

Water use efficiency and quality

- Much more efficient water use across the farm is another major benefit. The soybean crops receive their final watering just before maturity, to ensure high yields and large seed size, which is strongly desired by end-users. The following cereal crops can utilise the near-full profile of residual water from the soybean crop.
- *"The following winter crop can be planted on-time directly into moisture and gets away to a great start. The soybean stubble is spread evenly across the beds by the header's straw spreaders and we have never had an issue of planting wheat directly through it."*

- Soybeans are a low water user compared with other summer crops, and the combined gross margin both on a per hectare basis and a per megalitre basis is better than a single summer crop of rice or maize.
- *"While the main aim of the system is to make money, a major benefit from double cropping with soybeans is the reduced water use. The overall water used is less. In a normal year, soybeans followed by barley uses 9 megs (ML), compared with maize then barley, which uses 12 megs."*
- *"We get the best results with soybean quality if we water late, and double cropping gives us better use of the residual moisture after soybeans for a winter crop. It's too wasteful not to use that water."*

Reduced fertiliser inputs

- *"Another benefit of system is the fact that soybeans are a legume, and require no nitrogen fertiliser, a major cost for other summer crops."*
- With the continued increase in the cost of Urea and Nitrogen, growers are urged to considered legumes as part of the farm rotation. Cost savings are made on the legume crop and also on the following crop.

Time of sowing x variety trials

Time of sowing x variety trials were conducted at Yanco by the NSW DPI as part of the National Soybean Improvement Project, funded by the GRDC. The long-term combined results are a subset of data from advanced variety trials conducted at Yanco and Coleambally from 2003 to 2007.

Methods

All trials in 2006-07 were sown on grey self-mulching clays on 1.83 m beds following winter fallow. The achieved sowing density in all these trials for the mid-November and mid-late December planting were a minimum of 35 and 40 plant/m2 respectively. Irrigations were 6.5 to 7 ML/ha. The Coleambally trial was sown at the Bellato family's property on 14 November, and the Leeton trials were sown at the DPI's research site on 25 November and 23 December. Harvest dates were 27 March at Coleambally and 12 April at Leeton for the first time of sowing (TOS) and 11 May for the second TOS.

Table 3: 2006-07 Trial site details.

Site	***Coleambally***	***Leeton***	
Coordinator	Luke Gaynor, NSW DPI		
Cooperator	Bellato	NSW DPI	
Sowing date	14 Nov	25 Nov	23 Dec
Plant population/ha	350,000	350,000	400,000
Soil type	Grey self-mulching clay	Grey self-mulching clay	
Irrigation (ML)	7	7	6.5
Method	Raised Beds (1.83m)	Raised Beds (1.83m)	
Harvest	27 Mar	12 Apr	11May
Fertiliser		150 kg legume starter	

Results

Table 4: 2006-07 and long-term (2003-2006) yields (t/ha) of soybean varieties and advanced breeders' lines by time of sowing (TOS), and the number of days from sowing to physiological maturity (P95).

Variety/line	Long-term		2006-07			
	average yield		Mid Nov (ideal) TOS		Late Dec (late) TOS	
	TOS 1[a]	TOS 2 [b]	P95	Yield	P95	Yield
Early maturity						
F190-6	3.58	3.52	**109**	4.47	112	3.41
F190-4	3.30	3.63	**109**	4.14	111	3.23
Mid maturity						
Djakal	**4.10**	**3.82**	123	4.68	113	3.76
Empyle	3.65	3.47	128	4.05	114	3.88
99091A-18	3.63	3.76	130	4.93	117	3.61
99091A-7	3.61	3.76	128	4.83	115	3.62
Snowy	3.61	3.55	129	4.81	116	3.61
99091A-4	3.58	3.48	123	4.72	115	3.48
F147-5	3.52	3.61	120	4.52	115	3.80
F148-3	3.50	3.59	122	3.77	117	3.33
F148-4	3.45	3.67	120	4.16	114	3.46
Late maturity						
Curringa	3.35	3.35	134	4.05	119	3.22
Bowyer	2.99	3.22	136	4.27	120	2.54
Stephens	3.41	3.71	Not tested			
Average	3.52	3.58	124	4.42	115	3.46
LSD			2.7	0.64	1.7	0.34

Note: TOS 1 sown from the week of 20 November each year with 35 plants/m^2
TOS 2 sown from the week of 20 December each season with 40 plants/m^2

Early lines

Early lines generally have lower yield potential than mid maturity (Table 1), largely due to reduced total biomass (plant material), but also due to the fact that these lines may also finish in hotter temperatures. However, early maturity is a useful trait for double cropping and for water savings. Further testing will continue.

Late varieties

The late maturing older varieties have been outclassed in grain yield compared with newer varieties such as Djakal and Snowy. They also have less yield potential due to lodging from excessive biomass and height. Their longer maturity also increases water use, decreases water use efficiency and reduces the returns per ML. Longer maturity varieties also increase the risk of insect attack/damage due to their longer growing season. Stephens is also a black hilum unsuitable to the human consumption market.

Mid varieties

The mid maturing varieties Djakal, Snowy and Empyle have proven to be genetically superior in terms of grain yield, especially Djakal. It was released in 2001 by NSW DPI and has proven itself to be a robust, consistently high yielding variety. This, coupled with a relatively fast growing season and lodging resistance, has allowed it to become the most popular variety with experienced growers. Snowy also has excellent yield, seed size and end quality. It has slightly higher protein content than Djakal and is the first clear hilum soybean in this region. It is slightly longer in maturity than Djakal but similar to Empyle. Empyle has performed relatively consistently throughout the trials; however it is significantly lower yielding than Djakal and Snowy. Its major downfall is its seed-size, which is highly variable and generally small, which makes it unsuitable to the premium market of tofu/soymilk.

Time of sowing

The long-term data show that, on average, there is either a slight yield decline with current commercial varieties when sown late in December (as can be expected). However, the 2006-07 data show that the yield penalty for late sowing may be high in some years. Despite this, the yields of late December sown crops in 2006-07 are still very good (Table 1). This new finding creates new opportunities for soybeans in a back-to-back double cropping system, unlike other summer crops which cannot be sown this late.

Do not cut corners with late sown crops as this will increase the chances of yield losses occurring. A consistent plant stand will increase the chance of high yields. Yield losses are significantly reduced if sowing late by ensuring good agronomy practices are used.

Sowing as early as possible within the sowing window is still the 'best bet' to maximise yield. It gives more time for the plant to recover in the case of something going wrong. The soybean plant is able to recover well from early damage and still produce high yields.

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