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Irrigated soybeans: maximising yields and whole farm profitability

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Introduction

Soybeans have been grown in Southern NSW and Northern Victoria since the late 1960's early 70's. They have been a profitable crop for irrigated farming systems in the Riverina, particularly where the crop attains quality standards for human consumption markets. Significant premiums are paid for soybeans suitable for these markets making the crop more attractive when high yields are achieved. The planting area in the Riverina (Murrumbidgee and Murray Valleys) has fluctuated from 11,700 hectares (ha) in 1993/94 to as little as 2,000 ha in recent years. The decline is primarily the result of reduced availability of irrigation water. Although soybeans can be a water use efficient and a profitable crop, water is in strong demand, competing with other crops such as rice, maize and wheat. This makes the profitability and gross margins of the irrigation water high on the priority list for all growers and potential growers.

Soybeans can be utilised as a single cropping rotation or in an intensive double cropping system with winter cereals. New, shorter season, high yielding varieties suited to the culinary market produced by GRDC funded National Soybean Improvement Program ("NSIP") offer new opportunities to increase returns per megalitre and the competitiveness of soybeans against other summer crops. Shorter season soybean varieties can potentially increase overall returns when incorporated into a double cropping system which fully utilises sub-soil moisture and nutrients left by the previous crop. Profitability and returns per megalitre of water in a double cropping system are very attractive and favourable to the grower. New human consumption varieties such as Djakal and the recently released Snowy are excellent examples of high yielding shorter season culinary soybeans. Rotations such as soybean– barley– soybean– biscuit wheat can lift water use efficiencies (WUE) and gross margins/megalitre (GM/ML) by hundreds of dollars per hectare and can out-compete most other summer crop rotations.

Several key strategies and techniques are necessary to set the crop up for maximum yield, WUE and profitability. Thorough planning cannot be over emphasised prior to the planting of any seed or the running of any water.

Varietal selection

A preferred variety should be selected according to location, disease resistance, maturity, yield potential and suitability for the target market. Recommendations (Table 1) are based on extensive and on-going testing (updated yearly in NSW DPI Planting Guides – available www.dpi.nsw.gov.au or from NSW DPI Offices) of new and existing varieties. If it is anticipated that a large area of soybeans will be sown, growers should utilise varieties of different maturities to spread planting and harvesting operations, whilst still sowing in the ideal planting window.

New short season varieties such as Djakal and Snowy are high yielding, culinary types that are well adapted to southern NSW. New light hilum varieties have equal or more yield than older existing black hilum varieties (e.g. Arunta & Stephens). Growers have two options for the soybean markets, human consumption and/or crushing markets. Black hilum varieties are only suited to the lower priced crushing market, while light hilums are suitable to both. However human consumption markets attract a premium price compared to crushing markets.

Seed quality

Seed germination and seed quality should be reviewed prior to sowing. **Low quality planting seed should be replaced as it is likely to result in a sub-optimal establishment.** Soybean seeds are relatively short-lived and even when produced under optimum conditions can lose germination and vigour after a few months in storage. Seeds have a thin seedcoat, making them more susceptible to damage than other crop species. Larger seeded types, grown for human consumption markets, are at greater risk of mechanical damage (harvesting and handling) than the smaller-seeded crushing types. Excessive auguring should be avoided.

A reliable germination test should be obtained after harvest to ensure the seed is worth keeping and tested again before sowing to ensure it has not deteriorated. **Germination tests of planting seed should be carried out every year within 4–8 weeks of planting.** The germination test of harvested seed can vary greatly depending upon storage conditions over winter and costs $30–$50 per sample. Often a simple germination test can be completed at home with cotton wool or paper towel.

Table 1: Southern NSW & Northern Victoria adapted varieties (yield t/ha)

Location	Preferred varieties	Suitable varieties
Murrumbidgee and Murray Valleys	Djakal[1] (4.0) Snowy[1] (3.8) Curringa[1] (3.2) Arunta[2]	Empyle[1] (3.59) Stephens[2] Bowyer[1] (3.06)
Lachlan Valley	Snowy[1] Valiant[2] Djakal[1] Curringa[1]	Hale[2] Banjalong[2] Bowyer[1]

1. Light hilum varieties preferred for human consumption (samples are assessed from trials and commercial paddocks)
2. Black hilum varieties, crushing only (no premiums)

Soybeans grown on raised beds produce higher and more consistent yields than soybeans planted on a border check layout. In the Riverina, soybeans are typically grown on raised beds using furrow irrigation on slopes of 1:1500 or flatter with run lengths of 400–800m. This allows better drainage around the root zone, less water-logging problems (i.e. potential disease build-up) and minimal establishment difficulties. Raised beds facilitate the sowing of soybeans into a moist seedbed for successful and critical plant establishment. Border check layouts often have establishment problems, due to difficulties sowing into a moist soil that is not too wet to drive on. Often the soil surface dries out too quickly before, during and after sowing resulting in uneven and low plant population/establishment.

On raised beds, paddocks ideally **should be pre-watered one to three weeks before planting** and sown as soon as soil is dry enough to work. This strategy is best used when sowing into fallow. Watering up (double cropping strategy) once soybeans (on raised beds) are planted is possible if the soils are uniform, beds are high and well consolidated. Seed must be lightly covered with soil and the **seed line must remain above the furrow water level**. Watering up on border check is not recommended as the seed will drown and/or burst. Watering up is also not recommended for first time soybean paddocks, as rhizobia will die in the hot, dry soil before water can be applied. **Achieving a good, solid, even plant stand with the correct plant population is the cornerstone of a high yielding crop**.

Irrigation scheduling should be done according to the plant's water use and stage of growth. To achieve high yields, the grower must predict with reasonable accuracy the timing of the next irrigation. Timing irrigations to meet plant moisture needs is critical for high yields. NSW DPI and CSIRO have a Water Watch scheduling service which provides Evapotranspiration (ETo) rates on a daily basis for four locations in Southern NSW. They have also developed crop factors (Kc) that can be applied to different crops to reflect their water use and demand at certain periods of the season (Table 2). Soybeans should be watered at between 60–90 mm of accumulated ETo adjusted for soil type, Kc and rainfall during the peak water use period of the season (rainfall of less than 20 mm is often ignored in the heat of mid summer). The use of soil moisture probes (e.g. gypsum blocks, neutron probes or similar) are useful tools to monitor soil moisture movements and plant extraction.

Table 2: Crop coefficient figures, Wayne Meyer CSIRO

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Soybean	0.75	1.05	1.0	-	-	-	-	-	-	-	0.3	0.45
Barley	-	-	-	0.3	0.35	0.5	0.8	1.0	1.0	0.9	0.5	-
Wheat	-	-	-	0.4	0.4	0.6	0.9	1.05	1.05	1.0	0.5	-
Rice	1.1	1.1	0.3	0.3	-	-	-	-	-	0.8	1.1	1.1

Planting timing

Soybeans commence flowering in a response to shortening daylight hours after the summer solstice on December 22. Current varieties are all photoperiod sensitive and therefore the later they are sown, the fewer days they have to maximise vegetative biomass before the commencement of flowering. Late sown crops produce smaller, shorter less vegetated plants with fewer pods, which reduce seed yield potential per plant. On the other hand, if varieties are sown too early they will become over vegetative, grow too tall, lodge and result in lower yields

Soybeans should be sown from mid-November to the second week in December. Planting after this time reduces the probability of achieving high yields. Soybeans sown into fallow paddocks ideally should be pre-watered one to three weeks before planting and sown as soon as soil is dry enough to work. Seed should be sown into moisture to ensure even germination, full emergence and also the survival of applied inoculum (Group H inoculum). **Seed should always be inoculated at planting**, either with a seed dressing or by injecting liquid inoculant onto the seed. This is cheap insurance for free nitrogen fixing and N supply for the crop. Watering-up techniques can be utilised in double cropping situations to speed up the planting and establishment time. Beds need to be uniform, well consolidated and with no soil compaction problems (refer to irrigation layout notes).

Seeding rates, plant populations and row spacings

Two crucial factors in achieving maximum soybean yields are to plant on time and achieve the correct plant population. High potential yield is determined by the ability to obtain and maintain a uniform plant stand. The desirable plant density is:

- 35–40 plants/m^2 for crops sown on time (Mid-November to second week of December)
- 40–45 plants/m^2 from mid-December to late December

Growers planting tofu types such as Djakal, Snowy, Curringa and Bowyer will need to take into account the larger seed size of these varieties, in order to achieve the desired plant density. This will often result in an increase in sowing rates compared to older smaller seeded varieties. Current practice for row spacing is two rows per bed (1.8 m beds), with each row positioned on the outer edge of the bed. Research has showed 75cm to be optimum row spacing, however 90cm is still acceptable provided the crop is planted on time and an adequate plant population is achieved.

More research is currently taking place on the subject. **Soybean plant growth must achieve full ground cover by mid flowering for southern NSW indeterminate varieties**. Flowering should commence approximately 40–55 days after sowing in the Murrumbidgee Valley and southwards to achieve full ground cover by mid- flowering.

Double cropping

As a grain legume, soybeans are well suited to rotations which include winter cereals, canola, rice and maize. Soybeans and winter cereals is the most common double cropping system and offers growers opportunities to:

- increase water use efficiencies
- increase gross margins per megalitre of water used
- create a break crop in the rotation; and
- provide all the benefits of a legume crop.

The varieties Djakal and Snowy are ideally suited to the double cropping system. These shorter growing period soybean varieties (122 & 126 days respectively to P95) offer higher water use efficiencies by requiring less irrigations compared to the longer season varieties. High yielding soybeans typically use 6–8 megalitres of irrigation water per hectare depending upon soil type, variety, paddock, irrigation layout and seasonal conditions. Double crop soybeans will use closer to 6 ML/ha on average. These shorter maturity varieties also allow soybeans to be harvested before the autumn break and allow the following winter cereal to be planted on time into some stored moisture. This stored moisture within the soil profile can be completely utilised by the following crop and not wasted.

Double cropping practices are typically on permanent beds or under travelling irrigators. With careful selection of a short season cereal crop (i.e. barley or wheat), soybeans can be planted back into the same field after the harvest of the winter cereal. The rotation can consist of several years' alternate crops of cereals (wheat and barley) and soybeans (see Table 3). It is recommended due to the possible disease build up of phytophthora root rot that no more then 2–3 soybean crops should be grown in successive years. Alternatively, a summer crop rotation of soybeans and maize could be implemented.

Table 3: Cropping rotation with Gross Margins (GM) & crop management.

	Period		**Summary of production figures per hectare**					
Crop	**Sow**	**Harvest**	**Yield (t/ha)**	**Cost of production ($)**	**Water use (ML)**	**Profit ($/ha)**	**GM ($/ML)**	**Irrigation & sowing methods**
Soybean	3rd wk Nov 05	1st wk April 06	4.25	785	8.0	1425	178	Pre-water & sow into fallow
Barley	1st wk May 06	2nd wk Nov 06	5	470	2.0	155	78	Direct drill in soybean stubble
Soybean	4th wk Nov 06	2nd wk April 07	3.25	735	6.0	955	160	Burn barley stubble, sow & water up
Wheat	1st wk May 07	2nd wk Dec 07	6.5	495	3.5	545	156	Direct drill in soybean stubble
		Rotation totals		**$ 2,485**	**19.5**	**$ 3,080**	**$ 572**	
		Average per calendar year		**$ 1,242**	**9.75**	**$ 1,540**	**$ 286**	

Notes: Soybeans @ $520/ton (Djakal or Snowy), Barley @ $125/ton (Gairdner, Baudin or Schooner), and Wheat @ $160 (Biscuit or Bread wheats)

Table 3 shows a yield penalty can usually occur in soybeans in a double crop situation, but this is offset by the income from the previous cereal and lower growing costs. This yield penalty could be due to a number of factors including soil compaction from the previous harvest or a slighter later than desirable planting date. Good management can reduce the yield penalty. However, impressive and profitable yields can still be achieved in a double crop situation. Detailed planning, good time management and planting are the keys to a successful double crop. A complete range of pre-emergent and post-emergent chemicals are available to control almost all weeds, which is necessary to maintain seed quality and obtain premium prices.

Overall the GM$ per megalitre returns for a soybean/barley and soybean/wheat rotation are $256 and $316 respectively. As a two year cropping rotation this example returns an average of $286. In a single rotation of soybeans followed by wheat, a GM of $334 can be expected. The soybean figures and yields here are achievable and realistic with growers in the CIA and MIA achieving in excess of 4.5 tonne/ha of in the last two seasons. Older varieties such as Curringa and Bowyer, are slightly longer in maturity (10 & 14 days respectively), and do not have as high a yield potential as Djakal and Snowy.

Nutrition

As a high yielding crop, soybeans have a high demand for plant nutrients. Table 4 provides an approximate quantity of crop use. A soil test is the best way to determine soil nutrient status and requirements to achieve maximum yields.

Table 4: Approximate nutrient use in a 2.5t/ha soybean crop

	Plant nutrient (kg/ha)			
	Nitrogen	Phosphorus	Potassium	Sulfur
Total Plant uptake	230	28	70	14
Seed removal only	167	18	40	11

Insect monitoring and control

Monitoring for insects **throughout the season is highly recommended. It should initially take place weekly then twice a week from flowering.** The crop should be checked between 7 and 9am when the insects are most active on top of the plant's canopy. Soybeans can tolerate up to 35% loss of leaf area before flowering without any yield penalties. However, once flowering commences soybeans are less tolerant to leaf loss and damage can occur to growing points, flowers and pods. Loss of growing points can dramatically impede the plant growth and reduce yield potential. This can often occur well before visual damage can be seen. Leaf-feeding pests such as heliothis, soybean moth, looper caterpillar and grass blue butterfly are most likely to cause this damage. The spray threshold for heliothis and grass blue butterfly is 6 larvae per square metre per flowering, and lowers as the season processes.

Sucking pests such as green vegetable bug, red-banded shield bug, brown stick bug and brown bean bugs occur commonly in soybeans. The green vegetable bug (GVB) is the worst of the sucking pests severely reducing yields and quality by feeding on young pods and developing seed. Sucking pests cause damage from very early pod development to right through to harvest.

Table 5: Insect thresholds per metre^2 (*courtesy of H Brier, QDPI&F*)

Pest	Threshold (human consumption)	Threshold (crushing)
Green vegetable bug	0.33	1.0
Brown bean bugs	0.5	1.5
Red-banded shield bug	1.0	3.0
Brown stink bug	1.7	5.7

Growers targeting high quality tofu and milk markets should be aware of lower insect damage thresholds in seed for these markets. More detailed information on insect pests and their control is available in the second edition of *Soybeans* (Agfact P5.2.6), the QDPI&F publication *"What insect is that?"* and the guide *"Insect and Mite Control in Field Crops 2005"*. The latter publication is available from district agronomists or can be found on the NSW DPI website www.dpi.nsw.gov.au

Summary

Whole farm profitability and high soybean yields are very achievable if good planning and time management techniques are employed. New high yielding human consumption soybean varieties, Djakal and Snowy, provide growers with a shorter and manageable growing season, better water use efficiencies and returns per ML, resulting in an extra 2–3 weeks to fit better into a double cropping rotation. Gross margin returns of in excess of $285/ML are achievable with soybeans in rotation with winter cereals per calendar year. There are growers currently achieving this in the MIA & CIA. With soybeans as a stand alone crop, GM can be in excess of $195/ML with current prices. Good planning and management can result in these yields on a yearly basis.