Agriculture Notes

Growing soybeans in Northern Victoria

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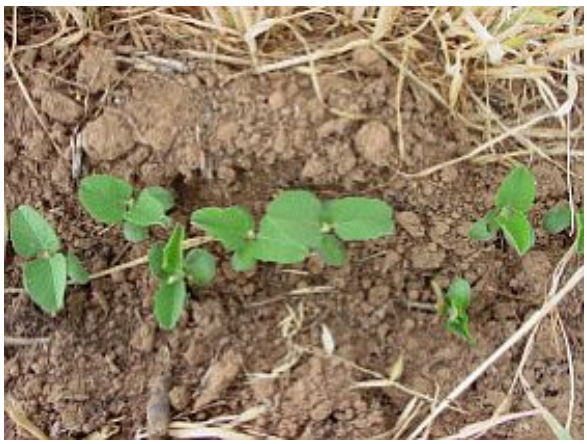
The Industry

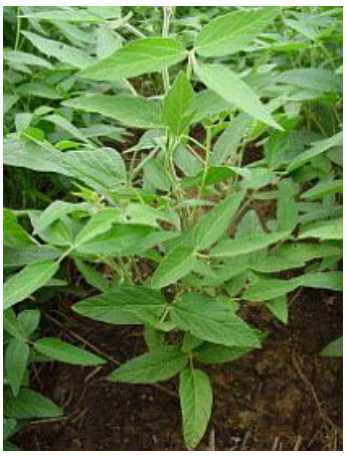
The Soybean (*Glycine max*) is an irrigated summer growing oilseed crop whose grain in Australia has traditionally been used for oil extraction and the meal used in the stockfeed industries. More recently soybeans have become a popular culinary grain used in the making of Asian foodstuffs such as milk and tofu. Australia and Victoria are net importers of soybeans with the majority used as meal for use in animal rations. Soybeans were first grown in Victoria in the early 1980's and have been grown commercially in Victoria since then. The aims of the current breeding program are to develop varieties that are-

- better suited to culinary uses
- adapted to growing in southern regions
- resistant to phytophthora root rot disease.

Highest prices are obtained for export grade soybeans for Japan, capable of filling an out- of -season supply from the Northern Hemisphere.



Soybean - 11 days after sowing



Soybean – 75 days after sowing

Soybean - 90 days after sowing

A healthy crop at 90 days after sowing

Figure 1. Some growth stages of soybeans

Victoria The Place To Be

Sowing Date

Soybeans are best suited to the northern irrigation areas of Victoria where summer temperatures are warm and day length is longer. In tropical areas of Australia they can be grown on stored and summer rainfall but southern Australia is too dry for this to be considered. Soybeans are a very photo-period sensitive plant, meaning the trigger to start flowering is brought on by the decreasing day length after the summer solstice on December 22. In southern latitude climates such as Victoria it is important to maximise vegetative growth before this period to maximise yield. Experience over the last 20 years has shown that there is little value in very early sowing and that the 15th November is an optimum date in most years. Sowing too late leads to a crop unable to reach optimum vegetative growth, low pods and lengthens the maturity time into late April/May, increasing the risk of weather damage, late harvest, small immature seed and reduced time available for winter crop planting. Varieties grown in Victoria have an indeterminate growth habit, flowering starts 50-60 days after sowing (20–35 cm height) and continues through to between 80-120 cm. The crop reaches physiological maturity 140 days after sowing.

Land capability

Soybeans have been successfully grown on many irrigated soil types, using border-check flood, overhead sprinkler and bed layouts. Soybeans have little tolerance to waterlogging up until the four leaf stage so a lasered layout capable of rapid watering and drainage is essential. Aim to have water on and then off within 12-18 hours. Mature plants have greater waterlogging tolerance and occasional periods less than 48 hours can cause minimal yield loss. Soybeans are intolerant of soil salinity and need soil with less than 2 dS/m EC_e and irrigation water needs to be less than 1.5 dS/m EC_w. Paddocks with a pH ($CaCl_2$) of less than 4.8 may need liming, soybeans are intolerant of acidity.

Seeding

Soybean seed is very fragile and cannot cope with seed coat damage. The use of spiral augers is not recommended and belt shifters or vacuums are much gentler on seed. Even though beans should be harvested at 15% moisture content to minimise seed damage, the seed should be stored at below 13% and preferably at 10% moisture content and kept cool to maintain viability. Regardless of this though, soybean seed loses viability quickly and a germination test as close as possible to sowing is essential. Sowing two-year old seed is not recommended and fresh seed, every year is the best option.

Sowing rates for soybeans need to be adjusted for seed size and germination % every year to achieve a density of 30-35 plants/m^2. Seed size between varieties and between paddocks of the same variety can differ remarkably. Stephens beans can have seed as small as 14g /100 seeds where large culinary grade beans could be 24g /100 seeds, 70% larger, necessitating a corresponding increase in seeding rate to achieve the same plant density. The following formulae can be used to calculate the required sowing rate.

$$\text{Seeding rate (kg/ha)} = \frac{\text{Required Plant density/m}^2 \times \text{100 seed weight in grams} \times 1000}{\text{Germination \%} \times \text{Establishment \%}}$$

Crop establishment is the biggest variable and is best known from experience using your sowing equipment and farming system. Poor vigour seed, sowing depth, high/low seedbed moisture and crusting can all lead to establishment problems. Low plant numbers lead to pods formed low to the ground, whereas high plant numbers lead to tall plants prone to lodging. Growers with open front headers claim that this is not a major impediment to harvest as they harvest the whole crop low anyway. High plant numbers can also increase the severity of *Sclerotinia* root rot if it attacks the crop.

Management practices

Inoculation

Soybeans have a large requirement for nitrogen, but can obtain the majority of this from the air via *Rhizobium* bacteria forming nodules on their root system. Soybean seed needs to be inoculated with group H *rhizobia* to get effective nodulation and ensure adequate nitrogen nutrition to the plant. *Rhizobium* bacteria need low nitrogen soils for optimum effectiveness and soybeans grown after cereal crops rather than pasture provide these conditions.

Fertilisers

Soybeans are large users of soil nutrients. In a properly nodulated crop up to 100 kg N/ha will be produced for every tonne of grain produced. Soybeans have a large requirement for phosphorous. For every tonne of grain produced the crop will take up 11 kg P/ha and the grain will remove 7 kg P/ha. Soybeans have an extended period of P uptake right up until mid pod-fill. High fertility paddocks may be better at providing extended P availability, rather than extra large doses of starter P fertiliser. Rates in the range from 24 to 40 kg/ha of P are regularly used. Sulphur is not likely to be a problem on soils that have seen single superphosphate application or where gypsum has been applied. Potassium is usually plentiful in Northern Victorian soils but may need close monitoring if many hay and silage crops have been removed. Molybdenum could be deficient in acid topsoils but addition of lime to correct the pH above 4.8 $CaCl_2$ is more beneficial. Zinc could be deficient in some highly alkaline grey or black clay soils.

Sowing

Soybeans can be sown on stored moisture and after rainfall but it is rare that this is possible. Soybeans must be pre-watered to ensure successful establishment and good nodulation. After watering, the crop is sown into receding soil moisture approximately 8-15 days afterwards depending on seasonal and soil conditions. Pre-watering early in November will lead to sowing at around the

optimum time. The soil temperature needs to be above 13°C for successful germination but above 25°C is optimum for rapid emergence.

Sowing depth is important for good establishment, too shallow will lead to desiccation of the seed but too deep can mean seedlings fail to emerge, 5 cm is usually optimal. Full cultivation and incorporation of pre emergent herbicides before sowing has been practiced, but modern direct drill machines with press wheels or harrows have enabled one pass sowing and incorporation with successful crop emergence.

On many soil types, rainfall after sowing can lead to crusting and emergence problems, use of high rates of gypsum can help to alleviate this problem. Watering up dry-sown beans is not recommended on most soil types because of crusting. Recently lasered paddocks are not recommended, as soybeans are a poor pioneering crop. The crop can live on pre-watered moisture for some time before the first irrigation and will usually be about 20 cm high. After this time more rapid plant growth leads to a higher water demand and irrigation every 10-14 days will be required.

When the crop has full ground cover and pod fill has just started watering may need to be brought to a tighter seven day schedule. Watering intensity is usually tapered off towards the end of the crops' growth. Many growers avoid late irrigation for fear of an early break to the season making harvest difficult. However, water stress at the final stages of pod fill can be costly to yield. Try to keep moisture availability up until 50% of pods have reached physiological maturity (yellowing pods and leaf drop). Tensiometers are a good way of monitoring soil moisture especially in the later stages of growth. They allow greater confidence in what water is available to the crop and give the ability to water when the crop actually needs it. Soybeans are a relatively low water use crop. Depending on season and soil type, irrigation water use varies between 4.5-8.5 ML/ha, the average is around 6.5 ML/ha.

Weed Control

Soybeans are a very vigorous crop that can out compete many weeds if they can achieve full canopy coverage of the ground early. Narrow sowing rows and early sowing can help to achieve this quickest. Early weed control is best for highest yields, as bean seedlings are at their most vulnerable between 4-7 weeks from sowing. Choice of a low weed background paddock that has been in rotation with other winter and summer crops helps. Use of pre-emergent herbicides against hogweed and other grasses is recommended initially followed up by post-emergent weed control at an early growth stage if required. Broadleaf weeds such as Bathurst Burr and Black Berry Nightshade are competitors and seed quality contaminants, while grass weeds such as Barnyard Grass thrive in wet conditions and are highly competitive. Weeds at crop maturity can delay harvest and block machinery and are best desiccated one to two weeks before harvest.

Diseases

There are few fungal diseases that affect soybeans in Northern Victoria. *Phytophthora* root rot is the major one since its re-discovery in 2002. This fungus was identified to be race 15, a common race in NSW. While most of the varieties have resistance or field tolerance to race 15 and other races, there is a need to be vigilant and to monitor the progress of this disease. The disease is favoured by wet and waterlogged conditions and is best identified at the bottom of bays. The disease leads to a brown/dead tissue lesion emanating from the ground and up the stem. The fungus effectively prevents water uptake by the plant and a major symptom is wilting and dead plants in the presence of living ones, dead patches can sometimes occur.

Sometimes the fungus *Sclerotinia* attacks soybeans, leading to isolated dead plants that sometimes develop to patches. Warm humid weather favours the disease and plants can be identified by having white fungal growth on the outside of stems and black sclerotes (looking like rat droppings) on the inside of the stems. *Sclerotinia* is an insidious disease that is difficult to control and lasts for long periods in the soil.

Insects

The soybean plant is vulnerable to insect attack over the whole of its growing period.

- In early seedling development the grubs of the Common Grass Blue Butterfly(GBB) and Soybean Moth can cause extensive foliar damage. At later stages GBB can destroy buds, flowers and eat developing seeds.
- During early pod formation the Green Mirid can cause abortion of pods and individual seeds in pods.
- Throughout the whole of podding, Green Vegetable and Red Banded Shield bugs, Bean bugs and Brown Stink Bugs can cause severe losses of pods and seeds as well as causing seed discolouration, distortion and yield loss.
- *Helicoverpa* grubs can cause severe damage to developing pods and seeds and usually arrive at the mid to late pod filling stage.

Harvest

Soybean seed is accepted by buyers at 15%-13% moisture on an oven dry basis but only if the seed falls out of the testing cup after being squashed tight. The optimal moisture level for harvest is 13% as lower levels can lead to pod shattering and cracking and splitting of seed.

Harvesting often starts at 12.00 noon when the dew has dried off, until 5.00 pm when it sets in again and the plants and seeds take up moisture. Harvesting in the early morning or evening may be required if the moisture content is too low during the day.

The use of desiccant herbicide to mature the crop evenly, dry off weeds and reduce seed moisture content is recommended in some seasons, and is probably good insurance in most. The crop is ready for desiccation when the plant has reached physiological maturity, this is when

the pods are yellow and the leaves are yellow and falling off. Desiccating too early can be detrimental to yield.

Harvest with an open front header held low to get the bottom pods. The concave should be open, drum speed low and wind high to minimise seed damage and maximise sample purity.

After harvest and depending on the season, some growers are making good money from baled soybean stubble, which is sold to the livestock industry or for garden mulch.

Varieties

Snowy (97016-11)

Snowy, bred by Andrew James and selected by Luke Gaynor and released in 2005, is a couple of days later than Empyle but significantly earlier than Bowyer and Curringa. It has a clear hilum, good seed size, protein and excellent tofu making ability.

Djakal (BAF212)

Djakal, bred by Ian Rose, selected by Judith Andrews and released in 2001, is similar to slightly earlier in maturity compared to Stephens. It has a buff/brown hilum and good seed size suitable for the culinary market. Djakal has good lodging resistance but has a tendency for lower protein content. Djakal is the highest and most consistent yielder available to date.

Empyle (TH247)

Empyle was bred by Ken McWhirter and released in 2001. It is a buff/brown hilum bean suitable for the culinary market. Empyle has good lodging resistance under high yielding conditions but has a tendency for small seed size. Empyle's maturity is a few days later than Stephens. Empyle requires a growing agreement including royalty to the breeder.

Naring (WNC133)

This variety was bred by Ian Rose, selected by Ken Pritchard and released in 2000. It has a small yield advantage over Stephens. It has better lodging resistance and a similar maturity to Stephens. It has a black hilum and is a crushing quality bean.

Curringa (DHF064)

Curringa was bred by Ian Rose, selected by Judith Andrews and released in 1999, being very similar in growth and seed type to Bowyer, it has increased yield, disease and lodging resistance compared to Bowyer. Likewise to Bowyer, its maturity is too late for reliable growing in Northern Victoria.

Stephens

This variety was bred by Ken McWhirter, released in 1987 and is the standard variety for maturity length in Victoria. Stephens is a crushing quality bean with a grey hilum. It has poor lodging resistance but has been a proven high yielding variety over many years.

Bowyer

Bowyer was bred by Ken McWhirter and released in 1982, it has been a high quality culinary bean for some time. It has good seed size, protein content and has a brown/buff hilum. Its maturity is at least a week to two weeks later than Stephens and for this reason cannot be recommended for Northern Victorian seasonal conditions.

Table 1. Yield of soybeans over 10 seasons (t/ha)

	93/94	94/95	95/96	96/97	97/98	00/01	01/02 i	01/02 adv ii	02/03	03/04	04/05	Average
Bowyer	1.95	3.73	2.05	1.50	2.40	2.98	2.71	1.90	3.95			2.57
Curringa		4.13	2.54	1.57	2.72	2.53	2.84	2.60		1.20	3.01	2.57
Djakal						2.91	3.13	3.01	3.94	3.09	3.28	3.23
Empyle							2	2.66	4.58	2.74	3.32	3.06
Naring	2.74	5.08	3.76	3.54	2.64				3.87			3.61
Snowy									4.81	2.18	2.92	3.30
Stephens	2.72	4.49	3.80	3.34	2.72	2.51	2.98	3.09	3.71	1.63	1.82	2.98

(i) Pre-release trial, (ii) Advanced trial

Breeding line 96248-23, clear hilum

Djakal, buff hilum

Bowyer, buff hilum

Stephens, grey hilum

Figure 2. Soybean seed samples

Economics

Gross Margin analysis for culinary soybeans

Soybean		YEAR 2005-6				Your Figures
YIELD		2.5 **tonnes per ha**				
PRICE		$500 **per tonne on farm**				
INCOME					**$/ha**	
Soybeans		2.5 t/ha	@	$500 per t	$1,250	
COSTS						
Seed bed preparation	4 passes	2 ha/hr	@	$54 per hr	$108	
Sowing						
Direct sowing		2 ha/hr	@	$54 per hr	$27	
Seed + inoculation		90 kg/ha	@	$0.90 per kg	$81	
Fertiliser						
Triple super		200 kg/ha	@	$536 per t	$107	
Pre-emergent herbicides to control:						
Broadleaf and grass weeds					$15	
Application/incorporation		6 ha/hr	@	$54 per hr	$9	
Irrigation and drainage		7.5 Ml/ha	@	$39 per Ml	$254	
Post-emergent herbicides to control:						
Broadleaf weeds					$38	
Application/incorporation		6 ha/hr	@	$54 per hr	$9	
Insecticides					$24	
Aerial application			@	$12 per ha	$12	
Crop dessication					$31	
Aerial application	1 pass		@	$12 per ha	$12	
Harvesting						
SP harvester		3 ha/hr	@	$110 per hr	$37	
Insurance			@	$11 per $'000	$14	
Total Variable Costs					$778	
GROSS MARGIN $ PER HECTARE					**$472**	
GROSS MARGIN $ PER MEGALITRE					**$73**	
TOTAL VARIABLE COSTS/TONNE					$311	
TOTAL OVERHEAD COSTS/TONNE						
PROFIT MARGIN/TONNE						
ON FARM TARGET PRICE						

Table 3. Effect of price and yield on gross margin per hectare

Yield (tonne per hectare)	Price ($ per tonne)						
	$350	$400	$450	$500	$550	$600	$650
1.0	($418)	($369)	($319)	($270)	($220)	($171)	($121)
1.5	($245)	($171)	($97)	($23)	$52	$126	$200
2.0	($72)	$27	$126	$225	$323	$422	$521
2.5	$101	$225	$348	$472	$595	$719	$842
3.0	$274	$422	$571	$719	$867	$1,015	$1,164
3.5	$447	$620	$793	$966	$1,139	$1,312	$1,485
4.0	$620	$818	$1,015	$1,213	$1,411	$1,609	$1,806

Key tips for success

- **Drainage:** Ensure layout allows irrigation and drainage within eight hours.
- **Soil structure:** Good soil structure.
- **Sub-soil moisture:** Use pre-irrigation to achieve adequate soil moisture at sowing.
- **Sown on time:** Sow recommended varieties within the preferred sowing window for your location.
- **Crop establishment:** Aim at a plant population of 35 to 40 plants per square metre.
- **Adequate nutrition:** Apply P according to paddock history, soil test results and target yield removal figures. Approximately 40 kg P per hectare is required by a four-tonne crop. Inoculate seed with appropriate *rhizobium* to meet N requirements of soybeans.
- **Control weeds, pests & diseases:** Use pre and post emergent herbicides and pesticides to ensure minimal yield loss. Check constantly for insects from emergence to maturity.
- **Soil moisture:** Check to ensure timely irrigation. Ensure plants have adequate available water for the entire growing season.
- **Harvest:** Desiccants can be useful for an early harvest and to achieve a quality high yielding crop.

The previous version of this note was published in November 2003.