Farming system update

soybeans

growing guide for Queensland

Soybean crops are a valuable part of crop rotations in both irrigated and rain-fed situations.

Soybeans are a versatile legume crop. Grain processors use soybean in the production of vegetable oils, processed foods such as tofu and soymilk, and soy meal for animal feeds. FAOSTATS[1] from 2008 show Australia imported $US70 million worth of soya meal, oil, beans and soya sauce, and exported $US6 million dollars worth of soy products. The industry is concentrated in Queensland and New South Wales.

Traditional soybean growing areas in Queensland include, the Darling Downs, central Burnett and Atherton areas. Recently production has expanded in coastal areas as a rotation with sugarcane. In the 2007/08 season an estimated 20 930 tonnes were produced in Queensland, which is almost double the production of 2006/07 at 11 125 tonnes. Plantings for the 2008/09 season are expected to be double this again due to good prices and the proven rotational benefits of soybeans in sugarcane farming systems.

Soybeans ‘fix’ nitrogen from the atmosphere through a symbiotic relationship with a soil bacteria, called rhizobia. Seed inoculation increases the rhizobia activity, adding to soil fertility and overall sustainability of the cropping system. In crop rotations, soybeans can provide both green manure and grain crop benefits. As a green manure crop soybeans produce up to 300 kg of nitrogen per hectare if turned in any time after mid-podfill.

The organic soybean sector is growing and can generate significant price premiums for growers. However, there is a marked difference in management between ‘conventional’ and ‘organic’ soybeans, particularly in pest management. Growers must factor in the costs such as certification, hand weeding and other labour. Sound planning and careful management are essential.

Key points

Growers who are aware of these key points are most likely to succeed:

- Plant only fresh, good quality seed at the recommended rate.
- Choose varieties that suit your planting time, climate and market. Discuss varieties with a local agronomist and potential buyers before planting.
- Ensure effective inoculation using group-H soybean inoculant.
- If irrigating, avoid moisture-stress throughout the growing season.
- Managing insect pests involves monitoring, correct identification and an understanding of economic thresholds and management options. *Helicoverpa spp.* caterpillars are a threat mainly from the commencement of flowering onwards. Loopers and other leaf feeders are a threat only if major leaf area is lost. Green vegetable bugs (GVB) feed on young pods and developing seed and can severely reduce both yield and quality.
- To reduce disease problems, avoid planting soybeans after other legumes or sunflowers. New varieties have genetic resistance to phytophthora, the main disease of soybean.
- Commence harvesting when seed moisture levels reach 16 percent because harvesting at 12–13 percent moisture causes more grain loss and seed cracking.
- Soybean crops yield an average 2.5 t/ha under irrigation and provide competitive returns, especially in premium market sectors. Higher yields are achievable through good management.

PR08-4105

AOF
SOYNORTH NORTHERN AUSTRALIAN SOYBEAN INDUSTRY ASSOC INC.
Queensland Government Department of Primary Industries and Fisheries

Marketing soybeans

There are two main markets for soybean grain – crushing grade grain for oil and culinary grade grain for the edible trade. Soy meal for stockfeed is a by-product of the crushing process.

Oilseed crushers and full fat processors usually contract purchase darker coloured hila varieties. The lighter coloured hila varieties are more suitable for the edible trade. Warrigal, Soya 791, A6785 and the new varieties Fraser, Bunya, Oakey and Stuart are all suitable for soybean flour production. This can attract a premium over the price for crushing beans.

Soya 791 and A6785 have been more sought after for the specialty tofu and soymilk markets but new, higher grade culinary varieties of Bunya, Fraser and Stuart are also highly suitable. Check with potential buyers prior to planting.

Culinary grade soybeans usually attract a significant price premium over standard crushing beans. Premiums will vary according to current market demand, the buyers' preference for certain varieties and the grain quality.

The Grain Research and Development Corporation (GRDC)-supported National Soybean Improvement Project led by CSIRO is developing a number of new culinary types for specialty domestic and overseas markets. For further details, contact Andrew James at CSIRO on 07-3214 2278. Annand and Robinson Pty Ltd conduct a private breeding program for specialty market soybeans. For more information contact Eric Robinson on 07-4632 2688.

Cotton Seed Distributors (CDS) Grains, manage a closed-loop production program using varieties suitable for the high-value natto trade variety Oakey. Natto is a fermented soybean product. For further details, contact 07-4698 5600.

The Australian Oilseeds Federation (AOF) has released a comprehensive marketing guide detailing conventional and organic traders and processors. The guide can be downloaded from the AOF website (see Further information section).

Marketing organic soybeans

Sizeable markets for organic soybeans already exist, offering some very attractive prices but limited market access due to its specialty marketing and limited processing sector.

Lower yields can occur and are often associated with poor weed and pest control. Weed and pest control options are limited under organic production systems and growers need to develop strategies to minimise pest and weed populations before planting the crop.

Demand has increased with the opening of National Food's soymilk plant and the general increase in the popularity of organic soy products. This demand may continue to grow.

Miso and natto are both fermented soybean products used in traditional Japanese cooking.

Varieties with light coloured hila are acceptable for the culinary trade.

Growers considering organic soybean production should discuss the industry's requirements with local traders and processors. Please refer to the AOF marketing guide.

Planting guide

Planting time and variety selection

As a general guide, use the maturity group ratings to select a variety suited to a summer planting situation for your region:

- north Queensland – groups 8 and 9
- central Queensland – groups 7 and 8
- southern Queensland – groups 5, 6 and 7

Recommendations for inland regions

December is the preferred planting time in southern Queensland, although in some situations the planting period may extend from mid-November to mid-January.

For central Queensland, mid to slow maturing types are the most suitable. Crops planted in mid-December mature in 115 to 125 days.

Because most soybeans flower in response to shortening day length, early plantings will take longer to flower, whereas late sowings will mature faster as the day length shortens. To avoid problems with excessive vegetative growth from early plantings, earlier maturity varieties such as Soya 791 are the best choice.

Conversely, late maturing varieties such as Stuart are a better option for late plantings because they will help extend the length of the vegetative phase which has a strong correlation with potential yield.

Avoid planting any variety after the third week in January otherwise growth, stature and crop yield are likely to be restricted. Leichhardt is the latest sowing option and will extend a couple of weeks longer in warmer situations but is not a preferred option in inland production areas.

Recommendations for coastal Queensland

The slow maturing Leichhardt and the newer Stuart varieties are specially adapted to the tropical coastal areas from Mackay to far north Queensland and are well-suited to rotation with sugarcane.

In coastal areas prone to waterlogging and hardsetting soils it is advantageous to plant into hills or beds. This practice promotes better emergence and establishment of the seedlings.

Detailed information is provided in three regional guides for coastal areas in Queensland. These guides are available on the DPI&F website or by telephoning DPI&F on 13 25 23.

- 'Soybeans – coastal regions: Bundaberg to Beenleigh'
- 'Soybeans – coastal regions: Mackay/Proserpine'
- 'Soybeans – coastal regions: Wet tropics'

Crop establishment

Plant population

In dryland crops aim for 200 000 plants per hectare (and up to 250 000 plants per hectare under very favourable dryland conditions). On lighter granite soils 180 000 to 200 000 plants per hectare is better.

In irrigated crops aim for 300 000 plants per hectare or up to 400 000 plants per hectare for high yielding situations, or for late plantings made in January. Some varieties of small or upright stature respond to higher planting rates.

Average seeding rate

As seed size can vary considerably, adjust the seeding rate accordingly. Refer to the seed packaging label for an accurate count, usually around 5000 to 7000 seeds per kilogram for most varieties.

Assuming an average seed size of 5700 seeds per kilogram and 80 percent establishment, Table 1 provides a guide to suitable seeding rates.

Germination percentage

All seed offered for sale must clearly state the germination percentage of that seed line. Use the best seed quality available. It is not recommended to use seed lower than 80 percent viable seed.

Strongly consider using seed from the 'Industry approved scheme' endorsed by the Northern Australia Soybean Industry Association (NASIA).

Establishment percentage

Soybean has a reputation for poor establishment, however, 80 to 90 percent establishment is achievable in friable non-crusting soils, using quality seed.

While poor seedbed environment can contribute to poor establishment, seed quality is often more important. Be sure to:

- avoid using planting material with hairline cracks in the seed coat. This usually indicates mechanical damage
- use belt elevators in preference to augers when handling seed crops
- avoid using seed damaged by pod sucking insects (e.g. green vegetable bug)
- avoid using old seed. The recommended storage life for soybeans is only about six months, even under good conditions
- avoid using seed with any sign of mould or weather damage
- only keep seed with an after-harvest germination test of more than 90 percent to plant your next crop. Keep the seed in a cool room
- strongly consider purchasing industry approved seed from suppliers at least every three years

If in doubt, check the rate of emergence of a small quantity of seed in soil prior to planting the crop.

A high germination percentage in soybeans does not necessarily mean a high level of seedling vigour. The accelerated ageing test is an internationally accepted method of assessing seed vigour in soybeans, and is now available in Australia. It should be used in conjunction with the standard germination test. For further details contact SGS Agritech, 214 McDougall St, Toowoomba, Qld 4350 or phone 07–4633 0599.

Row spacing

Row spacings of 70 to 100 centimetres are standard practice. Narrower row spacings of 20 to 30 centimetres can be an advantage in a high yielding irrigated situation, or with a late planting where smaller bush size is likely to limit yield.

Seed placement depth

Plant seeds 30 to 50 millimetres deep, preferably into moisture. Sowing deeper than 50 millimetres

Table 1 – Seeding rates.

Target population	Seeding rate*
200 000 plants per ha	42 kg per ha
300 000 plants per ha	63 kg per ha

*Assuming an average seed size of 5700 seeds per kilogram and 80 percent establishment.

can significantly reduce emergence, especially in hardsetting soils after rain. Precision planters should aim to plant at 30 millimetres depth.

Avoid watering the crop up as this can lead to establishment problems such as soil crusting and the germination of weeds as the crop emerges.

Inoculum

Soybeans do not need additional nitrogen if the seed is effectively inoculated at planting with the correct strain of the nitrogen-fixing rhizobia, however there is evidence that applying approximately 30 units of N at planting can assist early vigour of the plant. Inoculum is a mixture of the sensitive living bacteria (rhizobia) mixed in a peat culture.

Inoculation helps maximise nodulation and N-fixing ability. Effective nodulation also maximises the residual nitrogen carryover for the following crop (approx. 40–60 kg N/ha in a harvested crop). **Poor inoculation or avoiding inoculation will not save money or time as poor nodulation and reduced nitrogen fixation will have profound effects on both yield and protein content of the crop.**

While nitrogen application may produce taller, greener plants, trial results to date show no economic yield response from the addition of nitrogenous fertiliser to soybeans in dryland situations.

The rhizobia strain specific to soybeans is the Group H rhizobium. Refer to the container label for inoculant application rates and check the expiry date. Do not use inoculum if the expiry date has passed or if it has not been stored correctly.

Rhizobia are living organisms and very sensitive to hot, dry conditions. Store in a cool place, preferrably the refrigerator (but not the freezer). Likewise, inoculated seed should be kept in a cool shady place out of direct sunlight. Only treat enough seed for each day's planting and sow treated seed immediately.

Effective inoculation is essential for good nodulation.

Exercise caution when using air seeders, as hot air in the distribution system of some airseeders can affect the inoculum. Old air seeders with the oil cooler in front of the air intake should not be used. Temperatures greater than 30˚C can kill the rhizobia.

Methods of inoculation vary, but the general maxim applies, 'the better the job is done, the more effective the nodulation'. Methods include:

1. slurry inoculation – is the most common form of inoculation and is also the most reliable and effective. The peat inoculant is mixed with the appropriate volume of cool water indicated on the packet then introduced to the soybean seed and gently mixed to evenly coat the seed. Cement mixers and recirculating grain driers are suitable for mixing seed with the inoculum slurry. Take care to avoid seed damage (e.g. bouncing seed off metal can crack the seed coat). Do not use augers. Slurry inoculated seed should be sown within 12 hours of treatment, however if stored properly (5˚C or lower and out of direct sunlight) can be kept for longer, provided a peat inoculum and sticker have been used.
2. water injection and in-furrow sprays – places a band of inoculum, suspended in water, just below the seed. The germinating seed's roots grow through the band of inoculated soil, leading to formation of nodules. Results from this form of inoculation are generally good, except where the seedbed is very dry or the water jet is not directed properly. Water rates vary according to row spacing, but use at least 300 L/ha. A continuous flow of water from each outlet, without blockages, is essential. Conventional water injection equipment is suitable for this inoculation method.
3. pelleted seed – is prepared by commercial companies as required. Seed can be pre-pelleted with inoculum and fertiliser, insecticides, or fungicides. Pelleting increases the bulk of the seed, therefore appropriate adjustments need to be made to planting rates. This procedure is relatively expensive and is not always effective due to the time delay between pelleting and planting. Proper application and storage techniques are vital. Lime pelleting is another form of seed pelleting that is only recommended where soil acidity is below pH 6. Fine lime is added to form a protective coating around the seed.
4. Nodulator® granules – a clay-based granular inoculant, which was released in autumn 2007 in eastern Australia. It can be placed straight into sowing equipment (airseeders, seed boxes or granular insecticide boxes) and is a free flowing dust free product.

Generally, it is best not to mix fertilisers and insecticides with inoculum or inoculated seed as many pesticides are toxic to rhizobia. Check compatibility before use. In-field experience has shown that low rates of minimum dust, granular and prilled fertilisers (e.g. MAP), do not reduce the efficiency of inoculation when applied at planting. Where fertilisers or insecticides are mixed with inoculum, avoid prolonged contact. Use immediately, do not allow the mixture to stand.

Water injection application of inoculum seems to have a buffering effect, protecting the inoculum from fertiliser damage.

To test if nitrogen fixation is occurring, carefully dig up a plant, wash the root system and cut open a few of the nodules. A red or pink colouration indicates that N-fixation is taking place in the nodules. Be aware that in non-legumes, lumps on the roots that look like rhizobia nodules may be caused by root-knot nematodes.

Rhizobia can not survive in acidic soils (below pH 6). Lime pelleting can provide some protection for the inoculum under acidic conditions.

Molybdenum (Mo) also aids in the nitrogen fixation process. Addition of fertiliser containing Mo can aid the efficiency of N-fixation in legumes especially when soil deficiencies exist and the soil is acidic (pH less than 6).

Environmental conditions such as hot, dry weather at planting can kill the bacteria before they come in contact with the plant roots. During the growing period, rhizobia can die if the roots become waterlogged. While these environmental factors are often unpredictable, careful field selection is critical to ensure adequate nodulation and N-fixation. Try growing soybeans on raised beds in fields prone to waterlogging.

Weed management

Effective weed control is critical for maximising crop yields and meeting quality standards at harvest. Crop weeds are managed most effectively using a combination of chemical and non-chemical methods.

Critical points are:

- Plan weed control strategies well before planting.
- Effective crop selection, planting rate and inter-row cultivation can reduce reliance on chemicals.
- If using herbicides, take care to identify weeds correctly, time applications well and use effective application equipment.

Table 2 provides details on application rates for herbicides registered for weed control in soybeans.

Weed control in organic soybeans

There is no comprehensive ‘recipe’ for organic weed control. Organic methods employed to control weeds generally do not include the use of synthetic herbicides. Weed control systems must be developed to suit the particular weed spectrum, cropping rotation sequence, cost structure and so on.

In conventional and organic agriculture there is no substitute for the time-honoured practice of controlling crop weeds in the fallow as well as in-crop. This reduces the overall weed seed burden, reducing the need for in-crop weed control methods such as inter-row cultivation, and hand weeding. Increasing crop competition, by increasing the planting rate can be an effective tool for minimizing weed growth.

Table 2 – Herbicide options registered for weed control in soybean. Always refer to herbicide label prior to use.

	Weed	Herbicide	Product example	Rate
Pre-plant	Annual grasses and some broadleaf	trifluralin[1] pendimenthalin[1] metolachlor[2]	Triflur 480g/L Stomp Xtra Dual Gold	1.2 - 2.3 L/ha 1.8 – 2.2 L/ha 1.0 - 2.0 L/ha
Post-plant Pre-emergent	Grasses and some broadleaf weeds	imazethapyr[2] metolachlor[2] flumetsulam pendimethalin[2]	Spinnaker 700WDG Dual Gold Broadstrike Stomp Xtra	100-140 g/ha 1.0 – 2.0 L/ha 25 or 50 g/ha 1.8 - 2.2 L/ha
Post-emergent	Broadleaf weeds and grasses	imazethapyr imazamox	Spinnaker 700WDG Raptor	100 - 140 g/ha + wetter 50 g/ha + wetter
	Grasses	quizalofop haloxyfop butroxydim fluazifop clethodim sethoxydim	Targa Verdict 520 Falcon WG Fusilade Forte Select Sertin	0.25 – 1.0 L/ha + wetter 0.05 - 0.15 L/ha + wetter 120 - 180 g/ha + oil 0.82 - 1.65 L/ha + wetter 0.25 – 0.375 + oil 1.0 L/ha + oil
	Broadleaf weeds[3]	acifluorfen bentazone	Blazer[4] Basagran	1.0 - 2.0 L/ha + wetter 1.5 - 2.0 L/ha

[1]thoroughly incorporate prior to planting (recent mill mud applications or high trash levels will substantially reduce efficacy)
[2]this product requires rain/irrigation to activate the chemical
[3]broadleaf weeds should be very small (up to 4 leaf stage)
[4]under certain conditions Blazer can cause severe leaf burn in soybeans, consult your agronomist before use

When budgeting for organic crops, growers should not overlook the often considerable cost of hand weeding, an essential ingredient not only for the current crop but also for the future success of the organic farming system.

Alternative non-chemical weed controls such as flame, hot water and steam treatments are not yet fully developed for wide usage. However, development work continues and such techniques are expected to become more effective and economic in the near future.

Fallow soybeans

Soybeans are a valuable crop to use in rotation with other crops such as cereals and sugarcane. The change to a legume crop provides a disease break and enriches the soil with fixed nitrogen and organic matter for the following crop to use. Table 3 provides data comparing three legume crops commonly used in fallow situations.

As a green manure, soybeans can be sown anytime from late October to December. This usually fits in well with sugarcane rotation where the last ratoon is often cut at the end of the season and ploughed out. It is normally too late to replant cane at this time of year, making soybeans well suited to the six-month fallow period.

Recommended varieties

Leichhardt and Stuart are particularly suited to the wet tropics. They have a light hilum and sub-tropical/tropical adaptation. Dry matter production levels make them suited to green manure cropping. Leichhardt and Stuart have a number of useful attributes including being:

- the best fallow legume for the wet tropics
- tolerant of waterlogging (better than the current alternatives lablab and cowpeas)
- able to produce more dry matter and fix more nitrogen per hectare than alternatives with more potential soil health benefits
- a weed control option that will benefit the following plant cane crop
- able to reduce soil borne diseases and nematode numbers
- a good groundcover for erosion control over the heavy summer rainfall period.

However, for best results, soybeans do need to be established with a planter (preferably on mounds), and they require either a cultural or chemical weed control operation. Broadcasting soybean seed with a fertilizer spreader and harrowing is not recommended for successful crop establishment.

For more information about land preparation, residue incorporation and growing costs, please refer to 'Soybeans – coastal regions: Wet tropics'.

Table 3 – Dry matter and nitrogen returned to the soil by legume crops.

Legume species	Dry matter (kg/ha)	N returned (kg/ha)
Broadcast cowpeas	3313	50
Planted cowpeas	4689	140
Planted soybean	7429	310

Forage yields

Soybean crops are suitable for both green-chop and hay production. The best forage yields can be expected from early-planted, long-season varieties, cut around the mid-podfill stage. The preferred varieties for southern Queensland districts appear to be Warrigal, Jabiru and Oakey.

Silage yields (at around 35 percent dry matter, cut at the milky-dough/podfill stage) expected from dryland soybeans range up to 25 tonnes per hectare. This equates to around 8 tonnes per hectare dry matter yield. Remember that 2/3 of the fixed nitrogen is removed from the field if you cut the crop for hay or silage production.

Fertiliser

Nitrogen (N)

The addition of nitrogenous fertiliser is not recommended except when plants fail to nodulate. Soybean seed should be inoculated with its own specific strain of rhizobium before planting, particularly in areas where the legume crop has not been previously planted. Nodulated plants should not be lacking in nitrogen, and will rarely respond economically to nitrogen application at any stage growth. For more information read the inoculation section above and the grain quality section below.

Phosphorus (P)

The Mycorrhiza fungi in soils play an important role in plant uptake of phorphorus. The symbiotic relationship of the fungi and the plant root is known as VAM (Vesicular-arbuscular mycorrhiza).

VAM fungi colonise plant roots and grow out into the soil, effectively acting like an extension of the root system. Nutrients, especially P and Zn, have been shown to become more available to the plant due to VAM. The fungus relies on live plant roots for its food and during a long bare fallow mycorrhizae will die out in the soil.

Soybeans have a medium dependancy on VAM resulting in potential losses of 40 to 60 percent if Mycorrhiza are not present in the soil. In low VAM situations, such as after fallows of 12 months or more, large responses can be expected from phosphate fertiliser, particularly where soil bicarbonate P levels are below 20 mg/kg.

In high VAM situations, such as when double cropping or after short fallows of less than six months, responses to phosphate fertiliser are only likely if the soil bicarbonate P is below 10 mg/kg.

For further understanding of this important aspect of P nutrition, refer to DPI&F publication 'VAM boosts crop yields – the natural way to healthy crops', available from DPI&F ph 13 25 23.

Potassium (K)

Like most crops, soybeans require quite large amounts of K to achieve good yields and so soil K status is important. Critical soil test values for K in soybeans are currently being developed, but at this stage soils that have low exchangeable K levels prior to planting (ie. <0.3 meq/100g) are likely to respond to K fertilizer application. In coastal areas with sugarcane-dominant cropping systems, K is usually one of the main nutrients required for good soybean growth during a fallow.

Soybeans are capable of accumulating large amounts of potassium in the plant material (100-150 kg K/ha), and if the soil K status is good, this accumulation may be well in excess of the minimal requirements for growth and yield. Regardless of how much K is in the plant material though, soybeans are a crop that removes a lot of K in harvested grains (on average, 20 kg K/t). Therefore, in high yielding irrigated crops removal rates can be high and the resultant K fertilizer rate to maintain soil K status can be significant.

The main K fertilizers are generally muriate of potash (KCl) and sulfate of potash (K_2SO_4), with both obtained from naturally occurring mineral deposits, although some animal manures can also contain significant amounts of potassium (1-2% on a dry weight basis) if they have not been leached too heavily. The KCl form of K fertilizer is a lot cheaper per kg of K applied, but K_2SO_4 has advantages of also containing 18 percent S and not containing chlorides.

The key issue with the chlorides in KCl is not the amount applied (in many areas, more chloride falls naturally in rainfall each year than is applied in KCl fertilizer). Rather, the ready solubility and high resulting concentration of dissolved ions from a KCl band result in a 'salty' solution that can cause poor crop establishment (if too close to the seed) or cause damage to plant roots for a short period until the fertilizer dissolves and moves through the soil.

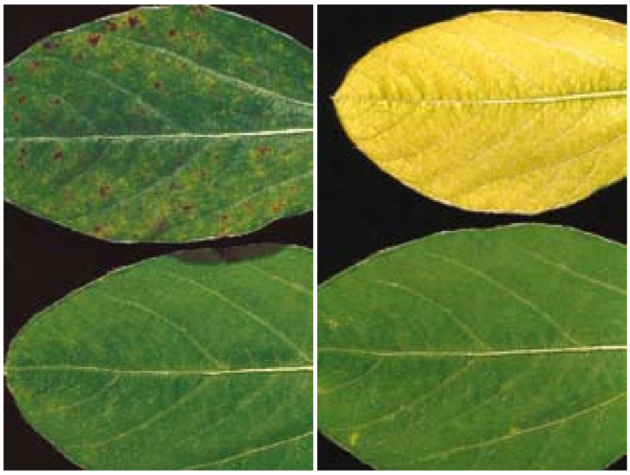
Sulfur (S)

Consider applying sulfur fertilisers when double cropping because the available sulfur levels can be severely depleted.

Using single superphosphate to apply the above phosphorus rates will alleviate any potential sulfur deficiency. Alternatively, use a starter fertiliser containing zinc or sulfur such as Phosul, Phozinc and Starter Z.

Low rates of sulfate of ammonia can also be used to correct a sulfur deficiency in situations where soil P levels are already considered adequate.

Nitrogen deficiency (left) is usually due to poor nodulation. Zinc deficiency (right) is treated with a foliar application of zinc sulphate.



Phosphorus deficiency (left) can occur in low VAM situations such as after a long fallow. Sulfur deficiency (right) is most common in double cropping situations.

Zinc (Zn)

A foliar spray of one to two kilos of zinc sulfate heptahydrate plus one kilo of urea in a minimum of 50 litres of water per hectare plus a wetting agent will correct a mild zinc deficiency.

Apply one to two sprays within four weeks of emergence. Broadacre zinc or Teprosyn Zn (Phosyn) as a seed treatment is a cost effective method of applying zinc in situations where soil P levels are adequate but zinc levels are deficient.

Agrichem recommend that Broadacre zinc be applied at a rate of five litres product per tonne of seed. This would supply in excess of the crop's zinc requirements. Apply the Broadacre zinc treatment to seed first and allow to dry before applying the inoculant.

Other seed treatments such as Teprosyn Zn (Phosyn) are also readily available. Read the label carefully before use. For further information on products and management issues, check with Incitec and Phosyn.

Molybdenum (Mo)

Molybdenum plays an important part in nitrogen fixing and so is an essential nutrient. Soils most commonly Mo deficient are light textured (sandy) and acidic. These soils are particularly common in coastal sugarcane areas. Apply 50 gMo/ha for two consecutive soybean crops. Mo is usually applied as a seed dressing of molybdenum trioxide (60% Mo) or Mo Superphosphate (commonly 0.025% Mo). Do not use sodium molybdate or ammonium molybdate as seed dressing because they are toxic to inoculant rhizobia.

Nutrition for organic soybeans

While organic certification organisations generally do not permit the use of processed inorganic fertilisers, the information above is still relevant to organic growers to understand the nutritional requirements of the crop.

Both organic and conventional farming results in a net outflow of essential plant nutrients from the farm. It is therefore important that managers address this by budgeting to replace these nutrients. With organic fertilisers, this can be more costly and more difficult.

Check for the types of naturally occurring fertilisers allowable under the standards of each organisation. Submit a soil test to a reputable laboratory and use trained personnel to interpret results.

Soil organic matter

Organic matter levels in cropping soils are often depleted. Improve soil organic matter levels by applying manures and composts and incorporating green manure crops and crop stubble. This will help retain moisture in the soil profile and encourage more soil microbial activity and diversity, all resulting in improved nutrient availability.

Nutrient deficiencies can cause economic yield loss well before the more obvious deficiency symptoms in the plant become evident. Nutrient imbalance can occur in lighter acid soils that are low in organic matter and have a history of superphosphate use.

Nitrogen (N)

See conventional soybean information.

Phosphorus (P)

Where soil levels of plant-available P are low, P in the form of soft rock phosphate (e.g. guano), and reactive rock phosphate are acceptable for organic standards. These products are obtainable in most districts. Crop availability of soil P is known to be improved by VAM as in conventional soybeans.

Potassium (K)

See conventional soybean information. Growers should check the suitability of the different products for their management objectives.

Sulfur (S), zinc (Zn), and other trace elements

If the soil is deficient in sulfur the cheapest form for agricultural use is gypsum. Organic certification bodies will accept mined natural gypsum, as opposed to phosphogypsum which is a manufacturing by-product. Gypsum is available in most areas.

Availability of Zn is often a limiting factor in soybean production, especially in soils with pH 7.0 or higher. Some products (e.g. zinc sulfate heptahydrate as a foliar spray, zinc sulfate monohydrate for soil application) are permitted by some certifier organisations. One to two foliar sprays will be needed within four weeks of emergence.

In acidic soils, lower than pH 5-6, manganese toxicity and iron chlorosis (yellowing) can affect crop yields.

Check with individual certification organisations on the types and forms of trace elements permissible under their standards. Growers should consider liming low pH soils to avoid nutrient imbalance problems.

Irrigation

Soybean crops will achieve maximum yield potential if they are free from moisture stress throughout the season. Moisture is critical during crop establishment as hot, dry soil kills rhizobia and root nodules.

Very hot conditions can also kill emerging seedlings. Experience has shown that many crops, particularly in the Burdekin, have failed to nodulate sufficiently (and thus grow to potential) because they did not receive sufficient irrigation when small.

Once the soybean plant is established it can tolerate minor moisture stress without significant yield loss in the vegetative stages. However, to maximise yield potential, the crop should be maintained in relatively well-watered conditions.

Yield potential in excess of 5 t/ha is common in crops with good plant populations that are maintained on a 60 mm or lower irrigation deficit. It is important to maintain irrigation into the grain fill period to ensure seed size and thus yield is maximised.

For fully irrigated crops on heavier soils, schedule irrigations so that soil moisture deficient does not exceed 70 to 90 mm, usually two to three irrigations.

Yields of 2.5 to 3.5 tonnes per hectare are normally realised with irrigated soybeans. In recent years, good crop husbandry practices under favourable seasonal conditions have seen some varieties return in excess of five to six tonnes per hectare.

Where sowing late or choosing varieties with a tendency to produce less vegetative growth, there may be some yield advantage in adopting narrower row spacings of 50 to 70 cm.

In coastal soybeans, many cane farmers irrigate soybeans in the same cycle as their cane and achieve good results as the peak moisture demand for cane in south east Queensland coincides with the peak demand for soybeans.

Pest management

Soybeans can be attacked by pests at any stage from seedlings to close to harvest, but are most attractive from flowering onwards. It is important to note that soybeans are very tolerant of insect damage at many stages of crop development, and that noticeable damage (particularly leaf damage) does not necessarily translate to yield loss.

Soybeans can tolerate up to 33% leaf loss (providing terminal and auxillery buds are not attacked) without yield loss but their ability to compensate for pest damage decreases as pods develop. Soybeans set a large number of reserve pods and can compensate for insect damage during early podding by diverting energy to fill these reserve pods. If developing seeds are damaged the plant diverts more energy to undamaged seeds, making these bigger and heavier.

Seeds damaged by pod sucking bugs during early pod fill are often lost at harvest, or are graded out post harvest, as they are lighter than undamaged seeds. However seeds damaged from mid pod fill onwards are similar in weight to undamaged seeds, and not lost at harvest, or able to be graded out without resorting to colour sorters.

Crops remain susceptible to late bug damage until the pods harden just prior to harvest. As a result, late bug damage is a major factor affecting seed quality. As a rule of thumb, only 2% seed damage is tolerable for soybeans targeting the culinary market.

Major pests of soybeans are:

- *Helicoverpa spp.*
- green vegetable and other pod-sucking bugs
- silver leaf whitefly

Less frequent or minor pests include:

- caterpillars – loopers, cluster caterpillar, leaf miners/webbers including soybean moth and legume webspinner, small podborers e.g. etiella,
- podsucking bugs – red banded shield bug, brown bean bug, brown shield bug
- soybean aphids
- red shouldered leaf beetle
- lucerne crown borer
- mirids
- mice
- field crickets

New permits and product registrations are occurring, so for chemical control options please refer to Infopest, APVMA website or local agronomists for the latest details.

Helicoverpa

Helicoverpa armigera, H. punctigera

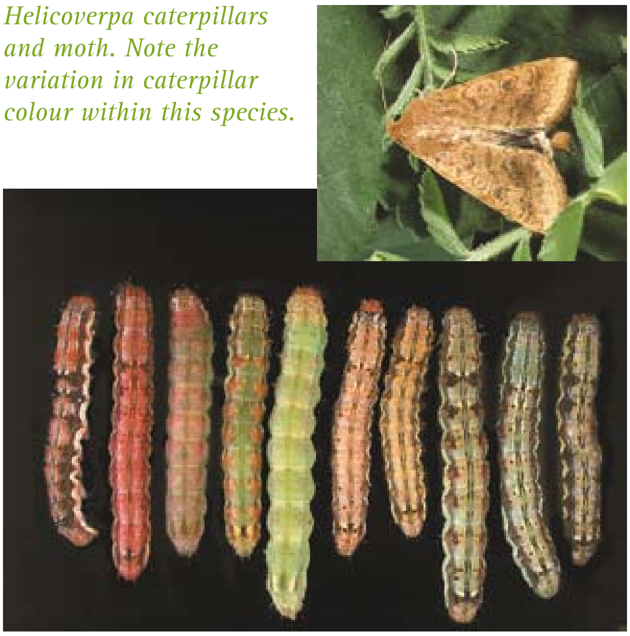
Helicoverpa can severely damage all crop stages and all plant parts of soybeans. Of the summer legumes, soybeans are the most attractive to helicoverpa during the vegetative stage and can even be damaged during the seedling stage. In sub-coastal and inland southern Queensland, summer legumes are at greatest risk from *H. armigera* from mid December onwards.

Identification: Helicoverpa larvae can be confused with loopers, armyworms or cluster caterpillars. Refer to the A-Z pest list for identification of pests on the DPI&F website or the DPI&F brochure 'Insects: understanding helicoverpa ecology and biology'.

Damage: *Helicoverpa spp.* defoliation is characterised by rounded chew marks and holes, (loopers make more angular holes). Helicoverpa will also attack auxillery buds and terminals in vegetative crops. High populations in seedling or drought-stressed crops can cause considerable damage if vegetative terminals and stems are eaten. This type of damage results in pods being set closer to the ground. Such pods are more difficult to harvest. In drought stressed crops, the last soft green tissue is usually the vegetative terminals, which are thus more likely to be totally consumed than in normally growing crops.

Once crops reach flowering, larvae focus on buds, flowers and pods. Young larvae are more likely to feed on vegetative terminals, young leaves and flowers before attacking pods. Small pods may be totally consumed by helicoverpa, but larvae target the seeds in large pods. Crops are better able to compensate for early than late pod damage, however in dry land crops, where water is limiting, significant early damage may delay or stagger podding with subsequent yield and quality losses.

Helicoverpa caterpillars and moth. Note the variation in caterpillar colour within this species.



Damage to well-developed pods also results in the weather staining of uneaten seeds due to water entering the pods.

Monitoring: Beat sheet sampling is the preferred sampling method for medium to large helicoverpa larvae. Small larvae should be scouted for by inspecting (opening) vegetative terminals and flowers. Damage to vegetative terminals is often the first visual clue that helicoverpa larvae are present. Ideally, soybeans should also be scouted for eggs and moths, to pinpoint the start of infestations and increase the chance of successful control.

- inspect crops weekly during the vegetative stage
- inspect twice weekly from early budding until late podding
- sample six widely-spaced locations per field.
- take five one-metre long samples at each site with a 'standard' beat sheet
- convert larval counts/m to larvae/m^2 by dividing counts by the row spacing in metres

Beat sheet sampling may only detect 50% of small larvae in vegetative and podding soybeans, and 70% during flowering, as they feed in sheltered sites such as leaf terminals.

Many of these small larvae will be lost to natural mortality factors before they reach a damaging size and in most crops, and this mortality will cancel out any sampling inefficiencies. For more information on the beat sheet technique please refer to the DPI&F website or call 13 25 23.

Thresholds: In vegetative crops, thresholds for many leaf feeding pests are expressed as % tolerable defoliation or % tolerable terminal loss. Before flowering, soy beans can tolerate up to 33% leaf loss without loss of yield.

However recent data (Rogers, unpublished) shows that helicoverpa populations inflicting less than 33% damage can cause serious yield loss, because the larvae not only feed on leaves, but also attack terminals and auxillery buds.

The data indicates an economic threshold of approximately 7.5 helicoverpa larvae per square metre (7.5/m^2) in vegetative soybeans. Helicoverpa thresholds for podding soybeans currently range from 1-2 larvae/m^2 (depending on crop value and pesticide cost).

Chemical control: Prior to flowering, biopesticides, particularly *Helicoverpa nucleopolyhedrovirus* (NPV), are recommended in preference to chemical insecticides. This helps conserve beneficial insects to buffer crops against helicoverpa attack during the susceptible reproductive stages, and avoids flaring of other pests such as silverleaf whitefly and mites. For more information please refer to the DPI&F brochure 'Insects: using NPV to manage helicoverpa in field crops'.

Cultural control: Where possible, avoid successive plantings of summer legumes. Good agronomy and soil moisture are crucial as large, vigorously-growing plants suffer less defoliation for a given helicoverpa population and have less risk of terminal damage.

In water-stressed crops, terminals are more attractive to larvae than wilted leaves. Vigorously growing plants with adequate available moisture are better able to replace damaged leaves and compensate for flower and pod damage.

Natural enemies: The number of beneficials varies with crop age, from crop to crop, region to region, and from season to season. The combined action of a number of beneficial species is often required to have a significant impact on potentially damaging helicoverpa populations. It is therefore desirable to conserve as many beneficials as possible.

Natural enemies of soybean pests include predators of eggs, larvae and pupae, parasites of eggs and larvae and caterpillar diseases.

Predatory bugs and beetles that attack helicoverpa eggs and larvae include: spined predatory bug, glossy shield bug, damsel bug, bigeyed bugs, apple dimpling bug, assassin bugs, red and blue beetle, predatory ladybirds and other important predators include ants, spiders and lacewings.

Parasites include: *Trichogramma spp.* are tiny egg parasite wasps; *Microplitis* and *Netelia* wasps and species of tachinid flies are caterpillar parasites. For more detail see the DPI&F brochures 'Insects: parasitoids: natural enemies of helicoverpa' and 'Insects: *Microplitis demolitor* and ascovirus: important natural enemies of helicoverpa'.

With the exception of the egg parasites and *Microplitis*, most parasites do not kill helicoverpa until they reach the pupal stage. Predatory earwigs and wireworm larvae are significant predators of helicoverpa pupae.

Naturally occurring caterpillar diseases frequently have a marked impact on helicoverpa in summer legumes. Outbreaks of NPV are frequently observed in crops with high helicoverpa populations.

Pod-sucking bugs

Pod-sucking bugs can move in at budding but significant damage is confined to pods. While bugs start breeding as soon as they move into flowering crops, nymphs must feed on pods to complete their development.

Bugs cause shrivelled and distorted seed, and can severely reduce yield and seed quality. Bugs can even damage seeds in pods that are nearing harvest maturity.

Late bug damage reduces seed quality but not yield. As only 2% seed damage is tolerable in culinary soybeans, bug thresholds are based on seed quality, not yield.

A number of pod-sucking bugs can attack soybeans and include:

- green vegetable bug
- redbanded shield bug
- large brown bean bug
- small brown bean bug
- brown shield bug

The green vegetable bug (GVB) and the brown bean bugs are equally damaging to crops, while the damage potentials of the redbanded and brown shield bugs are 0.75 and 0.2 of that of a GVB respectively. Nymphs of all species are less damaging than adults. While 1st instar nymphs cause no damage, subsequent instars are progressively more damaging with the 5th and final instar being nearly as damaging as adults. To determine the damage potential of mixed bug species populations, convert all species (adults and nymphs) to GVB adult equivalents (GVBAEQ) (refer to DPI&F website).

Green vegetable bug (GVB) *Nezara viridula*

Pest status: This species is the most damaging pod-sucking bug in soybeans due to its abundance, widespread distribution, rate of damage and rate of reproduction. Very high populations are frequently encountered in coastal Queensland.

Risk period: Adult bugs typically invade summer legumes at flowering, but GVB is primarily a pod feeder with a preference for pods with well-developed seeds. Nymphs are unable to complete their development prior to pod-fill. Soybeans remain at risk until pods are too hard to damage (i.e. very close to harvest). Damaging populations are typically highest in late summer crops during late pod-fill (when nymphs have reached or are near adulthood).

Damage: Pods most at risk are those containing well-developed seeds. While GVB also damages buds and flowers, soybeans can compensate for this early damage. Damage to young pods cause deformed and shrivelled seeds and reduce yield. Seeds damaged in older pods are blemished and difficult to grade out, reducing harvested seed quality, particularly that destined for human consumption (edibles).

GVB can even damage seeds in 'close-to-harvest' pods (i.e. pods that have hardened prior to harvest). Bug damaged seeds have increased protein content but a shorter storage life (due to increased rancidity). Bug damage also reduces seed oil content. Bug damaged seeds are frequently discoloured, either directly as a result of tissue breakdown, or because of diseases such as cercospora (purple seed stain), which may gain entry where pods are pierced by bugs.

Sampling and monitoring: Crops should be inspected for GVB twice weekly from flowering until close to harvest.

- sample for GVB in early to mid morning
- beat sheet sampling is the most efficient monitoring method.
- the standard sample unit consists of five one-metre non-consecutive lengths of row within a 20 m radius
- convert all bug counts per row metre to bugs/m^2 by dividing counts per row metre by the row spacing in metres
- at least six sites should be sampled throughout a crop to accurately determine adult GVB populations
- GVB nymphs are more difficult to sample accurately as their distribution is extremely clumped, particularly during the early nymphal stages (1st - 3rd instars)
- ideally, at least 10 sites (with five non-consecutive row metres sampled per site) should be sampled to adequately assess nymphal populations

Thresholds: Pod-sucking bug thresholds in edible or culinary soybeans (destined for human consumption) are determined by seed quality, the maximum bug damage permitted being only 2%. GVB thresholds typically range from 0.3-0.8/m^2 depending on the crop size (seeds per m^2) and when bugs first infest a crop (and are detected). Because thresholds are determined by % damage, the larger a crop (the more seeds per unit area), the more bugs that are required to inflict critical (threshold)

Green vegetable bug adults and nymphs.

Table 4 – Economic threshold chart for pod-sucking bugs at varying crop maturity.

days to harvest maturity	crop size (seeds/m^2)									
	500	1000	1500	2000	2500	3000	3500	4000	4500	5000
21	0.15	0.29	0.44	0.58	0.73	0.88	1.02	1.17	1.31	1.46
28	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.98	1.09
35	0.09	0.18	0.26	0.35	0.44	0.53	0.61	0.70	0.79	0.88

damage, and the higher the threshold (see Table 4). For crushing and stockfeed soybeans with lesser quality requirements, the threshold is doubled.

Chemical control: Bugs should be controlled during early podfill before nymphs reach a damaging size. Pesticides are best applied in the early to mid morning to contact bugs basking at the top of the canopy.

Cultural control: Avoid sequential plantings of summer legumes as bug populations will move progressively from earlier to later plantings, eventually building to very high levels. Also avoid cultivar and planting time combinations that are more likely to lengthen the duration of flowering and podding.

Natural enemies:

- GVB eggs are frequently parasitised by a tiny introduced wasp *Trissolcus basalis*. Parasitised eggs are easily recognised as they turn black.
- GVB nymphs are attacked by ants, spiders and predatory bugs.
- Final (5th) instar and adult GVB are parasitised by the recently introduced tachinid fly (*Trichopoda giacomellii*).

Redbanded shield bug (RBSB) *Piezodorus oceanicus*

Redbanded shield bugs in Australia were previously classified as *Piezodorus hybneri* and more recently as *P. grossi*.

Pest status: Major, widespread, regular. RBSB is 75% as damaging as GVB in summer pulses but is usually not as abundant. However, it is more difficult to control with current pesticides. Adults are similar in shape to GVB but are smaller and paler, with pink, white or yellow bands that GVB adults don't have.

Damage: Damage is similar to that caused by GVB, with early damage reducing yields, and later damage reducing the quality of harvested seeds.

Thresholds: Convert to GVB equivalents to determine damage potential i.e. multiply counts by 0.75.

Monitoring: As for GVB. Look for the distinctive twin-row egg rafts that indicate RBSB presence.

Chemical control: No insecticides are specifically registered against RBSB in Australia. Recent trials suggest pesticides currently registered against GVB are ineffective against RBSB. However, control can be improved, albeit to only 50-60%, with the addition of a 0.5% salt (NaCl) adjuvant.

Red-banded shield bug eggs, nymphs and adult.

Natural enemies: Spiders, ants, and predatory bugs are major predators of RBSB, particularly of eggs and young nymphs with mortality of these stages sometimes exceeding 90%. Eggs may be parasitised by the tiny wasp, *Trissolcus basalis*. Adults are infrequently parasitised by the recently introduced tachinid fly.

Large brown bean bug *(Riptortus serripes)* and small brown bean bug *(Melanacanthus scutellaris)*

Pest status: As damaging as GVB. More frequent on the coast.

Host range and risk period: As for GVB.

Damage: Damage is similar to that caused by GVB, with early damage reducing yield, while later damage reduces the quality of harvested seed.

Monitoring: Sample crops early in the morning. The beat sheet method is not totally satisfactory as both brown bean bugs are very flighty, particularly during the hotter parts of the day. Crop scouts should familiarise themselves with the appearance of flying brown bean bug adults and include these in sampling counts.

Silverleaf whitefly

Bemisia tabaci biotype B.

Silverleaf whitefly (SLW) poses a threat to soybeans in tropical and subtropical coastal regions. However the recently released SLW parasite *Eretmocerus hayati*, together with native parasites and predators, can reasonably be expected to stabilise SLW populations, provided they are not disrupted by the overuse of non-selective pesticides.

Distribution: SLW is widespread in tropical and subtropical Australia. In southern Queensland and northern NSW, SLW is most abundant in coastal regions with milder winters and a continuum of hosts. In the tropics, SLW is also abundant in inland regions such as the Emerald irrigation area of central Queensland.

Pest status: Major risk in susceptible crops such as soybeans.

Silverleaf white fly nymph (top, left), adult (top, right) and leaf damage (left).

Host range: Of the summer pulses, soybeans and navy beans are preferred SLW hosts. Significant populations of SLW adults are frequently seen in mungbeans but nymphal development on this crop is very poor. Other favoured hosts include capsicums, cotton, cucurbits, dolichos, milk thistle, poinsettia, rattlepods, sunflowers, sweet potatoes and tomatoes.

Risk period: Summer pulses maturing during late summer and autumn are at greater risk of attack because invading SLW have had more time to increase from low over-wintering populations. As a rule, the earlier crops are infested the greater the risk. Crops remain attractive to SLW until mid pod-fill. As photosynthetic assimilates are redirected from leaves to fill the pods, leaves become unattractive to SLW and adults leave the crop to find more attractive hosts.

Damage:

- SLW can reduce plant vigour and yield by the sheer weight of numbers removing large amounts of plant photosynthate from the leaves.
- Severe infestations in young plants can stunt plant growth and reduce yield potential.
- Later infestations can reduce the number of pods set, seed size, and seed size uniformity, thus reducing yield and quality. As a rule, the impact of SLW is worst in drought stressed crops.

In heavily infested soybeans, both pods and seeds are often unusually pale. While seed colour is unlikely to be of concern in grain soybeans (harvested seeds being naturally pale), pod and seed discolouration are a major marketing problem where pods are picked green, e.g. vegetable soybeans and green beans.

SLW can also secrete large amounts of sticky honeydew. Adult females produce more honeydew than other stages and nymphs produce more honeydew when feeding on stressed plants. Honeydew in itself is not a major problem, but sooty mould which develops on honeydew shields leaves from sunlight and reduces photosynthesis.

The impact of sooty mould is greatest during early to mid podfill when SLW activity is greatest at the top of the canopy, i.e. on the leaves with the greatest photosynthetic activity. Rain and overhead irrigation wash honeydew off leaves, lessening the risk of sooty mould.

Monitoring: SLW eggs, nymphs and resting adults are mainly found on the underside of leaves. Flying SLW adults are readily observed when crops with high populations are disturbed. The presence of honeydew and sooty mould may also indicate SLW attack, but can be due to aphid feeding.

SLW eggs are laid on younger leaves, so by the time eggs develop to large nymphs in crops with high growth rates, leaves with the greatest visible SLW nymphal activity are further down the plant. This may be as many as 5-7 nodes below the plant top. As vegetative growth slows, however, plant nodes with greatest nymphal activity move progressively upwards to the canopy top.

Thresholds and chemical control: There are no validated thresholds for SLW and no pesticides are specifically registered for SLW control in summer pulses in Australia. Use the softest options possible for other pests early in the life of the crop, to encourage SLW parasites and predators.

Cultural control:

- Where possible, avoid successive plantings of summer pulses to prevent movement from early to late crops.
- Avoid planting summer pulses in close proximity to earlier maturing SLW hosts such as cotton and cucurbits.
- Where damaging SLW populations are evident in other crops early in the season (early summer), or in regions with a history of consistently damaging widespread SLW activity, consider planting a pulse type less attractive to SLW, e.g. mungbeans or adzukis (*Vigna sp.*), rather than soybeans.
- Control SLW weed hosts such as rattlepod and milk thistle.
- Irrigate crops to reduce moisture stress which makes crops more susceptible to SLW damage. Overhead irrigation also washes off sooty mould and drowns adult SLW.
- Narrow leafed and smooth leafed (less hairy) cultivars may be less attractive to SLW. However, the latter attribute may leave crops more vulnerable to aphid attack.

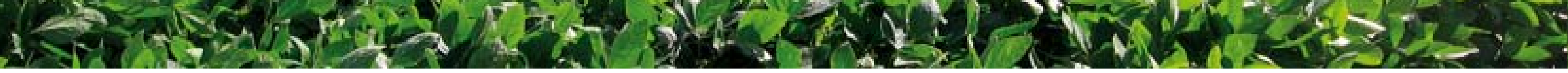
Natural enemies: SLW nymphs are parasitised by native species of *Encarsia* and *Eretmoceros* (both very small wasps). In 2005 CSIRO released the exotic parasite *Eretmoceros hayati* in the Bundaberg and Childers region. It has successfully established and spread up to 20 km from the original release sites, with high levels of parasitism reported. The parasite has now also been released in other areas of Queensland and, in conjunction with native SLW parasites, will hopefully help stabilise SLW populations.

Minor pests

Cluster caterpillar *Spodoptera litura* (often referred to as 'spods')

Pest status and damage: Cluster caterpillars are as damaging as helicoverpa but less frequent. They can cause significant damage to coastal soybeans in Queensland during flowering and podding. The small larvae 'window' leaves, but older larvae chew holes in leaves and may also attack flowers and pods.

Monitoring and control: As for helicoverpa but also look for egg masses and clusters of young



Cluster caterpillar moth and egg pouch.

larvae. In pre-flowering crops, control is warranted if defoliation exceeds (or likely to) 33% (refer to section on helicoverpa). Tolerable defoliation drops to 15-20% once flowering and podding commences. NPV does not control cluster caterpillars and they are difficult to control with Bt unless they are very small.

Natural enemies: As for helicoverpa and loopers.

Bean podborer *Maruca vitrata* (previously *Maruca testulalis*)

Distribution: A cosmopolitan pest found in most part of the world and in Australia most abundant in tropical and subtropical regions.

Pest status and damage: Not usually a pest in soybeans, but tunnelling has been reported in soybean stems in coastal regions such as Bundaberg.

Monitoring and control: Look for tunneling and associated larval frass in soybean stems. No thresholds are set as this pest is not regarded as a problem in soybeans. Report any unusually heavy podborer infestations in soybeans to DPI&F entomology on 13 25 23.

Etiella (lucerne seed web moth) *Etiella behrii*

Risk period and damage: Etiella is a spasmodic but important pest of specialist soybeans in drier regions (e.g. natto soybeans on the Darling Downs) due to near zero damage tolerance. Crops may be infested from flowering onwards, but are at greatest risk during late podding. Etiella larvae consume far less than larger caterpillar species such as helicoverpa, so seeds are usually only partially eaten out, often with characteristic pin-hole damage. This damage is difficult to grade out and its unattractive appearance reduces seed quality.

Green looper caterpillar and adult.

Mocis (brown looper) eggs and caterpillar.

Monitoring and control: Techniques are currently being developed to monitor moth activity with light traps or lures, as the moth is this pests' most vulnerable stage. No pesticides are currently registered.

Green loopers: soybean looper *Thysanoplusia orichalcea;* tobacco looper *Chrysodeixis argentifera;* vegetable looper *Chrysodeixis eriosoma*. Brown loopers: bean looper or mocis *Mocis alterna;* sugar cane looper *Mocis frugalaris; Mocis trifasciata* and *Pantydia spp.*

The following applies equally to green and brown loopers.

Risk period and damage: Loopers can attack crops at any stage but are greatest risk during flowering and podding. Summer legumes such as soybeans are least tolerant of defoliation at these stages. Loopers do not attack the flowers and small pods of soybeans. Looper leaf damage is different to helicoverpa damage, the feeding holes being more angular rather than rounded.

Monitoring and control: Using a beat sheet, inspect crops weekly during the vegetative stage and twice weekly from very early budding onwards until crops are no longer susceptible to attack. In pre-flowering crops, looper control is warranted if defoliation exceeds (or is likely to) 33%. Tolerable defoliation drops to 15-20% once flowering and podding commences. Products containing helicoverpa NPV do not control loopers however, Bt will control small loopers (< 12 mm long). For chemical control options refer to Infopest or APVMA website.

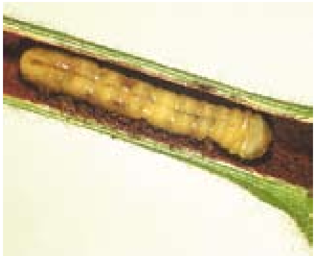
Natural enemies: Loopers are frequently parasitised by braconids (*Apantales sp.*) with scores of parasite larva developing per looper host. Predatory bugs, tachinid flies, and ichneumonid wasps also attack loopers. The use of Bt will help preserve beneficial insects. Outbreaks of looper NPV are frequently observed in crops with high looper populations. However, larvae are usually not killed by virus until they are medium-large (instars 4-5). Looper NPV is not the same as helicoverpa NPV.

Soybean moth *Aproaerema simplexella* (previously *Stomopteryx simplexella*)

Soybean moth is common in soybeans but is usually only present in low numbers with only the occasional leaf slightly webbed and folded to provide a shelter for larvae. However, they can occur in very high numbers and on rare occasions can destroy crops by denuding all the leaves.

Damage and control: Soybean moth larvae initially feed inside leaves (i.e. mine leaves) for about four days, and then emerge to feed externally, folding and webbing leaves together. The most obvious


Soybean moth caterpillar and adult.

Lucerne crown borer (Zygrita diva) (left) and a larvae feeding inside a sybean stem (right).

symptom of damage is the webbing and folding together of leaves. The larvae normally only cause cosmetic damage.

Infestations are favoured by hot, dry weather, with crops under severe moisture stress most at risk. Scout crops regularly for the early warning signs of rare plague events - numerous small, pale patches (leaf-mining) on the leaves and large numbers of soybean moths around lights at night. Indicative threshold is based on defoliation, i.e. 33% pre flowering and 15-20% during early podfill. Control will rarely be required and no specific registrations exist for soybean moth.

Legume webspinner or bean leafroller *Omiodes diemenalis* (previously *Lamprosema abstitalis*)

Risk period and damage: Legume webspinners are widespread in coastal regions but rarely at damaging levels. Crops are usually at greatest risk during early podding. The larvae are leaf feeders, webbing leaves together. Silken webs and frass are indicative of webspinner attack, but other leaf webbers cause similar symptoms.

Monitoring and control: Larvae will be sometimes detected when beat sheet sampling. Also inspect webbed leaves and look for the characteristic frass. The threshold is based on tolerable defoliation, i.e. 33% pre flowering and 15-20% during early pod-fill. Control is rarely required.

Monolepta or redshouldered leaf beetle or *Monolepta australis*

Risk period and damage: Monolepta are common in sugar cane areas. They can arrive suddenly in large numbers, inflicting rapid defoliation and flower loss. Soybeans are at greatest risk during flowering. Infestations are most likely after heavy rainfall events. Monolepta attack leaves and flowers with very high populations (e.g. > 50/m^2) shredding leaves and denuding crops of their flowers.

Monitoring and control: Monolepta are readily assessed visually or with a beat sheet but can be difficult to counts as they are extremely flighty. Estimate the number of groups of 5 or 10 beetles on the sheet to get a 'ball park' population estimate. Check crops after heavy rainfall that may trigger the mass emergence of adults. Thresholds are not yet established but populations greater than 20/m^2 can cause significant damage in flowering crops. Defoliation thresholds are the same as for leaf feeding caterpillars.

Plant legume crops away from larval hosts of monolepta such as sugar cane. Spot treatment of borders may be sufficient. Consult Infopest or the APVMA website for pesticide options.

Lucerne crown borer or zygrita *Zygrita diva*

Risk factors and damage: Soybean crops in the tropics, or growing in abnormally 'hot' summers, or in close proximity to lucerne are at greatest risk from crown borer. Proximity to lucerne increases the risk of early infestation. Larval feeding has little impact on yield but prior to pupating, plants are internally ringbarked or girdled above the pupal chamber causing plant death above the girdle and plants in thin stands may lodge before harvest.

In southern Queensland, this usually occurs after seeds are fully developed (physiological maturity) with no yield loss. In tropical regions, larval development is more rapid and there can be considerable crop losses. Crown borers are very damaging to 'edamame' soybeans where green immature pods are harvested by mechanical pod pluckers. The stems of infested plants are weakened and snap off, contaminating the harvested product.

Monitoring and control: Break open stems to look for larvae and eaten out and brown discoloured pith. There are no effective chemical controls as larvae in the stems are protected from insecticide so avoid planting susceptible crops close to lucerne and, if in an at-risk region, consider later plantings to shorten crop development. In the tropics, consider winter plantings. Also avoid thin plant stands to reduce the lodging of damaged plants. Currently there are no pesticides registered for zygrita in soybeans. Trying to control the only vulnerable stage, the adults in early vegetative crops, would greatly increase the risk of silverleaf whitefly attack.

Soybean aphid *Aphis glycines*

Damage: Aphids are not a major threat to soybeans but populations should be monitored. In the unusually cool summer of 2007/08 severe aphid outbreaks occurred in the Bundaberg region. Aphids are more prevalent on the coast than inland.

Cast off (white) aphid skins are evidence of past infestations. Heavily infested plants may be covered in sooty mould growing on honeydew secreted by the aphids. Such infestations can reduce yield significantly and delay harvest maturity. Infested plants can have distorted leaves. Crops become less attractive to aphids after early podding. The adult, winged-form of the aphid, is able to travel long distances on prevailing wind currents.

Monitoring and control: Look for aphid colonies on the upper stems, leaflets and terminal leaves. In heavily infested crops, cast off aphid skins, sooty mould and large ladybird populations are indicative of soybean aphids. However the latter two can also indicate significant whitefly activity.

Chemical control is rarely required due to the significant impact of natural enemies, especially ladybirds and hoverfly larvae. While, soybean aphids can be controlled with systemic pesticides, no products are specifically registered for this pest in soybeans. In the USA, the soybean aphid threshold is set at 250 aphids per plant from budding to podding. As a rule of thumb, once soybean aphids are present on the main stem, populations are in excess of 400 aphids per plant.

Two-spotted or red spider mite *Tetranychus sp.*

Damage: Mites can cause severe damage, particularly during hot, dry weather. Outbreaks are often the result of using 'hard' pesticides to treat other pests, where the killing of their natural enemies flares mite numbers. Heavy infestations at pod-fill lead to leaf drop and early senescence.

Soybean aphids (left) and two-spotted mites (right).

Top: Brown mirid nymph (left) and adult (right).
Bottom: Green mirid (left) and plant damage (right).

Seed size and yield may be reduced by as much as 30% in severe cases. Mites first occur on the lower leaves and gradually move to the top of the plant as the population builds up. They make fine webbing on the underside of the leaves, and feed by a rasping and sucking action. Infested leaves take on a speckled appearance and, in severe cases, the leaves turn a yellow-brown before they wither and drop from the plant.

Green mirid *Creontiades dilutus* and brown mirid *C. pacificus*

Risk period and damage: Budding, flowering and early-podding crops are at greatest risk from mirid attack while no damage has been observed in more advanced pods (DPI&F trials). Low populations (≤ 1 per m^2) of green mirids are often present in vegetative crops but there is no evidence they cause 'tipping' of vegetative terminals or yield loss.

Mirids attack buds, flowers and small pods. Soybeans are less susceptible to mirids compared to other pulses due to the synchrony of flowering and because they produce up to four times as many flowers as are necessary to set enough pods to produce a high yield (≥ 4 t/ha). DPI&F trials have shown no yield loss in crops with up to 5 mirids/m^2.

Monitoring: Mirids are very mobile pests and in-crop populations can increase very rapidly. Inspect crops twice weekly from budding onwards until post flowering. In row crops, the preferred method is beat sheeting, as this method is the most effective for helicoverpa and pod-sucking bugs. Sample five one-metre lengths of row (not consecutive) within a 20 m radius, from at least six sites throughout a crop. Avoid sampling during very windy weather as mirids are easily blown off the sheet. Thresholds for soybeans are 3-4 mirids/m^2.

Control: Shortening a crop's flowering period reduces the risk of mirid damage. To do this, plant on a full moisture profile and water crops just before budding. Consider planting crops in at least 50 cm rows (as opposed to broadcast planting) to facilitate easier pest sampling. Spraying for mirids is unwarranted in most crops unless populations are in excess of 5/m^2. Unneceassary spraying for mirids in soybeans increases the risk of flaring silverleaf whitefly.

Trials have shown that the addition of salt (0.5% NaCl) as an adjuvant can improve chemical control

Black field cricket adults and nymphs (left) and black field earwigs (right).

of mirids at lower chemical rates. Reducing pesticide rates (typically by 50-60%) reduces their impact on beneficials and reduces the risk of flaring helicoverpa.

Natural enemies: Spiders, ants, predatory bugs and predatory wasps have been observed attacking mirids in the field. Naturally occurring fungi (e.g. *Beauvaria*) may also infect and kill mirids, but are rarely observed in the field.

Field crickets *(Teleogryllus commodus)*

Field crickets shelter in cracks in the soil and can cause serious losses in soybeans during grain fill, particularly in areas with heavy cracking soils. Field crickets chew holes in the back of pods to eat the developing seeds. Plagues are most common when mild winters are followed by warm, dry summers. Inspect for crickets at night as most feeding occurs at this time.

Grain baits are recommended for in-crop control of crickets. Use a mix of four litres Lorsban® (50 percent) with five litres sunflower oil and 100 kilograms cracked wheat. Combine the Lorsban and oil before adding the grain then let the mix 'set' for six to eight hours before spreading 2.5 kilograms of the bait mix per hectare.

Use sorghum if cracked wheat is not available. Ideally the grain should be cracked into small pieces, but not ground to fines. Some aerial applicators will supply a similar bait mix.

Black field earwig *(Nala lividipes)*

Black field earwig periodically causes serious damage to seedling soybean crops. These soil dwelling insects feed on the germinating shoot, and on recently emerged seedlings which they ringbark at ground level. Black field earwig are most prevalent in areas with cracking soils.

In-crop treatments with chlorpyrifos grain baits can provide a degree of control. Black field earwig should not be confused with the much larger light brown predatory earwig.

Mice plagues

Mouse damage to soybeans is an ongoing and costly problem in certain areas such as the Darling Downs. Soybeans are especially vulnerable, as they are often the last of the summer crops to mature and as a consequence are the only food available.

Crop damage from mice is often unnoticed until it is severe. Signs of mouse activity include chewed stems or damage to seed pods. Debris such as seed husks at the base of plants suggest the damage to seed pods has been caused by mice rather than insects or birds.

Zinc phosphide grain baits are now registered for use in soybeans and other grain crops. It is an inorganic compound that rapidly breaks down in the presence of the stomach acids to release the toxic gas phosphine. Mouse death usually occurs within two hours of ingestion.

Contact Biosecurity Queensland on 13 25 23 or refer to the DPI&F website for further details on the use of these baits.

Disease management

Soybean crops can be prone to a range of fungal and bacterial diseases. Good crop rotational practices, careful varietal selection and thorough decomposition and incorporation of crop residues will minimise disease occurrences. Avoid planting soybeans after other legumes or sunflowers.

Fungal diseases

Fungicides are very expensive, so consider carefully before using them.

Seedling root rots *(Rhizoctonia, Pythium and Phytophthora)*

Symptoms include seeds rotting in the ground and death of young seedlings after emergence. Young seedlings often display red-brown lesions on the roots and along the lower stem near ground level. Outbreaks of pythium and phytophthora are most likely under cold, wet conditions. To minimise losses:

- avoid sowing deeper than 50 mm
- use high quality seed
- minimise the amount of stubble in the vicinity of the sowing line
- use crop rotation

Thiraflo® and Apron XL 350ES® (Syngenta Crop Protection) seed dressings may be worth considering, especially if only poor quality seed is available. Apply these fungicides to the seed and allow to dry before inoculating with soybean rhizobia. Apron® (Syngenta Crop Protection) will only control seedling losses from phytophthora and pythium, and reinfection is possible later in the growing season.

Phytophthora root rot *(Phytophthora sojae)*

The phytophthora fungus attacks soybean plants at all stages of growth. It causes pre-emergence and post-emergence damping off.

Infected plants will usually occur in patches in poorly drained areas of the paddock but may be later found throughout the field. On older plants the first symptom is wilting and interveinal chlorosis (yellowing), especially on the lower leaves. On closer examination, you may see a sunken brown lesion advancing up the stem.

Infected lateral and branch roots are almost completely destroyed and infested taproots turn dark-brown. Infected plants usually die and withered leaves usually remain on the plant for a week or more. Lesions may be confined to the upper stem, with the lower portion of the stem and roots having no obvious symptoms.

Phytophthora (left) and charcoal stem rot (right).

Downy mildew (left) and purple seed stain (right).

Phytophthora root rot is found throughout all growing regions, and is most severe on heavy, poorly drained soils where soybeans have been grown continuously for several years. Avoid planting susceptible varieties where there is a history of the disease in the paddock. The disease is specific to soybeans and does not occur in other crops or weeds.

Bunya, Warrigal, Jabiru, A6785 and Soya 791 are resistant to the two main races of phytophthora root rot that occur in Queensland. Manark is resistant to one of the races, but only has a low level of resistance to the other race of the disease. Dragon has partial resistance to both races of phytophthora root rot, and can suffer substantial yield loss from the disease.

Charcoal rot *(Macrophomina phaseolina)*

This disease is widespread under hot, dry conditions. Symptoms usually appear from pod-fill to maturity, with affected plants dying prematurely. Crops under severe moisture stress are particularly susceptible.

Affected plants often wilt and die before any external lesions or discolouration is visible on the stem. However, if the bark is peeled away, the inner stem will be orange-brown rather than the normal white to light-green colour.

Once the plant has died, the external surface of the lower stem and taproot darken to a charcoal colour. Affected stems contain minute, black fungal bodies called ‘microsclerotia’. Sclerotia can survive in the soil and crop trash and spread on seed.

At harvest, take a sample of plant stems and compare the number of green stems to brown stems. This will give an indication of the extent of charcoal rot infection. To control the disease, irrigate regularly and rotate soybeans with winter cereal crops.

Sclerotinia stem rot *(Sclerotinia sclerotiorum)*

Plants infested with sclerotinia develop a white, cottony growth on stems followed by the formation of large, black sclerotia (resting bodies of the fungus). These may also form in the pith where they are more uniform and cylindrical in shape. Plants are killed by the girdling action of the fungus.

The disease often occurs where soybeans are grown following susceptible crops such as sunflower, chickpeas, navy beans, cotton, peanuts and crucifers, especially broccoli.

Cool, humid weather conditions, tall, dense crops and overhead spray irrigation favour the disease. Regularly inspect the lower canopy of plants after flowering for signs of the disease. Once symptoms are obvious in the upper canopy, fungicide sprays are of doubtful benefit.

Crop rotation is the best management method. Do not grow susceptible hosts on paddocks known to be infested by sclerotinia for at least four years.

Downy mildew *(Peronospora manshurica)*

While this fungal disease is often widespread under mild, wet conditions, yield loss are considered insignificant. Current varietal status is not well documented due to the sporadic nature of disease incidence in trials. Resistance status of NSW coastal varieties may be better but the low incidence and relatively nominal impact of the disease on yield make this a low priority when selecting varieties. Do not to retain or use planting seed from downy mildew infected crops as it can reduce germination and establishment.

Purple seed stain *(Cercospora kikuchii)*

This fungal disease does not reduce yields, and is not considered detrimental to the quality of beans as the purple colour disappears upon heating. Avoid using infected seed for planting as it can reduce establishment and crop vigour.

Rust *(Phakopsora pachyrhizi)*

Soybean rust is a foliar disease, caused by the fungus *Phakopsora pachyrhizi*. The disease is present in most soybean growing regions, and can infect the crop at any stage in its development. Rust typically occurs on coastal crops in Australia, with an outbreak appearing every four to five years. On

Leaf rust. photo Natalie Moore: DPI NSW

Bacterial blight.

these occasions, pod formation and seed size are affected, often reducing yields by at least 10%.

The disease is favoured by showery weather. Once infected, plants will develop small yellow lesions on the upper leaf surface. Rust pustules develop on the underside of leaves and release wind-borne spores. Initially, the lesions will usually appear on the lower leaves, but may later spread over the entire plant, leading to yellowing and premature defoliation.

In addition to soybean, rust will infect a wide range of species, including a number of native *Glycine* species. The pathogen is an obligate parasite and requires a living host for survival. Between cropping seasons, rust may survive on volunteer soybean plants or alternative hosts.

Unfortunately, the current commercial varieties have limited resistance to the rust pathogen. Mancozeb can help to minimize rust damage if applied correctly. Early detection, followed by the application of fungicides will be necessary for successful rust management.

Bacterial diseases

Bacterial leaf diseases may be introduced in seed contaminated during harvesting of a diseased crop. Once established, they rapidly spread during wet, windy weather. Bacteria may survive on un-decomposed crop residues and volunteer soybean plants.

Bacterial blight *(Pseudomonas savastanoi pv glycinea)*

Bacterial blight causes brown, angular spots which join to form dark brown, dead areas with yellow margins on the leaves. These areas frequently tear, giving the leaves a ragged appearance. Spots also occur on stems.

While bacterial blight is a common disease it is never severe (<1% of the leaf affected), causing little or no economic loss. Management strategies involve using high quality seed, encouraging the breakdown of crop residue and destroying volunteer plants.

Bacterial pustule *(Xanthomonas axonopodis pv glycines)*

This disease causes small, yellow spots with light brown centres to form on leaves. A tan coloured, raised pustule develops at the centre of each spot, especially on the lower surface. The raised pustule collapses with age leaving a brown spot with a bright yellow margin. Pustules also occur on stems.

It is difficult to distinguish this disease from rust when both diseases are at an early stage of development.

While not generally regarded as an important disease, it can be a problem in coastal regions, especially under wetter, more humid seasonal conditions with extended cloud cover. Disease resistance developed through the plant breeding program and field screening is the only practical means of control.

Wildfire *(Pseudomonas syringae pv tabaci)*

Wildfire is distinguished by brown, dead areas of variable size and shape surrounded by wide, yellow haloes with very distinct margins on plant leaves. The spots may join as the disease progresses. Affected leaves fall readily.

Wildfire generally occurs only after bacterial pustule infection. A bacterial pustule, or a remnant of one, is usually found near the centre of each wildfire spot. Disease resistance developed through the plant breeding program and field screening is the only practical means of control. Wildfire is a rare disease.

Varietal performance

The important elements to consider are the overall yield stability and potential market demand. Some varieties will inevitably out-perform others in different years depending on seasonal conditions.

However, yields alone may not determine gross returns since market preferred varieties may command a significant price premium.

Soybean yield and quality may be compromised if grower-kept seed is not pure. Strongly consider replacing seed at least every three years with Northern Australia Soybean Industry Assoc. (NASIA) endorsed 'Industry approved scheme' seed.

Due to a reduction in soybean funding there is no recent yield comparison data that is replicated across regions.

Please discuss local results with agronomists, seed suppliers, marketers, DPI&F Futurecane extension officers or CSIRO.

Harvesting and drying

It is important to commence harvesting when seed moisture levels reach 16 percent because harvesting at 12–13 percent moisture causes more grain loss and seed cracking. Harvesting when the crop is too dry or the harvester is operating inappropriately can cause severe cracking and splitting of grain.

To minimise losses, consider:

- cutting as low as practical to gather as many of the pods as possible.
- using reduced ground speeds to keep shatter loss to minimum (4 to 5 km/h).
- using relatively low cylinder speeds to reduce grain damage, and select relatively high fan speeds to effectively clean the sample.
- using belt augers wherever possible to minimise cracking and damage to the grain.

Probably the greatest advance in harvesting legumes is the introduction of floating cutter bar tables. The cutter bar assemblies are flexibly attached to the table carcass and have some vertical movement independent of the table. When the table is lowered so that the cutter bar skids touch the ground, ground contours are accurately followed, permitting very close cutting and minimising seed lost from low setting pods. Coupled with automatic table height control sensed by the floating cutter bar itself, a very effective crop gathering mechanism is obtained.

The maturity of the crop is dependent on the variety and time of planting. Early plantings take the longest to mature, ranging from 120 to 150 days.

Some varieties mature very unevenly when planted early and can still be very green and difficult to manage at harvest time. Check the variety's suitability for early sowing prior to purchasing seed.

Desiccation

Growers aiming to maintain or improve grain quality, or simply speed up the harvest, may wish to desiccate the crop. Some crops are slow to drop leaves and some localities are prone to wet weather at harvest, thus reducing yield through shattering or weathering damage.

Excessive weed growth can delay harvest and cause green staining on culinary beans during thrashing.

There are two chemicals registered for desiccation of soybean crops, namely diquat (Reglone®) and glyphosate (not all product labels are registered for this use and not for seed soybeans). Reglone® is generally the preferred product to gain maximum advantage in dry down and quicker responses on weed growth. Generally, experience has shown that using the higher recommended rates of Reglone provides the most efficient results. Beware of potential drift damage to neighbouring crops. Damage is usually only of a cosmetic nature but it is a significant concern for vegetable crops.

Grain quality

Moisture

The maximum moisture percentage for soybeans delivered for processing depends on the end use. Under the National Agricultural Commodity Marketing Assoc. (NACMA) standards the maximum for crushing beans is 13 percent and the maximum for edible beans is 12 percent. The moisture content of soybeans to be stored on-farm should not exceed 12 percent. Use an unground sample of whole beans when using the Marconi moisture meter.

The maximum safe temperatures for drying soybean seed will depend on both the likely end use of the soybeans and the seed moisture content of the sample prior to drying. Table 5 provides a guide to maximum safe drying temperatures. **Caution: some processors prefer to dry seed themselves to avoid potential quality degredation. Please check with traders or processors prior to conducting any seed drying.**

Where the crop is being retained for planting seed it should be harvested around 15 percent moisture to avoid mechanical damage, and then dried down to 10 to 11 percent for storage. Avoid drying seed below 9 percent as the seed coats can crack badly during handling and small fractures can appear in the grain.

Table 5 – Maximum safe drying temperatures.

Maximum temperature °C	Initial seed moisture content (% wet basis)		
	14%	16%	18%
Planting seed*	65	60	55
Edible trade**	37	37	37
Crushing	80	70	80

Note: These are recommended temperatures for input airflow, they do not refer to grain temperature.
* If in doubt about drying temperatures for seed or tofu grades, revert to the lower industry standard drying temperature of 43°C.
** Edible uses require lower drying temperatures to avoid the development of 'off' flavours.

Grain yield and weight

Dryland grain yields are commonly between one and two tonnes per hectare while irrigated crops generally achieve grain yields of two to four tonnes per hectare.

Yields up to 50 percent higher than this have been recorded in favourable growing conditions. Grain weight is usually in the range of 70 to 75 kg/hL.

Oil and protein

Oil content varies from 18 to 22 percent in soybeans.

Grain protein is generally in the range of 32 to 40 percent, but culinary quality grades aim for protein levels up to 43 percent.

Both oil content and protein level are usually calculated back to a 12 percent moisture content basis. Oilseed processors prefer the soybean protein content to be above 36 percent to meet protein meal specifications. Protein levels below 36 percent are a concern to both the crushing and edible trades. Certain management practices can influence protein levels such as:

- certain varieties can have relatively higher protein levels.
- infection with phytophthora, charcoal rot and sclerotinia can reduce protein levels in the crop.
- where growers have an ongoing problem with low protein levels they may need to assess the effectiveness of their inoculation techniques.
- field applications of side-dressed nitrogen during flowering and podfill have endeavoured to boost grain protein. The results of this approach are inconclusive since a well-nodulated and healthy soybean crop has excellent capacity to generate adequate nitrogen requirements.

The agronomic conditions required for maximising grain protein are not well understood.

Delivery standards for edible and crushing beans

All producers and marketers of soybeans should check the current NACMA/AOF specification standard (including any revisions) required for each individual market destination. Processors may vary their intake specifications according to specific end use requirements, e.g. with respect to soil and sclerote contamination. AOF accepts no responsibility for any buyer or handler varying their purchasing specifications.

Table 6 summarises the AOF soybean standard for farmer-dressed beans and represents a minimum standard for soybeans for the food trade, across a range of applications. It applies to individual loads. Some buyers may have additional requirements depending on their end use and specific processing requirements. Growers must be aware of the specific requirements of their customers.

Top: Loading with a belt auger.
Bottom: Grain drier.

Moisture content

Moisture content is determined on the seed as it is received from the grower. Rapid direct reading moisture testers are used only as a guide for acceptance or rejection of a consignment by the crusher or his agent.

If the grain does not meet the moisture specification, a penalty is applied based on the results of the prescribed oven test method expressed to the nearest 0.1 percent on an 'as received' basis.

Impurities (foreign material)

Foreign matter is all organic and inorganic material other than soybean seeds. Foreign matter is determined as anything that passes through a 3.175 mm round hole screen. The impurity content is expressed to the nearest 0.1 percent on an 'as received' basis.

Damaged seed

Damaged seed is seed that is heat damaged, frosted, green, weather damaged or in any way materially damaged. Seeds which are surface damaged only, are classified as sound. Soybeans are classified green when a cross-section shows an intense green colour, or when it is green in colour and of a meaty or chalky consistency. Sprouted seed (also known as 'shot' or 'sprung') is seed that gives any indication of the commencement of growth.

Table 6 – Summarised Soybean Commodity Standards (AOF July 2007).

	Edible milling grade soybean*	Edible manufacturing grade soybean**	Crushing soybean***
Description	Clean, sound, whole soybeans of light hilum varieties suitable for milling into flour, free from uncharacteristic odours, infestations or any unacceptable contamination.	Clean, sound, whole soybeans of light hilum varieties suitable for tofu, tempeh, soymilk etc, free from uncharacteristic odours, infestations or any unacceptable contamination.	Soybeans free from uncharacteristic odours, infestations or any unacceptable contamination.
Genetic modification	nil	nil	n/a
Moisture (oven method)	12% maximum	12% maximum	13% maximum
Test weight	70 kg/hl minimum	70 kg/hl minimum	n/a
Protein	n/a	40% DMB	n/a
Seed retention	n/a	90% minimum	n/a
Germination	n/a	85% minimum	n/a
Defective beans	maximum % wt/wt based on a half litre sample retained above a 4.75 round mm hole sieve	maximum % wt/wt based on a half litre sample retained above a 4.75 mm round hole sieve	maximum % wt/wt based on a half litre sample retained above a 3.175 mm round hole sieve
Discoloured[1]	1 bean maximum	1 bean maximum	n/a
Split / broken seed[2]	10% maximum	5% maximum	20% maximum
Damaged seed[3]	3% maximum	3% maximum	3% maximum
Sprouted seed	nil	nil	5% maximum
Green seed[4]	2% maximum	2% maximum	n/a
Foreign seeds	tolerance varies from 0 to 10 individual seeds per half litre. See AOF standard for details.	tolerance varies from 0 to 10 individual seeds per half litre. See AOF standard for details.	tolerance varies from 0 to 65 individual seeds per half litre. See AOF standard for details.
Crushing soybean impurity tolerance			
Impurities[5]	4% maximum		
Snails/stones	nil above screen; 1 stone/snail per half litre below screen		
Field insects	10 large per half litre; 100 small per half litre		
Ryegrass ergot	0.5 cm maximum		
Objectionable matter	nil live or dead stored grain insects, live or dead pea weevil, sticks, stones, glass, metal, specified weed seed, chemical contaminants, smut, degraded seed etc		

* AOF standard reference no. CSO 6. ** AOF standard reference no. CSO 7. ***AOF standard reference no.CSO 8.

[1] Excessive seed coat stains. [2] Half or larger parts of a bean not classified as damaged. [3] Includes bean pieces and insect or weather damaged, diseased, soiled, mouldy or stained beans. [4] Beans where a cross-section shows an intense green colour or is of meaty or chalky consistency. [5] All material other than soybeans that pass through the sieve. Includes pods but excludes cottonseed, canola and weed seeds.

Broken or split soybeans are those beans not otherwise damaged that are three quarters of a bean or less in size. Separated hulls are included.

Damaged seed is taken as a percentage of the clean seed expressed to the nearest 0.1% and a penalty applies if specifications are not met.

Weed seeds

See the NACMA standards for full details of prohibited weed species. There is 'nil tolerance' of seeds of the castor oil plant, coriander, crow or wild garlic, Darling pea, opium poppy, ragweed, rattlepods, common broomrape, star burr and St. Johns wort.

Gross margins

A gross margin is the difference between the gross income and the variable costs of growing a crop. Variable costs include those associated with crop operations, harvesting and marketing.

Table 7 – The effect of yield and price on irrigated soybean costs and returns.

Price ($/t)	yield (t/ha)						
	2.1	2.4	2.7	3.0	3.3	3.6	3.9
$468	$258	$399	$539	$679	$820	$960	$1100
$535	$399	$559	$720	$880	$1040	$1201	$1361
$601	$539	$720	$900	$1080	$1261	$1441	$1622
$668	$679	$880	$1080	$1281	$1481	$1682	$1882
$735	$820	$1040	$1261	$1481	$1702	$1922	$2143
$802	$960	$1201	$1441	$1682	$1922	$2163	$2403
$869	$1100	$1361	$1622	$1882	$2143	$2403	$2664

Table 7 – Irrigated soybean gross margin

Information	indicative $ per hectare	your figures
Gross income		
Price $700/t		
less: Cartage		
Freight (e.g. Downs to Brisbane $25/t)		
Drying		
Storage		
Levies ($6.85/t)		
On-farm price $668/t		
Yield 3.0 t/ha		
Gross income (price x yield) (A)	**2004.00**	
Variable costs		
Machinery operations:		
Primary tillage (1 x $8.76/ha)	8.76	
Secondary tillage (1 x $6.98/ha)	6.98	
Fertiliser application		
Inter-row tillage ($3.34)		
Boomspraying (3 x $1.39/ha)	4.17	
Planting (1 x $4.55/ha)	4.55	
Fallow spraying:		
Glyphosate (2 x 1.2 L x $12/L)	28.80	
Seed (65 kg/ha x $1.00/kg)	65.00	
Inoculum (0.65 pkt x $6.05/pkt)	3.93	
Fertiliser: Starter Z (40 kg x $1670/t)	66.80	
Herbicide: Trifluralin (1 x 2.1 L x $6.54/L)	13.73	
Insecticide: Indoxocarb (1 x 0.4 L x $60/L)	24.00	
Deltamethrin (1 x 0.5 L x $19.50)	9.75	
Fungicide		
Aerial spraying (2 x $14)	28.00	
Scouting ($10/ha)	10.00	
Furrow irrigation (5 ML x $56.49/ML)	282.45	
Chipping		
Insurance		
Total pre-harvest costs	557.00	
Harvesting:		
Own harvesting costs		
Contract header (2 ha/hr @ $250/hr)	125.00	
plus fuel (24.3 L/ha x $1.31/L)	31.77	
Total harvest costs	167.00	
Total variable costs (B)	**724.00**	
Gross margin (A - B = C)	**1281.00**	
Gross margin ($/ML) [GM ÷ ML/ha used]	**$256**	
Yield to cover variable costs (t/ha)	**1.08**	
Price to cover variable costs ($/t)	**$273**	

Gross margins do not include overhead costs such as rates, electricity, insurance, living costs and interest that must be met regardless of whether or not a crop is grown. For this reason gross margins are not a measure of the profit of a particular enterprise.

Table 7 provides a sensitivity analysis on the effect of yield and price variation on the gross margin for irrigated soybean.

Table 8 details the irrigated soybean gross margin. Calculate using your own costings for a more accurate gross margin figure.

Please note: the figures listed are subject to change with price fluctuation. For more information on how to calculate a gross margin visit the DPI&F website.

Further information

DPI&F sources

Current national information on registered agricultural chemicals is available on the Infopest CD-ROM which can be purchased as a single copy or by annual subscription (4 updates per year). The CD includes coloured pictures of many pests for ease of identification as well as copies of chemical lables. Email infopest@dpi.qld.gov.au or phone 07-3239 3967 for further information.

Contact DPI&F on phone 13 25 23 (Queensland residents only; non-Queensland residents phone 07-3404 6999) for generalist information and specialist referral service.

DPI&F website www.dpi.qld.gov.au/fieldcrops provides a wide range of information about soybean crop management including using a beat sheet, calculating gross margins and pest identification and management. See also the Biosecurity area of the DPI&F website for information about pest management and chemical use.

Regional guides for coastal areas in Queensland available on the DPI&F website or by telephoning DPI&F on 13 25 23:

- 'Soybeans – coastal regions: Bundaberg to Beenleigh'
- 'Soybeans – coastal regions: Mackay/Proserpine'
- 'Soybeans – coastal regions: Wet tropics'

DPI&F publications available from DPI&F ph 13 25 23.

- 'VAM boosts crop yields – the natural way to healthy crops'
- 'Insects: understanding helicoverpa ecology and biology'
- 'Insects: using NPV to manage helicoverpa in field crops'
- 'Insects: parasitoids: natural enemies of helicoverpa'
- 'Insects: *Microplitis demolitor* and ascovirus: important natural enemies of helicoverpa'

Insect and disease management books available from SDS Publications, 1800 801 123, www.sds.qld.gov.au

- 'Crop insects: the ute guide, northern region grain belt'
- 'Mungbean & soybean disorders: the ute guide'

Organic information sources

New South Wales Department of Primary Industries www.agric.nsw.gov.au/

Biological Farmers Australia www.bfa.com.au/

References

[1]FOASTATS Food and Agriculture Organisation 2008, FAO Stat, viewed 31/10/08, <http://faostat.fao.org/site/535/DesktopDefault.aspx?PageID=535#ancor>

Australian Oilseeds Federation (AOF) marketing guide. Download from the AOF website www.australianoilseeds.com/__data/assets/pdf_file/0012/4044/Soybean_Marketing_Guide.pdf

APVMA website www.apvma.gov.au

Other useful contacts

Soy Australia 02-94276999

Northern Australia Soybean Industry Association (NASIA) 07-4690 6400

CSIRO, contact Andrew James on 07-3214 2278

Annand and Robinson Pty Ltd, contact Eric Robinson on 07-4632 2688

Cotton Seed Distributors (CDS) Grains 07-4698 5600

SGS Agritech 07–4633 0599.

Acknowledgements

The following people have contributed to, or helped edit, this publication:

Julie Ferguson, Hugh Brier, Mal Ryley, Lisa Keller, Mike Bell, Kate Charleston and Neil Halpin (DPI&F) and Greg Mills and Andrew Dougall (formerly DPI&F).

Andrew James (CSIRO), Ian Crosthwaite, Judy Plath, and Andrew McDonald (BGA AgriServices).

Ian Morgan (Philp Brodie Grains) and Chris Baker and Joe Erbacher (CSD Grains).

soybean variety update

2008

There are soybean varieties to cater for various production environments and the expanding number of niche markets.

Table 1a summarises the characteristics of the main varieties grown in Queensland. Brief descriptions of the varieties are also listed below in alphabetical order, not in order of preference.

Each variety has a maturity rating based on the grading system of 1 to 8, where lower numbers indicate quicker maturity. Based on a mid-December planting, the time taken to reach physiological maturity (i.e. the end of grain filling) for the three main maturity groups grown in Queensland is:

- Group 5 120 – 125 days (quick maturing)
- Group 6 125 – 130 days (medium maturing)
- Group 7 130 – 135 days (slow maturing)

A6785

A6785 is a medium maturing variety (6) originally released by Asgrow and marketed by Annand and Robinson. It has a buff hilum with moderate weathering tolerance. It is suited to soy flour and soymilk manufacturing, although the seed is smaller than this market prefers.

A6785 is resistant to the two main races of phytophthora root rot in Queensland. It is the best 'white-eyed' type to grow where crops are more subject to weather damage around harvest. It produces high yields if sown at the correct time but tends to have slightly lower protein content.

Bunya

Bunya is quick maturity variety in most regions (5-6). Bred by CSIRO, Bunya was released in 2006 under PBR, it is licensed to NASIA and is produced by Austgrains, Philp Brodie Grains and CSD Grains and is well suited for southern Queensland. It is a large seeded human consumption type with a clear hilum. It is a preferred variety for the tofu markets. Bunya is resistant to the two main races of phytophthora root rot in Queensland. The seed size of Bunya is very large which can increase the risk of damage at harvest time. Germination checks and careful attention to seed handling at planting is essential.

Dragon

Dragon is a slow maturing (7) public variety released in 1985. It is suited to soy flour, soy milk and tofu manufacture but its popularity is declining as newer culinary varieties are released.

Seed purity of Dragon is questionable and it is moderately susceptible to the two main races of phytophthora root rot.

Fraser

Fraser is a slow maturing variety (7) released by CSIRO in 2007 under PBR, it is licensed to NASIA and is produced by Philp Brodie Grains, Bettacrop and CSD Grains. It is suitable for southern Queensland from Gladstone to the NSW border. Fraser is a medium seed size and is accepted into soy flour and soymilk manufacturing. It may also be accepted into tofu markets. Fraser is resistant to the two mainraces of phytophthora root rot in Queensland.

Leichhardt

Leichhardt is a slow maturing variety (9) suited to northern and coastal Queensland. Its growing season is approximately 10 days longer than the Stuart variety when grown during the wet season. In southern coastal regions, plant Leichhardt later than the local shorter duration varieties to restrict vegetative growth. Leichhardt is generally not recommended as a human consumption type but quite acceptable for crushing.

Oakey

Oakey is a unique variety and suitable for the specialist natto trade as well as other human consumption markets. It was developed by CSD and CSIRO and operates in a closed loop marketing system. It is widely adapted from Southern to Central Queensland and is a tall determinant plant with a medium – slow maturity.

Stuart

Stuart is a long duration variety adapted to the tropics (8-9). Stuart was released by CSIRO in 2006 under PBR, it is licensed to NASIA and is produced by Bettacrop and North Queensland Tropical Seeds. It is the first light coloured hilum variety suited to coastal and tropical Queensland. Stuart is a slow maturing variety and should not be planted in areas south of Mackay. It is also adapted to dry season planting in the tropics. If sown at the correct time, Stuart is slightly less vegetative than Leichhardt. In rotation with sugarcane, this variety has the advantage of higher resistance to root nematodes than other soybean varieties. It also has resistance to the current rust races causing problems in cool, wet years on the Atherton Tableland.

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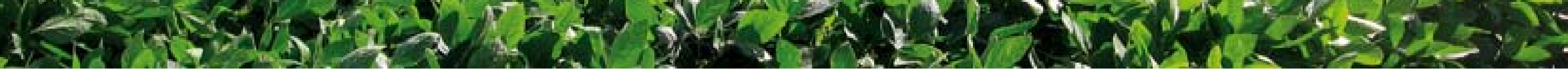

Table 1a – Attributes and market suitability of current soybean varieties.

Cultivar	Approx seed size	Approx maturity	Growth	Approx oil content	Approx protein content	Hilum	Crushing	Flour	Milk	Tofu	Natto
Cowrie	4500	V	short determinate	20.1	42.8	clear	***	***	**	**	
Soy 791 (PBR)	5500	late V	determinate	20.1	42.7	buff	***	***	**	**	
Bunya (PBR)	4000	V -VII	determinate	20.5	42.1	clear	***	***	**	***	
A6785	6000	VI	determinate	21	41.6	buff	***	***	**		
Surf	5800	VII	determinate	20.1	42.7	clear	***	***	*		
Oakey (PBR)	14 000	VI -VII	tall determinate	19	43.6	clear	***	**			***
Fraser (PBR)	5500	VII	determinate	20.1	42.8	clear	***	***	*	*	
Warrigal (PBR)	6000	VII	determinate	20	42.9	clear	***	***	*	*	
Stuart (PBR)	5500	VIII	indeterminate	20.1	42.7	light grey	***	*	*	*	
Leichhardt	6250	IX	determinate	20	42.9	brown	***	*			
Manark (PBR)	5500	VII	determinate	20	42.9	buff	***	***	*	*	
Dragon	5200	VII	determinate	–	–	buff	***	***	**	**	
Jabiru (PBR)	5800	VII	determinate	20	42.9	buff	***	***	*	*	

Soya 791

Soya 791 is a medium maturing public variety (5) released by Pioneer Hi-Bred under PBR, and is available through a range of resellers. It has a buff hilum, good protein content and moderate weathering tolerance. Soya 791 is suitable for the flour, soymilk and tofu markets. It is not resistant to Race 15, one of the two main races of phytophthora root rot in Queensland.

The best time to plant Soya 791 is from November to mid December. Delays to sowing may considerably shorten the crop height, reducing vegetative growth and so limiting yield potential and harvestability.

Surf

Surf is a medium maturity variety (6) released for northern NSW from DPI&F material reselected by NSW Agriculture at Grafton. It has a clear hilum with moderate to high weathering tolerance. It is suited to soy flour and soymilk manufacturing. Surf appears to possess either high field tolerance or resistance to both the main races of phytophthora found in Queensland.

Warrigal

Warrigal is a slow maturing variety (7) developed by DPI&F, released in 1992 under PBR. It is licenced to Pacific Seeds, and is marketed by Philp Brodie Grains. It has a clear hilum with moderate weathering tolerance. It is suited to soy flour and soymilk manufacturing although the seed is smaller than this market prefers.

Secondary varieties

These are by and large older varieties which are still produced by some growers who retain seed, but are largely superceded by newer varieties.

Cowrie

Cowrie is a medium-quick maturing (5) public variety released by NSW Agriculture in 2002. It is generally too quick maturing on the Darling Downs to produce a competitive grain yield. Cowrie's colourless hilum makes it suitable for the edible markets.

It is susceptible to *Phytophthora* Race 15 but is resistant to Race 1. Due to its very early maturity in the Queensland production environment, sow this variety two or three weeks earlier than other varieties, no later than the first week of December in southern Queensland.

Jabiru

Jabiru is a slow maturing variety (7) released by DPI&F in 1998 under PBR. It is licenced to Philp Brodie Grains. It has a buff hilum and good lodging resistance. It is suitable for flour milling and crushing.

Jabiru has resistantance or high tolerance to the two major races of phytophthora root rot found in Queensland.

Manark

Manark is a slow maturing variety (7) developed by DPI&F. It is registered under PBR to Pacific Seeds and marketed by Philp Brodie Grains. Manark has a buff hilum and is suitable for flour milling and crushing.

Varieties suited to organic production

Only certain varieties are suitable for the organic soymilk industry. Processors are particular about hilum colour, seed size, protein level and flavour.

Growers are advised to check with their buyer regarding variety preference.