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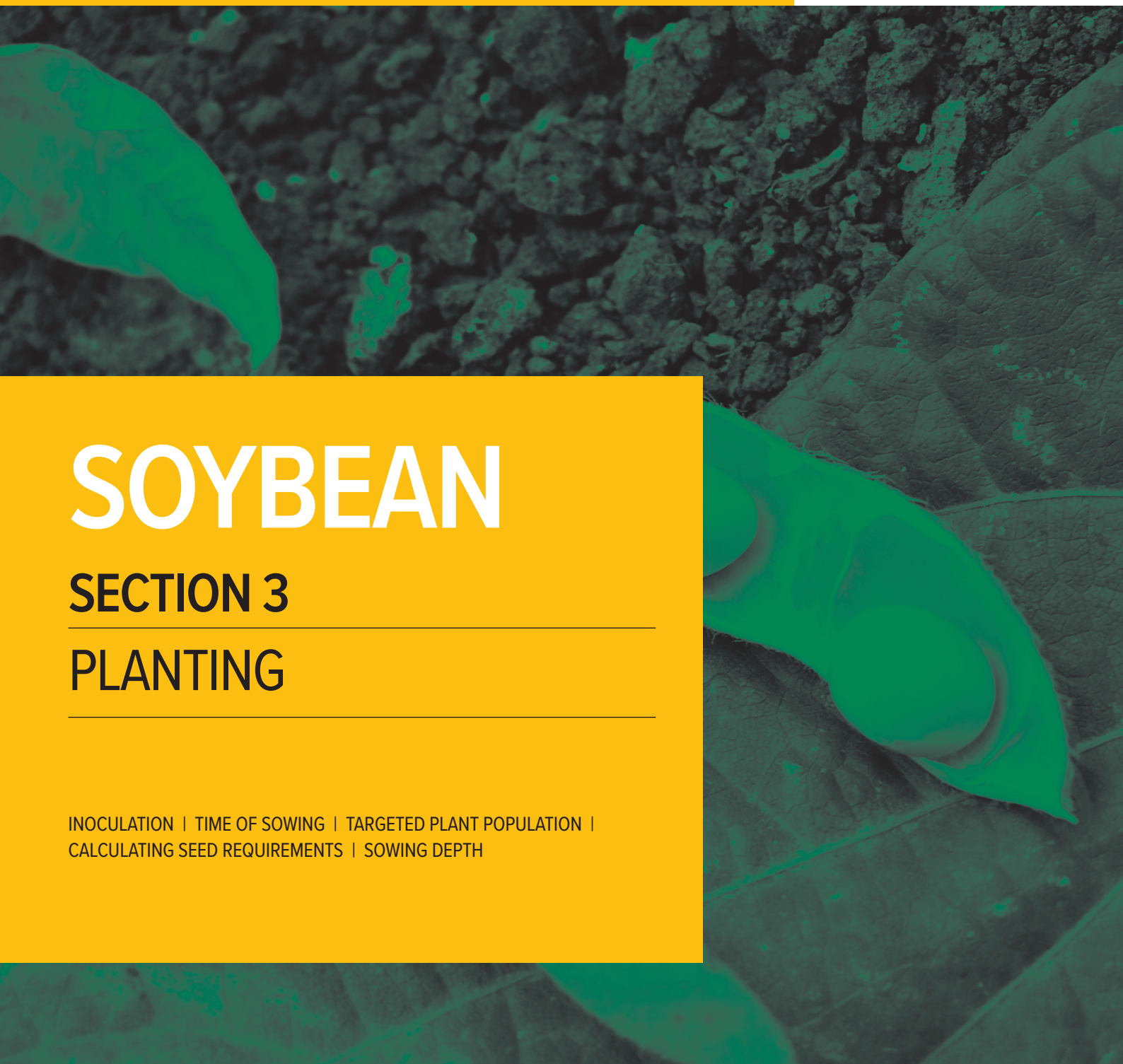

SOYBEAN

SECTION 3

PLANTING

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SECTION 3

Planting

FAQ 3.1 Inoculation

Soybeans do not need additional nitrogen if the seed is effectively inoculated at planting with the correct strain of nitrogen-fixing rhizobia. Inoculum is a mixture of the sensitive living bacteria (rhizobia) that can be supplied to seed in a peat culture, in a clay granule or even as freeze dried spores. Inoculation of soybean seed with Rhizobia helps maximise nodulation and N-fixing ability. Effective nodulation also maximises the residual nitrogen carryover for the following crop (at least 40–60 kg N/ha in a harvested crop, and possibly as high as 120 kg N/ha).[1]

Figure 1: Effective inoculation is essential for good nodulation. (Photo: Australian Oilseeds Federation)

If soybean seed is effectively inoculated with the correct strain of the nitrogen-fixing rhizobia at sowing, the plants rarely need any additional nitrogen (N) at planting or during the crop as they have the ability to fix far more nitrogen from the atmosphere than they require to grow. Soybean plants have a high nitrogen requirement, but when inoculated correctly will fix more nitrogen than their own needs.

Soybean inoculum is a living bacterium (*Rhizobium*) mixed in a peat culture or other medium. Correct inoculation enables the bacteria and the soybean root to form nodules, which are essential for fixing nitrogen from the atmosphere. Inoculation of every soybean crop is recommended as the bacteria that facilitate the nodulation process are largely absent in Australian soils, especially soils that have not recently grown soybeans or that have been waterlogged. Poor inoculation or avoiding inoculation will not save

[1] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

money as poor nodulation and reduced N fixation will have a negative effect on crop vigour, grain yield and protein content and the profitability of the crop.

Adding a small amount of starter N (up to 20 kg N/ha) may help if large amounts of organic matter (such as cane trash) have been incorporated prior to sowing soybean but care must be taken not to add too much starter N as this will interfere with timely nodulation of the crop. While additional nitrogen application may produce taller, greener looking plants, trial results to date show no economic yield response from the addition of nitrogenous fertiliser to soybeans in dryland situations. It is far more cost effective to inoculate the seed correctly at planting time than to supply additional N fertiliser during the crop.

The *Rhizobium* strain specific to soybeans is the Group-H *Rhizobium* strain CB 1809. 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 the number of live cells will decrease rapidly in hot, dry conditions. Store refrigerated (but not frozen). In the paddock situation, store inoculant in an esky with ice to keep it cool but not frozen. Likewise, after the seed is inoculated it should be kept in a cool shady place out of direct sunlight and planted as soon as possible after inoculation. Due to high summer temperatures, ideally only treat enough seed to plant a small area at a time. Do not inoculate large quantities of seed prior to planting and leave standing outside in high temperatures.

Exercise caution when using air seeders, as hot air in the distribution system of some air seeders (e.g. older style air seeders with the oil cooler in front of the air intake) can kill the inoculum. Temperatures greater than 30°C can kill rhizobia.

Methods of inoculation vary, but in general the better the job is done, the more effective the nodulation and the more nitrogen the crop can fix. Methods include:

- slurry inoculation
- water injection and in-furrow sprays
- pelleted seed
- Nodulator® granules[2]

3.1.1 Slurry inoculation

This is the most common form of inoculation and is also the most reliable and effective. The peat inoculant is mixed with cool water to make a slurry, which is then gently mixed to evenly coat the seed (follow label instructions for mixing rates–do not use too much water). Cement mixers are sometimes used for mixing seed with the inoculum slurry provided that care is taken to avoid seed damage (e.g. bouncing seed off metal can crack the seed coat–avoid excessive agitation). Do not use augers. Slurry inoculated seed should be sown within 2 hours of treatment, however, if stored properly (5°C or lower and out of direct sunlight) can be kept for longer (no more than 12 hours), provided a peat inoculum and sticker have been used. Remember the inoculant is a living organism and will commence dying almost immediately, especially if not treated correctly.[3]

3.1.2 Water injection and in-furrow sprays

For this method place a band of inoculum suspended in water, just below the seed in the furrow at planting. When germinating seed roots grow through the band of inoculum in the soil, nodules can form. The 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

[2] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[3] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

equipment is suitable for this inoculation method. This method can save time if sowing large areas.[4]

3.1.3 Pelleted seed

This method is offered by some commercial seed companies. Seed can be pre-pelleted with inoculum as well as fertiliser, insecticides, or fungicides. Pelleting increases the bulk of the seed, therefore appropriate adjustments need to be made to planting rates. This procedure is expensive and is not always effective for living inoculum due to the time delay between pelleting and planting. Proper application and storage techniques are vital to ensure survival of the *Rhizobium*. Do not lime coat the seed after inoculating as this will adversely affect the *Rhizobium*.[5]

3.1.4 Nodulator® granules

This is a clay-based granular inoculant released in 2007. It can be placed straight into sowing equipment provided an appropriate box is available (e.g. seeders with separate additional seed boxes or granular insecticide boxes). Placement should be as close as possible to the seed in the furrow to allow maximum contact between the granule and the seedling roots.[6]

3.1.5 Rhizobia, molybdenum and checking nodules

Rhizobia are extremely fragile; hence fertilisers, insecticides, fungicides should not be mixed with inoculum or inoculated seed as many pesticides are toxic to rhizobia.

Molybdenum (Mo) is essential for the nodules to function in the nitrogen-fixation process. Adding fertiliser containing Mo (typically Mo Super) can aid the efficiency of N-fixation in legumes especially when soil deficiencies exist and the soil is acidic (pHCaCl$_2$ less than 6). Alternatively, molybdenum trioxide can be applied at a rate of 50 g/ha.

To establish if nodules are functioning, growers are encouraged to dig up plants during the season to check on the success of their inoculation procedures. Check several locations within the crop. Carefully dig up a group of plants that are at least four weeks old, wash the root systems and cut open several nodules. Functioning nodules should be large, firm and white on the outside with a pink-orange colour on the inside (Figure 2). Nodules that are very small in size, or that have a green, grey or white colour inside are not functional and you should seek the advice of your local agronomist.

Figure 2: Functional soybean nodules should be large, firm and white on the outside (left) and have a pink — orange colour on the inside (right). Soybean growers are encouraged to dig up some plants in every crop to check that nodules have formed correctly. (Photos: N. Moore, NSW DPI).

[4] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[5] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[6] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

Environmental conditions such as hot, dry weather at planting can kill the *Rhizobium* bacteria before they come in contact with the plant roots. This is one of the primary reasons why soybeans must be planted into moist soil or irrigated immediately as planting dry and waiting for rain increases the risk that the bacteria will die before the seed can germinate. Accordingly, in irrigated districts, only plant as much as can be irrigated in a set. Considering that temperatures of over 50°C have been recorded in surface layers of black soil in summer, planting into these conditions carries a degree of risk in terms of inoculant survival. Consider planting very early in the morning or later at night when soil temperatures are cooler to reduce mortality of the rhizobia.

During the growing period, rhizobia can die if the roots become waterlogged. However, soybeans have remarkable tolerance to waterlogging, especially if grown on raised beds that allow the root zone to drain and maintain some aeration. Careful field selection and improvements to drainage are critical to ensure adequate nodulation and N-fixation as well as good root growth. Consider growing soybeans on raised beds or hills in fields prone to waterlogging.[7]

3.2 Time of sowing

Sowing windows and varieties vary widely across the soybean production regions of Australia. Consult your local agriculture department or crop agronomist to obtain the recommended sowing times and varieties for your region. If you choose to sow a variety outside its recommended window it is very unlikely to reach full yield potential.[8]

3.2.1 New South Wales and northern Victoria

In northern Victoria aim to sow from early November to mid-December while in southern NSW sow from mid-November to mid-December so crops can mature as early as possible, preferably by late March/early April. Sowing in these windows maximises plant dry matter pre and post flowering, setting the crop up for maximum yield. Planting in late December (after 25 December) shortens the growing season and reduces total plant dry matter considerably, resulting in the plants maturing in cooler overnight temperatures which delays harvest and reduces yields. It also reduces the flexibility in the timeliness of farming operations, and often crops are exposed to greater insect pressure. Planting in early January in southern NSW is not recommended.

In northern inland NSW the planting window for maximum yield potential commences in mid November. Yield potential declines with late plantings. The critical cut-off date varies from mid December in the Macquarie and Namoi Valleys and tablelands, to late December in the irrigated border areas. By mid January yield potential declines by 30% and other crops are preferred.

In the Manning, Hastings and Macleay Valleys, the recommended sowing times range from early November to the end of December.

In the North Coast districts of NSW, current varieties allow sowing in three planting windows from late November to about 20 January, with different varieties servicing each window (refer to the NSW DPI Summer Crop Production Guide for the latest variety and planting time recommendations).[9]

3.2.2 Queensland southern and inland

December is the preferred planting time in southern Queensland. For central Queensland, mid to slow-maturing types are the most suitable. Crops planted in mid-December mature from 115-125 days. To avoid problems with excessive vegetative growth from early plantings, earlier maturity varieties such as Soya 791 are the best

[7] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[8] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[9] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

choice in this region. Conversely, late maturing varieties such as Stuart are a better option for late plantings in this region 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.[10]

3.2.3 Queensland central and north coastal

For summer planting, mid-late December is the preferred planting time in central/northern Queensland. Variety Stuart matures around 2 weeks earlier than Leichhardt. Typically, Leichhardt planted in mid December will be ready for harvest around mid May (around 150 days), whereas Stuart will be 2 weeks earlier (around 135 days).

The ideal time to plant summer grown soybeans intended for grain production is mid December–early January. Planting earlier than this will result in tall crops that often lodge, making insect control and harvesting more difficult. Very early plantings are best confined to green manure crops.

For autumn/winter planting, both Leichhardt and Stuart can be successfully grown over the late autumn/winter in the Burdekin. Plant size and hence yield potential is generally lower than that of a summer planted crop because of the reduced temperature and consequent heat units. One major advantage of autumn/winter soybeans is that pest pressure is usually lower. Additionally the likelihood of rain at harvest is generally low in most years.

Leichhardt and Stuart can successfully be planted through summer and then in late autumn/early winter (up to 30 June). The ideal time to plant dry season soybeans is from early May-June 30. Plantings at the start of this window (May) will generally yield better than late June plantings, particularly in cooler winters. Do not plant soybeans after 30 June because the combination of day length and temperature may result in a commercial failure as a grain crop. Late plantings into autumn and winter are obviously not suited to frost-prone areas.[11]

FAQ 3.3 Targeted plant population

Recommended plant population for soybean varies widely depending on region and sowing time. Consult your local agronomist for the recommended plant population for your region and farming system. When the planting rate is higher than recommended for the planting conditions, individual plants become crowded. Over-crowding of soybean can result in:

- Fewer branches and fewer pods produced per branch and fewer pods developed at lower nodes.
- Plants growing tall, thin and producing weaker stems–causing lodging.
- Greater risk of disease development (e.g. *Sclerotinia* or white mould fungus, which favours humid, dense or lodged soybean crops). White mould disease can lead to further lodging and unfilled pods as the infection rots the stem.
- Difficulties in applying crop protection products like insecticides.
- Difficulties in harvesting a lodged crop and a higher risk of picking up soil that can reduce the quality of the grain and reduced access to higher value markets.

Higher than recommended sowing rates can therefore be costly due to the extra seed, lost returns in lower yield, harvesting difficulties and reduced grain quality.

[10] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[11] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

For New South Wales the target plant populations for the major production regions are listed in Table 1 below. Note that lower plant populations are preferred when sowing is early in the recommended window, while the higher densities are preferred for sowing later in the recommended sowing window.

Table 1: Target plant populations for soybean in New South Wales

Production Region of NSW	Target Plant Population–established plants/m²
NSW Northern Inland	
Irrigation/mild dryland areas	25–30
Dryland/Slopes and Plains	15–20
Tablelands	35–40
NSW Coastal	
Narrow rows (< 75cm)	30–40
Wide rows (> 75cm)	28–32
NSW Southern	
Mid Nov–Mid Dec	30–35
Mid Dec–Late Dec	35–45

For Queensland, summer plantings in coastal Queensland (Bundaberg, Mackay, Burdekin districts), aim for plant populations of 250,000-300,000 plants/ha. Anecdotal evidence would suggest that the extremely vigorous growing conditions of the Burdekin may allow the plant population to be reduced to 200,000-250,000 plants/ha to limit lodging. Do not use high plant populations under summer tropical conditions as lodging commonly occurs, resulting in difficulties with insect control from poor spray penetration and greater risk of fungal diseases such as white mould (*Sclerotium rolfsii*). For autumn/winter in the Burdekin, increase this population to 400,000—500,000 plants/ha. With autumn/winter planting, plants will not grow as large. Always use the highest recommended population if sowing at the end of the planting window (late June).[12]

3.4 Calculating seed requirements

As seed size can vary considerably between varieties and between seasons, you must adjust the seeding rate accordingly to avoid over or under planting. Refer to the seed packaging label for an accurate seed count (number of seeds per kg). All seed offered for sale must clearly state the germination percentage. Use the best quality seed available. It is not recommended to use seed lower than 85% germination. Increasing the seeding rate to compensate for low germination seed is risky as low germination seed commonly also has low vigour.

To calculate your planting rate you will need to know:

- the targeted plant population for your region–get this from your local agronomist (the example below uses 250,000 plants/ha)
- a seed germination test result (%)–this should come with the planting seed (the example below uses 92%)
- number of seeds per kg for the variety to be planted–this should be stated on the bag of planting seed (in this example the variety has 6,400 seeds/kg),
- establishment rate of the germinative seed (assume 85%). Use one of the following formula to calculate sowing rates:

[12] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

Formula to calculate sowing rate (kg/ha) =

$$\frac{\text{targeted plant population (plants/ha) 100 x 100}}{\text{(seed germination \%) x (establishment rate \%) seeds/kg}}$$

Worked example:

$$\frac{250{,}000 \times 100 \times 100}{(92\ \%) \times (85\ \%)\ 6400} = 50\text{kg per ha}$$

What does this equate to in terms of seeds per linear m of row?

Formula to calculate seeds to drop per linear m of row =

$$\frac{\text{row spacing (m) x targeted plant population (plants/ha)}}{\text{(seed germination \%) x (establishment rate \% of germinative seed)}}$$

For example, for a row spacing of 0.75m:
Seeds per linear m of row = (0.75 x 250,000)/(92 x 85) = 24 seeds per metre of row[13]

3.4.1 Establishment percentage

Soybean can sometimes have variable and poor establishment, however 80% to 90% establishment is achievable in friable non-crusting soils, using fresh, high quality seed. While poor seedbed environment can contribute to poor establishment, poor seed quality is often more likely to be the cause. Using low quality seed is a primary reason for soybean's reputation as a difficult germinator.

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.

Be sure to:

- strongly consider purchasing industry approved seed from suppliers with a current (<3 months) germination certificate
- treat seed carefully and avoid dropping bags onto the ground

If you choose to use seed from other sources:

- avoid planting seed with hairline cracks in the seed coat. This usually indicates mechanical damage.
- avoid using seed damaged by pod sucking insects (e.g. green vegetable bug)
- avoid using old seed
- avoid using seed with any sign of mould or weather damage
- the only long term storage conditions recommended for soybeans in the tropics are low humidity refrigeration.

If in doubt, check the rate of emergence of a small quantity of seed in soil prior to planting the crop.[14]

FAQ

3.4.2 Row spacing and configuration

Soybean has a large seed size relative to other crops and a delicate, thin seed coat. It is, therefore, not suitable to broadcast through a spreader and be disced in. Soybean is best grown in defined rows using a seeder to achieve uniform seed depth and placement along the row. Row cropping allows more options for weed control including the use of banded sprays, shielded sprayers and inter-row cultivation. It also facilitates the use of directed sprays for insect control and aeration of the crop, which is

[13] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[14] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

particularly important to minimise the development of fungal diseases such as leaf rust and Sclerotinia in humid environments.[15]

Dryland

For dryland (rainfed) crops on the slopes and plains of northern New South Wales a wide row spacing of 100 cm is suggested to help conserve moisture for pod-fill. However, in potentially higher yielding situations row spacing should be narrowed to 75 cm or less.

In the more favoured rainfall areas of the Northern Tablelands and North Coast of New South Wales, crops are normally planted at 18–53 cm row spacing. Wider rows are acceptable provided complete canopy closure is achieved by early-mid flowering and weed control is adequate. Narrow rows are preferred when planting late or where weeds are likely to be a problem as the crop canopy closes more quickly.

In cultivated seedbeds, seed is generally sown in 18 or 36 cm row spacings using conventional seed drills. With minimum– or no–till systems, specialised direct drills (preferably disc openers) or precision planters are necessary to ensure uniform seed placement and clearance of pasture residue or crop stubble.[16]

Irrigated

In irrigated cotton rotations in northern New South Wales soybeans are planted on a row spacing of 100 cm to suit row spacing used in the cotton farming system. However, grower experience suggests that soybean yields can be up to 10–20% higher using a narrower row spacing of 50 cm.

In southern NSW irrigation areas the industry standard configuration is 1.8 m raised beds (furrow to furrow) with two rows of soybean planted on the top of each bed (90 cm row spacing). However, row spacing can range from 30 cm to 90 cm depending on the farming system, stubble loads, time of sowing and inter-row sowing capability. Sowing a single row of soybean in the middle of the raised bed is only suitable on soils with very good lateral water movement. Sowing more than two rows per bed requires more water (to fill to the middle of the bed to field capacity) where the centre row will be located.

Irrigated soybeans grown on raised beds produce higher and more consistent yields than soybeans planted on a border check layout. In the Riverina region of NSW, soybeans are typically grown on raised beds using furrow irrigation on slopes of 1:1500 or flatter with run lengths of 400–800 m. This allows better drainage around the root zone, less water-logging problems (i.e. potential disease build-up) and minimal establishment difficulties. Raised beds facilitate the sowing of soybeans into a moist seedbed for successful and timely crop establishment.

Border check layouts often have establishment problems, due to difficulties achieving a moist soil suitable for sowing but that is not too wet to drive on. Often the soil surface dries out too quickly before, during and after sowing resulting in uneven and low plant population and patchy crop establishment.

On raised beds, paddocks ideally should be pre-watered one to three weeks before planting and sown as soon as soil is dry enough to work. This strategy is best used when sowing into fallow. Watering up (double-cropping strategy on raised beds) once soybeans are planted is possible if the soils are uniform, and beds are high and well consolidated. Seed must be lightly covered with soil and the seed line must remain above the furrow water level. When double cropping on raised beds, most growers remove a large proportion of the winter stubble prior to sowing by baling or burning, for example. This allows better water flow down the furrows without the stubble blocking the water.

[15] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[16] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

Watering up on border check is not recommended as the seed can drown and/or burst due to lack of drainage. Watering up is also not recommended for first time soybean paddocks, as inoculant rhizobia can die in the hot, dry soil before water can be applied. Achieving an even plant stand with the correct plant population is the cornerstone of a high yielding crop.

Pressurised water systems (pivots and laterals) are increasing in number in southern NSW. This provides a very flexible system for soybean growers. Best strategies are to pre-water (for both single and double cropping) and then sow into a moist seedbed. Often growers will apply a light watering post-sowing to ensure even emergence. In double cropping, many growers are inter-row sowing and on skip rows to achieve a wider row spacing for the soybeans (e.g. wheat on 30 cm and soybean on 60 cm as illustrated in Figure 3). Stubble removal is not required in these systems and is considered highly beneficial to reducing soil water evaporation and water use by the crop.[17]

Figure 3: Soybean growing between wheat stubble in an irrigated, raised bed system in southern NSW. (Photo: L. Gaynor, NSW DPI.)

Tropical Queensland cane systems

Due to the relatively short summer days of the Queensland tropics, the wide (1 m) row spacing of the southern cropping systems will usually result in reduced yield compared with narrower row spacing of <75 cm. In North Queensland there is some flexibility in row spacing. Row spacings from 45-75 cm are common and similar yields have been achieved when planted within this range. Row spacing decisions will normally be dictated by bed sizes and previous cane row configuration.

The ideal row spacing in the coastal tropics of Queensland is 50–75 cm. A 75 cm row spacing fits well with the standard sugarcane system which uses a 1.5–1.6 m row. With

[17] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

GPS now commonly used in the industry, it allows planting cane between the two rows of soybean with minimal requirements to cultivate.[18]

3.5 Sowing depth

It is very important to plant soybean seed at the correct depth. In general, soybean seed should be sown into moist soil as shallow as possible whilst allowing maximum contact between the seed and moist soil.

In dryland (rainfed) situations aim to place seed at a depth of no more than 5 cm. Where soil moisture is deeper than this, drilling to 7.5 cm has been successful but emergence can be poor, particularly if heavy rain causes the soil to pack or crust before seedlings emerge. Restrict seed depth to around 3 cm on medium clay soils, up to 5 cm on light sands and 2.5 cm on heavy clays or hard-setting soils. In irrigated situations shallower sowing (2–3 cm) is preferred, especially if crops are sown dry and watered up.

The use of rollers or heavy press-wheels that press soil directly over the seed row after planting is generally not advised. Planters with press wheels that press the soil onto the sides of the seeds whilst leaving a crown of uncompacted soil for easy seedling emergence are preferred.

It is best to avoid planting if heavy storms are forecast within 24 hours of sowing. This is often difficult in the tropics but growers should consider this when making a decision to plant. Waterlogging or over irrigation immediately after sowing is not conducive to germination and usually results in patchy crop establishment.[19]

[18] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[19] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production