4.5 Irrigated soybeans – best practice guide

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Key points

- Water required varies from 600 to 800 mm
- A full irrigation strategy is preferred as soybeans are very sensitive to moisture stress
- Plant into a full profile (pre-irrigation may be required) and avoid watering up.
- The first irrigation is unnecessary before the V4 stage (four sets of trifoliate leaves unfolded). Stress beyond this stage will shorten plants and produce low set pods.
- Excessive, frequent irrigations will produce tall plants prone to lodging and Sclerotinia.
- Flowering (R1 and R2) and podding (R3 and R4) are the most sensitive stages to water stress.
- During early podfill (R5) moisture levels should be maintained above 50% of available water to minimise pod abortion. Moisture stress later in podfill (R6) reduces seed size.
- The last irrigation must be timed so beans will reach maximum weight – this occurs after the first leaf yellowing.
- Attention to varietal choice, planting date, row spacing, plant population and nutrition are critical to achieving a profitable soybean crop

Plant Water Use

A soybean crop achieving maximum production will use between 600 and 800 mm of water depending on the weather.

The amount of water required to produce a soybean is not a fixed value as temperature and relative humidity during the growing period, along with wind and soil moisture, all determine the rate of evaporation from the soil and transpiration from the plant (evapotranspiration or ET_C). The DAFF Queensland free on-line tool CropWaterUse) can be used to examine the seasonal variability in crop water requirement for fully irrigated soybean at your location.

Table 4.5.1 summarises the output from CropWaterUse used to estimate the irrigation needed to grow soybean at three locations (Dalby, Goondiwindi and Emerald) for a 1 December sowing date. The analysis assumes that the crop is fully-irrigated to target maximum yield. An irrigation application efficiency of 75% and a 75 mm irrigation target deficit are assumed. Results show a large variation in seasonal crop water demand, rainfall and irrigation demand between locations and season types.

Figure 4.5.1 shows the daily water use in soybean which peaks during podding and seed fill (R3 to R5).

The area of irrigated soybean to plant is a function of soybean price, available water and your planned irrigation strategy.

Irrigation Strategies

Full Irrigation

Table 4.5.2 summarises the impact of excessive and inadequate water on soybean at different growth stages. Key points to consider for fully irrigated soybean are:

- Actively growing soybeans can water from depths of 90 to 120 cm. To achieve this, a full profile of moisture is needed at planting. **Pre-irrigating** fields one to three weeks prior to planting is recommended and plant into moisture as soon as the soil is dry enough to work
- **Watering up** to establish soybeans planted into dry soil only works with furrow irrigation on uniform, self-mulching clays. Seed must be covered with soil and the seed line must remain above the furrow water level. Watering up is not suited to soils prone to hard setting or crusting, and is not recommended in fields that have not previously grown soybean, as the hot dry conditions can kill rhizobia reducing nodulation effectiveness. Very hot conditions can also kill emerging seedlings.

Table 4.5.1. Comparison of average water requirements for soybeans planted on the 1 December at Goondiwindi, Dalby and Emerald, based on historical weather data (1957 to 2008)

	Narrabri			Dalby			Emerald		
Season Type	Dry	Ave	Wet	Dry	Ave	Wet	Dry	Ave	Wet
Crop ET_c (mm)	759	726	691	671	633	622	697	657	614
In-crop Rainfall (mm)	175	274	445	208	312	462	212	337	505
Irrigation Demand (ML/ha)	8.0	6.7	5.5	6.1	4.9	4.6	6.7	5.5	4.3
No. of Irrigations	8	6	5	6	5	4	6	5	4

- Ideally soybeans should be planted into a full profile at the optimum time. A crop established this way should not need irrigation before the V4 stage, usually around 40 days after planting. Moisture stress beyond this period will shorten internode length and overall plant height. This can result in low pod height that can exacerbate harvest difficulties.
- On the other hand, frequent light irrigations (less than 25mm) during the vegetative stages will increase crop height that can induce lodging and losses from diseases such as Sclerotinia. They will also produce a shallow rooted crop.

  As the crop begins more rapid vegetative growth water use increases until around 70% groundcover. Plant available water content (PAWC) should be kept above 50% (the refill point).
- Flowering (R1 and R2) and podding (R3 and R4) are the most sensitive stages to water stress. Late flowering and early podding stress reduces pod number and yield potential.
- During early podfill (R5) moisture levels should be maintained above 50% of available water to minimise pod abortion. Moisture stress later in podfill (R6) reduces seed size.

Figure 4.5.1. Average daily water use pattern and critical growth stages for soybean

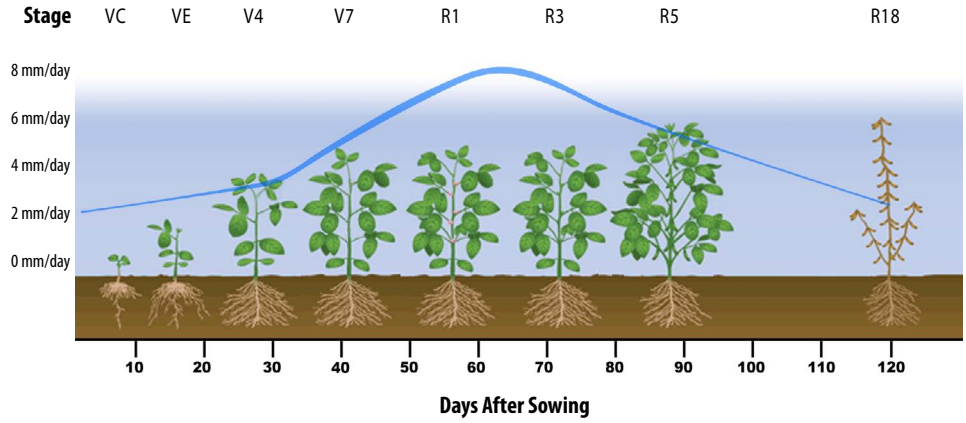

Chart for a 1 December planted crop at Dalby – daily water use values for hotter districts like Emerald would be 10 to 20% higher.

- Soybeans continue to extract soil water until all seed is physiologically mature. This means that the crop will continue using water beyond the first leaf yellowing. Water deficit beyond this will result in shrivelled seed and poor seed quality.
- Daily water use varies through out the season depending on weather conditions and stage of growth (see Figure 4.5.1). The crops ability to take up water increases as the canopy develops, peaking at the late flowering (R2) and early podding (R3) stages. Hot, drier conditions will increase the crop's water requirement.
- The final irrigation must be applied late enough to ensure moisture is available until the beans have gained maximum weight (Stage R8). This occurs at the R6 stage when the beans within the pods are touching. Inspect several pods at about four nodes down from the terminal of the plant to determine this stage. On heavier soil types this usually means that the last irrigation should be applied when the first yellow leaves appear in the crop – 15 to 20% of pods should be brown. On lighter soils with lower plant available water content, apply the final irrigation when 30% of the pods are brown.

Irrigations can be scheduled based on soil moisture monitoring using one of the commercial soil moisture monitoring tools available. This equipment can tell you the rate of crop water use and the depth of water extraction.

This can be used to make irrigation scheduling decisions.

Irrigation can also be scheduled based on estimation of crop ET_c from weather data. Watersched2, a free online irrigation scheduling tool developed by DAFF Queensland is now available. This tool automatically downloads daily weather data from different locations in Queensland and New South Wales and, using farm-specific inputs, conducts a daily soil water balance and economic analysis to determine when and how much to irrigate.

Figure 4.5.2 is an example of the end of season report generated by Watersched2 for an irrigated soybean crop at Dalby in the 2009-10 season. This report summarises the water, crop and economic data for the crop. It provides the WUE indices for predicted and actual yield achieved. The graph at the bottom of the report shows the daily soil water depletion.

During the season, this report provides the information needed to decide on the most appropriate irrigation scheduling strategy in response to crop water requirements, likely economic returns and whole farm water availability.

Limited Water Strategies

If there is a high probability of reduced water allocation and insufficient rainfall, then the yield target may need to be revised down, and supplementary irrigation strategies adopted. Supplementary irrigated crops are 'water limited' – there is not enough water available to fully irrigate the area to be sown. Growers faced with this situation have two main choices:

1. maximise production per hectare by growing an area that can be fully irrigated from the water available
2. grow the largest possible area possible where irrigation is only applied during the most critical growth stages.

Growers wanting to maximise productivity per ML of water will need to strike a balance between these options based on their local conditions and climatic forecasts. Growing a smaller, fully irrigated area of crop may limit the potential upside but avoids the extra costs associated with growing a larger area. On the other hand, yield may be poor if a larger area is planted and seasonal conditions are not favourable.

Under conditions of limited water availability, restricting irrigation during the vegetative stage has the least impact on crop yield. The periods most affected by limited water availability are the later part of flowering (R2) and early pod development (R3). Light water deficits during early flowering can be compensated for by better retention of late flowers and pod set.

When drought stress is severe but is alleviated by irrigation during the reproductive period, yield increase comes primarily from an increase in seed number rather than seed size. Soil moisture levels during pod fill must be kept above 50% of available water to maximise yield.

Table 4.5.2. Critical water management considerations by growth stage for soybean

Stage	Stage Length (Days)[1]	Description	Water Management Consideration
VE	5	**Emergence** – cotyledons above soil surface	Adequate water (between 15 and 50 percent soil water depletion) must be available for germination.
VC	5	**Cotyledon** - Unrolled unifoliate leaves	Water deficiency or excess during the vegetative period will retard growth. Ideally there should be a full profile of moisture at planting. This will reduce the need for frequent irrigation during the vegetative period and encourage plants to develop a good root system – fully irrigated soybeans will extract water to a depth of 90cm. Excessive moisture stress will shorten the internode length resulting in stunted plants. Too frequent irrigation will increase plant height and exacerbate lodging. Irrigation should be managed to ensure the plant height is sufficient for harvest (that the lowest pods are easily harvested), but not great enough to contribute to lodging.
V1	5	**First trifoliate** - One set of unfolded trifoliate leaves	
V2	5	**Second trifoliate** - two sets of unfolded trifoliate leaves	
V4	5	**Fourth trifoliate** - four sets of unfolded trifoliate leaves	
V(n)	3	**nth trifoliate** – V stages continue with the unfolding of trifoliate leaves	
R1	3	**Beginning of flowering** – plants have at least one flower on any node	Flowering is much more sensitive to water deficits than the vegetative period. The tolerance to deficits in early flowering is the result of the 4-week flowering period. Light water deficits during this period can be compensated for by better retention of later-formed flowers and pod set. Water stress in late flowering reduces the number of flowers and pod set.
R2	10	**Full flowering** – there is an open flower on one of the upper two nodes	
R3	9	**Beginning pod** – pods are 5mm at one of the four uppermost nodes	Early pod fill is particularly sensitive to water deficits. Stress at this time results in pod drop and loss in yield potential. This can lead to delayed crop maturity as there may be insufficient pods and seed demand to extract existing photosynthate from the plant.
R4	9	**Full pod** – pods are 20mm at one of the four uppermost nodes	
R5	15	**Beginning seed** – seed is 3mm long in the pod at one of the four top nodes on the main stem	Developing soybean seeds place a heavy nutrient demand on the plant. Water stress at this time reduces seed size or causes pod drop. Soil moisture levels should be kept above 50 percent of available water in the root zone until physiological maturity.
R6	18	**Full seed** – pod containing a green seed that fills the pod capacity at one of the four top main stem nodes	
R7	7	**Beginning maturity** – one normal pod on the main stem has reached it's mature pod colour	Soybeans will continue to use soil water following the first sign of leaf yellowing so there needs to be sufficient water available to maintain seed size and yield. Physiological maturity (maximum dry seed weight) occurs when the seed has separated from the pod, commonly when the plant has half defoliated with age.
R8		**Full maturity** – 95% of the pods have reached their full mature colour	

Figure 4.5.2. WaterSched2 End of Season Field Summary report for an irrigated soybean crop at Dalby in the 2009 season

WaterSched2

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End of Season Summary

Field Summary

Farm:	Wallon Park	**Plant Date:**	1/12/2010
Location:	Dalby	**Season:**	2010/2011
Field Name:	Wallon Park	**Length of Season:**	116 days / 1531 GDD
Field Size:	100 ha	**Irrigation Type:**	Surface 100%
Crop:	Medium Soybean	**Irrigation Trigger Deficit:**	75 mm

Water Summary

	mm	ML/ha
Total Irrigation:	300	3
Total Rainfall:	720	7.2
Total Losses:	410	4.1
Starting Soil Water:	178	1.78
Ending Soil Water:	210	2.1
Soil Water Change:	-32	-0.32
Total Water Input:	988	9.88
Net Water Supply:	578	5.78

Crop Summary

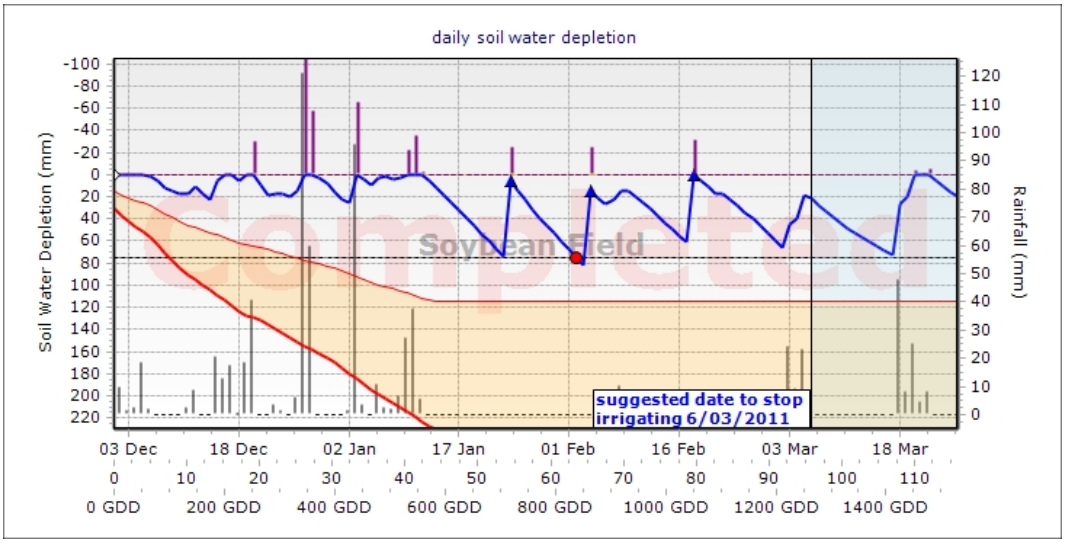
Expected Yield:	4 tonnes/ha
Predicted Yield:	4 tonnes/ha
Actual Yield:	3.75 tonnes/ha
Accumulated ETp:	579 mm
Accumulated ETc:	579 mm

Economics Summary

Price Per Unit:	$500 / tonnes
Variable Costs:	$602.5 / ha
Gross Margin:	$1272.5 / ha

Water Use Efficiency

	Predicted	Actual	Gross Margin
Total Water Use Index TWUI	0.4 tonnes / ML	0.38 tonnes / ML	$129 / ML
Gross Production Water Use Index GPWUI	0.69 tonnes / ML	0.65 tonnes / ML	$221 / ML
Irrigation Water Use Index IWUI	1.33 tonnes / ML	1.25 tonnes / ML	$424 / ML
Crop Water Use Index CWUI	6.91 kg / mm	6.48 kg / mm	$2.2 / mm



Agronomy

To achieve high irrigated yields it is necessary to follow good agronomic practices. High yielding crops use water more efficiently than lower yielding crops.

Nutrition

Soil test regularly so that the most appropriate nutrition program can be drawn up based on your yield expectations.

The major nutrients required by soybean are nitrogen (N), phosphorus (P), potassium (K), sulphur (S) and zinc (Zn). Soybeans do not need additional nitrogen if the seed is effectively inoculated at planting with Group H rhizobia.

Soybeans use a significant amount of phosphorus which must be available throughout the growing season. The greatest demand starts just before pods begin to form (R3). The crop is generally more responsive to residual phosphorus than that applied to the current crop. Aim to maintain phosphorus levels above 25 mg/kg bicarbonate P. They are also moderately dependent on VAM (vesicular-arbuscular mycorrhizae) which assist uptake of soil phosphorus. Where VAM numbers may be low (following long-fallows) higher rates of phosphorus fertiliser may be necessary.

Potassium is readily taken up by soybeans, with 20 kg of K per tonne of soybeans exported from the field at harvest. Large amounts of potassium will be accumulated in plant material (100 to 150 kg K/ha).

Variety Choice

Choice of variety is based on location, disease resistance, maturity, yield potential and suitability for target market. Soybeans are photoperiod sensitive so choice of variety and appropriate planting date is critical for good yields.

Planting Date

Sowing windows and varieties vary across soybean production regions. In southern NSW, crops should be sown between mid November and mid December so that crops can mature as early as possible (by late March/ April). Planting in late December shortens the growing season and reduces total plant dry matter, leading to lower yields and plants maturing in cooler overnight temperatures which delays harvest.

In northern NSW and southern Queensland the planting period is from mid-November through to the end of December. December is the preferred planting month.

In central Queensland the planting period is December through to mid-January – December is preferred.

Soybeans are photosensitive – they flower in response to shortening day length. So planting too early produces a crop that takes longer to flower, and can result in excessive vegetative growth. Planting too late hastens flowering resulting in a crop that produces shorter plants with pods set closer to the ground.

Row spacing

Row spacings of 100cm are used in cotton rotations. However, narrower row spacings (down to 50cm) will increase yield potential by 10 to 20%.

Narrower row spacings should be used when planting late or where weeds are likely to be a problem as the crop canopy closes more quickly.

Plant population

The optimal plant population varies with planting time and row spacing. A population of 300,000 plants per hectare should be used for irrigated crops planted at the optimal planting time. For late plantings this should be increased to 400,000 plants per hectare.

Further Reading

Moore et al 2011 Soybean. In Summer Crop Production Guide 2011, NSW DPI

Ferguson et al 2008 Soybean – growing guide for Queensland, QPIF