4.7 Irrigated barley – best practice guide

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Key points

- Seasonal water requirement varies from 320 to 470 mm
- A full irrigation strategy or limited water irrigation strategy can be used
- The period leading up to and including flowering (which takes place at booting in barley) is the most sensitive to water stress.
- Good agronomic practices are needed to maximise production and minimise lodging risk
- Good nitrogen management needed to meet malting barley protein specifications
- Aim to establish 100 plants per m^2
- Planting on rainfall preferred over pre-irrigation and watering up which can delay planting and produce excessive biomass respectively
- Irrigate to encourage secondary root development if needed
- Foliar disease can be a significant problem in barley – varietal choice, seed dressings and crop rotation needed to manage these

Plant Water Use

The amount of water required to produce a barley crop with maximum yield 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). In favourable seasons the water requirement may be as low as 320 to 420 mm whereas in a warmer dry year this requirement could be up to 360 to 470 mm to produce maximum yields.

The DAFF Queensland free on-line tool CropWaterUse can be used to examine the seasonal variability in crop water requirement for fully irrigated barley at your location (see Table 4.7.1).

It shows the irrigation demand for 1 June planted barley at three locations (Narrabri, Dalby and Emerald), assuming that the crop was 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 4.7.1 shows the daily water use in barley which peaks during flowering and milk development (GS60 to GS70). Moisture availability at this stage is critical to the yield of the crop. Moisture stress for more than a few days during this period will result in lower grain yield and quality.

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

Irrigation Strategies

Full Irrigation

For fully-irrigated barley where water is not limited, the aim is to maximise yield by scheduling irrigations to match crop water demand and avoid crop stress during the entire growing season. This requires the close monitoring of soil moisture once secondary root development has been completed (normally GS31).

In order to avoid crop stress, do not allow soil water to fall below 50% of plant available water capacity (PAWC). This is commonly referred to as the 'refill point'.

Once below 50% of PAWC, crops use more energy extracting the remaining soil water. Plant growth and yield potential will fall considerably if soils are allowed to dry down beyond this threshold.

Table 4.7.1. Comparison of average water requirements for barley planted on the 1 June at Narrabri, 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)	383	352	301	410	387	363	420	405	375
In-crop Rainfall (mm)	112	196	319	89	158	238	26	77	186
Irrigation Demand (ML/ha)	3.6	2.3	1.8	4.1	3.4	2.6	4.8	4.3	3.1
No. of Irrigations	4	2	2	4	3	3	5	4	3

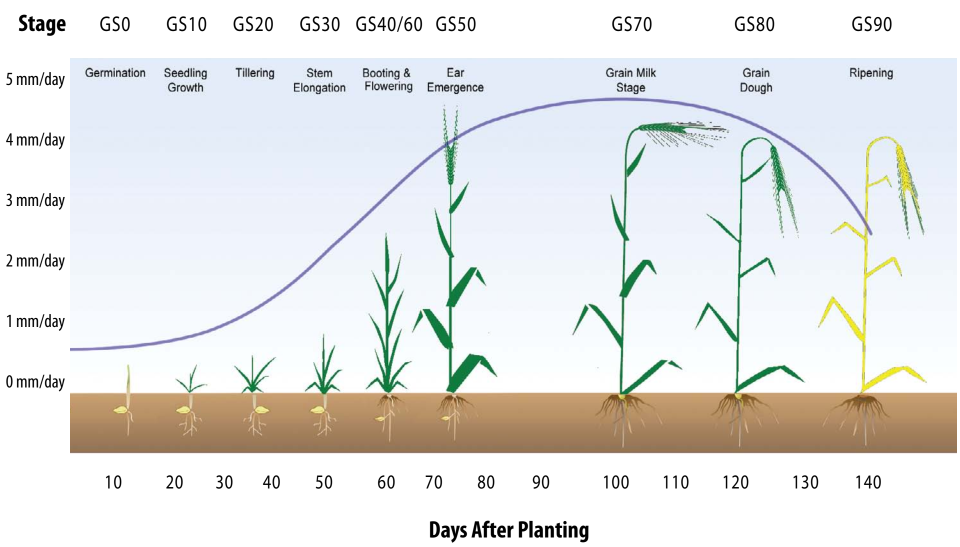
Make sure water is available for 2 to 3 days before the crop reaches its refill point. The reproductive growth phase typically coincides with an increase in temperature and an acceleration of plant water use. Any delay in water application can cause significant yield losses. As barley flowers in the boot stage it is important that a full profile is available to the crop at booting.

The period leading up to and including flowering is the most sensitive to water stress. Stress at this time will reduce the number of heads per plant, head length, and number of grains per head. It can also restrict root growth. Yield losses from excessive water deficits at this time cannot be recovered by later irrigations.

Key points to consider when scheduling irrigation for fully-irrigated barley are:

- crop stress must be avoided. ET_c is usually linearly related to crop yield. Stressing the crop at any stage of development reduces ET_c and yield. This yield loss cannot be recovered by irrigating at a later time. To avoid crop stress, it is important to know when to irrigate and how much water to apply. Table 4.7.2 summarises the water management considerations for each growth stage of barley.

Figure 4.7.1. Barley water use pattern and growth stages



- The application of a fixed water depth at each irrigation can lead to deep drainage losses. It is not necessary to refill the soil profile at each irrigation. Overhead systems are especially suited to application of small irrigation depths, but application depths can also be reduced with surface irrigation systems by increasing siphon flow rates and reducing irrigation runtimes.
- Crops can only extract water from their effective root zone. Therefore, the depth of soil wetted by irrigation needs to be adjusted during the season to respond to increases in root zone depth and irrigation wetted front should not go deeper than the effective crop root zone.
- The soil water deficit to trigger irrigation also depends on the depth of the root zone and needs to be adjusted during the season. Both the ET_c rate and the soil water deficit change daily, so irrigation frequency needs to be adjusted in response to these changes.
- The desired soil water deficit and the irrigation frequency also depend on the irrigation system capacity (mm/day). This highlights how much water the irrigation system can apply in one day, allowing for system breakdowns or maintenance. The greater the system capacity, the greater the soil water deficit that can be replenished quickly.

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 4.7.2 is an example of the end of season report generated by WaterSched2 for a fully irrigated barley crop at Dalby in the 2009 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.

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.

Correct timing of the last irrigation will ensure adequate grain fill and also reduce the risk of lodging and harvesting delays. It should be applied around the soft dough stage (GS85) if readily available water has been used to 60 to 90 cm soil depth. This will produce maximum yields on clays and loams, minimise black tip and provide best test weights. Irrigating beyond this stage will generally not improve yields, will lower test weights and increase black tip. It will also reduce water use productivity.

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 area possible where a single in-crop irrigation can be applied.

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.

In general, maximum crop productivity under irrigation is achieved when good soil moisture is available at sowing and then one or two supplementary spring irrigations are applied (one irrigation in wetter districts such as the Liverpool Plains, and two irrigations in drier areas such as Emerald and Goondiwindi).

If a large area of barley must be planted as part of a rotation, and only a single irrigation is possible, the best timing is one which applies water at the most critical growth stage – from stem elongation (GS30) through to flag-leaf emergence (GS39).

Table 4.7.2. Critical water management considerations by growth stage for barley

Zadoks Development Stage		Water Management Consideration
0	**Germination**	Adequate soil moisture essential to establish desired plant population. Waterlogging can increase seed mortality
1	**Main stem leaf production** Seedling Stage is the growth stage from emergence until the plants begin to tiller	Early weed control will conserve plant available water.
2	**Tiller production** Tillering usually starts when the plant has 3- 4 leaves. A (short growth cycle) barley plant will typically produce 7-8 leaves on the main stem before stem elongation occurs.	Early weed control will conserve plant available water. Good nutrient and water supply are determining the potential number of heads produced by the crop
3	**Stem elongation** Main stem node production. The maximum potential number of florets (and therefore maximum yield potential) is now set. The tillers produced last during stem elongation will often die. The final number of productive tillers depends on the conditions.	Good nutrient and water supply are determining yield potential. If stress during stem elongation is followed by heavy water application, barley has the ability to produce new tillers and additional heads. However these additional heads will delay harvest and the risk of losses from lodging and non-uniform ripening usually increases. Soil water depletion should not exceed 50% of PAWC.
4	**Booting** By booting each plant should have 2-3 productive tillers depending on growing conditions and crop density.	Pollen formation is sensitive to stress so water deficits and high temperatures at this time will decrease the number of seeds that form and may reduce yield. Soil water depletion should not exceed 50% of PAWC.
5	**Heading** The spike (also called the head or ear) is emerging from within the flag leaf.	
6	**Flowering** Pollen is being released and the individual grains are being fertilized. Flowering takes place before or during head emergence – barley flowers are primarily self-pollinating.	
7	**Grain milk stage** When the grain is squeezed, a milky solution is apparent.	
8	**Grain dough stage** When squeezed, the grain will still deform slightly, but no liquid is apparent.	Yield is almost set, but water stress will still reduce grain size and yield. Soil water depletion should not exceed 50% of PAWC.
9	**Ripening** Grain is hard and firm and ready for harvest. Grain is best harvested below 14% moisture content. Wetter grain (>14% moisture content) has storage problems.	Lodging will reduce harvestable grain yield.

Figure 4.7.2. WaterSched2 End of Season Field Summary report for a fully irrigated barley crop at Dalby in 2009

WaterSched2

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End of Season Summary

Field Summary

Farm:	Wallon Park	**Plant Date:**	1/06/2009
Location:	Dalby	**Season:**	2009
Field Name:	Wallon Park	**Length of Season:**	131 days / 1894 GDD
Field Size:	100 ha	**Irrigation Type:**	Surface 100%
Crop:	Medium Barley	**Irrigation Trigger Deficit:**	75 mm

Water Summary

	mm	ML/ha
Total Irrigation:	300	3
Total Rainfall:	63	0.63
Total Losses:	107	1.07
Starting Soil Water:	230	2.3
Ending Soil Water:	79	0.79
Soil Water Change:	151	1.51
Total Water Input:	514	5.14
Net Water Supply:	406	4.06

Crop Summary

Expected Yield:	6 tonnes/ha
Predicted Yield:	5.9 tonnes/ha
Actual Yield:	5.75 tonnes/ha
Accumulated ETp:	412 mm
Accumulated ETc:	407 mm

Economics Summary

Price Per Unit:	$150 / tonnes
Variable Costs:	$537 / ha
Gross Margin:	$325.5 / ha

Water Use Efficiency

	Predicted	Actual	Gross Margin
Total Water Use Index TWUI	1.15 tonnes / ML	1.12 tonnes / ML	$63 / ML
Gross Production Water Use Index GPWUI	1.45 tonnes / ML	1.42 tonnes / ML	$80 / ML
Irrigation Water Use Index IWUI	1.97 tonnes / ML	1.92 tonnes / ML	$109 / ML
Crop Water Use Index CWUI	14.51 kg / mm	14.13 kg / mm	$0.8 / mm

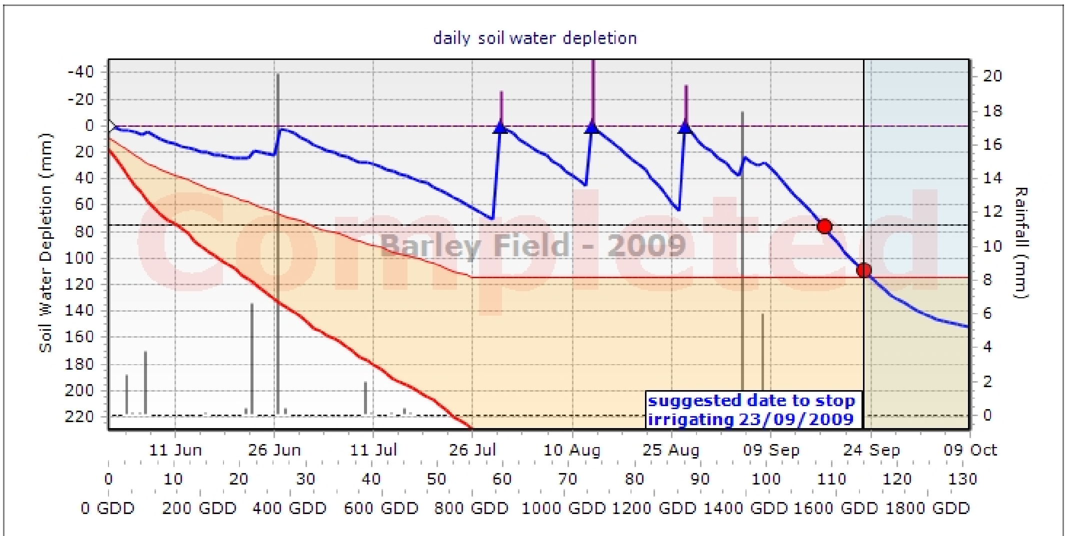

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Table 4.7.2 summarises the impact of water stress on barley at different growth stages.

The best timing for a single in-crop irrigation of around 1 ML/ha is from early stem-elongation through to flag-leaf emergence. It will still have time to help the crop develop a little more biomass, yet will also leave some soil water for flowering and early grain filling. The best timing of a single irrigation within a particular season will vary depending on the timing of in-crop rainfall, and stored water at sowing.

If two irrigations (or 2 ML/ha) is budgeted, then an irrigation applied at early to mid-stem elongation (GS30 to GS33) and again between flag-leaf (GS39) and the first awns being visible (GS49) – this is because flowering in barley takes place in the boot and early ear emergence stages.

Agronomy

To achieve high irrigated yields and meet market quality requirements it is necessary to follow good agronomic practices.

Barley is particularly prone to lodging – this is exacerbated by targeting high yields under irrigation. Lodging occurs mostly after ear emergence and can significantly affect grain yield and quality. Factors affecting lodging potential include:

- variety lodging susceptibility;
- shallow root systems due to abundant soil moisture or frequent irrigations;
- subsoil constraints like sodicity or compaction;
- high nutrition levels causing plants to grow too quickly; and,
- severe weather during crop ripening.

The range of agronomic practices discussed below is aimed at maximising yield and controlling lodging through canopy management.

Nutrition

Management of nitrogen availability is vital to achieve optimal yields and quality in barley. The level of nitrogen and plant available water will impact strongly on yield and protein having potentially a major impact on crop return. Unlike wheat where premiums are available for high protein, barley premiums for malting require moderate proteins of 9 to 12%. If you target around 12% protein this will also be maximising yield potential for barley.

A large percentage of Queensland's barley crop is classified as feed with protein levels above 12%. Older cultivation or double crop situations with lower soil N supplies can produce malt-grade barley especially in a good season, however, skill is required to balance the requirement for nitrogen to maximise yield without over fertilising and increasing the protein level.

A rule of thumb used by some to grow malting barley is to use 0.4 kg of nitrogen for every mm of available soil moisture. Thus if there is 400 mm of available moisture (stored soil water plus irrigation), this will require 160 kg of nitrogen to produce a barley crop with protein between 8.5 and 12 per cent. In high yielding years, grain protein can be reduced through nitrogen dilution as grain yield increases.

Test soil for starting nitrogen (to 90 cm depth) and phosphorus (to 20 cm depth) in April/May before sowing.

Use the nitrogen calculation guidelines in the Barley production in Queensland website to develop your nitrogen nutrition program.

Low phosphorus levels will affect crop establishment and can delay flowering which affects the yield potential and grain filling time of the crop. It is recommended that starter fertiliser with phosphorus containing 10 to 20 kg P/ha be used unless soil P levels are very high.

Variety Choice

Choice of variety is particularly important. Only certain varieties are accepted for malting. Select varieties with a proven performance in your region.

It is particularly important to consider the standability of varieties and their post-ripe straw strength to minimise losses from lodging. Susceptibility to the foliar diseases leaf rust, net blotch and powdery mildew is also an important consideration in choosing the variety to grow.

For the latest information on available barley varieties refer to the most recent Barley – planting and disease guide.

Plant population

For maximum yield potential a plant population of 100 plants per square metre or higher is needed. The required seeding rate will be between 40 to 60 kg/ha depending on number of seeds per kg and estimated establishment rate. Plant populations below 80 plants per square metre will have reduced yield potential and provide less weed competition.

Seedbed Preparation

Seedbed preparation has a significant impact on seedling emergence and yield potential. Following pupae-busting, tillage should be used to prepare a new seedbed that is free of clods and cotton stubble. Seedbed tilth needs to be in an optimum condition for seed placement and emergence.

Planting Date

Planting time is a management compromise that balances having the crop flowering soon after the last heavy frost, but still early enough to allow adequate grain fill before the heat in spring. At flowering barley can tolerate a 1ºC lower frost than wheat. But a frost of -4ºC at head height during flowering can cause yield losses of 5 to 30 per cent.

Varieties differ in the time they take from planting to flowering. Select the planting time for your variety that ensures it will flower after there is little chance (1 in 10 years) of a frost occurring.

Sowing early within the optimum range is better suited to low-N paddocks where canopy can be managed through delayed N application, and when irrigating up.

Establishment

Ideally barley should be planted after a rainfall event which provides planting moisture and ensures seed germination and establishment. This provides the best opportunity to achieve high yields (particularly if starting soil N levels are low). In this situation a uniform plant stand can be achieved and you can manage early season canopy growth and allow an irrigation to ensure secondary root development.

Pre-irrigation is risky as sowing can be delayed if rain occurs. However, establishment can be better in this scenario than if a paddock is dry-sown and watered up.

If the profile is completely dry at planting the only option may be to plant shallow and water-up. This is the least desirable option, particularly if starting soil-N levels are very high. Often, in water-up situations, plants still do not initiate secondary root growth and require further irrigation during tillering which can result in excessive early season biomass. This can predispose the crop to lodging, particularly where soil starting N levels are high.

Secondary Root Growth

Assess soil moisture status at 25 to 30 days after emergence. If there is dry soil below the sowing depth of seed, apply an irrigation to encourage secondary root development on low soil-n paddocks. Early secondary root development will enhance water and nutrient uptake.

Disease Management

Choice of variety is critical in managing the risk of disease losses. The most significant diseases are the foliar ones – powdery mildew, leaf and stem rust, net blotch and spot blotch. Choose varieties with the highest levels of resistance (note there are no Spot blotch or Stem rust resistant varieties currently available).

Treat seed with appropriate fungicidal dressings as smuts and net blotch (net form) may be seed borne.

Do not plant barley on barley as stubble borne spores are the main source of infection for net blotch and spot blotch.

Further Reading

Franckowiac, J.,Sturgess, J. and Platz, G.2012 Barley – planting and disease guide 2012, DAFF Queensland

McIntyre, K. 2010 Barley production in Queensland, DAFF Queensland