

4.2 Irrigated sorghum – best practice guide

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Key point

- Water required varies from 400 to 850mm
- Sorghum has a high demand for nitrogen, phosphorus and potassium
- Full season maturing hybrids use more water but have higher yield potential
- Planting date affects water use
- Narrow row spacing out-yield wider rows (1 metre and greater)
- Use populations of 100,000 to 150,000 plants/ha
- Waterlogging can reduce yields by 0.2 t/ha/day of waterlogging
- Irrigation timing is determined by available water supply – full irrigation and limited water strategies are used

Plant Water Use

The amount of water required to produce a sorghum 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 ETc). In favourable seasons the water requirement may be as low as 400 to 450 mm whereas in a hot dry year this requirement could be up to 700 to 850 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 sorghum at your location.

Table 4.2.1 shows an example of the information that CropWaterUse can produce. It shows the irrigation demand for 15 September planted grain sorghum 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 75mm irrigation trigger deficit are assumed.

Results show a large variation in seasonal crop water demand, rainfall and irrigation demand between locations and season types.

Figure 4.2.1 shows the typical

daily water use pattern for grain sorghum, which peaks during the late boot to early flowering stage.

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. Standability can be affected where severe moisture stress is encountered in the 2 weeks after flowering.

The area of irrigated sorghum to plant is a function of sorghum price, available water and your planned irrigation strategy. If there is a high probability of reduced water allocation and insufficient rainfall, then you may need to consider revising down your yield target and adopting limited water strategies. If water is limited, you can:

1. Plant the area as a raingrown crop
2. Plant more area than can be fully irrigated and then deficit irrigate the crop, or
3. Reducing the area planted and fully irrigating the crop

A fully-irrigated crop is irrigated to completely meet crop water demand that is not met by rainfall and soil water storage. On the other hand, deficit-irrigation occurs when the full crop demand for water is not satisfied, and can be a useful strategy to maximise the potential upside from improved seasonal conditions.

Table 4.2.1 Comparing of water requirement for grain sorghum planted on the 15 September at Narrabri, Dalby and Emerald, based on historical weather data (1957 to 2008)

Season Type	Narrabri			Dalby			Emerald		
	Dry	Ave	Wet	Dry	Ave	Wet	Dry	Ave	Wet
Crop ET _c (mm)	639	608	577	589	565	551	669	644	622
In-crop Rainfall (mm)	137	232	364	171	265	361	154	221	367
Irrigation Demand (ML/ha)	6.3	5.2	4.1	5.6	4.2	3.2	6.8	5.6	4.7
No. of Irrigations	6	5	4	5	4	3	6	5	5

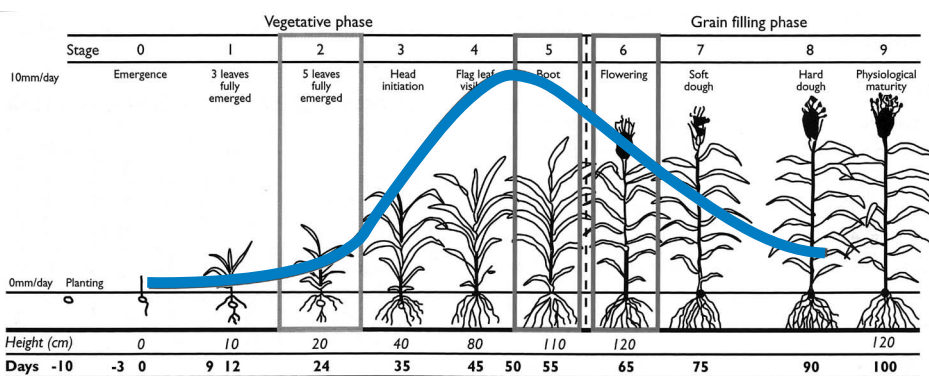
The limited irrigation water should be applied during the most water stress sensitive growth stages of the crop. Therefore, irrigation may be withheld during early vegetative stages (until 6 to 8 leaves) and the late ripening period. The aim of deficit irrigation is to maximise irrigation water productivity rather than achieving maximum yields.

The feasibility of these strategies depends on how much water is available from in-crop rainfall and stored soil water and whether the rain-grown yield produces acceptable profits at that location. In such situations it would be advantageous to plant as much area as possible. However, in a dry environment, planting more area that can be effectively irrigated can result in crop failure and financial loss.

Another point to consider is that to maximise profits of the whole farm, it is important to prioritize the allocation of water to those crops that have a higher return per unit of the limiting factor (either land or water). Therefore, even though enough water may be available to grow a fully-irrigated sorghum crop, it may be more profitable to save the water to grow an alternative summer crop or winter crop.

These types of economic decisions require complex analysis. For assist in this decision making, a free online tool called [Irrigation Optimiser](#) has been developed by the Agricultural Production Systems Research Unit. This tool makes it easier for farmers to decide which crops to plant and what irrigation strategies to implement to achieve maximum whole of farm profitability.

Figure 4.2.1 Grain sorghum water use pattern and critical growth stages



The Irrigation Optimiser is very easy to use allowing farmers to input information specific to their own farm enterprise to answer crucial questions about how to maximize farm profits given the volume of water and area of land available for any individual operation.

Nutrition

Sorghum is potentially a very productive crop and as such can place high demands on soil nutrient supplies.

For instance, studies have shown that a sorghum crop yielding 7t/ha would require around 215kg of nitrogen, 25kg of phosphorus, 170kg of potassium and a balance of trace elements. Adequate supplies of nutrients in the correct proportion are essential for normal crop development and maturation. A nutritional deficiency or imbalance invariably increases the duration of sorghum growth, thus increasing susceptibility to midge attack and increasing moisture usage.

Studies have shown that N, P, K uptake by sorghum is greatest during the rapid vegetative (G.S.1) growth period

and during the grain formation stage (G.S.3). The period from emergence to floral initiation has the greatest influence on potential grain yield as head size and tiller number is established during this period. Since the potential yield is set at the time of head initiation (6 to 8 leaf stage), the plant should have optimum growing conditions at this time, although when water is limited it is more important to minimise water stress at flowering.

Maintenance of adequate nutrition after floral initiation is essential to maintain the potential grain number already determined and to increase the protein content of the grain.

Nitrogen (N)

Sorghum takes up 75% of its nitrogen requirement in the vegetative period prior to floral initiation. A shortage of nitrogen during this period significantly reduces growth in stems and leaves and consequently in the number of flowers produced and so leads to a reduction in yield. For the remaining nitrogen demand, that taken up between flowering and maturity is most important, for a shortage of plant available nitrogen

during this period results in large reductions in the protein content of the grain.

Nitrogen fertilisers are best drilled into the beds prior to planting as germination is severely reduced if nitrogen is in direct contact with the seed. Applications with seed contact are limited.

Split applications may be preferable if there are reservations as to the future water supply or substantial rates are to be used.

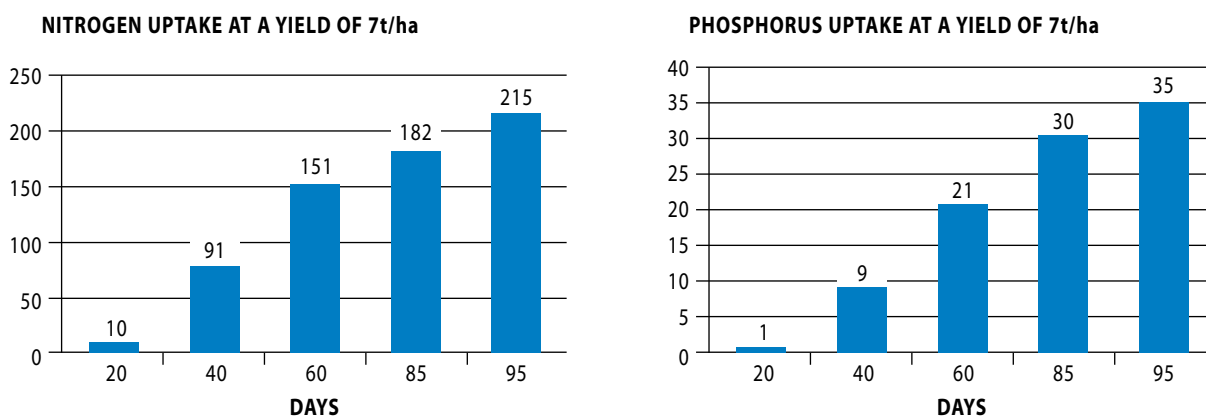
Side dressings applied at the boot stage have produced significant yield and protein increases when insufficient nitrogen has been applied at planting.

It has been suggested that less total nitrogen is needed with side dressings if two thirds is applied at planting and one third at the boot stage.

Irrigated sorghum will access between 70-80% of its total nitrogen requirement from the top 60cm.

Soil testing and nitrogen recommendations should be based on subsoil results concentrating on the top 60cm. Dryland crops will access deeper nitrogen as they chase water if available.

Figure 4.2.2 Nitrogen and phosphorus uptake patterns for grain sorghum



Phosphorus (P)

Phosphorus is vital for the early development of young sorghum. It is an essential component of substances which manufacture sugars and proteins in the plant. The uptake of phosphorus peaks at early flowering, with 45% of the total phosphorus demand being taken up during booting and flowering. A phosphorus deficiency in sorghum leads to restricted root development and delayed flowering and maturity.

Phosphorus is best applied as a band at planting so that seedlings have immediate access to the element.

Sorghum crops will only respond fully to applied nitrogen if the soil phosphate is adequate and readily available.

Early planted spring crops, growing in cool conditions, will often respond to phosphorus even if soil phosphate tests are good. Recent studies into phosphorus and sorghum have identified that sorghum is susceptible to [long fallow disorder](#). Due to enforced long fallows, yield responses to phosphorus fertilisers are becoming more common. Another side effect of utilising stored soil moisture is the possible redistribution of nutrient to the surface, where it remains unavailable for much of the season. Average yield responses to seed applied phosphorus have been around 400kg/ha. This is probably best applied by an ammonium phosphate (DAP, MAP or a proprietary Starter).

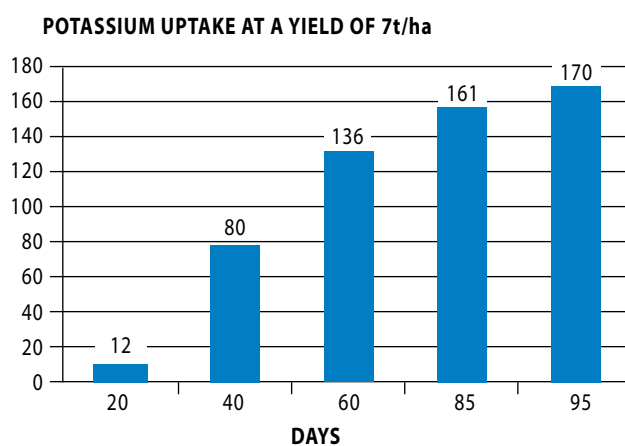
The 'pop-up' effect (the fast start given to seedlings in cool conditions by phosphorus fertiliser) does not appear as clear cut in sorghum as in corn.

Phosphorus responses are likely when soil P levels are less than 15 ppm.

Potassium (K)

Potassium is taken up in large quantities by the sorghum plant. Potassium plays a major role in the water relations within the plant and increases vigour, disease resistance and grain quality. Sorghum takes up 50% of its potassium requirements during the vegetative period prior to floral initiation. Adequate supplies of potassium are therefore essential in the establishment of a healthy stand of grain sorghum.

Figure 4.2.3 Potassium uptake pattern for grain sorghum



Zinc (Zn)

Zinc, although required in relatively small amounts, is essential during the development of the young sorghum plant. A zinc deficiency which most commonly occurs on alkaline soils can greatly delay flowering and maturity. Yield potential is also depressed by zinc deficiency. Soil tests give some indications as to soil zinc status but best judgements are from visual symptoms and/or leaf analysis. Zinc can be applied as a foliar when the problem is noticed but by the time the yield depression is under way the treatment is really only a correction. Zinc applications as foliar sprays should be applied within four weeks of emergence. Prevention is better than cure and any suspicion of zinc deficiency should be counteracted by one of the various soil applied zinc formulations. The oxide and sulphate monohydrate forms should be applied twelve weeks before planting if the crop is to derive any benefit from it.

Establishment

Variety Choice

Variety maturity determines the duration of the growth period, which coupled with daily evapotranspiration, determines the total water requirement of the crop. Thus sorghum of different maturities requires different amounts of water for optimum production. A full season late maturing hybrid will use more water and nutrients than a quick season hybrid but longer season hybrids may have higher yield potential.

Planting Date

Typical optimum early sowing times in cotton growing districts are late September to early October. Emerald is the exception as sowing can begin in mid August through to the end of September and then recommence in January through to mid February. Soil temperatures at the spring planting time are normally rising (taken at 8am at planting depth) and temperatures of 16 to 18°C are ideal for spring plantings.

Planting as early as agronomically possible will provide a number of benefits:

- increased water use efficiency, by avoiding yield loss from heat
- maximise tillering and leaf production
- lessen the risk of yield loss from sorghum midge
- reduce the influence of heat at flowering
- higher yields compared to later plant.

Late plantings in summer should be timed to complete flowering before diurnal temperatures fall below 18°C (day) and 13°C (night) as temperatures below these may result in reduced seed set.

Sorghum is sensitive to frosts so grain fill should be completed before the first severe frost.

Row spacing and plant population

Overhead sprinkler irrigation lends itself to any combination of row spacing from narrow rows 15 to 20cm apart to wider rows up to one metre apart. Wider rows can allow inter row cultivation for better weed control, however experience and trial work has shown that evenly spaced narrow rows have a yield advantage over wider rows.

With surface irrigation in furrows, the situation is slightly different. In trials conducted at Emerald comparing single rows one metre apart at 120,000 plants per hectare and twin rows 40cm apart on one metre beds, the single rows yielded 7.0 t/ha while the twin rows yielded 9.2 t/ha.

Narrow rows at populations of 80,000 to 150,000 allow for higher rates of tillering, which allows for compensation and yield increase if seasonal conditions are better than expected. In situations where stress pre-flowering reduces viable tiller numbers, higher populations will yield more if water supply is adequate through flowering and grain fill.

If the surface irrigation system allows and the soil type is suitable, two metre beds with four to six rows on the bed have proved very successful with plant populations up to 150,000 per hectare.

Higher populations yield more if stress occurs post flowering. Recent trial work demonstrates a very flat response curve under full irrigation and optimum populations would be 120,000 at 1m rows and 140,000 at 75cm rows.

Plant populations on the higher end may be an advantage for management with detail to high water and nutrition inputs.

Some hybrids have reputations as low population hybrids. This may occur where a hybrid has a high ability to tiller as varieties with tillering ability can be planted at lower densities.

Seed companies can provide recommendations of plant populations for each hybrid.

Irrigation Management

Irrigation System

Irrigated grain sorghum is produced under two main systems – surface irrigation or overhead sprinklers.

Surface irrigation can be by furrow or bays where the water is applied by syphons, gated pipe or various types of check valve systems.

Overhead sprinklers systems range from the large centre pivot and lateral moves to hand shift pipes and travelling irrigators.

All have their advantages and disadvantages and certain soil types are more suitable to one system over another. However, when looking at setting up an irrigation system such things as topography, soil types, water supply, water infiltration rate, evaporation rate, potential crop types and of course cost all have to be considered.

When using furrow irrigation, the duration of each watering or the time of inundation can have a major impact on yield. If watering time is prolonged and water logged conditions result for more than 24 hours at each irrigation, yield losses of up to 50% have been recorded compared to non water logged areas. Rule of thumb is 0.2t/ha/day of waterlogging lost.

However, be careful using time as a measure of an irrigation's efficacy, as soil type, length of the field, the slope, the flow rate and the deficit of each field is different.

When the soil becomes waterlogged following long periods of surface irrigation, nitrogen uptake by the plant is reduced and nitrogen is lost from the soil through leaching and denitrification. To minimise yield losses when surface irrigating, the crop should be irrigated quickly and evenly and then drained rapidly to reduce the duration and severity of the water logged soil condition.

Field layout and irrigation management are main causes of waterlogging of irrigated crops. Most of the irrigation in Australia occurs on medium to heavy clay soils with slopes less than 2%. Generally these soils have a very good water holding capacity, but have slow infiltration rates and slow drainage rates. These soil types waterlog easily under the wrong type of management. Generally clay soils with slopes of less than one percent should not exceed furrow lengths greater than 500m.

However, through good bed/row preparation, head ditch layout, and the use of lower soil water deficits, flat paddocks can be managed effectively.

Furrow irrigation efficiency is maximised where fields are professionally levelled.

Crop Water Use Efficiency

Grain sorghum is a very water efficient crop and is more tolerant to stress than maize. Sorghum is capable of very high water use efficiency, but under cooler environments with good water supply, maize will produce more grain per mm of crop ETC. Sorghum CWUE ranges between 10 to 25 kg/mm depending on stress levels and management. With careful management and today's hybrids, 25 kg/mm is possible.

For maximum yields the available water in the active root zone should not drop below 50% storage capacity. At peak use, sorghum will use about 80 to 95 mm of water in a 12 day period.

Timing Irrigations

There are a number of ways to determine the proper time to irrigate – soil moisture instruments, taking soil samples, keeping records by logging water use and supply, and by stage of plant growth. Most likely the best system would be a combination of two or more of these, but the most practical method for many growers is to go by stage of plant growth (see Figure 4.2.1.)

When irrigation water is in limited supply, the pre-plant application should be followed by one watering applied just as the sorghum starts to boot.

Should rainfall be favourable to the boot stage, this one watering should be delayed as late as possible so it will carry the crop well into the grain development stage.

Should you have a moderate water supply, enough for a pre-plant application plus two waterings, the first irrigation should be applied a few

days prior to boot and the second a few days after flowering has been completed. If significant rainfall occurs prior to booting, application of water may be delayed with good results.

Watering up is an alternative to pre-irrigation, especially under overhead irrigation. This aids in the incorporation of pre-emergent herbicides.

Watering-up with surface irrigation also works as long as the beds sub to the top well, and the paddock doesn't have grass weeds.

Planting depth should not be shallower than 3cm when watering up, as herbicide damage can occur and secondary root growth will be poor as the crown will initiate on the soil surface.

If you have enough water for pre-plant plus three irrigations, your best irrigation schedule would be to apply the first irrigation five to seven days prior to boot, the second at boot, and the third 10 days later or by milk stage. Should you plan to apply four or five irrigations, apply the first seven to nine days prior to boot and one every 10 days thereafter.

Total water required during the maturation stage is small but moisture is essential during this stage to ensure full grain fill and to maintain plant quality. Irrigators sometimes encounter the question of when to stop irrigating grain sorghum so as to permit proper grain fill but leave the soil moisture reservoir depleted to allow room for storing off-season precipitation.

In sorghum, the crop is said to be physiologically mature when the grain reaches the hard dough stage. Experience and research indicate soil moisture availability measurements of 50 to 60% of field capacity are adequate to carry the crop once it has reached physiological maturity. In most cases this is around 30 days after flowering.

Figure 4.2.4 Summary of Irrigation management strategies for irrigated grain sorghum

Limited irrigation available		Full Irrigation	
COOL AREA - MEDIUM TO HIGH RAINFALL			
Irrigation scheduling	Established plants	Irrigation scheduling	Established plants
Vegetation stage (6-8 leaves)		Post emergence (4-6 leaves)	
Pre-flowering / Late boot	60-100 000 / ha	Mid vegetative (8-10 leaves)	
Early grain fill		Late boot / Pre-flowering	100-150 000 / ha
		Early grain fill	
		Mid grain fill	
HOT AREA - LOW TO MEDIUM RAINFALL			
Irrigation scheduling	Established plants		
Vegetation stage (6-8 leaves)			
Pre-flowering / Late boot	40-70 000 / ha		
Early grain fill			

To assist field crop irrigation scheduling decisions, DAFF Queensland have recently released an on-line irrigation scheduling tool [Watersched2](#). This tool simplifies the scheduling of irrigations across all fields on your farm by estimating crop water use from available weather data. 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.