3.3 Managing irrigation of cotton with limited water

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Key points

- Decide on a strategy preseason, before planting; be flexible as things may change for better or worse during the growing of the crop.
- Know what water is available from all sources; do not discount stored soil moisture and predicted rainfall. Calculate the area you are able to irrigate with the available supply.
- Select fields on the basis of efficient water supply and good yield history and plant water holding capacity.
- Choose a variety normally suited to your production region. Best performing dryland varieties in your region should be a guide.
- Characteristics in a variety should be high yield potential, inherently good fibre quality parameters, even in tough conditions, and indeterminacy of growth habit.
- Avoid excessive nitrogen which encourages rank vegetative growth and wastes irrigation water.
- The irrigation strategy in limited water scenarios is to limit or minimise the amount of stress on the crop. It should be based on water available and cropping system. Concentrate available water into the flowering period.
- Approach defoliation as normal, deciding on the last harvestable boll and follow maturity up the plant to determine the defoliation date.

In a limited water situation, the normal range of factors needs to be considered but there may be a shift of emphasis. In particular, the management aim moves from bales/ha to bales/ML. A number of agronomic decisions will need to be made at, or prior to, sowing as part of the planning associated with land preparation and sowing. These decisions include row configuration, nitrogen application method and amount, sowing date and varietal selection. The critical requirement is to ensure that agronomic management does not result in an excessively vigourous crop nor delay crop maturity too much.

How much cotton should I plant and irrigate?

When water becomes the limiting resource for production, the relative importance of various management decisions begins to change. Two key questions arise:

- What area of land should be prepared for irrigated cotton?
- How should the remaining area be prepared to allow for flexibility if conditions improve closer to planting?

The answers are a function of the total water supply available for the crop from all sources: from the river and bore allocation, on farm storage and any expected off allocation pumping. No single option is the best in every season, but research has indicated which options perform best over the long term, when taking into account year-to year variation in weather.

Growers in situations of limited water supply should consider what area to plant and how much of this should be irrigated. The answers to these questions will be influenced by many factors specific to the location, farm and grower.

A number of studies have been undertaken to consider the area to dedicate to irrigated production. The results are summarised in Table 3.3.1. Generally the answer is to aim to irrigate an area that will allow 5 to 6 ML of supply per ha.

To allow an appreciation of the risk level involved, data has been presented on the supply required to ensure that the break-even yield is attained in 9 years out of 10. In most cases, the supply which maximises the average returns is greater, and so based on the long-term weather record, the risk of failing to break-even using this supply is less than 1 in 10.

Note that these figures refer to the available supply, not the expected application, and are calculated based on a whole farm irrigation efficiency of 75% (That is, ¾ of the water supplied is used by the crop as evapotranspiration. This accounts for storage, distribution and application losses). If your irrigation efficiency is markedly less than this, the figures will need to be adjusted accordingly.

Table 3.3.1. Water supply required on September 1 to reduce the risk of failing to break even to less than one in ten and the supply which maximises returns per megalitre (N.B. Solid plant cotton; assumes a whole farm irrigation efficiency of 75%).

Region	Supply to break-even in 9 years out of 10 (ML/ha)	Supply to maximise returns per megalitre (ML/ha)
Emerald	4.5	5
Darling Downs	5.0	5
St George	5.5	5
Border Rivers	5.2	6
Gwydir Valley	5.3	6
Namoi Valley	5.2	6
Macquarie Valley	6.3	6

This question can be re-examined just prior to the first irrigation. At this time, the supply that needs to be on hand is less, as the water to establish the crop has already been dealt with. The long-term weather record suggests an irrigation supply of 3 to 4 ML per ha will maximise returns at this point. The results for the various regions are given in Table 3.3.2. and the supply for breaking even is again presented.

Adjusting to lower water availability by removing selected rows after establishment (converting to skip row) is detrimental to the overall performance of the field. Row configuration decisions (see below) should be made pre planting. Planting with the option to remove rows later is not desirable for two reasons.

1. Water used by the plants in the skip row has been wasted on unproductive growth.

2. Plants remaining have suffered more moisture stress than would have otherwise been the case, and therefore have difficulty in recovering from this stress for the entire season. Early stress leads to slow growth and fruit development and premature cutout.

Table 3.3.2. Water supply required on December 1 to reduce the risk of failing to break even to less than one in ten and the irrigation supply which maximises returns per megalitre (N.B. Solid plant cotton; assumes a whole farm irrigation efficiency of 75%).

Region	Supply to break-even in 9 years out of 10 (ML/ha)	Supply to maximise returns per megalitre (ML/ha)
Emerald	2.3	3
Darling Downs	3.2	3
St George	3.5	3
Border Rivers	3.2	4
Gwydir Valley	3.4	4
Namoi Valley	3.2	4
Macquarie Valley	4.0	4

In light of this, sowing more cotton than the estimated water supply would suggest allows reassessment prior to the first in-crop irrigation. If this favourable rainfall does not occur, some area can be reverted to dryland production. The question of what total area to sow to cotton is independent of the question of how much to irrigate: dryland cotton is a legitimate cropping option for the remaining, non-irrigated area. This depends on your location. The decision of how much dryland cotton to sow should be based simply on those factors which dictate whether dryland cotton production is viable. Key variables here are the amount of stored soil moisture and the anticipated rainfall, hence the yield expectation.

Row configuration

If, when calculating the area to plant, the irrigation supply is pushed below 5-6ML per ha, then partially irrigated skip row may become an option in some regions. Irrigated skip row systems have been suggested as offering some potential for increasing water use efficiency in water limited situations. Skip row cotton is being considered for use in limited water situations more widely for a number of reasons. The practice:

- Extends the planted area to allow utilisation of full moisture profiles.
- Buys some time in which to benefit from in-crop rainfall.
- Minimises the potential for fibre quality discounts.
- Allows easier insect and weed management with biotechnology.
- Takes advantage of marketing options and upside from growing cotton.
- Offers significant variable cost savings.

Skip row configurations function by increasing the volume of soil that plants have to explore, providing a bigger reservoir of available moisture and allowing the plants to hold on for longer during dry periods. Skip row cotton provides an 'in between' option for increasing the area of cotton which can be grown, allowing some upside in production if conditions improve and far less downside in potential fibre quality discounts if the season deteriorates.

However, in some cases, inherent growing characteristics such as soil type, in-season rainfall, and location may mean there is minimal advantage in adopting skip row practices.

Research trials have established that row spacing has a larger effect on yield and quality than number of plants per metre of row. Evidence from rain-fed cotton trials shows there is little or no yield reduction between 4 and 12 plants per metre.

There are a range of different configurations being used by growers across the cotton industry in semi-irrigated situations. These include:

- single skip (two plant rows, one skipped row);
- 60 inch (1.5m) rows;
- 80 inch (2m) rows (or 1 in 1 out);
- double skip (two plant rows, two skipped rows); and,
- super single (one plant row, two skipped rows).

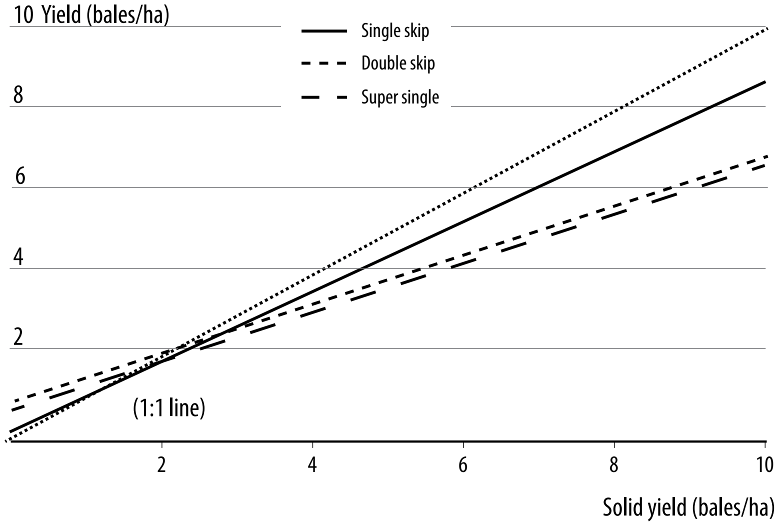
The positive and negative features of each configuration, including the relative water use efficiencies, depend on the individual situation. What works best in one farming system may not in another due to differences in soil type, environment, cropping history, available equipment, water availability and other factors.

Growers contemplating whether they would benefit from using skip row configurations, and which skip row configuration they should use, should consider the yield, cost and fibre quality mix of each configuration. Extensive research has shown that while skip row cotton does limit yield potential (Figure 3.3.1.), the combination of reduced fibre length discounts and variable cost savings in growing skip row cotton often lead to a better risk/return proposition. Growers need to consider their yield potential, based on all the factors discussed later in this chapter.

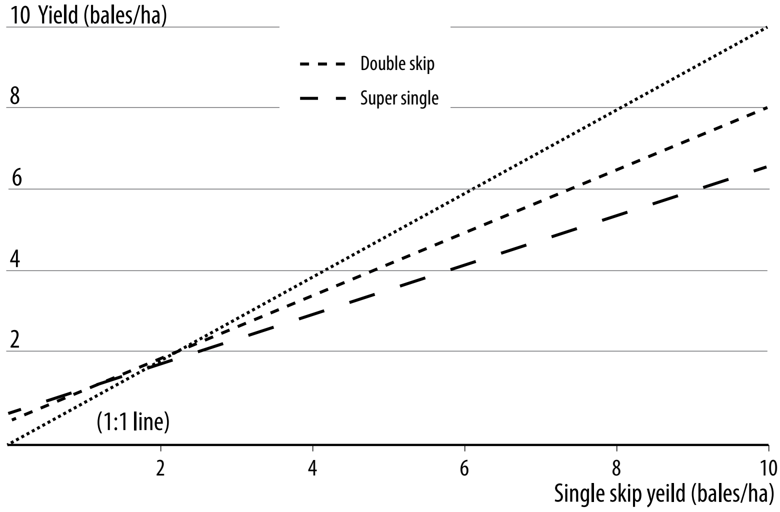
Figure 3.3.1 - Comparison of average solid and skip row yields in dryland and irrigated

systems across several seasons and regions (Bange, 2012).

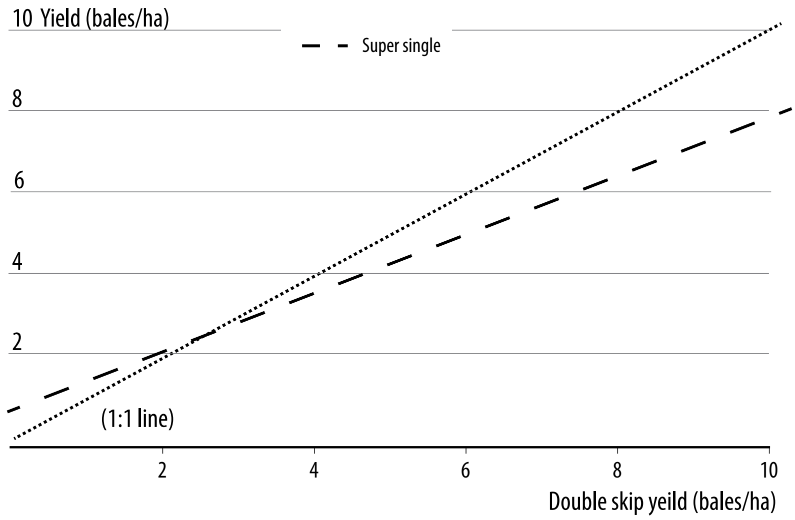
Single Skip has the highest upside yield potential of these configurations,



Crossover for single 2.1 (solid) for double 2.2 (solid) for super single 2.5 (solid)



Crossover 2.3 bales (single) Crossover 2.6 bales (single)



Crossover 2.3 bales (double)

however it will also use its moisture profile the quickest. Having a plant row 50 cm one side and a one metre skip row to the other, this configuration is best suited to situations on heavier soil types with high plant available water content (PAWC) and more irrigation water and rainfall availability

Double Skip having a plant row 50cm one side and a 1.5m skip row to the other, this configuration tends to impose small amounts of moisture stress to the plant, restricting early excessive vegetative growth compared with wider configurations. Plants can be prone to lodging, especially vegetative branches, which take advantage of the extra light available in the skip area. It is best suited to drier profiles and hotter environments when compared to single skip environments.

While **one-in-one-out (alternate row or 80 inch)** cotton has not been included in the research illustrated in Figure 1, grower experience and some preliminary trial work has shown its yield potential to be slightly higher than double skip in certain circumstances. Preliminary trial results suggests that despite increased water use in the alternate row configuration compared with double skip, this did not result in increased stress later in the season as yield was unaffected. The equidistant row spacing in the alternate row configuration may contribute to better access to soil moisture and investigations are continuing to determine the potential of these configurations. A more uniform growth habit in 80 inch cotton can reduce lodging and allow better spray penetration and defoliation processes when compared to double skip.

A couple of advantages perceived by some double skip growers compared to 80 inch are:

- Growth management is easier as vegetative growth seems to be reduced.
- Double skip is easier to cultivate, especially compared with 80 inch systems where the row is in the middle of a 2m bed.
- It is more difficult for water to sub to the centre of the bed when watering up 80 inch rows.

Super Single (one-in-two-out) has been tried in semi-irrigated situations. The widely spaced plant rows (3 metres apart) means the yield potential and potential upside in a good season is severely limited. However, it may be an option with a full soil moisture profile at planting and minimal irrigation water resources. This configuration allows growers to minimise growing costs as well as limit the likelihood of fibre quality discounts.

Skip Row Irrigation Strategies

Irrigation strategies used in skip row cotton need to work on the principles that yield is maximised by avoiding or at least minimising moisture stress while the plant is flowering (Table 3.3.4.).

With this in mind, the optimum timing to maximise the benefit of each irrigation will depend on the field, the amount of water available and the environmental conditions your crop is enduring. This is why it is so important that a range of monitoring techniques is used.

Table 3.3.4. Yield loss (%) per day of water stress (extraction of > 60% plant available water) (Source Yeates et al. 2010#; Hearn and Constable 1984*)

	Past Conventional*	Bollgard#
Squaring	0.8	1.1
Peak flowering	1.6	1.7
Late flowering	1.4	2.7
Boll maturation	0.3	0.69^

^ 14 d post cut out

Furrow irrigation of skip cotton

Irrigation of skip cotton may require a different approach, particularly when using furrow irrigation. Water extraction from the soil profile is often far less uniform than under a solid plant configuration, with the soil between the plant rows being drier than that in the skip, particularly in double skip. Furrow irrigation between the plant rows will be slowed considerably by the larger soil moisture deficit in the dry soil. Conversely, irrigation in the skip, particularly in double skip, may be faster as the deficit is smaller, but lateral movement of soil moisture to the plant rows may not be ideal. Three options might be considered:

1. Irrigate between the plant rows only. In this situation a higher efficiency may be more likely if flow rates are increased to overcome the effects of the large soil moisture deficit. High flow rates should be managed closely as tailwater volumes can be significant, especially if irrigation is allowed to continue after the water has come through.
2. Irrigate the skip rows only. In this situation, the effective lateral movement of water must be monitored carefully. Running this form of irrigation for a long period to ensure adequate wetting of plant rows is likely to result in excess tailwater and water losses deep in the profile beneath the skip rows. If plant rows remain reasonably dry following irrigation, plants will only be able to access water in the skip, where there may be less roots and access might be more difficult for the plant.
3. Irrigate plant and skip rows. In this situation, a more even wetting front might be achievable, although it may still be necessary to have a higher flow rate in plant rows. This strategy is most likely to result in a wet field with reduced potential for rainfall capture until water has been used by the crop.

Increased monitoring of irrigation performance will be extremely useful for determining the most appropriate strategy for individual circumstances. Moisture probes in skip and plant rows can provide valuable information and furrow irrigation performance evaluation (see Chapter 5.3) can be used to determine the efficiency of different options. Breakouts will be more likely under scenarios (1) and (2), particularly where flow rates need to be very high to ensure efficiency. To avoid breakouts across soft rows, wheel tracks may need to be worked out.

The first irrigation

The timing of the first irrigation in skip row cotton is critical. Stretching it too far can result in rapid-cut out, resulting in a restricted boll load and triggering crop re-growth when moisture eventually becomes available. This will result in a big maturity gap making the crop difficult to finish and defoliate. The decision of when to start irrigating also needs to consider the capacity to water all areas to avoid being late on the last fields. Although irrigation intervals may be greater in skip row, each irrigation may use as much if not more water than solid plant.

Field choice

Fields with a history of high yield may be valuable, but reference to water use records may show that yield is commensurate with water use. In this case, yield history alone would be of limited advantage. Rather it is necessary to consider either water use efficiency or yield under restricted water supply.

If only part of the irrigable area can be planted with the available water supply, the choice of which fields to sow and irrigate will be governed by yield expectation and efficiency of water supply. On most properties, there are far greater gains to be made in storage, distribution and application efficiency than in crop water use efficiency.

Soil type and moisture status are critical elements when determining the priority of fields to plant. Target fields with high plant available water holding capacity; a bigger bucket of water will be beneficial, especially for buffering against stress in hot temperatures, between irrigation events and as the crop dries down the soil profile late in its development. Also calculate how full soil profiles are, ideally with the aim of establishing the crop on rain moisture. Using irrigation water to establish the crop is appropriate only if there is no other option.

The efficiency with which water is supplied to the field is more variable than the efficiency with which a crop uses the water delivered to it. Thus proximity to the best storages and/or being supplied by the best channels are factors to consider in field choice.

In most circumstances, fields with drip or centre pivot/lateral move (CPLM) systems should be cropped as a priority as these systems can apply small amounts of water as required throughout the season. In addition, CPLM systems have a distinct advantage over both drip and surface irrigation in their ability to germinate crops. Alternative row spacing strategies are not often utilised under these irrigation systems as small, regular water applications can keep solid plant cotton growing through the season with greater potential upside when rainfall occurs.

Nitrogen fertiliser

As discussed in WaterPAK Chapter 3.1 and NUTRIpak, nitrogen fertiliser application should be made on the basis of soil tests, petiole tests or at least cropping history. This is given added significance in the water limited situation. Crops which are water limited are less responsive to applied nitrogen and so excess nitrogen, at best, is non-productive. Further, if excessive water supply from irrigation or rainfall occurs in combination with high nitrogen, it may lead to the development of a large canopy, resulting in increased water requirements that cannot be met. It may also lead to a delayed maturity resulting in a need for continued water supply.

In scenarios where excessive nitrogen is present, the use of growth regulators at cut out should be considered to limit the detrimental effects. Using high rates of growth regulators at this period of crop growth will restrict vegetative growth, promote crop uniformity and redirect efforts into filling and maturing set bolls.

Variety choice

Choice of variety should be based on matching the variety to your production region. This is particularly so with respect to disease and season length.

The CSIRO and Cotton Seed Distributors conduct many trials across all growing regions which examine the performance of varieties in all growing scenarios. Many studies in Australia have shown that the varieties which do best under irrigated conditions are generally those which do best under dryland or reduced irrigation conditions also.

The principles behind selecting a variety for limited water scenarios are similar to those in selecting a dryland variety. Firstly look for varieties with high yield potential for your region and that have an inherently good fibre quality characteristic, especially fibre length. Varieties with inherently long fibre provide a buffer against reductions in fibre length which may occur due to water stress.

Varieties should be indeterminate in nature to respond to late season rainfall or irrigation if forthcoming. The advantage of early maturing or determinate varieties under dryland production which is seen in some overseas production areas does not apply in Australia. The advantage of short season varieties in these situations is based on the need to avoid a terminal drought. Using such varieties in Australian growing areas imposes an absolute yield limitation from the time of sowing. There is thus no scope to take advantage of any changes in water supply or rainfall that may occur during the season. Such varieties also tend to shut down abruptly when any stress is encountered and once they have ceased fruit production, do not readily recommence. Clearly this is a particular risk where water is limited.

If sowing is significantly delayed in the hope of receiving planting rain or further soil recharge, a shorter season variety than usual or a lessening in the row configuration may also need to be considered. Variety selection guides are generally released annually by seed providers (for example see www.csd.net.au).

Sowing date

The optimum date of sowing differs between a fully irrigated crop and crops grown with a restricted allocation. Cotton yield declines with delayed sowing due to the shorter time available to initiate and mature an adequate number of bolls.

As a general rule, as the available water supply decreases, the expected decline in yield potential with sowing date begins somewhat later. This is because the crop is already yield-limited and so doesn't need as much season length to achieve the new water-limited yield potential.

This is illustrated in Table 3.3.5. using simulation output from the OZCOT model. It should be noted that in this example, some of the supply levels are below that which might be expected to provide break-even returns anyway. While there is more flexibility in sowing date with lower allocation, excessive delay must be avoided. This may increase the risk of quality downgrades due to the chance of maturing late bolls in cool weather.

In northern areas where there is a longer growing season and more summer rainfall, low allocations may show an optimum sowing time rather than a simple decline. This is because (1) the impact of late sowing is less in these areas and (2) there is potential to match crop water demands to the long term rainfall distribution.

Table 3.3.5. Sowing date after which yield declines for different irrigation supplies

Region	Irrigation supply per hectare		
	2 ML	4 ML	6 ML
Emerald	30 Nov	30 Nov	30 Nov
Darling Downs	15 Nov	30 Oct	30 Oct
St George	30 Nov	15 Nov	15 Nov
Border Rivers	30 Nov	15 Nov	30 Oct
Gwydir Valley	15 Nov	15 Nov	15 Oct
Namoi Valley	15 Nov	30 Oct	15 Oct
Macquarie Valley	15 Nov	30 Oct	30 Sep

Irrigation scheduling with limited water

By and large, the general practice when irrigating with limited water is to adhere to the optimised irrigation strategy for your region using the suggested level of supply. This will mean a reduction in the irrigated crop area. A generalised approach is outlined in WATERpak Chapter 3.1.

Establishing on rain moisture is preferable. However, if that is not an option then watering-up is preferred to pre-irrigation, as less water is lost from the system in establishing the crop. After pre-irrigation, the soil profile must be allowed to dry down to allow for trafficking by tractors and other implements, and this water is a loss from the system. Watering up allows for the seed to be placed much more shallowly and the crop can establish much more quickly. However, the general management difficulties associated with watering-up need to be borne in mind.

Don't risk stretching the irrigation interval beyond the target deficit. While this may pay off in some seasons, it is better to skip the last irrigation to allow maximum chance of catching rainfall or increased allocation before locking in to a reduced yield potential.

With very severe shortages there may be some advantage in delaying first irrigation a little. This is preferable to risking stressing the crop during flowering, when the crop is more sensitive (see Table 3.3.4. and WATERpak Chapters 2.1 and 3.1)

Some Irrigation Scenarios

The following scenarios are based on grower experience and their success in individual situations and will be influenced by environmental conditions, including in-crop rainfall and the chosen row configuration.

- **One irrigation available.** Delay irrigating for long as possible into flowering without letting the crop go into serious stress or fully cut out. This may be at 4 to 5 nodes above white flower (NAWF). This will limit yield potential should further irrigation water become available later on but will give the best opportunity for good fibre quality on the fruit that is set. If planting rainfall is not forthcoming, this one irrigation at planting will establish the crop, and the crop can be managed as if it was dryland from this point onwards.
- **Two irrigations available.** Target the first irrigation early in the flowering period and the second at around cut-out to provide adequate moisture to mature the set fruit. Close plant monitoring around this second irrigation is essential as growth regulator may be required to prevent re-growth and target resources into filling bolls.
- **Three irrigations available.** Use a similar approach to two irrigations, although the extra irrigation can be applied following the first irrigation, with the aim to extend the flowering period and prevent early cut-out. The third irrigation can then be applied at cut-out. The aim of the third irrigation is to help add size to later bolls.

In any of these scenarios, if the crop is looking good enough, a decision to purchase more water can be made.

Soil Moisture monitoring

As with fully irrigated crops, soil moisture monitoring is invaluable for irrigation management in limited water situations. As is normally the case, probes should be located in the predominant soil type of the field. Some guidance is provided in WATERpak Chapter 2.7.

In addition, it is advantageous to have moisture probes positioned in both the skip row as well as the plant line. This will give an accurate measure of crop water extraction when the plant is growing well and help predict when skip row moisture will run out. Probes can be double checked with a spade or moisture spear to determine whether roots are getting across into skip rows. Finally, calibrated probes can deliver actual daily water use, which is invaluable for determining correct irrigation date.

Plant Monitoring

Plant monitoring is essential to track the progress of the crop throughout the season. In limited water situations, timing of irrigations should take into account both the soil water and plant stress. Plant vigour can be measured using squaring nodes (before flowering), Nodes Above White Flower (NAWF) (during flowering) and Vegetative Growth Rate and fruit numbers throughout the season. This information can be benchmarked against 'ideal' crop growth using the Cotton CRC Crop Development Tool.

Case Studies

A number of trials have been undertaken to evaluate the impact of different watering treatments on yield and fibre quality and the water use efficiency of skip row treatments. As can be seen below, the results from these trials are not always consistent, highlighting the variability in growing cotton in this way. Results are particularly reliant on the volume and timing of in crop rainfall.

Row configuration case study: Irrigation trial – "Redbank" Gwydir Valley, 2010/11.

This trial compared three row configurations (solid, single and double skip) with 3 watering regimes superimposed (Full - 8 irrigations; Semi- 3 irrigations; Limited - 1 irrigation).

The trial was established on rain moisture and all treatments apart from the fully irrigated solid plant had irrigation scheduling determined by moisture probes and nodes above white flower (NAWF). The semi-irrigated regime had three irrigations timed at 7, 5-6 and 4 NAWF whilst the limited irrigation regime had one irrigation timed at 4 NAWF. Evapotranspiration was calculated using percentage ground cover to determine appropriate crop coefficients (see WATERpak Chapter 2.1) although this method does not account well for the level of stress that limited water crops may be experiencing.

Table 3.3.6. Yield and Water Use in Redbank, Limited Water Experiment 2010-11

Irrigation regime	Full	Semi	Limited	Semi	Limited	Semi	Limited
Row configuration	**Solid**	**Solid**	**Solid**	**Single**	**Single**	**Double**	**Double**
Yield (b/ha)	12.54	7.08	6.67	8.65	6.26	6.81	5.09
No. Irrigations	8	3	1	3	1	3	1
Irrigation Applied (ML/ha)	4.15	3.20	1.43	2.64	1.11	2.28	0.89
Effective Rainfall (ML/ha)	2.28	1.87	1.94	1.61	1.69	1.53	1.60
Starting Soil Water (ML/ha)	2.20	2.20	2.20	2.20	2.20	2.20	2.20
Ending Soil Water (ML/ha)	1.15	0.56	0.00	0.57	0.11	0.61	0.11
Total Water (ML/ha)	7.48	6.71	5.57	5.88	4.89	5.39	4.58
Estimated Evapotranspiration (mm)	735	687	582	732	639	752	679
IWUI (Bales/ML)	3.02	2.21	4.66	3.28	5.65	2.99	5.72
GPWUI (bales/ML)	1.68	1.06	1.2	1.47	1.28	1.26	1.11

By the end of December the skip row treatments had started to extract water from both the plant line and the skip, effectively giving the skip-row treatments access to more water than the solid treatments from that point on. By the end of the season, the semi and fully irrigated solid treatments were extracting moisture down to 100 cm, the limited solid treatment down to 120 cm, the single and double-skip semi irrigated treatments were extracting to 120 cm in the plant line and 100 cm in the skip. The single and double-skip limited irrigation treatments were extracting water from 120 cm in both the plant line and the skip by the end of the season.

Accounting for the skip proved to be a challenge in calculating plant available soil water. Water use is difficult to calculate in real time in skip row systems and requires the development of new tools or technologies to accurately determine water use and root exploration.

Estimating crop evapotranspiration (ET_C) using a calibrated crop coefficient based on canopy cover worked very well in the solid, fully irrigated and the semi-irrigated treatments, but this approach over-estimated water use in the limited irrigations and skip row treatments because it does not account for declines in crop water use due to plant stress and tended to overestimate the amount of water in the skip-rows.

Yields were highest in the solid, fully irrigated treatment, followed by the single-skip, semi irrigated treatment and the solid, semi irrigated treatment (Table 3.3.6.). However, water use was higher in the fully irrigated and semi irrigated solid plant treatments than in the single-skip semi-irrigated treatment.

Yield was much lower in the double skip scenarios, with the semi-irrigated double skip configuration yielding similarly to the limited solid plant configuration, even though more irrigation water was applied.

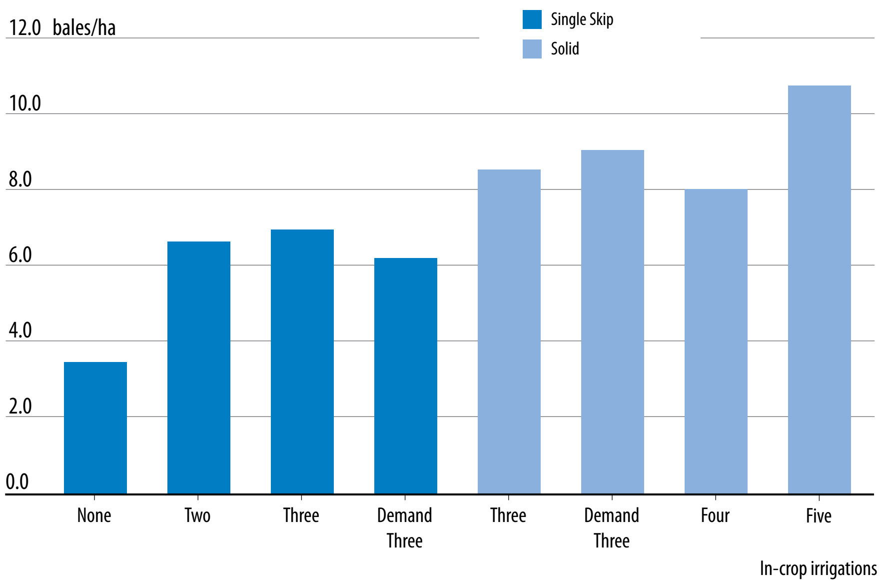
The results of this particular trial suggest that the single-skip semi irrigated treatment provided reasonable yields with high water use efficiency, suggesting that it may have potential in a limited water situation. The efficiency gain in the single-skip irrigated treatment indicates that it may have potential in a limited water situation, but more research is needed to develop irrigation strategies for limited water situations, across a range of environments to understand the consequences of the timing and amount of irrigation applied on plant stress, yield and quality.

Row configuration case study: Irrigation trial - Auscott Namoi Valley, 2002/03.

In this trial, a combination of eight different irrigation and row configuration treatments were tested. All treatments received a pre-irrigation and a flushing but then received none, 2, 3, 4 or 5 in-crop irrigations with two additional 'on-demand' treatments. Four of the eight treatments were grown in a 2:1 pattern or single skip row configuration.

The yields achieved ranged from 3.4 to 10.5 bales/ha with higher yields achieved with more irrigations and water applied. The exceptions were the skip on demand with 3 irrigations and solid plant with 4 irrigations, which were waterlogged during a rain event following the first crop irrigation. Subsequently the solid plant treatments achieved higher Irrigation Water Use Indices (bales/ ML applied) than the skip plant treatments, which improved with higher numbers of irrigation events.

Figure 3.3.2. Single skip and solid plant yield under a range of irrigation scenarios



The skip irrigation treatments followed a negative IWUI trend with increased application volumes. In other words, the yield gains were not big enough to increase the IWUI. The trial results from this year lead to the conclusion that the cotton area in a year with limited water supply should be limited to allow for a full irrigation program.

Limited water case study: Defoliation under drought conditions, Darling Farms, 2002-03

On Darling Farms, between 3 and 6 irrigations were applied to upland cotton, with the majority of the farm receiving 4. Fields had their last irrigation applied as early as the 9th January and as late as the 14 February, where traditionally this is applied in the last week of February. The management approach taken was to irrigate as required, rather than stretching the 1st irrigation. Most plants remained relatively green and retained most of the fruit provided they had 3 or more irrigation's. Based on advice from dryland cotton consultants and early trial work at Dirranbandi, defoliation was approached as normal.

Maturity was determined by the cut boll method on the last harvestable boll. Many of the very top fruit were spongy and would crack open if pressed long before the seed was mature. As a result, defoliation dates were only slightly earlier than if the crop had received full water. Given that some crops were dried down (last irrigation to defoliation) for 45 –50 days, boll maturity was found to move up the plant at a slightly slower rate than normal. Generally 3 days per node is required, however under these circumstances 4 – 5 days per node was found.

The defoliation program was:

- **1st Application.** 80 – 100ml Dropp® liquid applied 3 days before the designated top boll was mature.
- **2nd Application.** 1 – 1.5L of Ethephon® applied either alone or with 20ml of Dropp® liquid if significant green leaf remained on the plant. The 2nd application occurred when enough leaf shed exposed bolls, generally 7 days later.

Opening the very top fruit on water stressed plants depends on the size of the discount on fibre quality versus extra yield obtained from picking this fruit. It was felt that in all cases it was worth chasing the extra yield and the chance of quality discounts.

Table 3.3.7. below shows the effect of each irrigation on fibre length and micronaire. The assumption has been made that limiting water would affect length and micronaire but not necessarily colour or leaf / trash content. A Dunavant P& D 2002 crop sheet was used to calculate discounts using a grade 31, leaf 1 for all calculations, with only length and micronaire varying. Although this is not the actual premium or discount we received it does highlight the effect of limiting water on fibre quality. Table 2 details the different response between varieties to fibre quality to limited water situations.

It was noted that limiting water appeared to affect only fibre length. The timing of moisture stress relative to the development of the boll load is important here, in addition to the canopy size and boll load. With reduced le-ngth comes a lower requirement for carbohydrate required to thicken the fibre. This limited dataset shows that some varieties, such as 189/289i and S80, produce less short fibre than other varieties given 3 or 4 irrigations. It highlights that the cotton plant is a remarkably robust plant and fruit continued to develop and mature relatively similar to normal even under extremely stressful conditions.

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Table 3.3.7. Comparison of multiple simulation results from Narrabri and Emerald

Multiple scenario comparison – end of season status
Farm: Big Bolls – Narrabri

Field: Field 1, Crop: 2003-04 plant

Variety: SICOT189, sown 01.10.03

Scenario	Run date	Final irrigation	Total irrigation	Pre-run pumped (ML)	Post-run pumped (ML)	Water pumped (ML)	Water left (ML)	Total rain (mm)	60% open	Total bolls (/m²)	Yield (bales/ha)	Irrigation water use index (bales/ML/ha)
3 ML/ha	01.10.03	20.12.03	2	0.0	2.7	2.7	0.3	353	21.02.04	82	4.6	1.7
5 ML/ha	01.10.03	24.01.04	4	0.0	5.2	5.2	-0.2	375	03.03.04	106	7.2	1.38
7 ML/ha	01.10.03	29.01.04	4	0.0	2.8	5.8	1.2	388	12.03.04	119	8.9	1.53
3 scenarios					**4.5**	**4.5**	**0.4**			**102.3**	**6.90**	**1.54**

Multiple scenario comparison – end of season status
Farm: Emerald

Field: Field 21, Crop: 2003-04 crop

Variety: SIOKRAV16, sown 01.10.03

Scenario	Run date	Final irrigation	Total irrigation	Pre-run pumped (ML)	Post-run pumped (ML)	Water pumped (ML)	Water left (ML)	Total rain (mm)	60% open	Total bolls (/m²)	Yield (bales/ha)	Irrigation water use index (bales/ML/ha)
3 ML/ha	01.10.03	19.12.03	2	0.0	3.0	3.0	0.0	303	30.01.04	82	5.70	1.90
5 ML/ha	01.10.03	06.01.04	3	0.0	4.8	4.8	0.2	322	06.02.04	94	7.20	1.50
7 ML/ha	01.10.03	06.01.04	3	0.0	4.8	4.8	2.2	324	18.02.04	97	7.50	1.56
3 scenarios					**4.2**	**4.2**	**0.8**			**91.0**	**6.80**	**1.65**

Further Reading

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