Crop water use

By **LANCE PENDERGAST**

Water is a production tool just like any other management input. Regardless of how growers manage their water or how much water is available the goal is to optimise water use efficiency (WUE). When the volume of available water is limited, improving water use efficiency involves a whole farm water management plan.

The first step is to have a water budget. Water budgets consist of components such as crop/plant requirements, and potential water sources. Budgeting requires knowledge of all water sources; fallow rainfall and fallow efficiency, reliable in-crop rainfall, irrigation allocation and reticulated water. Water losses, such as by deep drainage and leaching in-field and through evaporation and seepage from on-farm storages and channels, should be also considered.

In the planning process, decisions about cropping and what area to sow can be made seasonally, dependent on expected water availability. Tools such as CropWaterUse – a web based application, is available to help growers calculate the theoretical daily and seasonal water use of a crop. (http://cropwateruse.dpi.qld.gov.au)

The overall production target must suit the type of irrigation system and the available water resource.

A successful philosophy to follow from the start is 'measure to manage'. The use of both water meters and soil moisture probes enables the fine tuning of management strategies that can lead to improved efficiencies.

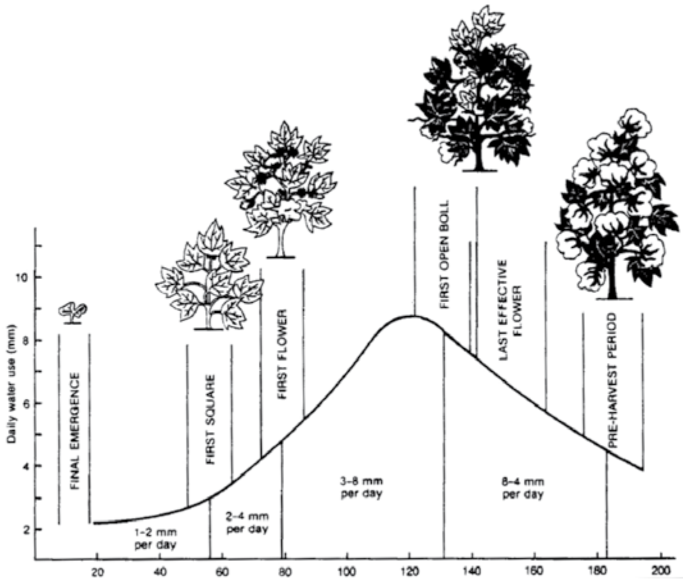
Dryland growers can use HowWet?, a Windows based program which uses farm rainfall records to estimate how much plant available water has been stored in the soil and the amount of organic nitrogen that has been converted to an available form during a fallow (non-crop period). HowWet? tracks daily evaporation, runoff and soil moisture using estimates of weather conditions and rainfall input by the user. Accumulation of available nitrogen in the soil is calculated based on soil moisture, temperature, soil type and age of cultivation.

http://www.apsru.gov.au/apsru/Products/HowWet/how%20wet.htm

BE AWARE OF

- Measure to manage.
- The first irrigation is a balancing act between not stressing the plant while stored water is fully explored by the developing root system.
- For further support in all aspects of crop water use refer to the Water Management module in *my*BMP.
- Poor quality irrigation water causes reductions in cotton growth and degrades soil.
- Exposure to waterlogging, particularly at early stages of flowering, can significantly impact on yield.
- The prime objective of the last irrigation is to ensure that boll maturity is completed without water stress.
- Deep drainage reduces WUE.

FIGURE 1.
The changing scale of water use by the cotton plant as it moves into each stage of growth



Influence of row spacing on crop water use

For many years dryland growers have employed a variety of skip row configurations to successfully produce cotton. Choice of the appropriate configuration is largely dependant on the soil moisture available at planting, the timing and volume of anticipated in-crop rainfall, the machinery available, and both the options for risk management and the level of risk deemed acceptable by the individual grower.

Research trials have demonstrated that row spacing has a larger effect on yield and quality than number of plants per m of row. There is little or no yield reduction between 5 and 13 plants per metre. Gaps in plant stands should be avoided as they contribute to the production of large plants that are difficult to pick.

Irrigation scheduling with limited water

More recently, in the face of reduced water allocations that preclude normal (full) irrigation practises, irrigators have also employed skip row strategies into their production systems. As with dryland production, the number and timing of irrigations in skip row planted cotton will vary with location, soil type, previous history, and weather conditions, with the interval between irrigations increased with skip row plantings. Ideally the irrigation deficit used should be the same as for normal planting configuration.

For more information on row spacing refer to Chapter 7b 'Row configurations' of this publication and the following references:

'Row configuration' (WATERpak pg 145)

http://www.cottoncrc.org.au/content/Industry/Publications/Water/WATERpak.aspx

'Getting the most out of skip row irrigated cotton' (Cotton Seed Distributors Pty Ltd, 2009
http://www.csd.net.au/asset/send/2221/download/original/Getting%20the%20most%20out%20of%20skip%20row%20irrigated%20cotton.pdf

Water quality

"Crop production can decline if the salts in irrigation water exceed certain levels."

Poor quality irrigation water is enriched with salts and nutrients, and consequently its long-term use can cause soil degradation and reductions in cotton growth. These consequences can be minimised or avoided by vigilant crop and soil management, but this does involve additional costs (see pg 257 WATERpak).

As the quality of surface water (and bores) often varies over time and between locations (and may affect the suitability of water for irrigation) it is important to monitor (simple and relatively inexpensive to do). Over 50% of cotton growers regularly monitor their irrigation water quality. The Water Quality tool on the Cotton CRC website can help growers make water shandying decisions to dilute impacts of poorer quality bore water. This simple web tool can be used to calculate the salinity (EC), Sodium Adsorption Ratio (SAR) and pH when water sources are mixed together to provide irrigation water.

For further information refer to

"Assessing and managing irrigation salinity: including EM surveying" (WATERpak pg 235)

http://www.cottoncrc.org.au/content/Industry/Publications/Water/WATERpak.aspx

http://CottASSIST.cottoncrc.org.au/WQC/About.aspx

Water logging

Because clay soils drain slowly, many cotton crops are subjected to some degree of waterlogging (see 'Field preparation' Chapter 7a). This problem is accentuated by rainfall after irrigation, cloudy conditions, and inadequate land preparation. Water logging may reduce crop yield by up to 1 bale/ha with yields affected before symptoms are noticed. Visual symptoms of waterlogged cotton include a general yellowing of the crop and stunted growth.

The major and immediate effect of waterlogging is a reduction in the transfer of oxygen between the roots and the soil atmosphere. Plant roots may become so oxygen deficient that they cannot respire. As a consequence, root growth and absorption of nutrients is decreased leading to less overall plant growth. A reduction in node numbers leads to a reduction in the number of fruiting sites and consequently a reduction in the number of bolls produced.

Cotton is most susceptible to waterlogging during the early stages of flowering as this is when the plant is setting the fruit load that will dictate final yield. As the plant gets older there will still be effects but they won't be as severe because the fruit is basically established on the plant.

Plants exposed to rainfall induced waterlogging may also suffer from the reduced sunlight availability associated with overcast conditions. Under these conditions the plant cannot fix enough carbon to maintain normal functions and may shed fruit as occurs under any other form of stress.

In addition to the immediate physiological impacts of waterlogging on the crop, there are also significant impacts on nutrient availability and uptake. Waterlogging increases the rate of denitrification and plant uptake of Nitrogen (N), Iron (Fe), Zinc (Zn) (reduced) and Manganese (Mn) (increased) are directly affected by a decline in soil oxygen. Irrigation strategies designed to avoid potential waterlogging events not only contribute towards improved yield and water use efficiencies but can also benefit crop nutrient efficiencies.

Waterlogging also tends to decrease the plants ability to regulate sodium uptake and, although cotton is reasonably tolerant of salinity, exposure to increased concentrations does impinge on yield potential.

Optimised irrigation system designs allow delivery to the head-ditch, run-times and tailwater collection/return such that exposure to waterlogging and deep drainage are minimised.

Pre irrigation

The decision for the cotton grower to pre-irrigate or water up the crop is, like so many others, a decision that has to be made specifically to suit a particular farm. In certain situations it can be beneficial to combine the two options: pre-irrigate to plant into moisture and give the crop a quick watering to ensure good plant stands" (WATERpak pg 91)

Every farm is different and a range of questions need to be considered before making a decision e.g. is it likely to rain before/during/after planting?, what are the implications associated with the different tactics in relation to seedling disease and weed control, am I set up for dry or moisture planting?

WATERpak provides a useful table outlining the pros and cons of pre irrigation (See Table 2. 10.2. Advantages and disadvantages of different options for the first irrigation) http://www.cottoncrc.org.au/content/Industry/Publications/Water/WATERpak.aspx

Scheduling in-crop irrigations

Irrigation scheduling is the decision of when and how much water to apply to an irrigated crop to maximise crop productivity. Good scheduling should provide plants with water that is within a desired range and should limit over or under irrigation so that balanced growth is achieved. For BollgardII varieties insufficient available water prior to and during flowering will reduce plant size and lead to early cut-out while too much water can lead to rank growth or waterlogging.

The first irrigation plays an important role in setting up for plant growth, fruit retention, fibre quality and boll weight. Its timing is perhaps the most difficult irrigation scheduling decision as it is a balancing act between not stressing the plant while stored water is fully explored by the developing root system.

The demands of high fruit retentions afforded by Bollgard II® cotton, in conjunction with tight water scenarios which growers and consultants have been faced with for the past few seasons, has seen the timing of first irrigation become a key management issue.

Irrigating too early can increase potential for exposure to waterlogging. Irrigating too late will incur yield penalties due to the impact of stress on plant development. Like many crops cotton has stages of development at which it is particularly sensitive to stress. Irrigation scheduling should strive to avoid exposure to stress during flowering and early boll filling stages. Research by Steve

Yeates and Dirk Richards, CSIRO, in both BollgardII® and conventional cotton, has shown similar losses in yield attributed to being late on the first irrigation. Delaying the 1st irrigation will place the plant under stress which will impact on the performance of the crop. Results have shown a dramatic reduction in yield (up to 23%) due to stress in the lead up to flowering. Recent research by Marcelo Paytas and Steve Yeates has shown for BollgardII crops that when conditions are hot and dry irrigation up to 2 weeks prior to flowering on clay soils will increase yield provided there is no water stress after flowering.

It is important to tailor your irrigations to meet the needs of high retention crops to optimise yield and water use efficiency. High boll load early in flowering can lead to premature cut-out and lower yields.

Subsequent irrigation scheduling

One of the most important things besides monitoring your soil moisture is monitoring crop development. Keep a check on squaring nodes, first position retention and NAWF. Use the Crop Development Tool on the CRC website (www.cotton.crc.org.au) to help keep track of how the crop is progressing.

Research by Yeates has shown that low deficit scheduling or frequent watering eg 40 to 50mm deficit or 6 to 7 day intervals (Wee Waa clays) increased Bollgard II® yield by 17% and WUE by 8% when conditions were hot and dry during flowering. Trials showed where mild growing conditions were experienced, generally associated with higher in-crop rainfall and less evaporative demand, scheduling irrigations to a greater deficit maximised yield and WUE, by allowing the opportunity to capture more in-crop rainfall rather than irrigating at a 40mm deficit. Irrigation scheduling based on small deficits requires skill and a system that can apply water quickly. Otherwise application efficiencies will be lower and the crop waterlogged.

When irrigation water is limited, save water for the flowering period. Bollgard II® crops with high fruit retention are most susceptible to water stress late in flowering and at cut-out. Yeates and Richards have measured a yield decline of 2.7% per day of stress compared with 1.2% per day for conventional cotton at this stage of growth.

Scheduling – final irrigation

Ideally the last irrigation will provide sufficient water to optimise final yield and fibre quality, adequate soil moisture to facilitate efficient take-up and function of applied defoliant, and a soil profile that is sufficiently dry enough to enable harvest without causing soil compaction.

End of season water requirements can be estimated from the date of the last effective flower ('cut-out'). Although location specific it takes about 50 days from cut out to maturity. Given reduced daily water use late in growth and a full profile, a crop should be able to rely on stored soil water for up to 30 days, on most clay soils depending on the rate of evapotranspiration experienced . Hence irrigation water is required for the first 20–25 days after last effective flower – possibly two irrigations would be required during this time. The last harvestable bolls take 600 to 650 day degrees to reach maturity. Crop water use during this period will vary, at the time of first open boll, water use may be 5–7mm/day, and may decline to around 3–4mm/day prior to defoliation.

There are a number of methods available to accurately time final irrigation and defoliation: Measuring Nodes Above (last) Cracked Boll (NACB), is most commonly used www.cottoncrc.org.au/files/0f2a74ed.../Fp11_Open_Boll_to_Harvest.pdf. On average, bolls will sequentially open at a rate of a node every three days. This will depend on a number of factors, particularly climatic conditions.

"The prime objection of the last irrigation is to ensure that boll maturity is completed without water stress" (WATERpak pg 93). Once a boll is 10–14 days old, the abscission layer responsible for boll-shed cannot form. Consequently late water stress (beyond cut out) does not significantly reduce boll numbers and therefore yield. However, fibre quality can be more seriously affected by late water stress. Crops that come under stress prior to defoliation (60% bolls open or 4 boll carrying NACB), can suffer some fibre quality reduction, especially micronaire. The degree of reduction obviously increases the earlier the stress occurs.

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For more Information: http://www.cottoncrc.org.au/content/Industry/Publications/Water/WATERpak.aspx