Australian Cotton
Cooperative Research Centre

COTTON information sheet

Irrigation Scheduling of Cotton

June 2002

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Either too much or too little water can cost you yield. Poor irrigation scheduling can reduce yield potential by as much as 10-20%. A basic strategy is: pre-irrigate or water up, don't stress the plant before the first irrigation, stick to target deficit and aim to dry the soil down to the refill point by 60% bolls open.

Irrigating cotton requires balancing excessive vegetative growth due to abundant water supply against limited yield potential due to water restriction. In addition, there is the need to minimise the risk of waterlogging from rainfall after an irrigation application, and maximise the opportunity to use rainfall productively.

Response to Water Stress

To understand the issues involved in managing irrigation supply to cotton, it is useful to know a little about its responses to moisture. We will consider these briefly from high moisture supply to low supply.

Waterlogging is one extreme. Too much water results in depleted soil oxygen and thus lowers root activity and subsequently impacts the whole plant. It reduces nitrogen uptake by the plant, affects the metabolism of a range of other nutrients, reduces leaf area production and reduces the rate of photosynthesis. As a result the growth and yield potential are also reduced.

With water in abundant supply the plant is under minimal stress, but agronomically this is not optimum. Excessive leaf production can occur causing management difficulties such as poor spray penetration and possibly difficulties with defoliation. Altered light conditions lower in the canopy or poor spray penetration, lead to reduced fruit retention on lower branches. Additionally, the larger canopy will increase water demand.

Drought stress reduces the rate of a wide range of plant functions. In descending order of sensitivity, some of these are: leaf expansion, organ production (both leaves and fruiting sites), fibre length, photosynthesis, boll retention, fibre thickening and root growth and function. The aim is to be operating with a small amount of water stress to keep leafiness under control but not to impinge on any other processes.

Growth Stage	Yield loss (kg/ha/d)
Squaring	9
Peak flowering	19
Late flowering	16
Boll maturation	4

Table 1. The impact of one day's water stress varies with growth stage. Note that these effects are not simply additive. (e.g. One day's stress at peak flower plus one day at late flower is not simply 19+16=35).

The overall strategy is to produce a large and productive plant without excessive vegetative growth and without risking waterlogging or wasting water.

Changes with Growth Stage

As the crop develops, the water supply/demand situation varies. At each stage there is a balance to be achieved. Prior to flowering, the yield potential is being established but water demands are generally low. However, so too is the extent of root development. During early flowering, the yield potential is still being set but the crop water demand is increasing (and so is the soil volume being accessed). The plants are very sensitive to stress. By late flowering the plant structure has been established and the maximum soil volume has been accessed. The crop is still sensitive to stress, however a little stress may benefit

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by reducing excessive leafiness and improving partitioning to bolls. During boll maturation, water limitation may affect fibre quality but excess water can keep leaves lush making defoliation more difficult. The soil should be dry by harvest.

An Optimised Strategy

The optimum irrigation strategy for cotton has been well studied in Australia. It is important to realise though, that the optimum is not going to be best in every year. It is the best strategy across years. This is valuable, since we don't know what the coming season's weather will do. There are basically four decisions:

1 **Watering at sowing:** Pre-irrigate or water.-up The choice will largely depend on other management considerations but only sow without irrigation if you are sure of the soil moisture status.

2 **First irrigation:** Don't let the crop stress prior to watering but withhold water as long as possible to encourage it to explore the soil profile. Watch the crop for stress. If leaves aren't cool to touch, if the internode length is short or there are any other sign of water stress, water immediately. For many cotton-growing soils, there shouldn't be a need to water earlier than half way between squaring and flowering. Irrigation will need to be earlier on lighter soils or soil with root penetration problems, such as occurs with soil compaction.

3 **Irrigation interval:** Once in-crop watering has started, stick to the target soil moisture deficit.

Don't try to save water by stretching the interval. You will save water but will also lose yield.

4 **Final irrigation:** Aim to deplete the soil to the target deficit at 60% open. This means that the timing of the last irrigation will depend on soil type and the rate at which the crop is using water. On heavy soils in southern Queensland and northern NSW, a useful approximation is to stop irrigation at approximately 20% open bolls or in the middle of March, which ever occurs first.

What is My Target Deficit?

As a rule, the best deficit to aim for is approximately 50% of the plant available water-holding capacity (PAWC). This is conservative for heavy clays and at times it may be possible to dry them to a 60% deficit without penalty. On light soils or under conditions of high evaporative demand (very hot and dry conditions or hot winds) the deficit as percentage of PAWC needs to be reduced because the stress occurs more rapidly and the crop can't adjust its growth and metabolism quickly enough.

The PAWC is the amount of water held between the drained upper limit and the lower limit of plant extraction. This can be derived by taking the highest soil moisture reading (2 or 3 days after an irrigation) and subtracting the lowest moisture measured just before defoliation or harvest. It is a good idea to revise these as more seasons of soil moisture data are collected.

For example with a PAWC of 200mm, the refill point would be 100mm. If the evapotranspiration is about 7-8 mm/day this equates to 12-14 days between irrigations.

SOIL TYPE	Plant Available Water Capacity (mm)
Sand	70
Sandy loam	140
Clay loam	140
Heavy clay	150
Well structured clay	200

Table 2 Some generalised estimates of plant available water capacity down to one metre.

Irrigation with Limited Water

By and large, the general practice when irrigating with limited water is to adhere to the above strategy. This may mean reducing the area of irrigated crop. Watering up becomes more attractive than pre irrigation. Don't risk stretching the irrigation interval beyond the target deficit. It is better to skip the last irrigation to allow maximum chance of catching rainfall or increased allocation before locking into a reduced yield potential. With very severe shortages there may be some advantage in delaying first irrigation a little. There are many other management options that can be explored at the farm scale to deal with water limitation. One important one is to decide what area of crop to plant and how much of it to irrigate.

Some Useful Tools

Water balance calculators such as Watersched (Queensland DPI) can be used for any crop species, provided appropriate crop coefficients are available. These calculators allow you to keep track of water use and predict when you are likely to reach your refill point a few days ahead. HydroLOGIC (CSIRO Plant Industry) is a scheduling tool specifically for cotton. At the time of writing it is currently under re-development. It allows irrigation management decisions to be explored for their likely impact on yield. These tools are best used in conjunction with actual soil moisture measurements, such as with a neutron moisture meter or similar.

TRC 21 03/02

Design, Layout : Technology Resource Centre of the
Australian Cotton Cooperative Research Centre
June 2002