

## Optimising irrigation practices reduce stress and waterlogging of dry season cotton in the Ord.

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### Introduction

An understanding of likely impact of water stresses on yield and quality is important for developing optimum irrigation practices for cotton in the region. Irrigating a crop for 12 h to 24 h depending upon the bed length (between 200 m and 500 m) is a common practice in the valley (Wood et al., 1998). This practice of extended duration of irrigation is commonly associated with shallow rooted crops on 1.8 m wide beds. This might contribute to water logging stress in this cracking clay soil as Hearn and Constable (1984) and Hodgson and Chan (1982) reported inadequate soil aeration for cotton in a clay soil after furrow irrigation. Furthermore, a rapid onset of water deficit stress, particularly in the top 30 cm soil profile which dries out within 5 to 10 days of watering has also been observed due to a hot and dry conditions in the Ord (Muchow and Keating, 1998).

The aim of this study was to compare the relative magnitude of water logging and water deficit stresses on plant water status and yield between wide and ridge beds for a range of irrigation management systems. Gravimetric and volumetric soil water contents and air-filled porosity were measured to a depth of 1.2 m, before and 48 h after irrigation.

### Materials and Methods

**Experimental design and treatments:** A split-split plot design was used with factorial combination and three replications of the following treatments: (1) Irrigation interval at 7, 14 and 28 d, as the main plot; (2) Duration of watering for 6, 9 and 12 h, as the sub-plot; and (3) Bed system, wide and ridge beds, as the sub-sub-plot. A set of 2 wide beds (each 1.8 m wide between adjacent furrows) or 4 ridge beds (0.9 m wide between adjacent furrows) was used for each irrigation interval by duration combination. The length of beds was 175 m.

**Variety and growing conditions:** Siokra L-23i was used with a planting density of around 12.5 plants per linear metre. Row spacing on the wide bed system was 90 cm. Fertilisation was completed two weeks before planting with nitrogen @ 100 kg N/ha as urea, phosphorus @ 100 kg P/ha as DAP, potassium @ 100 kg K/ha as Muriate of Potash, ZnSO<sub>4</sub> @ 20 kg/ha and Sulphur @ 10 kg/ha. All fertilisers were mixed together and split at two depths, 15 cm and 30 cm below the plant line. This fertiliser placement was intended to match root distribution and enhance nutrient uptake.

**Measurements:** The soil water content to a depth of 1.2 m was determined with neutron moisture metre (NMM). Gravimetric water content (GWC) and bulk density (BD) of top 30 cm soil profile was determined with a soil corer. Soil sampling and water measurements were undertaken one or two

day prior, and 48 h after irrigation at two occasions, one at the start of flowering during early July, and other at the time of peak boll load in mid September 1999. Daily crop evapotranspiration was estimated from the NMM readings. Air filled porosity was calculated from GWC and BD. Plant measurements included plant water status by measuring leaf water potential (LWP) and seed cotton yield.

## Results and Discussion

**Climatic conditions:** The 1999 dry season at Kununurra had lower minimum temperatures and evaporation when compared with long term averages (Table 1). This was particularly the case in July and those conditions would influence irrigation schedules.

**Table 1. Growing conditions at Kununurra in 1999 compared with long term averages.**

Growing conditions	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov
<u>Mean Max. Temperature (°C)</u>								
Long Term	35.2	33.0	30.5	30.3	33.0	36.1	38.3	38.8
1999	34.3	33.1	31.2	30.3	33.4	36.6	37.2	37.2
<u>Mean Min. Temperature (°C)</u>								
Long Term	20.8	18.3	15.5	14.4	16.0	19.6	22.8	24.7
1999	21.8	14.4	15.0	12.4	15.3	18.8	23.9	24.0
<u>Pan Evaporation (mm/day)</u>								
Long Term	7.2	6.7	6.5	7.3	8.6	9.9	10.4	9.8
1999	6.5	5.8	5.8	5.6	6.7	7.3	7.6	6.7

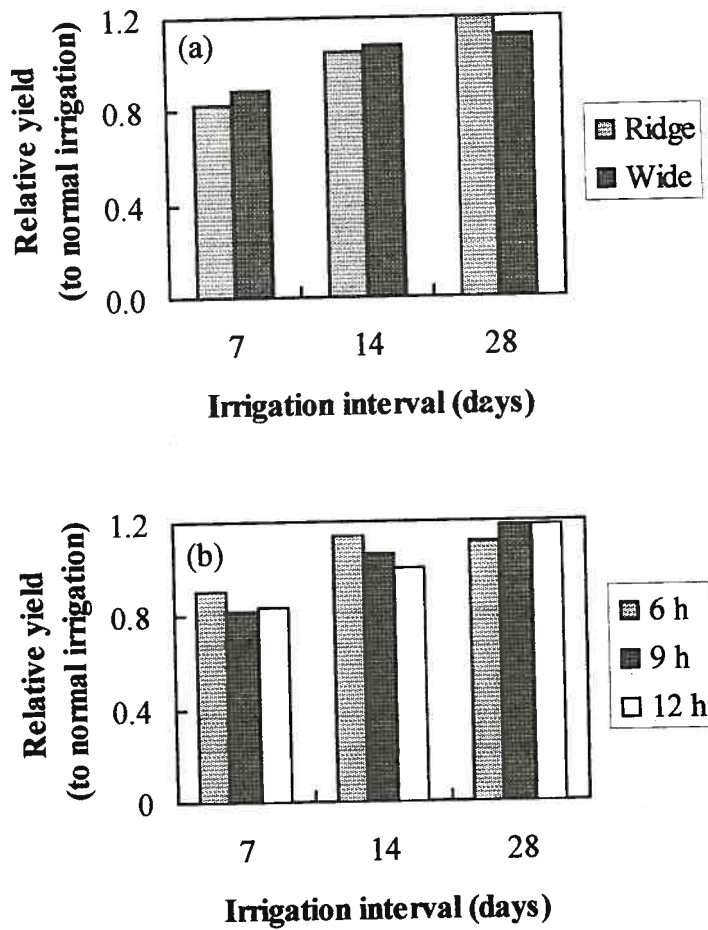
**Yield:** Increasing the irrigation interval from 7 to 28 days improved yield by 29% (Figure 1). Neither duration of irrigation or bed configuration had a direct effect on yield, but there were interactions:

There was a 15% increase in yield when extending the irrigation interval from 14 to 28 days on ridges, but only 3% increase for that comparison on wide beds (Figure 1a).

For best yield, a longer duration of irrigation (9h) was required for a 28 day irrigation frequency; a shorter duration (6h) was required for a 7 day frequency (Figure 1b). This difference would be expected as a longer duration would be required at each of the infrequent irrigations to refill the soil profile.

The best yielding treatment was 28 day irrigation frequency with 9h duration on ridges. This combination yielded 21% more than the standard practice of 14 day frequency, 12 hour duration on wide beds.

Figure 1. Effect of irrigation practices on yield; (a) interaction between irrigation interval and bed shape; (b) interaction between irrigation interval and duration.



**Soil and plant water status:** Plant water use in July and September was about 65% of pan evaporation (Table 2) and it was only the September measuring date which showed a reduction in evaporation with extended irrigation intervals. Leaf water potential for 28 day irrigation was only -2.1 Mpa, below the level of severe stress.

**Table 2. Evapotranspiration (mm/day) and soil and plant water status as influenced by irrigation frequency.**

Irrigation interval(days)	Evapotranspiration, Et (mm/day)		Soil and plant water in September	
	July	September	GWC (g/g)	LWP (MPa)
7	3.6	5.0	0.25	-1.36
14	3.5	5.0	0.18	-1.76
28	3.3	4.4	0.15	-2.09

Frequently irrigated treatments had reduced air filled porosity and were especially low for the 30-60 cm layer for most of the irrigation cycle (Table 3). Other experiments have shown an airfilled porosity less than 0.10 represents a waterlogged situation.

**Table 3. Air-filled porosity before and 48 h after irrigation in July for two depths**

Irrigation interval (days)	0 – 30 cm		30 – 60 cm	
	before	after	before	after
7	0.23	0.21	0.09	0.08
14	0.29	0.19	0.12	0.09
28	0.43	0.19	0.17	0.08

If it is assumed two days of waterlogging occur at each irrigation, there were 32 days waterlogged for the 7 day irrigation frequency treatment, 18 days for the 14 day, and 12 days for the 28 day treatment. Given the yield difference between the 7 and 14 day treatment of 249kg lint/ha, the mean loss in yield for a day of waterlogging was 18kg lint/ha, very close to previous estimates for cotton (Hearn and Constable, 1984; Hodgson and Chan, 1982). These calculations show water deficit stress which may have occurred later in the irrigation cycle for the 28 day treatment had a low impact on yield under these conditions

**Water Use Efficiency:** Compared with the standard practice of 9 irrigations as 14 day frequency and 12 h duration, the best treatment of 6 irrigations and 9h frequency would mean a considerable reduction in total labour and irrigation application time. A 28 day irrigation would apply more water one each occasion. We have insufficient data to calculate a full water budget, but it appears a greater yield has been obtained from equal or reduced water application – an apparent increase in agronomic water use efficiency.

### Conclusion

The evidence for yield penalties from waterlogging emphasises the importance of accurate irrigation scheduling to consider evaporative demand, crop growth stage, water requirements and soil

conditions. For the Ord, the cooler, shorter days during July certainly only require a long irrigation frequency to avoid waterlogging. For the hotter days in August/September a shorter frequency may be required.

Soil management practices can assist with avoiding waterlogging and encourage a deeper root system to ensure the crop is not stressed during longer irrigation intervals. Tillage practices should avoid soil compaction and fertilizer placement should recognise active root zones rather than surface layers.

### **Acknowledgement**

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### **Further reading**

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