INVESTIGATION OF IRRIGATION MANAGEMENT OF DRIP IRRIGATED COTTON SOIL TO MAXIMISE YIELD

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Abstract

A field experiment comparing irrigation treatments of 100% of predicted ETcrop applied with subsurface drip irrigation with 50%, 75% and 125% ETcrop was conducted at Warren in the 1999/2000 season.

Cotton yield of 7.8 bales/ha was greatest in the 100% treatment followed by the 75% and 125% treatments with lowest yield coming from the 50% treatment. This yield trend, combined with similar soil moisture contents in the 100% and 125% treatments indicated that the 100% treatment was supplying adequate water to satisfy crop demand.

Neutron probe readings showed that treatments receiving insufficient water to satisfy crop demand were able to extract water from part of the soil profile that was not wet by irrigation. Use of this water allowed the 50% and 75% treatments to grow at similar rates to the 100% and 125% treatments for 1 month in peak growing conditions after the soil was saturated by rain moisture in late December.

Introduction

Drip irrigation has been advocated as one way of improving both yield and water use efficiency for irrigated cotton. It has even been claimed that drip irrigation can be used to 'crop areas previously considered unsuitable for conventional irrigation methods'.... because.... 'the root zone is maintained at both optimal water and nutrient levels' (Anon, 1988). In this context drip irrigation may be considered a 'soil independent' irrigation system where the uniformity of application of water and nutrients by the irrigation system overcomes variability in soil properties.

Experience with drip irrigation has not lived up to these lofty expectations. Performance of drip irrigation system in Australian cotton has been variable. In a 4 year field trial Constable and Hodgson (1990) recorded a 4% increase in lint yield of cotton irrigated by subsurface drip compared to furrow irrigation. Reports of performance of commercial systems vary. B. Smith (pers comm.) reported a 33% yield improvement from conversion furrow irrigation of sodic clay to subsurface drip, while Hulme (1998) stated that half the area under drip irrigation in the Macquarie Valley in the 1997/98 season yielded less than the valley average. The relatively poor performance of these systems was attributed to suboptimal irrigation management based on observed cotton water deficit stress.

Australian cotton growers have claimed that drip irrigation led to significant savings in irrigation water when compared to furrow irrigation. These claims have been viewed with scepticism because different methods are used to measure water on and off furrow irrigated fields and on to drip irrigated fields. However, researchers have found that drip irrigated cotton can have high water use efficiency by making good use of stored water (Hutchmaker *et al.*, 1995).

A field experiment was established on a subsurface drip irrigated cotton field near Warren to gain insights into the historically variable performance of drip irrigation. Our aims were to:

- Determine the effect of a range of irrigation application rates on cotton growth and production.
- Validate published methodologies for estimating potential daily crop evapotranspiration (ETcrop) of cotton.

Treatments

A replicated experiment was set up at "Bellevue" Warren in a randomized complete block design with four treatments and four replicates. One treatment was irrigated with 100% of estimated plant water use for the previous day. In the remaining treatments 75%, 50% and 125% of estimated crop water use was applied. The crop water use was estimated with a weather station using the FAO Penman Monteith equation and the crop coefficients of Allen *et al.* (1998). Irrigation treatments were imposed after an initial "wetting up" of the soil in early December.

Management Summary

The drip irrigation system was laid out 2 m beds with one drip tape buried 15 cm deep beneath the centre of each bed. The system was designed to apply 1.15 mm/hr.

Sicala 40 seed was planted at 15 kg/ha on 17.10.99 and flood irrigated to wet up the seeds. A stand with average density of 7 plants/m then established two weeks later than the optimum time.

The whole experiment was managed uniformly throughout the season. It was fertilized with composted gin trash at 15 t/ha, was treated with a soil-applied insecticide at planting. The herbicide regime was Stomp applied preplant, a mixture of Stomp and Cotogard at planting, one application of Staple, and one application of Glyphosate applied with a shielded spray. It also received one post planting cultivation. The area received 5 insecticides and one application of Pix near the end of February.

The last irrigation was applied in early March. Rain during the harvest delayed the picking of the 125% treatment by 10 days.

Measurements

Soil Water Content

The soil water content was measured using a neutron probe at 64 sites. Four access tubes were placed in each treatment, two in the plant line and two within 10 cm of an emitter. The water content was measured at 5 depths (20, 30, 50, 70 and 90 cm). The readings were taken on a weekly basis prior to the daily irrigation. The Trangie combination equation (McKenzie et al. 1990) was used to determine profile water content.

Applied Water

The volume of water applied to each treatment was metered each day.

Leaf Area Index (LAI)

LAI was measured approximately weekly from mid December to mid March. Two samples of one metre were taken per plot. Each sample was weighed then the leaf area of a subset determined using a planimeter and the subset was weighed. The leaf area was then calculated by multiplying the leaf area of the subset by the ratio of the weight of the subset to the total sample weight.

Destructive Plant Sampling

Two destructive plant harvests were conducted. The first at peak flower and second at early boll opening. Two samples of one metre were harvested per plot. Samples were weighed fresh, then separated into leaves (less petiole) fruit (squares and bolls) and stems. These components were weighed fresh, dried for 48 hours at 75°C in a dehydrator then weighed dry.

Statistical Analysis

Data were subjected to analysis of variance by G. Melville. Analysis was incomplete at the time of writing this report.

Results

Crop growth

Cool conditions prevailed during November and December delaying the crop progress. Treatments were imposed in early December then a week of rain over the Christmas New Year period wet the soil in all treatments to field capacity. Warmer and drier weather prevailed in January and February resulting in differences in soil moisture and plant growth between treatments.

Yield

The 100% treatment had significantly greater yield than the 75 and 50% treatments (Figure 1). There was no significant difference between the yield of 75 and 125% treatments neither was there between the 100 and 125% treatments.

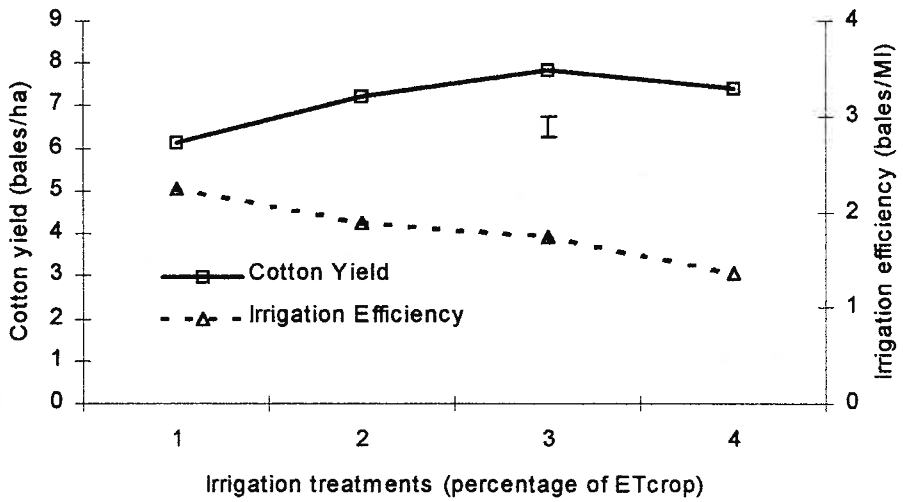

Figure 1. Cotton yield measured from picker harvested weights (assuming 38% turnout and 227 kg/bale) and irrigation efficiency. Bar is for 5% lsd for cotton yield

There was a trend for Irrigation efficiency to decline with increasing water application (Figure 1).

Leaf area index (LAI)

Leaf area appeared to increase at a similar rate for all treatments until the 5.2.00 (Figure 2). The leaf area then tended to increase at a slower rate in the 50% and 75% treatments from this date until the final sampling on 20.3.00.

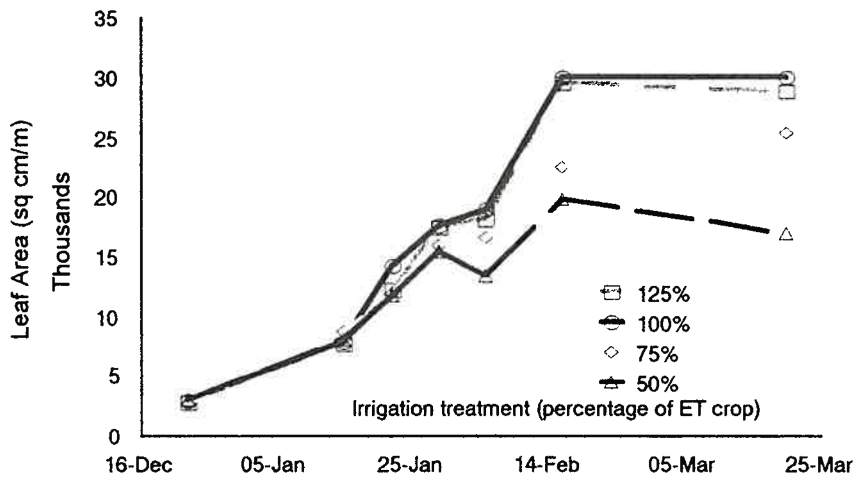

Figure 2. Effect of irrigation treatment on leaf area index.

Destructive plant sampling

The destructive sampling at peak flowering (16.2.00) showed that no significant differences in the dry weights of the individual plant components (squares, boll, stem and leaf). However, the weights of leaves, bolls and stems of the 50% treatment were significantly lower than the other treatments on 20.3.00 (Table 1). There was a consistent trend for weights of these components to be greater in the 100% treatment than both the 75% and 125% treatments.

Table 1. Dry weights of plant components on 20.3.00 (g/m). L.s.d is included for comparisons where it was calculated.

	Leaves	Bolls	Stems	Stems
50%	132	449	145	726
75%	176	580	194	950
100%	215	657	259	1131
125%	191	567	215	973
Lsd (5%)	32	117	-	-

Soil water content

The profile water contents for the 0 to 90 cm depths in the plant line were not significantly different until 8.2.00 (Figure 3). The peak at the end of December coincides with rain events over the Christmas period.

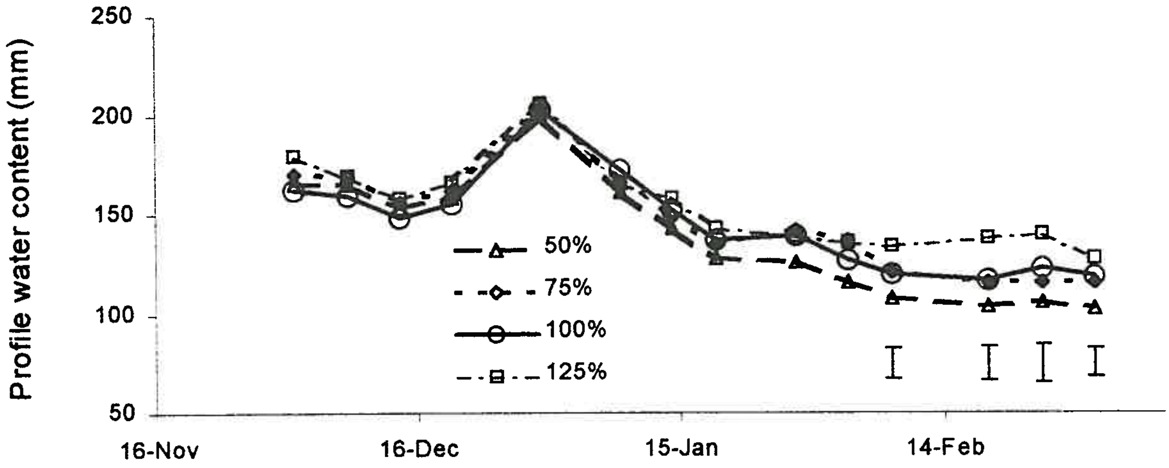

Figure 3. Volume of water stored in soil from 0-90 cm depth in the **plant line** at "Bellevue". Bars are for 5% lsd.

The profile water content next to the drip tape (Figure 4) showed that the 100% treatment remained relatively constant through the season. Profile water content in the 75 and 50% treatments declined towards the last irrigation.

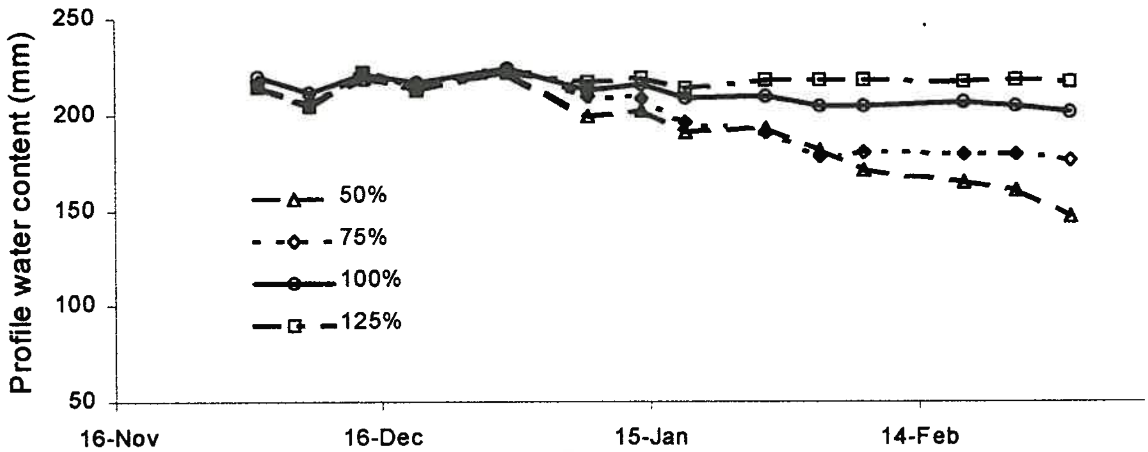

Figure 4. Volume of water stored in soil from 0-90 cm depth 10 cm from **drip tape** emitters at "Bellevue".

Applied water

The volume of water applied to each treatment was 273 mm to the 50% treatment, 382 mm to the 75% treatment, 452 mm to the 100% treatment and 545 mm to the 125% treatment.

Discussion

The yield of the trial field was 7.6 bales/ha. This compared favourably with yields from furrow irrigated areas of the farm of 6.7 bales/ha, and an estimated Macquarie Valley yield of 6.1 bales/ha (H. Woldring, pers comm.). Water use on the highest yielding treatment of 4.5 Ml/ha was less than 5.8 Ml/ha that was applied to the remainder of drip irrigated cotton on 'Bellevue' and 6.9 Ml/ha applied to furrow irrigated areas on 'Bellevue'.

The yield response (Figure 1), and measured leaf area (Figure 2) and dry weights (Table 1) showed that there was no benefit of applying more than 100% of ETcrop. This supports the findings of Hutchmaker et al. (1995). We observed that lower leaves in the 125% plants senesced to a greater degree than the other treatments indicating that shading of the lower canopy was reducing growth of these leaves.

The water contents of the 100 and 125% treatments 10 cm from the emitters (Figure 3) were similar throughout the season, indicating that the 100% treatment was receiving adequate water. In contrast, water content in the 75% treatment in the plant line declined 49 mm between 29.12.99 and 2.3.00. The profile water content in the 75% treatment remained similar for 5 readings between 3 2 00 and 2 3 00 indicating plant water uptake was in balance with irrigation water supply. Profile water content in the 50% treatment declined 76 mm between 30.12.99 and 2.3.00 indicating that water supply was insufficient to satisfy plant demand.

The soil water in the plant line acted as a reservoir and it was not until this water was used that the effects of the treatments became noticeable in the 50% and 75% treatments. Soil in the plant line dried in all 4 treatments (Figure 4), with the reduction in stored soil water ranging from 80 mm in the 125% treatment to almost 100 mm in the 50% treatment. The decline in stored soil moisture in all treatments supports the observation by Battam and Hulme (2000) that subsurface drip irrigation wets the soil only 30 cm horizontally from the tape in this soil.

Destructive harvests at early boll opening gave a good indication of the trends in the final yield however, they did not quantify treatment differences until at least 2 weeks after differences in plant growth between the treatments were visible. None of the plant measures reported here was able to differentiate between the vigour of the plants under water deficit stress until after the plants had suffered significant stress. Consequently, we need to use a more sensitive measure if we are to use plant indicators as a guide for irrigation management.

Conclusions

We have demonstrated that in the cool season experienced this year irrigating at 100% of predicted crop water use gave better cotton yield than the 75%, 50% and 125% treatments.

This indicated that the FAO Penman Monteith model gave a good indication of potential crop evapotranspiration.

Water stored in the soil outside the zone wet by drip irrigation provided water that delayed the onset of water deficit stress. Thorough drying of the non-irrigated zone contributes to greater irrigation efficiency of drip irrigation than furrow irrigation.

We were able to visually differentiate between treatments before we were able to measure the differences with destructive harvests. This indicates that we need to use more sensitive indicators such as leaf water potential and canopy temperature if we are to use them as scheduling tools.

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