

Managing cotton under limited water conditions using HydroLOGIC

Dirk Richards, Grant Roberts, Michael Bange, Clare Felton-Taylor and Ross Gregory
CSIRO Plant Industry, Australian Cotton Co-operative Research Centre,
Narrabri, NSW, Australia.

Key Points

- Under limited water scenarios HydroLOGIC was able to optimise yield.
- Irrigation application efficiencies were estimated to be near the industry average of 60%.
- Combining soil moisture probe information with HydroLOGIC predictions gave reliable assessments of crop growth, response to moisture stress and final yield.

Introduction

Increased pressures are being placed on irrigators in Australia to maximise their water use efficiency. This has in turn highlighted the need for more focused research and extension on water management. The HydroLOGIC irrigation management system has been developed to provide information for irrigation decisions. The system provides a range of information to assist with the effective and timely application of irrigations for furrow irrigated cotton crops. Uniquely, the software has the ability to evaluate the consequences of different irrigation strategies on daily crop growth, yield and water use, using a range of simple plant and soil moisture measurements. HydroLOGIC especially offers opportunities for optimising irrigation management in limited water situations, where understanding the consequence of different irrigation strategies become even more important to productivity.

Field experiments conducted during the 2002-03 cotton growing season demonstrated that HydroLOGIC could achieve above average yields and water use efficiency (Richards and Bange, 2003). This paper presents the results of a HydroLOGIC experiment in 2003-04, which aims to further demonstrate the 'value' of HydroLOGIC in improving water use efficiency.

Materials and Methods

The experiment was established at the Australian Cotton Research Institute, Narrabri, NSW in October 2003. The trial site was sown with Sicot 189 on the 21st of October and watered-up following sowing. With the exception of irrigation timing and allocation, the crop was grown and managed under normal cultural conditions. Three different water allocation treatments were imposed; 8ML/ha, 4ML/ha, and 2ML/ha, with timing of irrigations determined individually using HydroLOGIC. Each treatment was replicated three times. Soil moisture and nitrogen was determined prior to sowing, with 130mm soil water and over 400 kg nitrate nitrogen (NO₃) available.

Plant sampling during the season determined the numbers of squares, green and open bolls on a square metre basis, and estimates of leaf area were made using the HydroLOGIC photo guides. Neutron probes were installed in each treatment to estimate the soil moisture deficit prior to irrigation.

On a weekly basis, the most recent crop information and farm weather data was entered into HydroLOGIC software. The decision to irrigate a treatment was made using a range of HydroLOGIC scenarios, which varied the soil moisture deficit used to initiate irrigation from 60mm to 130mm and by the available water allocation. The scenario with the highest potential yield was selected and the corresponding predicted irrigation used. This operation was also done following significant rainfall events.

At each irrigation event, the water levels were monitored using Odyssey capacitance water depth recorders at head ditch and tail drain. Siphon input was then estimated using the Bos head height siphon flow equation (Bos, 1989), and tail water was estimated from recording flumes. The total water applied to the experimental plot was then calculated, taking the soil moisture deficit into consideration. Following irrigations, the total water applied was deducted from the remaining allocation within each treatment, with subsequent HydroLOGIC scheduling scenarios using this revised allocation. The application efficiency was calculated by dividing the irrigation water supplied to the crop by the water applied by siphon.

Crop maturity for each plot was determined by weekly hand harvests over 4 metres of planted row, giving a total of 12 metres of hand harvest per treatment. The 16 hectares of the experiment was harvested by twin row pickers and weights for each plot determined using boll buggy fitted with weigh cells. An assumed turnout of 40% allowed calculation of final lint yields. To determine the irrigation water use index or the productivity of applied irrigation water, final lint yield was divided by the total applied water for the season. To calculate the gross water use index, final lint yield was divided by the total water inputs for the crop, which includes irrigation water applied, rainfall and the difference in soil moisture between sowing and harvest.

Results and Discussion

General

October and November temperatures remained cool, with the incidence of cold shocks considerably higher than average until mid November. The following months of December to February recorded above average number of hot days, and day degree accumulation returned closer to the long term average. Unlike other locations within NSW, rainfall in Narrabri was close to average for most of the season, although April was dryer than normal. There were however five rainfall events of above 40mm, that had a significant

impact of the response and growth to the irrigation treatments. In particular the 150mm received from 14th to 17th January kept the 2ML/ha treatment growing, whilst potentially waterlogging the 4ML/ha and 8ML/ha treatments which were irrigated on the 5th of January. In the week 12th to 16th of March, following the final irrigation in the 4ML/h and 8ML/ha treatments, another 75mm was recorded during this boll filling and opening period.

HydroLOGIC predictions were run on the 29th November to determine the first irrigation date in all scenarios, with only the 8ML/ha treatment to be irrigated on December 17th. Predictions continued to be assessed during the season and following rainfall, with actual irrigations on the dates given in Figure 1.

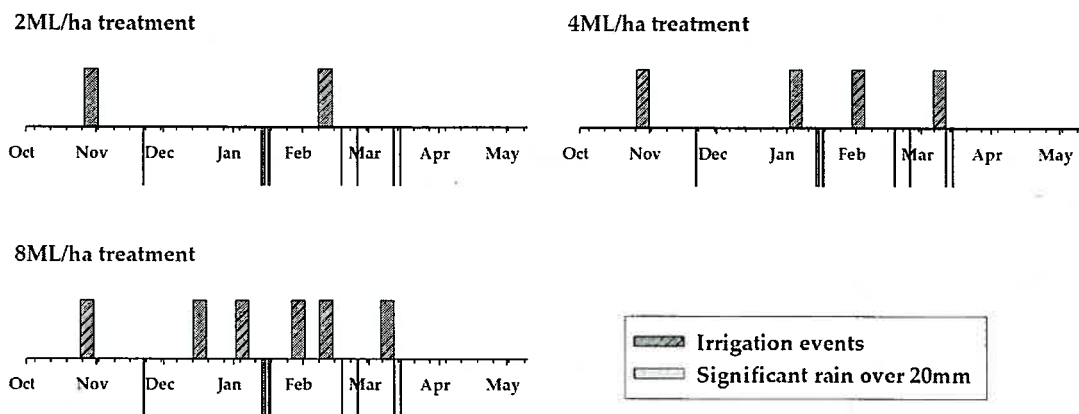


Figure 1. Irrigation and rainfall timeline in HydroLOGIC irrigation experiment, 2003-04 season.

A range of plant sizes was the most apparent impact of the different irrigation dates and allocations. Under a full allocation regime, the 8ML/ha treatment grew to 115 cm and averaged 27 nodes at harvest, as opposed to 108 cm and 29 nodes in the 4ML/ha treatment, and 104 cm and 29 nodes in the 2ML/ha treatment. The reduction in plant size with allocation indicates moisture stress has occurred to some degree in both the 2ML/ha and 4ML/ha treatments. Regrowth was also apparent from the final boll numbers.

Applied irrigation water

Following irrigations, the total water applied to each treatment and the in-field application efficiency was estimated. The soil moisture deficit at sowing was 104mm, however during the water-up event over 2ML/ha was applied to the field. This indicated that a considerable amount of applied water (99mm) percolated below the rooting zone, due in part to the large cracks in the dry soil which did not close immediately. Tail water of 0.9ML/ha was also recorded during this event. As a consequence, the application efficiency for this particular irrigation was only 36%. Total water applied in all irrigation events for the season was calculated at 1.56ML/ha for the 2ML/ha allocation treatment, 3.02ML for the 4ML/ha

allocation treatment, and 4.29ML/ha for the 8ML/ha allocation treatment (Figure 2a). The application efficiency for the whole season was found to be 59% (Figure 2b) or close to the industry average of 60% (Tennakoon and Milroy, 2003).

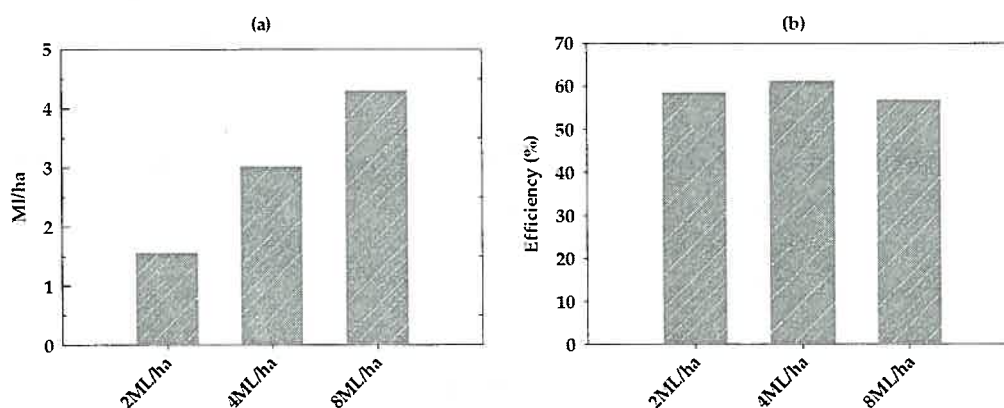


Figure 2. The (a) applied irrigation water and (b) application efficiencies calculated for the whole of the season.

Yield and maturity

Maturity picks commenced in March and continued on a weekly basis until harvest, which began on the 7th of May 2004. Very little difference was observed in crop maturity, with 60% of bolls being open between the 19th and 25th of April in all treatments (Figure 3a). Final open boll numbers on a square metre basis were 95, 100, and 103 for the 2ML/ha, 4ML/ha and 8ML/ha treatments respectively. As expected, yields increased with the frequency of irrigation and total allocation applied (Figure 3b), although boll size was not greatly different between treatments. The average boll sizes (seed cotton per boll) for the 2ML/ha, 4ML/ha and 8ML/ha treatments were 4.30 gm/boll, 4.45 gm/boll and 4.29 gm/boll respectively.

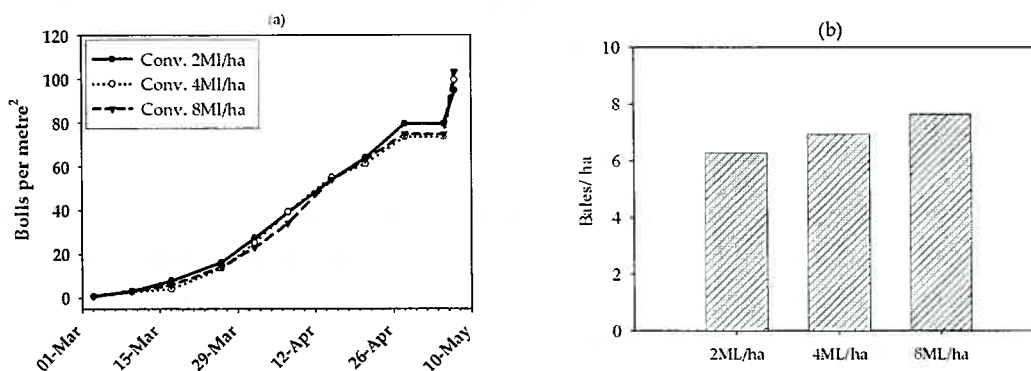


Figure 3. The (a) number of open bolls over time used to identify crop maturity and (b) final machine harvest yield results for 2003-04 HydroLOGIC trial.

Water use indices

The yield benefit of the irrigation water applied (or irrigation water use index) was calculated following harvest. The 2ML/ha treatment achieved the highest index, where 1.8 bales was grown for each megalitre of irrigation water applied. This compared favourably with 1.4 bales/ML and 1.2 bales/ML from the 4ML/ha and 8ML/ha treatments respectively. Comparisons with recent industry surveys show that all treatments were above the Australian average of 1.3 bales/ML (Tennakoon, Milroy and Richards, 2003). The high irrigation water use index in the 2ML/ha can be attributed to the relatively high yield, primarily due to the 150mm rainfall event contributing to favourable crop growth prior to the only irrigation. Increasing the frequency of irrigations may have also increased the waterlogging from subsequent rainfall, and may have reduced yields in the 4ML/ha and 8ML/ha treatments. The gross water use index, which includes the input of rainfall and utilised soil moisture, was also calculated. These values ranged from 0.69 bales/ML in the 2ML/ha treatment to 0.66 bales/ML in the 8ML/ha treatment, with the 4ML/ha in between.

Conclusion

The results from this experiment again demonstrate that HydroLOGIC can be used to effectively schedule in-season irrigations within cotton, especially under limited water situations. The complementary nature of the software was also highlighted, with the information from soil moisture probes being value-added by HydroLOGIC to give predictions of the next irrigation date and crop growth. Work is continuing to evaluate the HydroLOGIC system under a range of growing conditions and scenarios. Future refinements to HydroLOGIC in response to requests include; the ability to assess years that have certain characteristics (e.g. hot seasons); seasonal climate effects; and use for overhead irrigation systems.

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