Irrigation Management and the Effect on Cotton Yield

Comparative Observations in the 1996-97 Cotton Season.

Introduction

Neutron probes and **the PROBE** software are widely used in Australia to accurately measure the soil water content of irrigated cotton fields. The collection of quality soil moisture data is an important part in making an informed decision regarding the irrigation schedule of a cotton field. However, the most critical part is the interpretation of the data back to the field itself. This paper illustrates the importance of analysis and interpretation of soil moisture, especially in regard to the second irrigation and to both real or potential rainfall events, in making sound decisions in irrigation management. Data obtained from two farms in the 1996/97 season is compared to illustrate this point. The farms selected were from the same area and fields were back-to-back with similar refill points.

Background Literature

The ideal water use pattern of an irrigated cotton crop planted at Narrabri is illustrated in Figure 1. The graph is a bell shaped curve with daily water use increasing to a peak of 8 mm/day in early February.

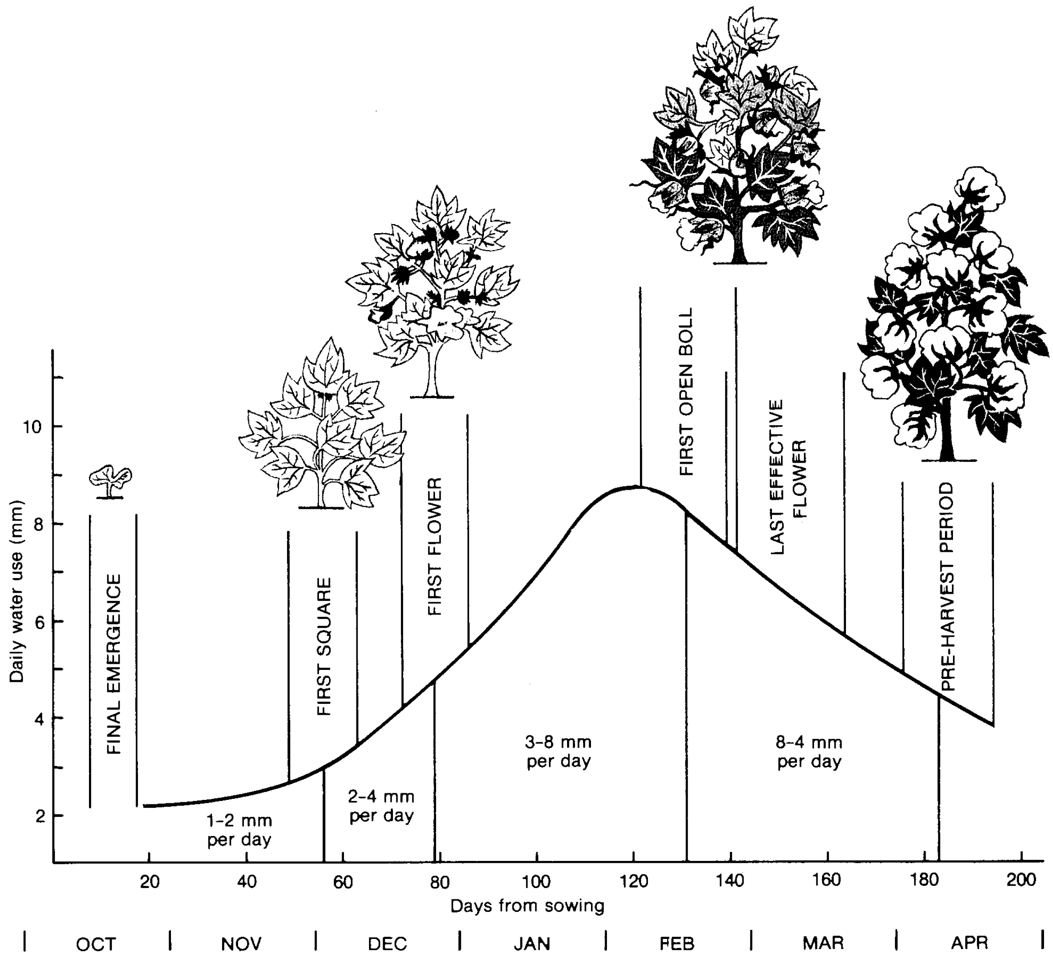

Figure 1. Daily water use of cotton at Narrabri.

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The importance of timing irrigations, especially the second, has been well documented and researched. In the 'Irrigation Management of Cotton' Agfact, Browne outlines the important role the second irrigation plays in controlling crop development to achieve a favourable balance between vegetative growth and reproductive development. During this period the plant is flowering and a number of young bolls are establishing. These young bolls, if successful, will have a high contribution to final yield. However, it is during this stage that they are highly sensitive to moisture stress. Browne states one day of stress at this stage has been shown to decrease lint yield by up to 18 kg/Ha.

Research at Narrabri by Turner et al (1986) showed that water deficits influence photosynthesis, leaf expansion, the retention of flowers and bolls, and ultimately the yield of cotton. They found severe stress during flowering when the second irrigation was due, reduced the leaf area index and the number of fruiting sites throughout the remainder of the crops life. This reduced the number of bolls and final lint yield.

Comparison

Farm A was planted early October, flushed early November, first irrigation mid December, second irrigation early January. December growth was vigorous with good crop development and fruit setting. This continued up to the second irrigation. The second irrigation was delayed and the crop severely stressed to the point of wilting. The daily water use (DWU) declined very rapidly from 6.0 mm/day approaching refill to 1.5 mm/day five days past the refill point. In addition, a rainfall event at the end of January is examined for utilisation of 'free' water.

Farm B was planted in the third week of October, received sufficient rainfall to cover the first irrigation and therefore the first irrigation (effectively the second) was applied early January. As with Farm A, December growth was vigorous with good crop development and fruit setting. DWU at the time of the second irrigation was 5.0 mm/day.

Using **the PROBE** software, data from Farm A and Farm B was analysed with the following graphs generated using the Time Graph function. The graph of Farm A (Figure 2.) illustrates the detrimental effect of the delayed second irrigation on later crop growth and development. The DWU was reduced especially mid to late season. The graph of Farm B (Figure 3.) illustrates the achievement of the desired water use pattern for an irrigated cotton crop. A pattern of daily water use similar to Figure 1.

Both graphs further illustrate the use of neutron probe data in making informed decisions concerning rainfall events and irrigation scheduling.

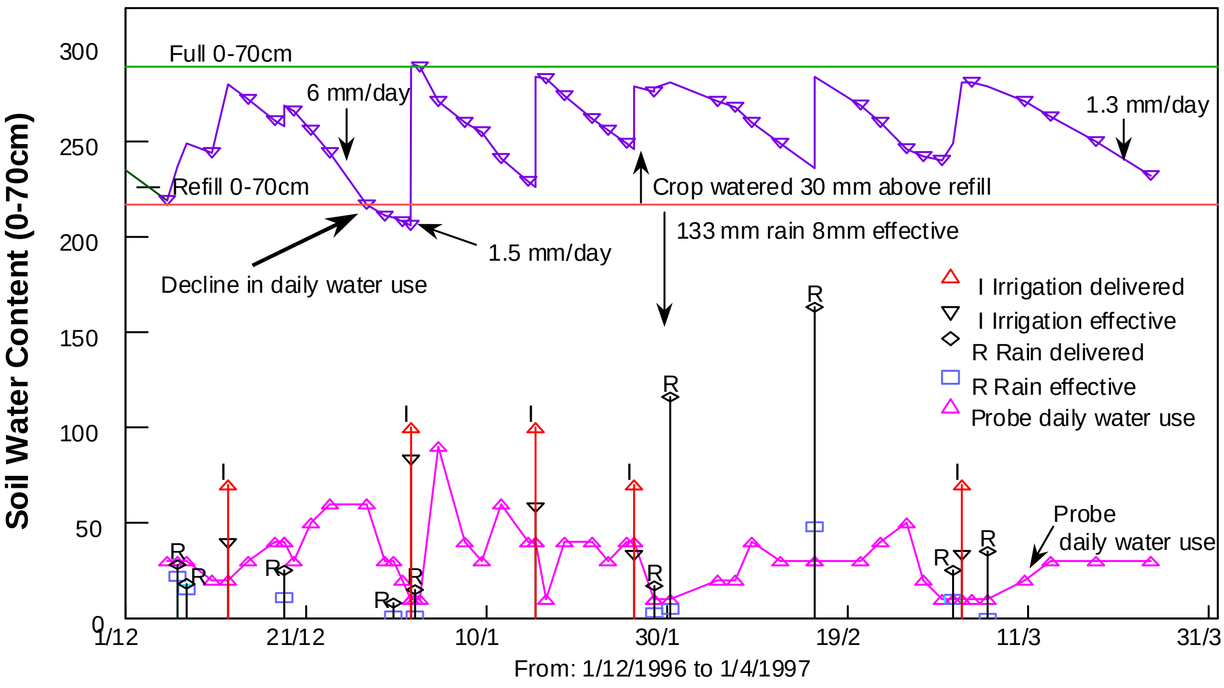

Figure 2. Farm A seasonal soil moisture content, crop water use and rainfall efficiency.

On Farm A, the period corresponding with the second irrigation indicated a rapid decline in water use by the crop after it past the refill point (Figure 2). DWU almost stops two days prior irrigation. The trend of the DWU following the second irrigation is a general decrease for the remainder of the crop's life, rather than an increase to early February followed by a decline. It is in this period of crop growth that research has found irrigation delays to be most detrimental to final yield. After the second irrigation, DWU averaged 3.4 mm/day until the refill was reached prior defoliation. From this time (28/3) through to defoliation, the crops average DWU was 1.3 mm/day.

The Farm A crop moved to cut-out after the second irrigation. Subsequent irrigations were at progressively higher refill points (or smaller soil moisture deficits) to try and halt this. Towards the end of January, the crop was watered 30mm above the original refill. Two days later, rainfall of 133mm was received over three days of which only 8mm of was effective. As the chance of rain was better than average at this time, proper analysis of the neutron probe data plus paddock inspection would have indicated the irrigation could have been delayed to take advantage of the probable rain. If this had been done, an irrigation would have been saved.

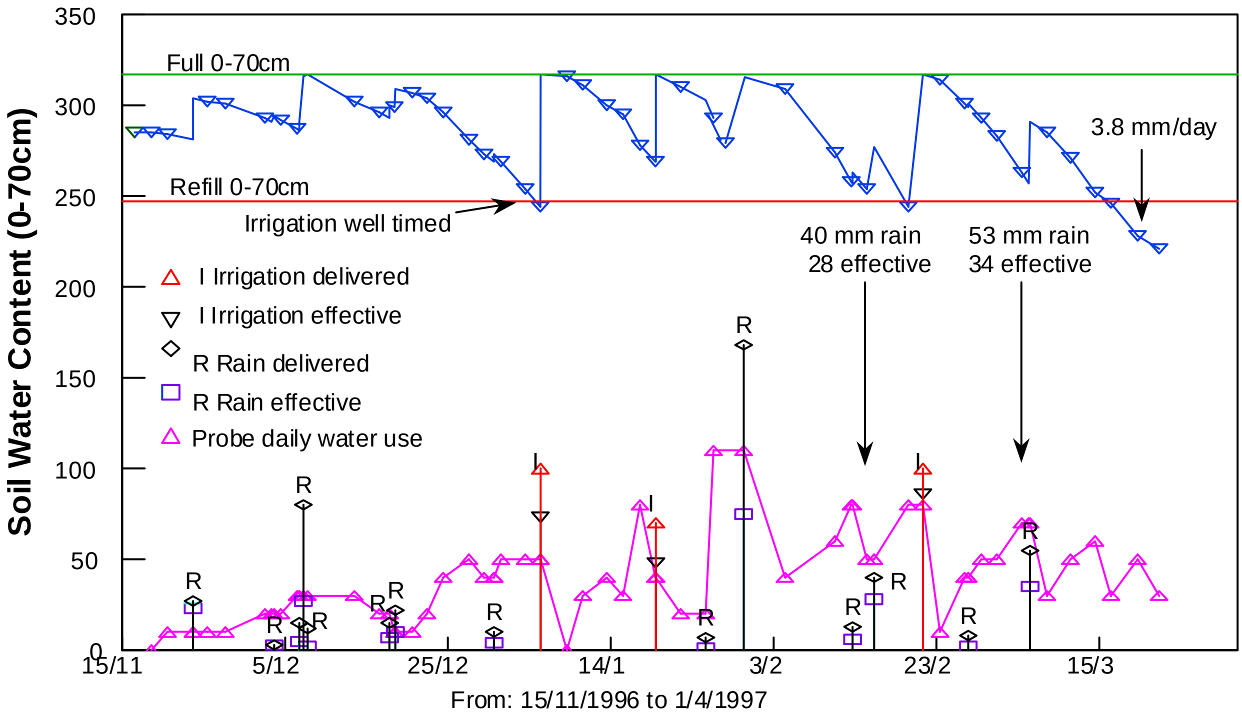

Figure 3. Farm B seasonal soil moisture content, crop water use and rainfall efficiency.

In contrast to Farm A, the DWU of Farm B is constant up to the irrigation in early January. After this, the DWU progressively increases as the boll load increases through to early February when it starts to decline as the crop matures. After this irrigation DWU averaged 5.0 mm/day until the refill was reached prior defoliation. Post refill (14/3) through to defoliation, the crops average DWU was 3.8 mm/day.

Within the field of the Farm B crop an area of lighter soil showed signs of cut-out post the first irrigation so the second irrigation was applied three days early. As the third irrigation approached, there was a chance of rain. After considering the neutron probe data in conjunction with the crop, the grower decided it was safe to hold off the irrigation by at least one day. This resulted in 28 mm of available moisture (effective) from 40 mm of rain (delivered). Thinking the gain would be at least five days, the grower was surprised when the neutron probe reading after the rain showed there was only a gain of three days, from this rain event. This was because the rain had not infiltrated deeper than 20cm. Even though the surface was wet, the crop showed signs of wilting mid afternoon four days after the rain. This irrigation was delayed long enough for the surface to dry sufficiently to allow good water infiltration. A similar result was achieved later in mid March when the last irrigation was due. In this situation however the irrigation was not applied as the grower was able to wait for rain in the knowledge of adequate soil moisture. Using the neutron probe the grower was able to quantify his soil moisture and make an informed decision concerning the crops remaining water requirements.

A direct comparison of crop water use shows that Farm B delivered less irrigation water to the field and had a higher irrigation efficiency. This irrigation efficiency of 77% has been recorded in a previous study of cotton irrigation practice. (Cull, et.al. 1985). Farm B had almost twice the utilisation of natural rainfall compared to Farm A. The cumulative daily water use as measured with the neutron probe was 120 mm greater for Farm B than Farm A. This difference would explain a yield difference of 1.5 bales/ha or 0.6 bales/ac at a water use efficiency of 1.3

bales/hectare/megalitre of crop water use. The differences developed from late January when the Farm A crop was starting to cut out in response to the earlier water stress (Figure 4). The detailed analysis is possible using **the PROBE** software program to analyse the neutron probe data.

Table 1. Comparative water use efficiencies for Farm A and Farm B.

	Farm A	Farm B
Effective Irrigation	267	207
Delivered Irrigation	450	270
Irrigation Efficiency	**59%**	**77%**
	116	227
Delivered Rain	451	475
Rainfall Efficiency	**26%**	**48%**
Total Effective Irrigation & Rain	383	434
Total Delivered Irrigation & Rain	901	745
Total Efficiency Irrigation & Rain	**42%**	**58%**
Cumulative Daily Water Use Planting to 4 April	**430**	**553**

NB all units are mm

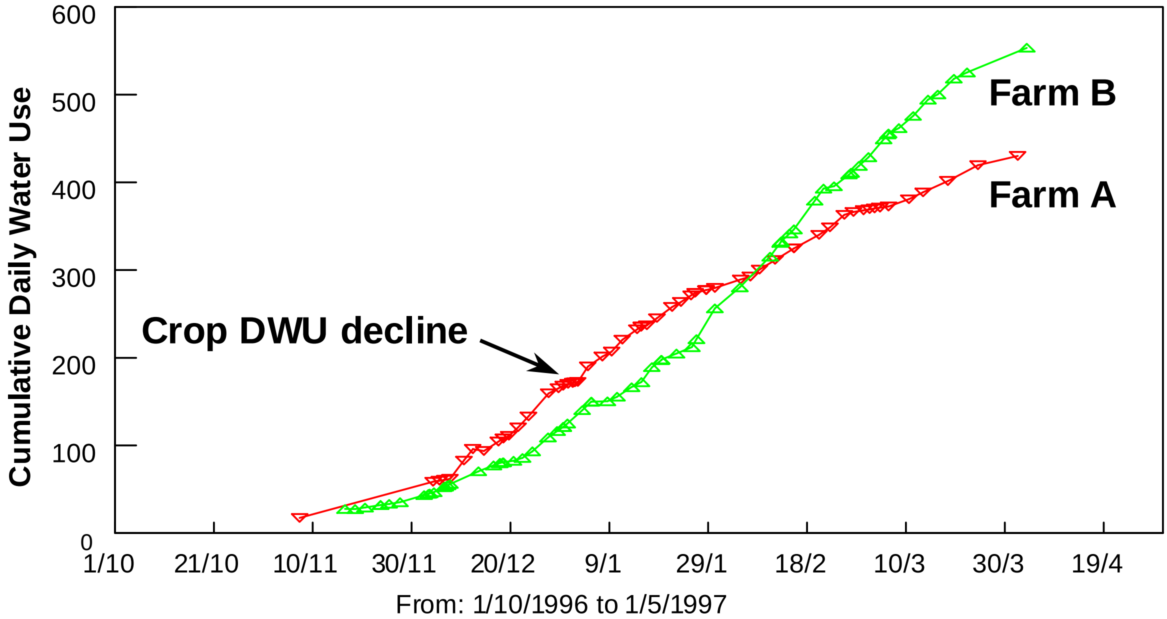

Figure 4. Cumulative daily water use for Farm A and Farm B

Conclusion

The lint yields prior ginning of Farm A was 6.42 bales/ha or 2.6 bales/ac and Farm B was 7.9 bales/ha or 3.2 bales/ac. The pest and fertiliser management plus soil conditions as measured by root extraction patterns from neutron probe readings were similar. The major contributing factor to the yield difference was water management, in particular the delay of the second irrigation on Farm A.

The interpretation of neutron probe data back to the field is essential for good crop management decisions. The neutron probe and **the PROBE** software, when used effectively, can be an important crop and farm management tool for maximising the utilisation of farm inputs to increase financial returns.

References

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George, B., and Finney, B., 1985. Whole Farm Irrigation Efficiency and Water Management for the 1984/85 Cotton Crop at Moree. The Australian Cotton Grower, November, 1985.

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