SEMI-IRRIGATED COTTON: MOREE LIMITED WATER EXPERIMENT

Rose Brodrick[1] James Quinn[2], Zara Lowien[3], Rod Jackson[4], Janelle Montgomery[4], Michael Stone[5], Alison Young[6], Ray Fox[6] and Joe Robinson[6] (AFF),

1. CSIRO Plant Industry, Narrabri, NSW, rose.brodrick@csiro.au
2. Cotton Seed Distributors, Moree, NSW,
3. Gwydir Valley Irrigators Association, Moree, NSW
4. NSW Department of Primary Industries, Narrabri and Moree, NSW
5. Integrated Crop Management Services Pty Ltd, Moree, NSW
6. Australian Food and Fibre Limited, Moree NSW

SUMMARY

• We compared the yield and water use of partially irrigated systems using solid, single-skip and double skip configurations to a fully irrigated solid crop

• Irrigations were scheduled using NAWF with the aim to keep the crop in the partially irrigated system flowering as long as possible to take advantage of any in-crop rainfall where three irrigations were available or to finish the crop off where only one was planned

• The season was characterised by a very wet start and dry finish, with less ability for the partially irrigated treatments to capture rainfall than in a more typical year

• The solid, fully irrigated crop yielded over 12.5 bales/ha but the single-skip semi-irrigated had a respectable yield of 8.65 bales/ha with better irrigation water use efficiency

• Difficult to make conclusions about these systems from one year's data and more research is needed to determine the potential of the single-skip semi-irrigated system (or others) in a partially irrigated production system

INTRODUCTION

A key challenge for growers is knowing when to use water when they have water for a limited number of irrigations to optimise yield, quality and water use efficiency.

Irrigation timing is critical in cotton to minimise negative impacts on yield and fibre quality. Much of the research into irrigation scheduling in cotton has focused on improving water use efficiency in fully irrigated systems. Transferring our knowledge of measuring soil water and scheduling irrigations to maximise profitability and minimise risk in a semi-irrigated situation is not a simple undertaking.

Improving the ability to make decisions when to irrigate in these situations involves:

- identifying precisely that crops are stressed or not;
- having a clear understanding of the consequences of water stress at different critical stages of crop growth;
- understanding the effectiveness of irrigating to assist crop recovery in terms of yield and quality following the crop reaching stress; and
- quantifying the risks associated with irrigating or not in terms of the crop response and the short-term climate outlook.

Using skip-row configurations has been proposed to minimise crop stress in a semi-irrigated system. Skip row configurations aim to reduce water stress and limit fibre quality discounts by:

- by providing the plant row to an increased volume of stored soil moisture
- increasing the planted area and
- maximising the ability to capture in-crop rainfall

Cotton's response to water stress varies depending on the stage of growth that the crop occurs, the degree or stress and the length of time the stress is present. New Research is required to develop irrigation strategies for cotton in a limited water situation. Identifying irrigation strategies (e.g. skip row, 60 inch, 1 in 1 out, partially irrigated) in a limited water environment will enable growers to improve their decision making when they have a limited amount of water to apply.

The bread and complexity of these issues became apparent in a large-scale irrigation experiment in 2010-11 at Redbank in Moree, NSW. This experiment aimed to compare the yield potential of different skip row configurations and partially irrigated treatments; and establish the relationship between crop stress and yield in under these scenarios.

METHODS

The experiment was planted on 28 September 2010 using Sicot 74BRF. Each plot was large enough (at least 24 rows wide) to allow separate irrigations to be applied to each plot and there were three replicates of each treatment. Row spacing treatments were solid (1 m spaced rows), single-skip (2 in, 1 out) and double skip (2 in, 2 out). The control treatment was solid with full irrigation according to normal farm scheduling and two partially irrigated treatments were applied to each row spacing.

7 treatments by 3 replications
1. Solid – normal irrigation (full)
2. Solid – three irrigations (semi)
3. Single Skip – three irrigations (semi)
4. Double Skip – three irrigations (semi)
5. Solid – one irrigation (limited)
6. Single Skip – one irrigation (limited)
7. Double Skip – one irrigation (limited)

Timing of irrigations

Normal – as per normal deficit (Scheduled by Mike Stone as per rest of field)
Semi-irrigated - Three Irrigations – timed to keep crop developing at 7-6 NAWF. Irrigating to be considered if NAWF < 7, depending on climate, crop stress and fruit load.
Limited - One Irrigation – applied approaching cutout (NAWF <5) to allow further growth and boll set or to mature and retain bolls already set.

Comprehensive soil water and plant development measurements were collected throughout the season. Capacitance probes and neutron moisture probes were installed in both the plant line and skip rows to monitor soil water. Plant mapping, nodes above white flower, heights, nodes, light interception, canopy cover and maturity were monitored at least weekly to determine differences in crop growth and development. The water balance was also calculated during the season using a calibrated canopy coefficient (Kc) approach by estimating canopy cover by using a 50 cm x 50 cm chequer board placed under the canopy with cover estimated by counting the proportion of visible squares compared with those covered by the canopy. James Quinn (CSD) has been using this approach to estimate crop water use in different systems where detailed soil moisture measurements are not available.

RESULTS

Climate

The 2010-11 season was cooler in terms of cumulative day degrees and characterised by above average rainfall up until Christmas followed by below average rainfall from January to March (Figure 1). This meant that all the treatments had a full profile of soil moisture until late November and developed in relatively mild conditions in the first part of the growth period.

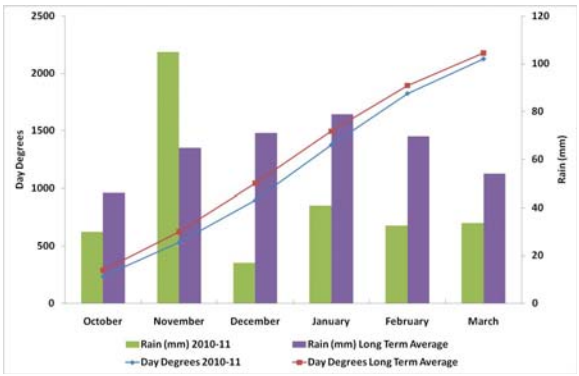

Figure 1. Day Degrees and Rainfall at Redbank Experiment 2010-11 compared with the long-term averages for Moree. Source: Cottassist Climate Analysis Tool

Irrigation Scheduling

The first irrigation was applied to the solid, fully irrigated treatment on 22nd December and this treatment was irrigated at around a 50-60mm deficit a total of eight times during the season. Irrigations were applied to all the semi-irrigated treatments on 31st December and to the solid treatment on 14th January and the single and double skip treatments on 23rd January to prevent NAWF in the three row spacings from declining to < 7 NAWF. The limited treatment received an irrigation on 14th January when all row spacings had reached <5 NAWF to provide supplemental water at cutout to mature and maintain the fruit already set, however the double skip treatment had only just reach 5 NAWF and responded to the irrigation by putting on more nodes. The final irrigation on the solid, fully irrigated and the semi-irrigated treatments was applied on 9th February. Real time water use measurements were difficult to calculate during the season, with no developed methodology for accounting for water use in the plant line and the skip.

Tracking NAWF

The fully irrigated crop sustained NAWF above 8 until mid-Jan whereas the semi and limited water treatments rapidly declined from late December. The second irrigation led to an increase in NAWF in the semi- single skip and double skip treatments and stopped NAWF in the solid treatment declining further. The limited treatment received an irrigation on 23 January and the response of the double skip treatment was to put on more nodes.

Yield and Water use

Calibrated neutron moisture meters, c-probes and measurement of water applied at each irrigation provided a water balance for each row spacings and irrigation treatments. Irrigations were applied to every second row as per normal farm irrigation practice. A single siphon was used in each treatment (except for the solid, limited irrigation treatment where double siphons were required to prevent overflow in the head ditch). Where the irrigation interval was greater than 21 days between irrigations, the irrigation took more than 15 hrs to complete compared to 10-11 hrs for the fully irrigated treatment.

Accounting for the skip proved to be a challenge in calculating plant available soil water. Patterns of

extraction were followed and plant available soil water adjusted for both the depth of extraction in the plant line and skipped rows.

Estimating crop evapotranspiration (ETc) using the chequer board method to calibrate it to the crop worked very well in the solid, fully irrigated and the semi-irrigated treatments, but this approach over-estimated water use in the limited irrigations and skip row treatments because it does not account for declines in crop water use due to plant stress and tended to overestimate the amount of water in the skip-rows (Table 1).

Yields were highest in the solid, fully irrigated treatment, followed by the single-skip, semi irrigated treatment and the solid, semi irrigated treatment (Table 1). Water use however was higher in the solid, fully irrigated and solid, semi irrigated treatment when compared to the single-skip semi-irrigated treatment, which had the highest irrigation water use efficiency and higher total water use efficiency than any of the other partially irrigated treatments. The solid, fully irrigated treatments took longer to mature than the other treatments and rainfall in March led to the fully irrigated treatment having higher effective rainfall and more stored soil moisture remaining at the end of the season than the other treatments.

CONCLUSION

Evaluating these systems based on one season's data is not possible but the single-skip semi irrigated treatment had the highest irrigation water use efficiency and maintained reasonable yields. It is important to note that very little in-crop rainfall fell during the later part of the season and differences between the solid planting and hence ability for the skip row treatments to capture more rainfall than the fully solid treatments was less than would be expected in a more typical season.

The semi-irrigated treatments required a significant amount of water in each of the three irrigations which needs to be considered when planning a partially-irrigated approach, i.e. three irrigations in a partially irrigated system is not necessarily equal to three in a fully-irrigated system.

In hindsight we may have scheduled the final irrigation earlier in the semi-irrigated treatments to maintain fruit numbers, crop water use rapidly declined in the partially irrigated treatments before the final irrigation and the crop wasn't able to recover to fully utilise the final irrigation, evident by over 0.5 ML of stored soil moisture remaining in the profile in the semi-irrigated treatments.

The efficiency gain in the single-skip irrigated treatment indicates that it may have potential in a limited water situation, but more research is needed to develop irrigation strategies for limited water situations, across a range of environments to understand the consequences of the timing and amount of irrigation applied on plant stress, yield and quality.

Table 1. Yield and Water Use in Redbank, Limited Water Experiment 2010-11

	Full Solid	Semi Solid	Limited Solid	Semi Single	Limited Single	Semi Double	Limited Double
Yield (b/ha)	12.54	7.08	6.67	8.65	6.26	6.81	5.09
No. Irrigations	8	3	1	3	1	3	1
Irrigation applied	4.15	3.20	1.43	2.64	1.11	2.28	0.89
Effective Rainfall	2.28	1.87	1.94	1.61	1.69	1.53	1.60
Starting Soil Water	2.20	2.20	2.20	2.20	2.20	2.20	2.20
Ending Soil Water	1.15	0.56	0.00	0.57	0.11	0.61	0.11
Total water	7.48	6.71	5.57	5.88	4.89	5.39	4.58
Evapo-transpiration	7.35	6.87	5.82	7.32	6.39	7.52	6.79
WUE (kg lint/applied)	6.9	5.0	10.6	7.4	12.8	6.8	12.9
WUE (kg lint/mm)	3.9	2.3	2.6	2.7	2.2	2.1	1.7
WUE (plant line)	3.9	2.3	2.6	4.1	3.4	4.1	3.4

ACKNOWLEDGMENT

The concept and implementation of the experiment was initiated by GVIA, Australian Food & Fibre Limited, ICMS Pty Ltd (Integrated Crop Management Services), Cotton Seed Distributers and CSIRO. Irrigation extension and technical support was also provided by NSW Department of Primary Industry. Funding from the National Water Commission and the generous donation of the Smart Crop sensors by Smart Field enabled the experiment to be fully instrumented and managed with a fully replicated trial design.