



Optimising Field and Farm Scale Water Use Efficiency for Cotton Farming Systems (CRC 48C)

Final Report

June 2005

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Vision: Profitable primary industries for Queensland



Queensland Government
Department of Primary Industries and Fisheries

CRC project number CRC 48C: " Optimising field and farm scale water use efficiency for cotton farming systems".

Final Report

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Summary

Growers whose water supply is critically low and are experimenting with novel ways to grow cotton with this limited water. These include irrigated skip-row techniques which are showing promise following a number of successful crops in recent seasons. However, no recent studies to examine the response of new cotton varieties, particularly Bollgard II, to varying irrigation regimes under various row configurations have been carried out. Answers are also sought on the results of applying minimal irrigations to skip-row plantings and on the long term economics of using skip-row cotton within cropping systems.

The focus of the project is on both irrigated and dryland farming systems and is involved with agronomy and physiology to understand water, in a systems context in relation to irrigation, raingrown cropping, crop rotation, fallow, management practice, row configuration etc., using modelling capacity, field research, farming systems approach and adult learning (associated with the RWUE 2 project).

Preliminary trials have now been conducted during 2003-04 and 2004-05 seasons on an irrigated cotton growing property (27° 04.5' S, 150° 59.7' E) in the Daandine area near Macalister on the Darling downs.

The initial objective was to conduct over a number of seasons: row configuration x irrigation (quantity and timing) x variety (Bollgard II and conventional) x soil type (low and high PAWC soils) trials. Plantings were made in mid and late October 2003 and 2004 respectively to establish a single –skip configuration at 1 m row spacing. Varieties were Sicot 14B (Bollgard II) , Sicot 80 (conventional) in year 1 and Sicot 80B (Bollgard II), Sicot 80 in year 2. The plots received either 1 or 2 irrigations. Detailed crop growth and soil water extraction data were monitored as were yield and fibre quality.

As expected plots receiving 2 irrigations out-yielded those with only one irrigation. The grower cooperator estimates the value of the second irrigation to him in 2003-04 was about \$1000 per ha for the extra 1.1 ML applied. The project when (if ?) completed will be capable of examining the economics of various row configurations, variety, soil moisture , rainfall and irrigations applied.

The 2003-04 trial, in addition to adding to the data set on soil moisture uptake dynamics, provided the opportunity to make a direct comparison between Bollard II and conventional cotton, as Sicot 80B and its “equivalent”, Sicot 80, were planted. Given the same irrigation treatment Bollgard II and conventional were similar in yield (lint bales/ha) and fibre quality, although Bollgard II was earlier maturing and appeared to use less soil moisture than conventional.

In both seasons soil moisture was used in and close to the plant line before the middle of the skip, where its use down the profile was rapid, as shown by the higher extraction front velocity. There is some evidence that the roots position themselves into the mid-skip area and

wait for a plant signal before water extraction commences in that area. Further evidence of this is required and investigations would be assisted by the use of mini-rhizotrons. If this theory is correct then the search for the switch (fraction of transpirable water in the plant line ?) could be conducted.

Further trials need to be carried out so the data set can encompass various climatic conditions and soil types. Then Ozcot can be enhanced and management scenarios investigated.

Impact on Cotton Industry

The data obtained from this project will be added to data resulting from a new project which has been proposed to the Cotton Catchment Communities CRC for funding:

'Determining strategies for irrigated and dryland farming systems which maximize WUE to enhance environmental and economic benefits for new and existing cotton growing regions'.

It is envisaged by the completion of this project:

- 1) An improved cotton crop model will be developed to enable determination of optimum crop management and farming system irrigation practises to increase WUE.
- 2) Reliable climatic forecasting indicators will be identified for existing and future proposed growing regions.

A decision support package, using the enhanced cotton model and climatic forecasting, as a risk management tool will then be available. It will evaluate the probability of achieving a given level of economic return for a range of farming system practises, given cropping area and water availability for a given seasonal outlook.

Introduction

With diminishing water supply (due to possible change in weather patterns and pressure to enhance environmental flows) growers are looking for strategies to make best use of limited water. Queensland's Rural water Use Efficiency Initiative's Cotton and Grains Adoption Program team has been demonstrating management techniques to enhance irrigation efficiency. In many cases it has been observed that crops are being over irrigated, to the extent that in some cases up to three times more water is being applied than is required. With an awareness to this, the growers involved are in a much better position to produce with a reduced water supply.

However there are many growers whose water supply is critically low and are experimenting with novel ways to grow cotton with this limited water. These include irrigated skip-row techniques which are showing promise following a number of successful crops in recent seasons.

Recommendations drawn from past research on skip-row cotton to cope with limited water were compiled by Gibb (1995). New varieties are now available with differing agronomy to those previously researched. Goyne (2000) reported on the soil water extraction dynamics of raingrown skip-row cotton. This revealed new information which assisted in the understanding of the soil water balance for skip-row raingrown systems.

However, no recent studies to examine the response of new cotton varieties to varying irrigation regimes under various row configurations have been carried out. Answers are also sought on the results of applying one or two irrigations to skip-row plantings and on the long term economics of using skip-row systems compared to solid configurations. Growers have

an immediate need for this information as has been shown by their own experimentation with irrigated skip-row plantings.

Models could readily supply this information, but the current cotton model Ozcot does not have the capability to perform adequately for skip row configurations (Hearn 1999). Trials were therefore conducted to understand the interaction of row configuration with crop agronomy and soil water extraction. The data can be extended and various management scenarios tested using the model modified to suit skip- row configurations.

Materials and Methods

Trials were conducted during the 2003-04 (year 1) and 2004-05 (year 2) summers on an irrigated cotton growing property (27° 04.5' S, 150° 59.7' E) in the Daandine area near Macalister on the Darling downs. The soil was a grey vertosol with a PAWC of about 270 mm to 1.8 m.

All cultural operations, including planting, were carried out by the grower. The year 1 trial site was fallowed during the previous 12 months. Urea (120 kg/ha), Starter Z (75 kg/ha) and Sulphate of Potash (25kg/ha) were applied. Herbicides used were Treflan, Fluometron and Dual. The year 2 site grew single skip cotton the previous season and received similar pre-planting treatment.

10 to 15% damage from a hail storm was recorded during the Christmas of 2003 and severe sun scald was experienced by the early maturing plots during late February 2005.

The trial was established within commercial furrow irrigated cotton crops having row lengths of approximately 550 to 600 metres. It consisted of 12 blocks each of 16 rows 4 metres in length in the first season and 24 rows by 3 metres in year 2. . Every third row was not planted which resulted in a single skip row configuration. Plantings were on October 16, 2003 and October 30, 31 2004 at 11 kg/ha resulting in an intra- row plant density of 9 plants per metre. Varieties were Sicot 14B (Bollgard II) , Sicot 80 (conventional) in year 1 and Sicot 80B (Bollgard II), Sicot 80 in year 2. These received either 1 or 2 irrigations as shown in figure 1.

2003-04

| | Sicot 14B 1 Irrigation | Sicot 14B 2 Irrigations | Sicot 80 2 Irrigations | Sicot 80 1 Irrigation |
|----|---------------------------|----------------------------|---------------------------|--------------------------|
| R1 | 3 | 6 | 9 | 12 |
| R2 | 2 | 5 | 8 | 11 |
| R3 | 1 | 4 | 7 | 10 |

2004-05

| | Sicot 80 B 1 Irrigation | Sicot 80 1 Irrigation | Sicot 80 B 2 Irrigations | Sicot 80 2 Irrigations |
|----|----------------------------|--------------------------|-----------------------------|---------------------------|
| R1 | 1 | 4 | 7 | 10 |
| R2 | 2 | 5 | 8 | 11 |
| R3 | 3 | 6 | 9 | 12 |

Figure 1. Trial layout.

The first irrigation in year 1 was considered a “flush” by the grower to correct slow early growth, 0.8ML/ha being applied to every second row on January 10, 2004 (86 das) on all blocks. Blocks 4 to 9 (Figure 1) received a second irrigation, during peak flowering, of 1.1

ML /ha on February 13, 2004 (120 das). Unfortunately on 12 January tail water from the irrigation of an adjacent crop backed into the furrows of blocks 1,4, 7 and 10. Data from these had to be eliminated which affected subsequent data analysis.

Irrigation (1.2 ML/ha) in year 2 was applied to all blocks on 3 January (64 das, early flowering) and again(1.2ML/ha) to blocks 7 to 12 on 27 January (88 das).

Crop development, biomass accumulation, leaf area accumulation, were monitored, in addition to final yield and fibre quality, on the middle two rows of each block. Yield of cotton was determined by hand picking 8 and 6 metres of row in each block in year 1 and year 2 respectively, in addition to mechanical harvesting two rows 200 metres in length per block. Meteorological data were recorded with an automatic weather station (ACGRA Daandine site) 1km from the site. Rainfall was also recorded on site.

The time course of soil water depletion within the plant row (P2), between rows (P1) and at intervals of 0.5m from the plant line to the middle of the skip (P3, P4) (figure 2), was followed at 10 cm intervals down the profile about every 10 days to a depth of 1.7m with a neutron moisture meter (NMM) from 5 November (20das, 2 leaf stage of growth) until final boll opening in year 1. Because of neutron loss near the soil surface, soil moisture content in the first two depth intervals was measured using a ThetaProbe®. Soil moisture monitoring in year 2 commenced at the 6 leaf stage (end of November 2004, 30 das) and ceased on 9 March 2005 (128 das).Data indicated that soil water content at 20 das to 165 cms was 95% of the upper limit in year 1 and was 86 % at 30 das in year 2.

Soil samples were taken for nutrient analysis during neutron probe access tube installation (following emergence) in both seasons. Results indicated high Cl levels from about the 120 cm depth level (Appendix 1) which could have restricted root growth at depth.

The calibration curve used for the NMM, which relates neutron count ratio to soil moisture content, was that which was established on similar soils by Goyne (2000). The inbuilt calibration for the ThetaProbe® was used, as it has been found to adequately represent volumetric soil water content in this soil type (Goyne unpublished).

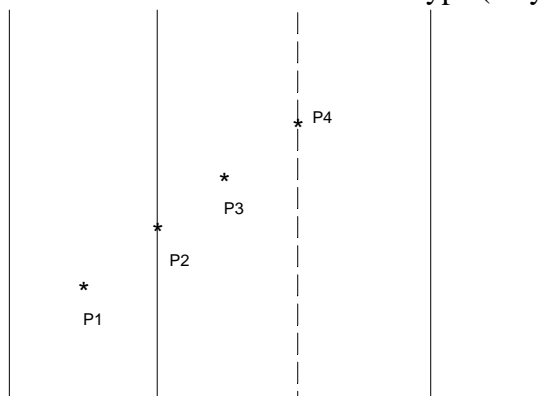


Figure 2. Solid lines depict planted rows and the broken line is the skip. P1 to P4 are the positions of the neutron moisture meter access tubes.

EnviroSCAN® sensors were installed in block 1 in positions P2 and P4 in year 1. These were set to read soil moisture at depth intervals 20, 40 60 80 cms. In addition, Diviner 2000® access tubes were installed in blocks 2 and 8 in positions P1 to P4 in year 1 and adjacent to blocks 2,5, 8, 11 in year 2, to provide soil moisture data at 10 cm intervals to 1.6 metres for comparison with the NMM data.

Results and Discussion

Year 1 and Year 2 Seasons

Year 2 growing season received only 257 mm rainfall compared with 510 mm in year 1. The higher average temperature and lower rainfall in year 1 resulted in a 217 day season compared with 162 days in year 2 (figure 3).

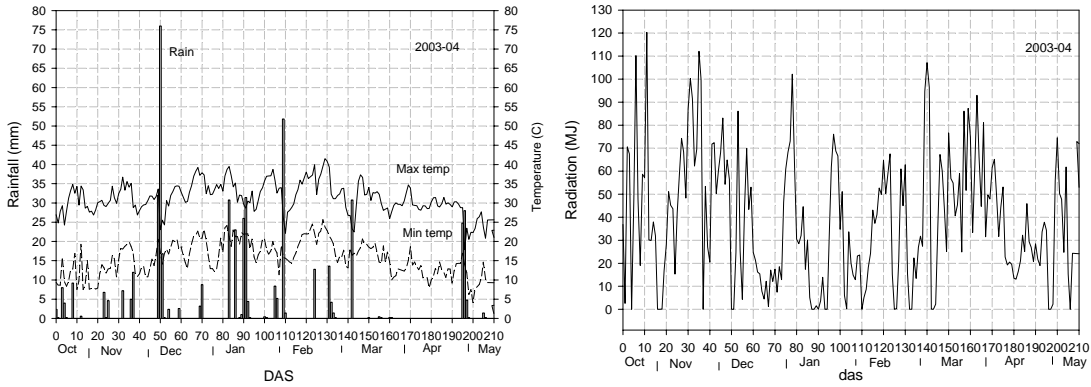


Figure 3. Rainfall, temperature and radiation recorded at the ACGRA Daandine weather station approx. 1 km from the trial site.

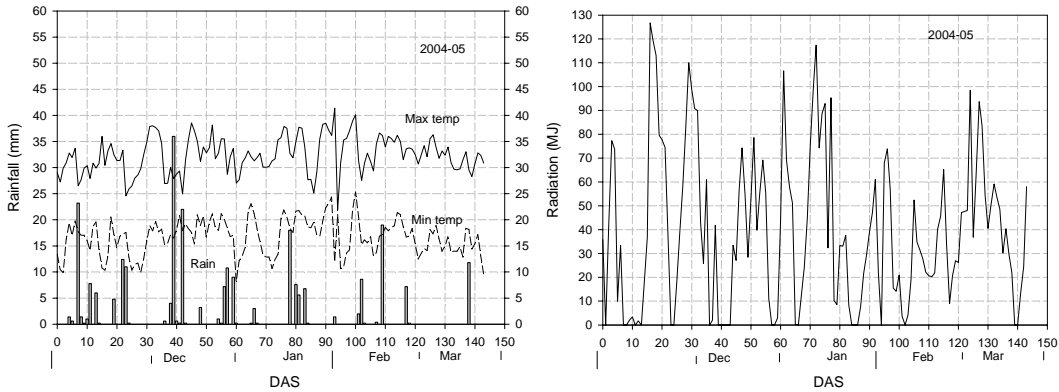


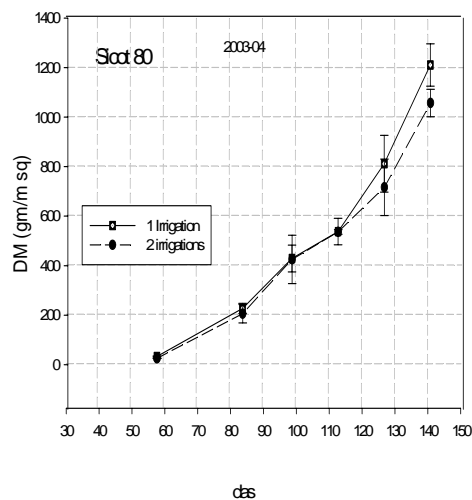
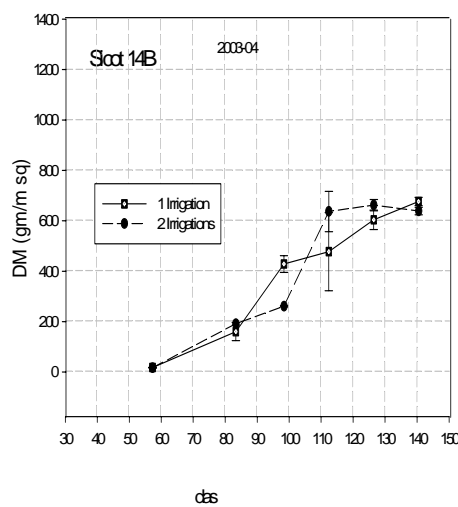
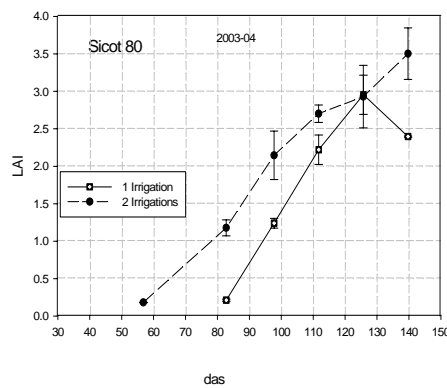
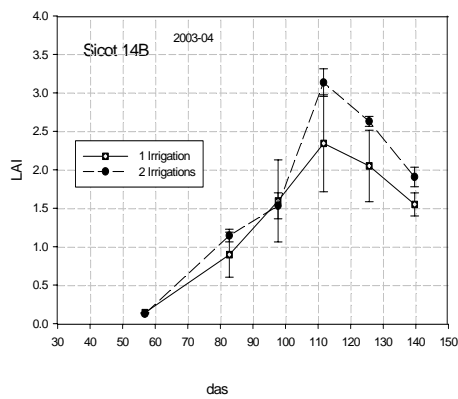
Figure 3. (contd.)

Crop Growth

Average dates of major events during the season:

| Event | das | year 1 | year 2 | Date | year 1 | year 2 |
|-------------------------------------|-----|--------|--------|------|-----------|-----------|
| Sowing | | 0 | 0 | | 16 Oct 03 | 30 Oct 04 |
| 4- 6 leaf stage | | 26 | 31 | | 13 Nov 03 | 30 Nov 04 |
| First flowers | | 76 | 61 | | 31 Dec 03 | 29 Dec 04 |
| First irrigation | | 86 | 64 | | 10 Jan 04 | 3 Jan 05 |
| Second irrigation | | 120 | 88 | | 13 Feb 04 | 27 Jan 05 |
| First open bolls | | 140 | 76 | | 4 Mar 04 | 15 Jan 05 |
| 1st pick (hand) | | 161 | 123 | | 25 Mar 04 | 3 Mar 05 |
| 2nd pick (hand) | | 174 | 129 | | 7 Apr 04 | 9 Mar 05 |
| 3rd pick (hand) | | 189 | 142 | | 22 Apr 04 | 22 Mar 05 |
| 4 th pick & machine pick | | 217 | 162 | | 20 May 04 | 11 Apr 05 |

Figures 4 and 5 show treatment comparisons of leaf area index (LAI), biomass (DM), squares/plant, bolls/plant, plant height, 4-5 internode length:



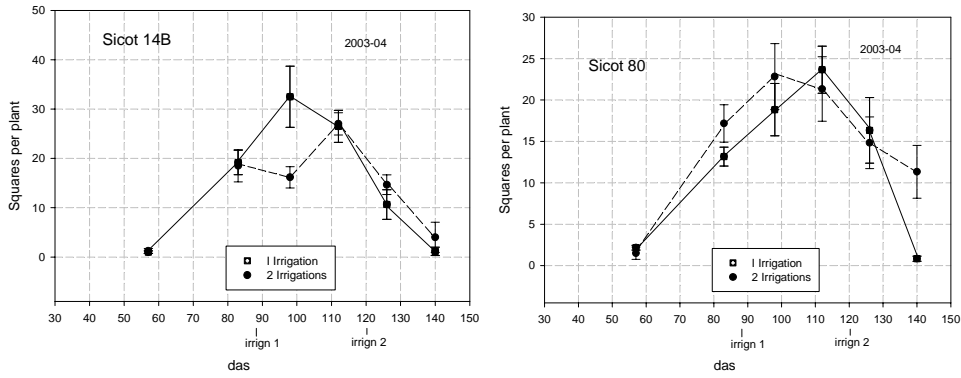


Figure 4 a. Treatment comparisons of LAI, DM squares and bolls/plant. Vertical bars are standard errors.

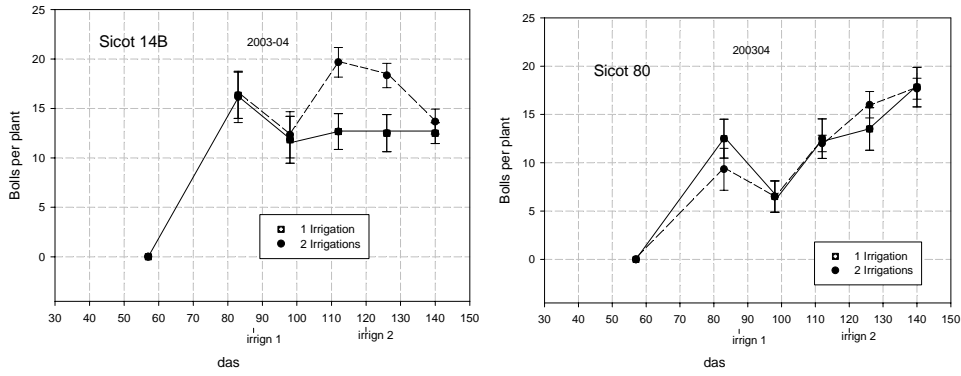


Figure 4 a (contd). Treatment comparisons of LAI, DM squares and bolls/plant. Vertical bars are standard errors.

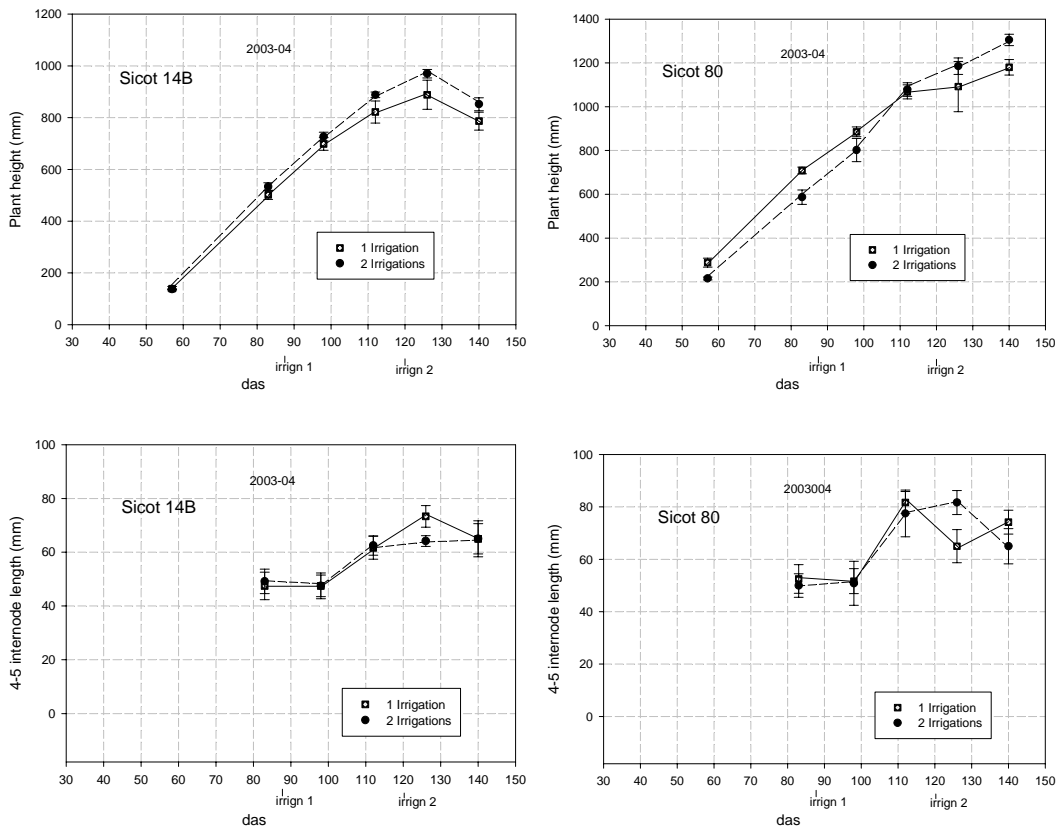


Figure 4 b . Treatment comparisons of plant height and 4-5 internode length.

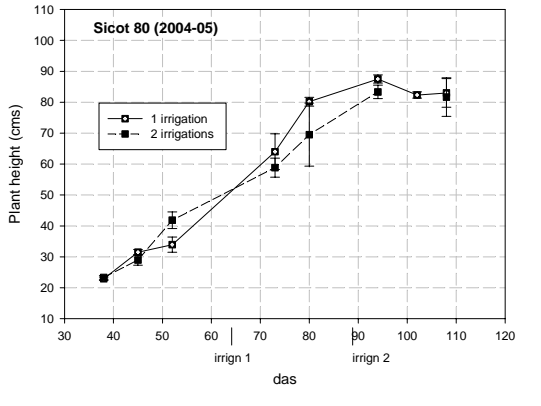
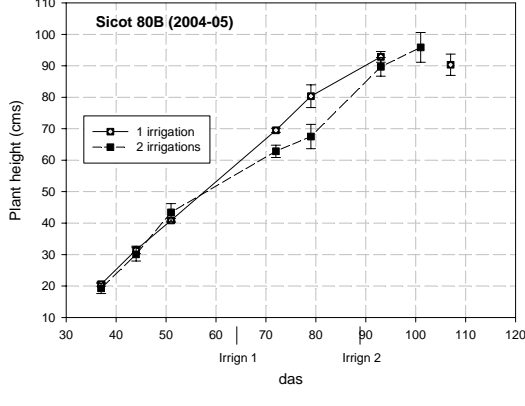
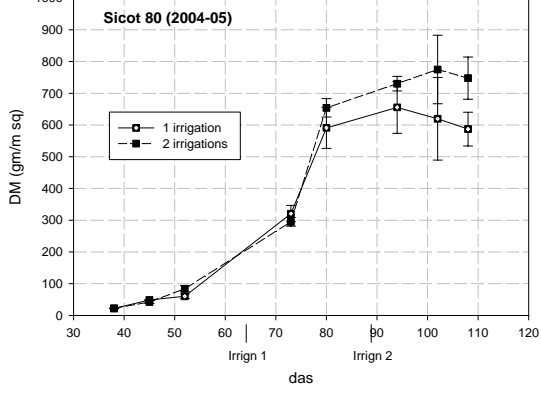
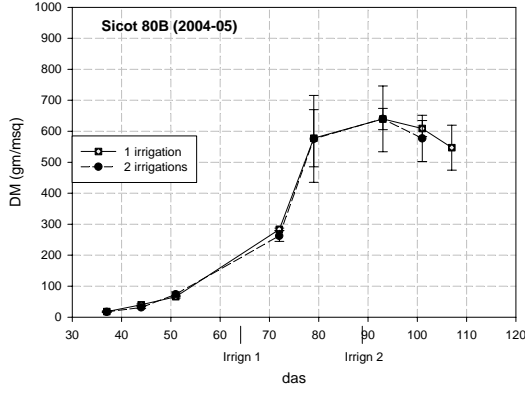
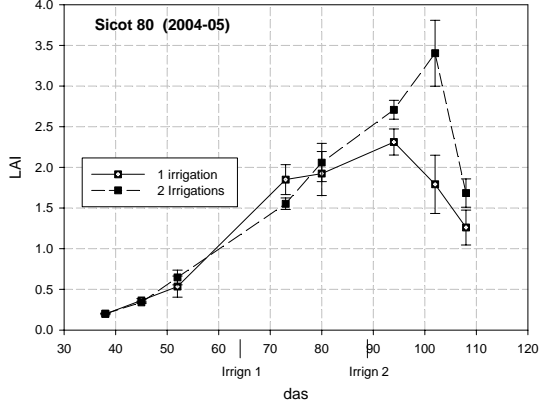
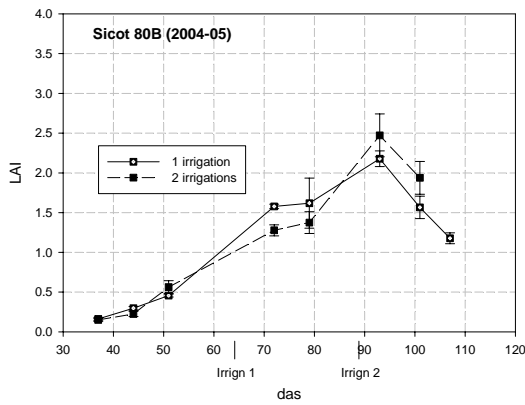


Figure 5 a . Treatment comparisons of LAI, DM and plant height 2004-05 season. Vertical bars are standard errors.

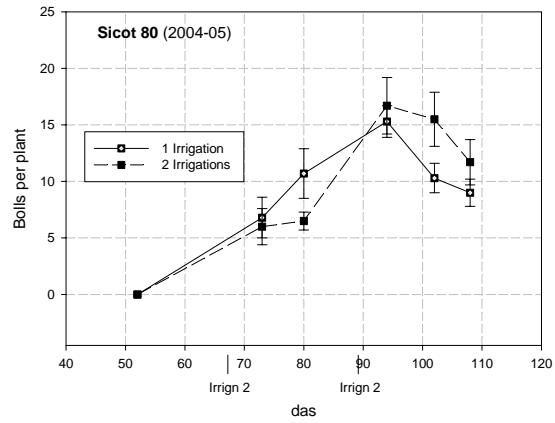
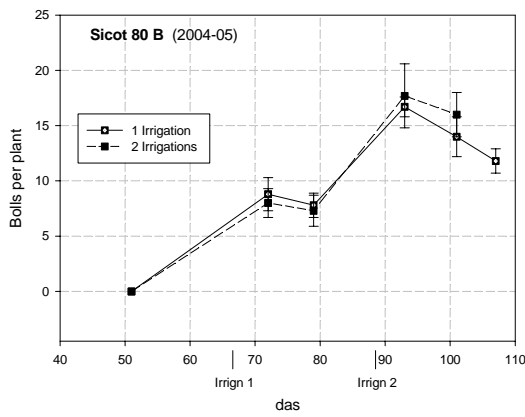


Figure 5 b. Bolls per plant 2004-05 season.

Analysis of growth rate using the early season diagnosis tool (Aust.Cotton CRC 2003) in year 1 indicates slow early growth in year 1 which prompted the trial cooperators to apply a “flush” irrigation on January 10 (figure 6).

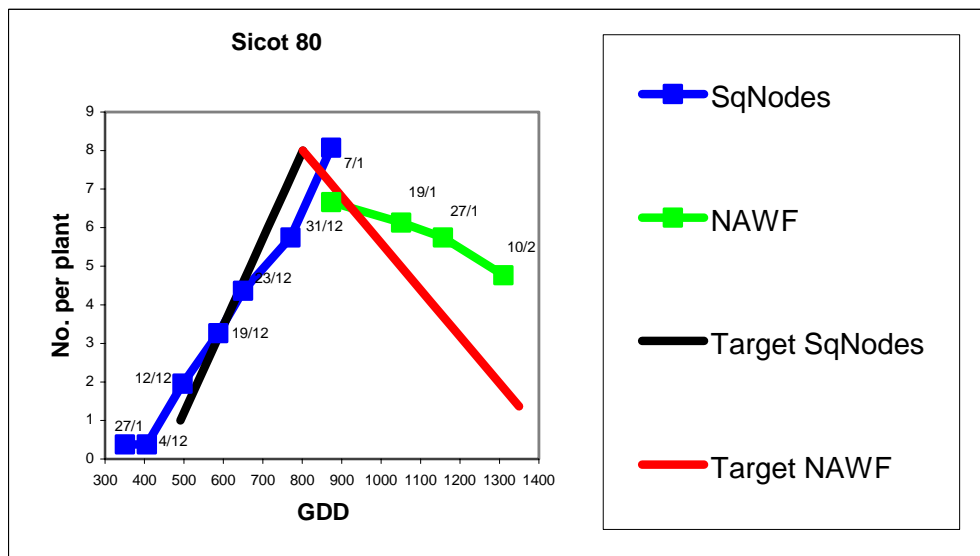


Figure 6. Growth rate of the crop compared with the ideal using the early season diagnosis tool.

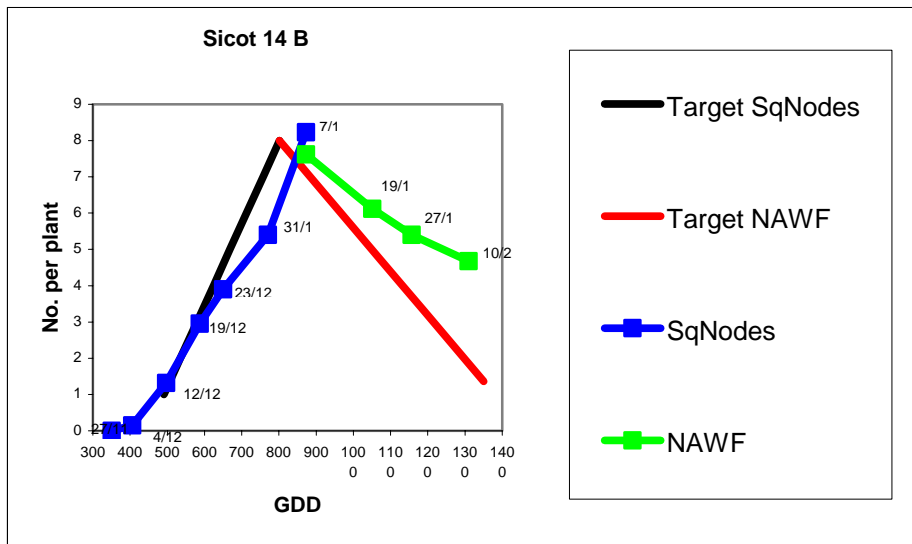


Figure 6. (contd.).

In year 2 the number of nodes above white flower in all treatments were below the optimum and lagged well behind the target throughout the season leading to early “cutout” , a short season and low yields.

Yield (year 1)

On 12 January in year 1, tail water from the irrigation of an adjacent crop backed into the furrows of blocks 1,4, 7 and 10. Data from these had to be eliminated consequently analysis of variance procedures could not be performed on the data. However, the primary aim of the trial was to obtain soil water extraction information and this was achieved.

Hand harvested:

| Treatment | Yield bales/ha (lint) | Ginning % |
|-------------------------|-----------------------|-----------|
| Sicot 14B 1 irrigation | 6.2 | 39.7 |
| Sicot 14B 2 irrigations | 8.4 | 37.9 |
| Sicot 80 1 irrigation | 9.9 | 43.3 |
| Sicot 80 2 irrigations | 10.1 | 42.2 |

Machine harvested:

| Treatment | Yield bales/ha (lint) |
|-------------------------|--------------------------|
| Sicot 14B 1 irrigation | 6.4 |
| Sicot 14B 2 irrigations | 7.8 |
| Sicot 80 1 irrigation | 7.0 |
| Sicot 80 2 irrigations | 8.7 |

Fibre Quality (year 1)

| Variety | Irrigations | Length | uniformity | Short fibre index | strength | elongation | micronaire |
|-----------|-------------|--------|------------|-------------------|----------|------------|------------|
| Sicot 14B | 1 | 1.14 | 84.5 | 8.35 | 28.6 | 6.95 | 4.4 |
| Sicot 14B | 2 | 1.21 | 85.1 | 7.95 | 29.8 | 6.75 | 4.5 |
| Sicot 80 | 1 | 1.12 | 82.2 | 9.15 | 28.7 | 8.15 | 4.6 |
| Sicot 80 | 2 | 1.21 | 84.9 | 8.2 | 29.1 | 8.15 | 4.5 |

Yield (year 2)

Hand harvested:

| Variety | Irrigations | Bolls per m sq | Wt per boll (gms) | Seed kg/ha | Lint bales/ha | GTO % |
|------------------|-------------|----------------|-------------------|------------|---------------|---------|
| Sicot 80B | 1 | 44.1 ab | 4.42 a | 1185.3 b | 3.37 a | 39.2 a |
| Sicot 80B | 2 | 64.0 c | 4.85 b | 1832.7 c | 5.59 b | 40.9 ab |
| Sicot 80 | 1 | 39.9 a | 4.62 ab | 1039.8 a | 3.54 a | 43.5 b |
| Sicot 80 | 2 | 57.9 bc | 5.55 c | 1843.6 c | 6.03 b | 42.7 b |

(for columns- numbers followed by the same letters are not significant at $p < 0.05$)

The table above shows that for the same irrigation treatment Sicot 80 and Sicot 80B produced similar yields.

Machine harvested

| Treatment | Yield bales/ha (lint) |
|-------------------------|--------------------------|
| Sicot 80B 1 irrigation | 3.2 |
| Sicot 80B 2 irrigations | 5.4 |
| Sicot 80 1 irrigation | 3.2 |
| Sicot 80 2 irrigations | 5.3 |

Fibre Quality (year 2)

| Variety | Irrigations | Length | uniformity | Short fibre index | strength | elongation | micronaire |
|----------------------|-------------|--------|------------|-------------------------|----------|------------|------------|
| Sicot 80B | 1 | 1.17 a | 80.97 a | 12.70 a | 34.9 a | 4.6 a | 3.27 a |
| Sicot 80B | 2 | 1.19 a | 82.73 a | 10.27 a | 33.8 a | 5.4 c | 3.70 a |
| Sicot 80 | 1 | 1.13 a | 81.83 a | 11.47 a | 33.3 a | 5.0 ab | 3.57 a |
| Sicot 80 | 2 | 1.17 a | 82.17 a | 10.97 a | 33.2 a | 5.1 bc | 3.73 a |

(for columns- numbers followed by the same letters are not significant at $p < 0.05$)

Year 2 analysis showed there were no differences within treatments for fibre quality characters except for elongation.

There were limitations of the trial design for statistical analysis, but the design used was necessary for practical considerations as this work was conducted on a commercial property. Consequently, in year 2 the options which were used for analysis of the hand picked plots were:

- Consider the 2 irrigation treatments as replicates (blocked). Hence there are 2 replicates of each variety with 3 samples within each plot and can analyse each of the variables using analysis of variance (anova).
- Calculate 95% confidence intervals for each variety mean (based on the 6 observations of each variety mean for each variable), then compare confidence intervals to see if they overlap or not. If they do not overlap we can reasonably say that the two variety means are significantly different .

None of the analysis of the variables in the Hand picked table (year 2) using anova showed a significant variety effect. Analysis using confidence intervals indicated that only for gto% were the varieties significantly different.

Profile Soil Water

Figure 7a shows, for year 1, the total mm of water in the soil profile to 165cms. Although some graphs have missing data (equipment failure) they indicate that soil water was maintained above 50% PAWC (527mm) by irrigation and rainfall until about days 135, 150, 125 and 150 for Sicot 14B/ 1 irrigation, Sicot 14B / 2 irrigations, Sicot 80/ 1 irrigation and Sicot 80/ 2 irrigations respectively. From the comparison of figures 7a and 7b it is apparent that year 2 profile soil moisture was well below that for year 1.

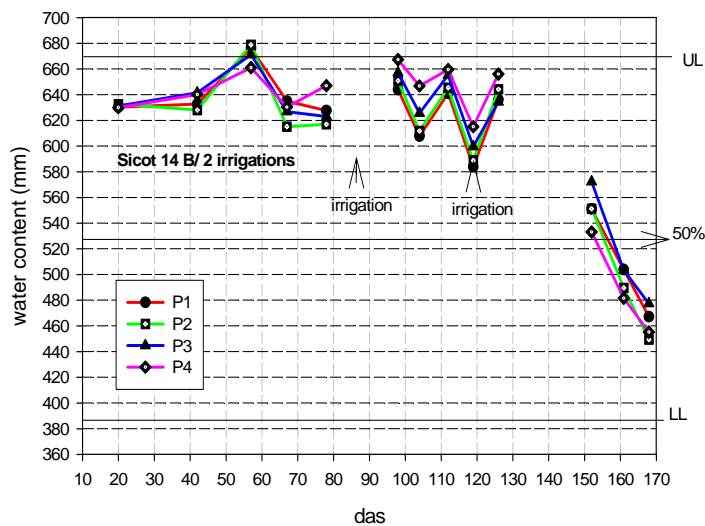
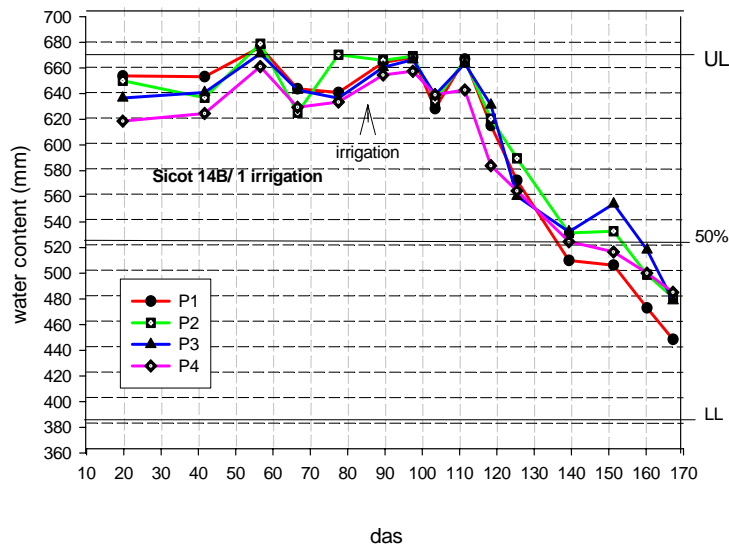


Figure 7a. Total mm of water in the soil profile to 165 cms and days after sowing (das).

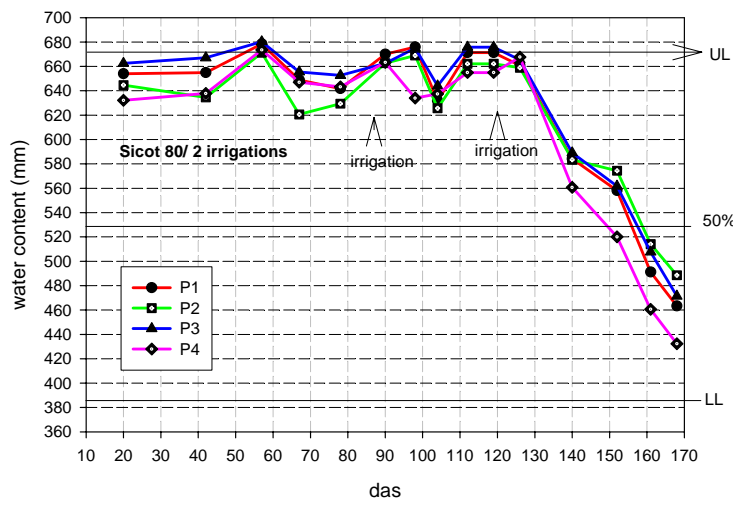
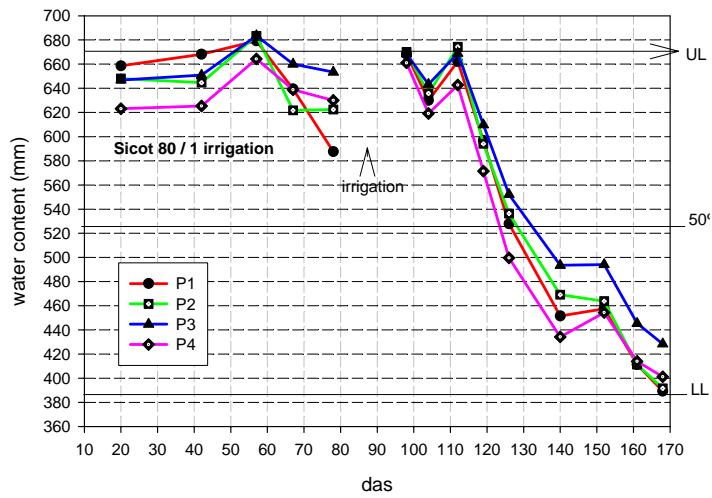


Figure 7a. (Contd.)

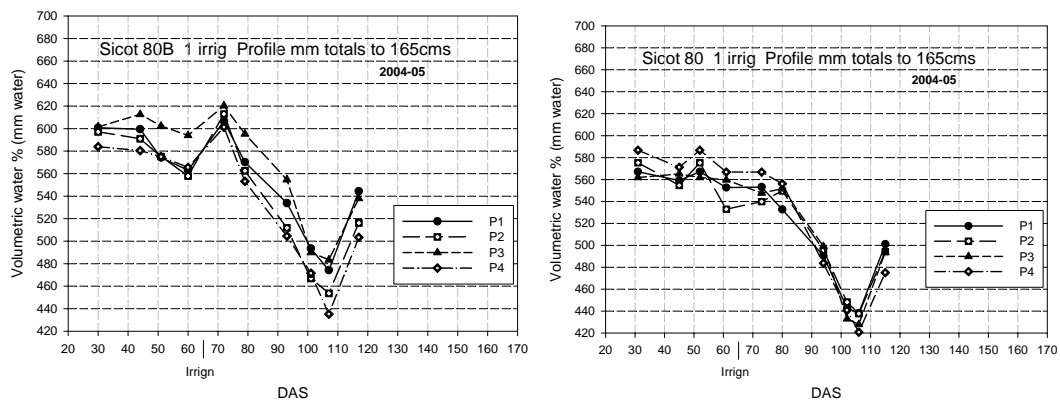


Figure 7b. Total mm of water in the soil profile to 165 cms and days after sowing (das).

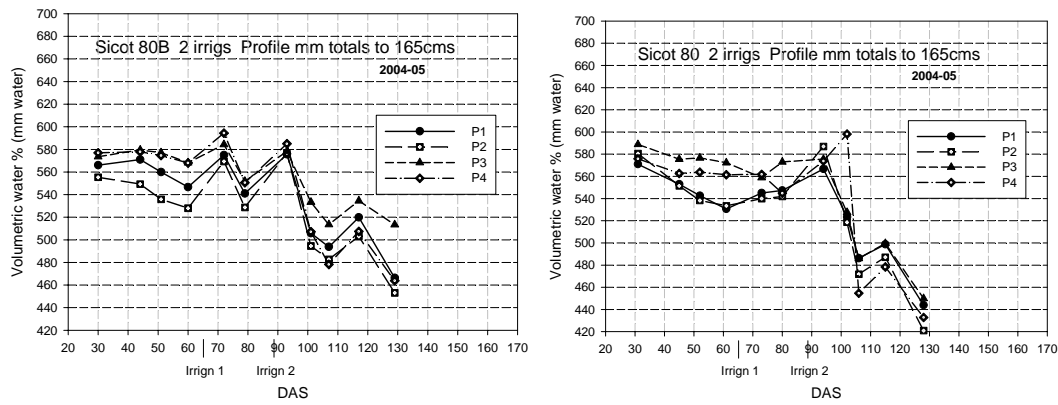


Figure 7b. (Contd.)

In Year 2 there was significantly ($p < 0.05$) more water left in the profile, at the end of the season, in Sicot 80B plots than in Sicot 80 plots.

Soil Water Extraction

This project is concerned with understanding the supply of soil water to the plant which is limited in skip row cotton culture. Monteith (1986) proposed a scheme which is an improvement over the approaches commonly used in modelling the soil water supply. The scheme has been validated for sorghum and millet (Monteith, 1986) and sunflower (Meinke et al., 1993).

The analytical framework of the scheme comprises a function describing the downward movement of the extraction front and a function which accounts for the extraction behaviour of a static root system. When the root front arrives at a particular depth and starts to extract water, the soil water begins an exponential decline.

Goyne (2000) applied this scheme to raingrown cotton data with reasonable success. These data were obtained over seasons which were relatively rain free resulting in the soil profile being exposed to continually drying conditions. However, rainfall during both seasons (figure 8) and the applied irrigations, resulted in the analytical scheme being inappropriate for these data.

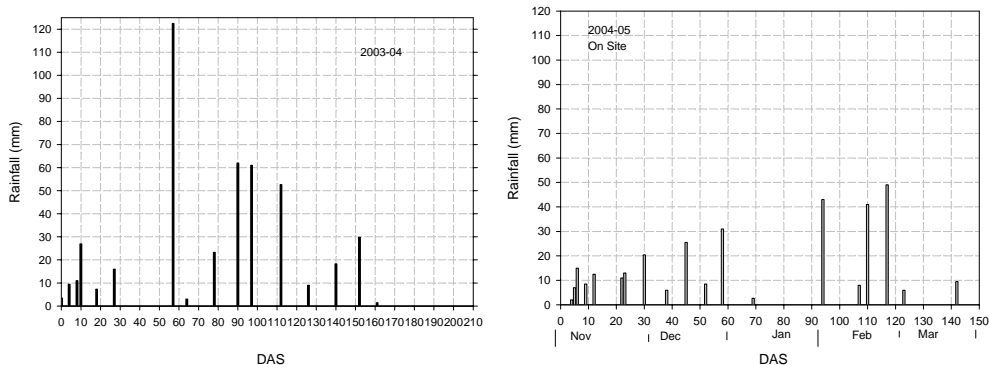


Figure 8. Rainfall accumulated in gauge at trial site by days shown since previous reading. An alternative procedure was applied as follows:

Neutron moisture meter recordings were therefore converted to volumetric moisture then mm water per 10 cms for each recording date. The means for each variety/irrigation treatment and access tube position were then plotted for each depth interval, an example of which is shown in figure 9. The very low soil water content shown, (less than 15% volumetric) was possibly due to the interference of soil cracks when present.

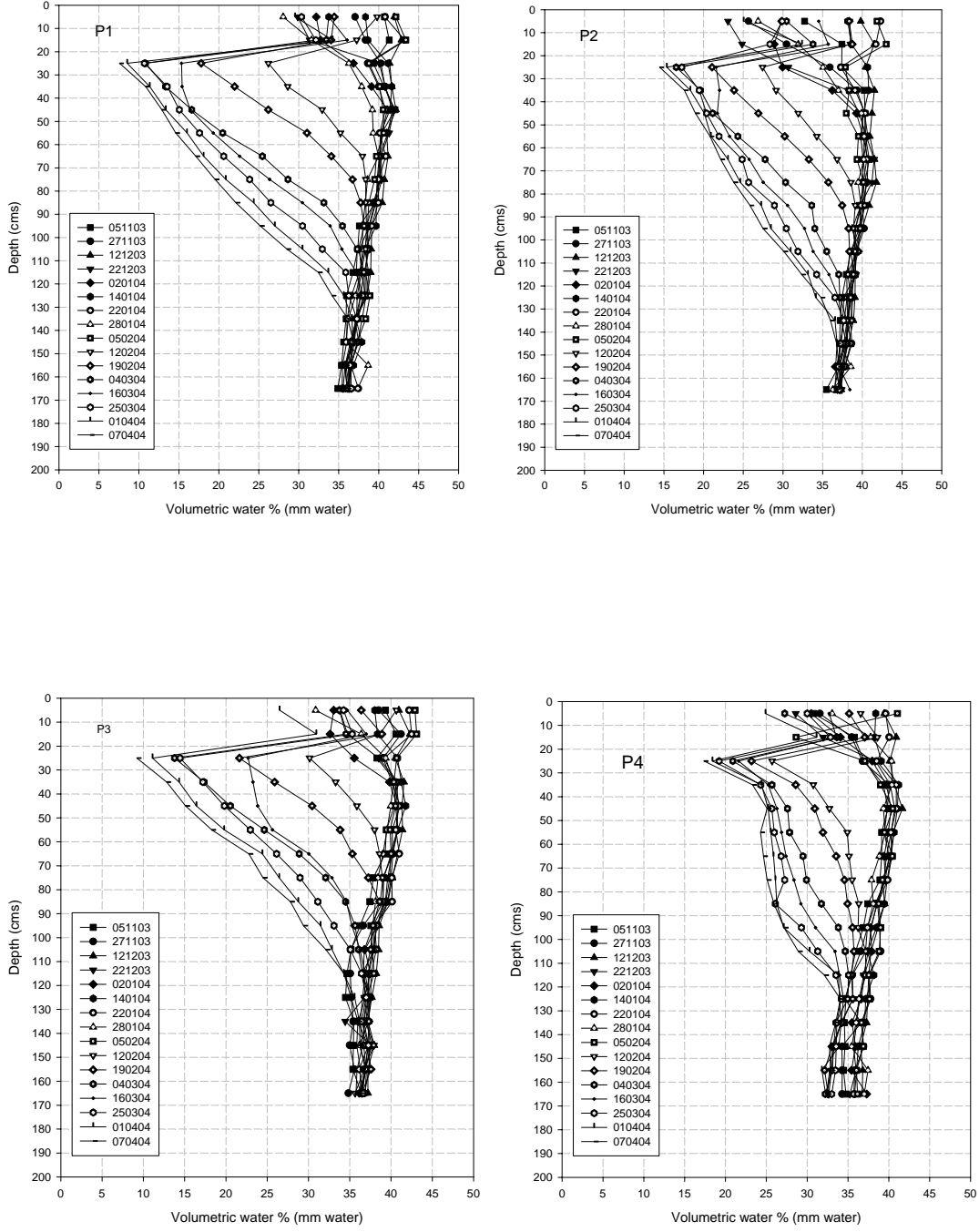


Figure 9. Profile soil water content for Sicot 14 B/1 irrigation at positions P1 to P4 on the dates shown in Year 1.

The high values at 5 and 15 cm levels (determined with a Theta Probe) were due to the frequent rainfall events and low evaporation under the plant canopy.

Data following major rainfall and irrigation events were removed (figure 10) to enable dates (and hence days after sowing- das) and corresponding depths of extraction to be read from the graphs. An example of the data for Sicot 14B/ 1 irrigation is shown in the table following:

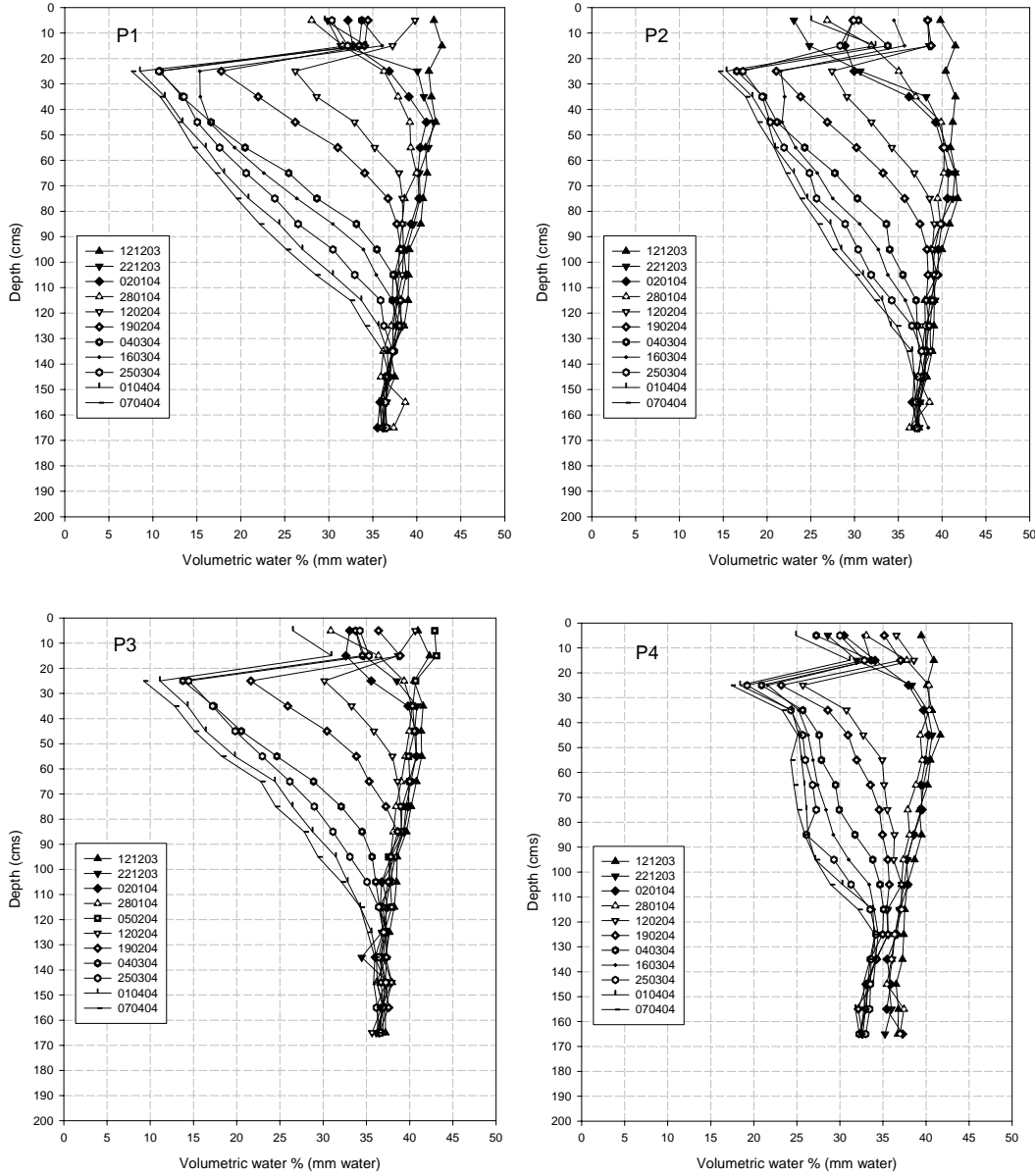


Figure 10. Profile soil water content for Sicot 14 B/1 irrigation at position P1 with major rainfall and irrigation events removed. Depth of extraction and corresponding dates are clearly seen.

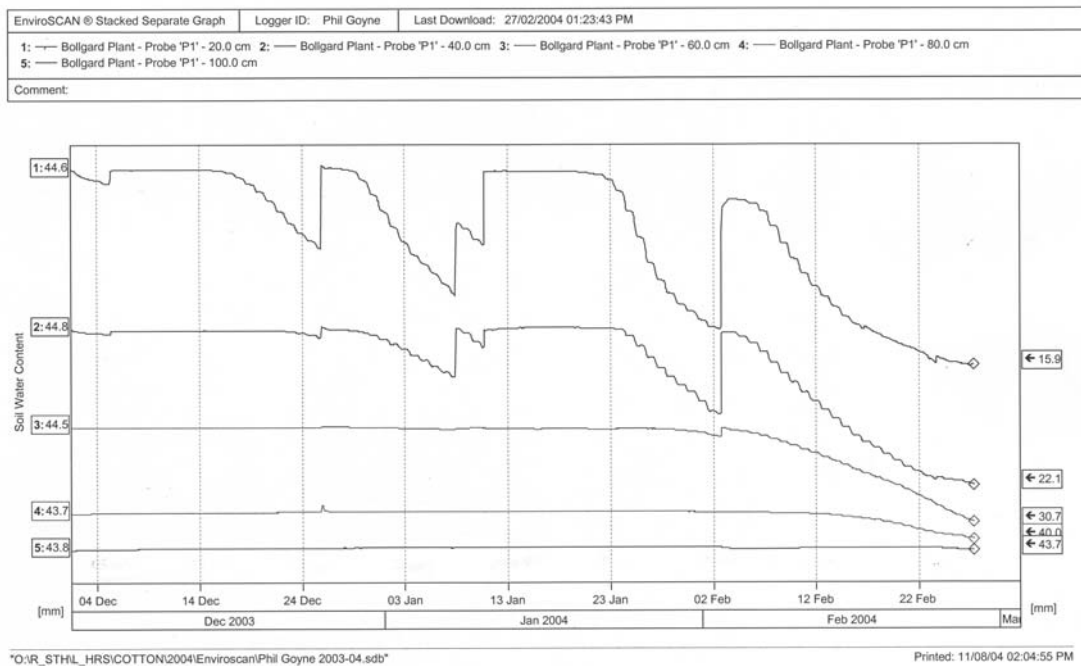
Year 2 profiles for all treatments are shown in Appendix 2.

The profile soil water graphs indicate that the maximum depth of extraction was about 140 cms and 105 cms in years one and two respectively.

Days after sow (das) and corresponding extraction depth for Sicot 14B/1 irrigation:

| Extraction depth (cms) | P1 das (date) | P2 das (date) | P3 das (date) | P4 das (date) |
|------------------------|---------------|---------------|---------------|---------------|
| 25 | 67 (221203) | | 78 (020104) | |
| 35 | 78 (020104) | 67 (221203) | | |
| 45 | | 78 (020104) | | 104 (280104) |
| 55 | | | 104 (280104) | |
| 65 | 104 (280104) | | | |
| 75 | | 104 (280104) | | |
| 85 | 119 (120204) | | 119 (120204) | 119 (120204) |
| 95 | | 119 (120204) | 140 (040304) | |
| 105 | 140 (040304) | 140 (040304) | 152 (160304) | 140 (040304) |
| 115 | 152 (160304) | 161 (250304) | 161 (250304) | 152 (160304) |
| 125 | 161 (250304) | 168 (010404) | 168 (010404) | 161 (250304) |
| 135 | | 174 (070404) | 174 (070404) | 168 (010404) |

A number of these das/depth data could be confirmed from comparison with the EnviroSCAN records although only a limited number of sensors were installed in the Sicot 14B/1 irrigation treatment (figure 11).



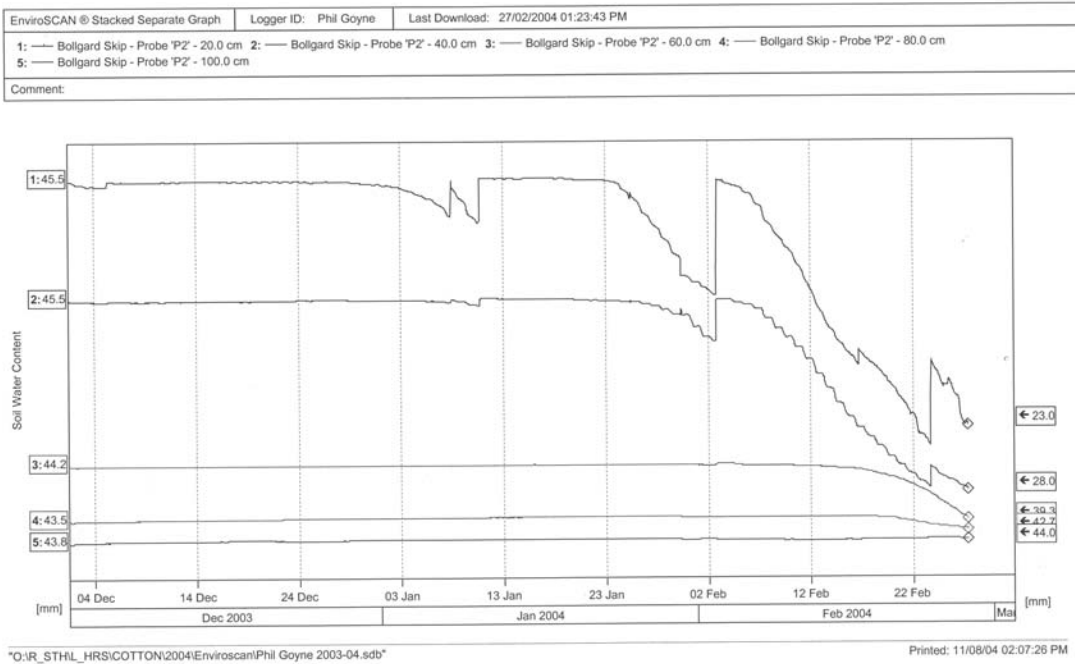


Figure 11. EnviroSCAN graphs treatment Sicot 14B/1 irrigation. Top graph from position P2 and bottom graph position P4. Note the EnviroSCAN was not calibrated to soil type therefore being used only to relate extraction depth to date.

It can also be seen from the EnviroScan graphs that considerable waterlogging was experienced following some rainfall and irrigation events. For example, the graph for P2 at 20 cm depth indicates waterlogging from 26 December to 29 December. A further 12 days of waterlogging occurred from 10 January after the first irrigation which was followed by 123 mm of rainfall received during the next 11 days.

The Diviner data did show reasonable similarity to the neutron moisture meter data in determining depth of extraction in some cases. For example, depth of extraction data taken from figure 12 are compared in the table following.

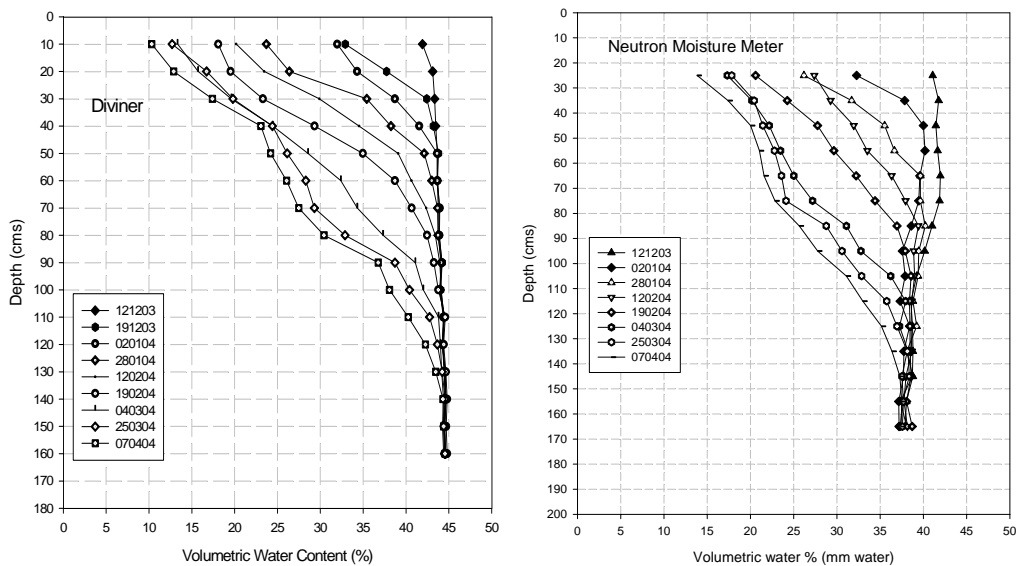


Figure 12. Plot of Diviner data for Sicot 14B/1 irrigation position P2 compared with that for the neutron moisture meter.

Depth of extraction and das estimates for the neutron moisture meter compared with those from the Diviner:

| Depth (cm) | Das (date)- Diviner | das- neutron moisture meter |
|------------|---------------------|-----------------------------|
| 45 | 78 (020104) | 78 |
| 75 | 119 (120204) | 119 |
| 95 | 126 (190204) | 126 |
| 105 | 140 (040304) | 140 |
| 115 | 161 (250304) | 161 |
| 135 | 174 (070404) | 174 |

Although the similarity between the Diviner data and neutron moisture meter were consistent in the above example, some data from the other sampling positions were not. Before depth of extraction estimates are determined solely using the Diviner, further investigations need to be carried out. Diviner data for year 2 are presented in Appendix 3.

Days after sowing (das), determined from the neutron moisture meter depth/moisture content plots, were regressed against extraction depth- figure 13.

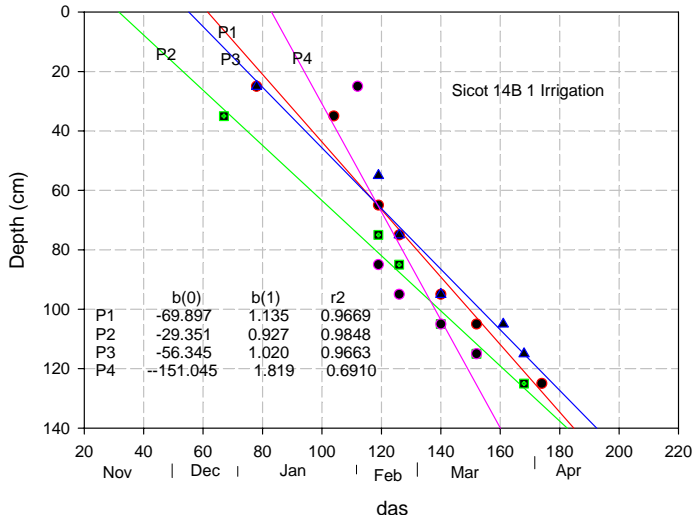


Figure 13. Depth of extraction vs das – Year 1

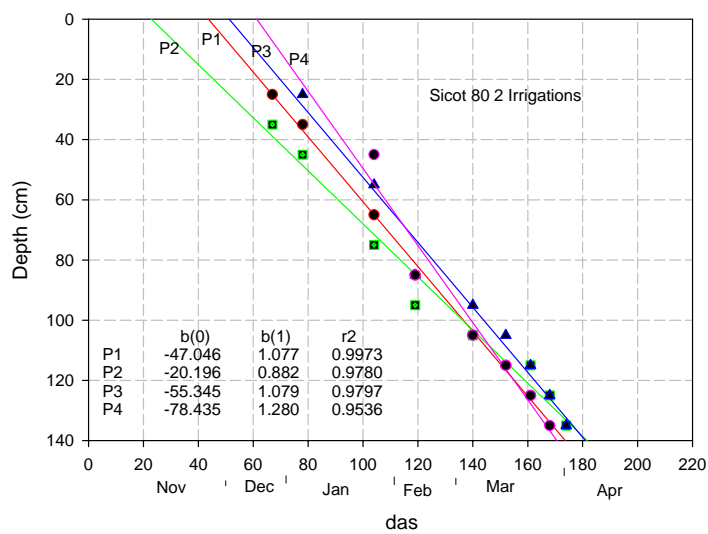
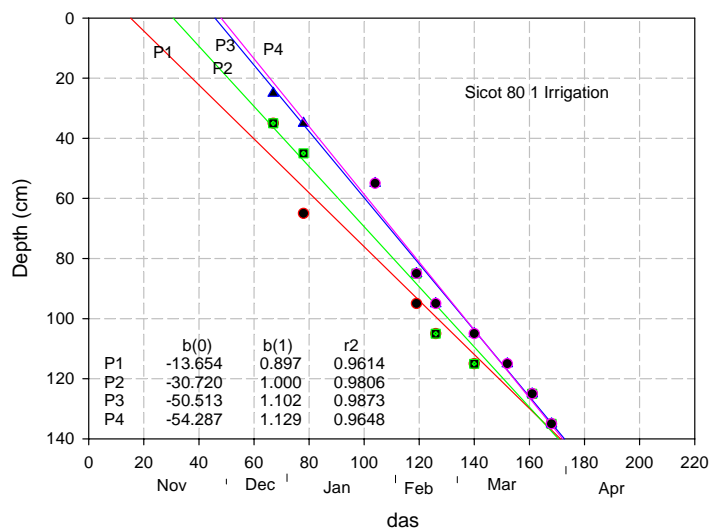
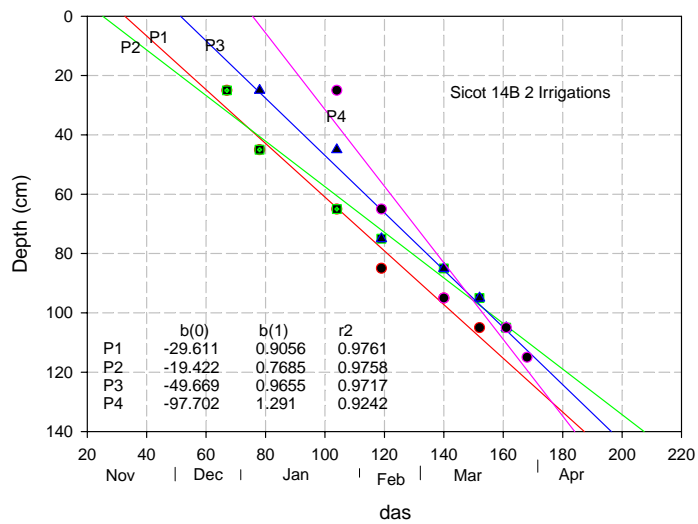


Figure 13. (Contd.)

Similar relationships were obtained in Year 2 and presented in Appendix 4.

The relationship between das and depth is similar to the regressions of t_c (time ,das, of first water extraction in a layer) and depth of extraction presented by Goyne (2000) for raingrown cotton. In all cases position P4 has the steepest slope (but only marginally in the case of Sicot 80/1 irrigation) which is in agreement with P4 having the highest extraction front velocity as reported by Goyne (2000). It is suggested that the roots grow into the skip area (to P4) and down the profile and are triggered by some plant signal to begin extracting after water at or near the plant line has been extracted. This extraction at P4 generally takes place at a more rapid rate than at the other positions.

Interestingly these relationships are linear. It is observed that although the movement of the extraction front down the profile can be interrupted by a rainfall, or irrigation event for a number of days, movement is then resumed with the extraction front following the same linear trend.

The timing of depth of extraction calculated from figure13 relationships is shown in figure 14.

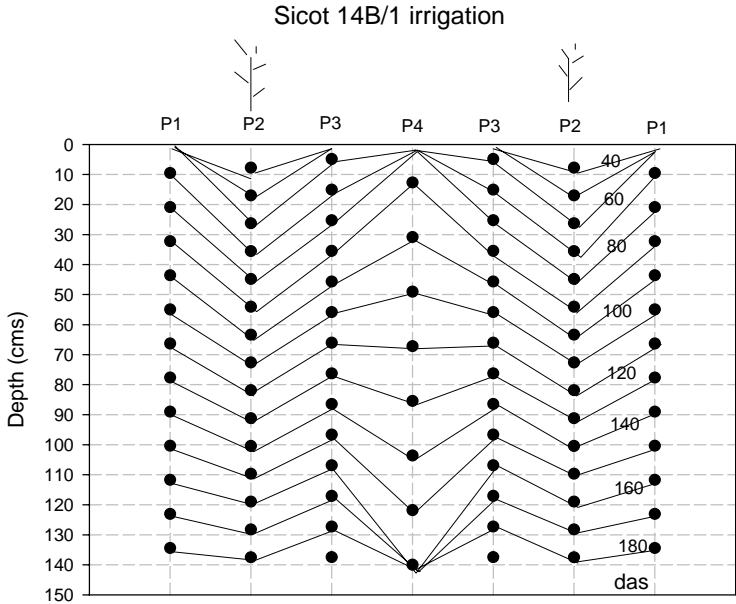
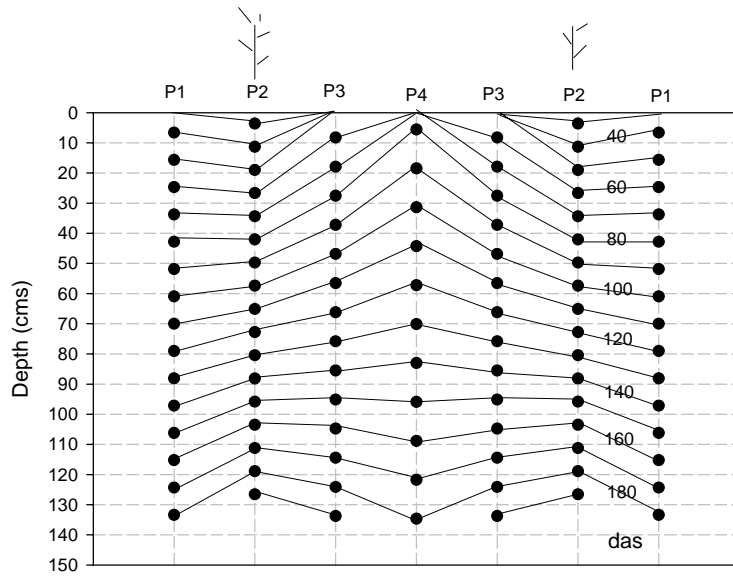


Figure 14. Timing of soil water extraction down the profile 2003-04.

Sicot 14B/2 irrigations



Sicot 80/1 irrigation

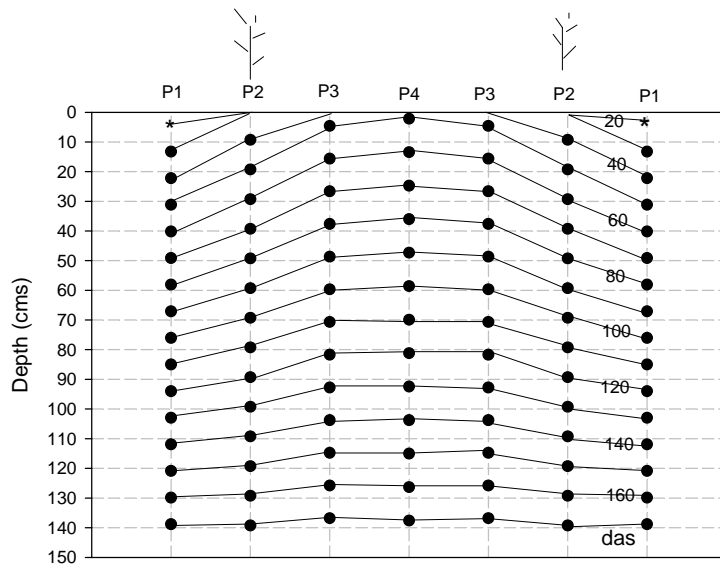


Figure 14. Contd.

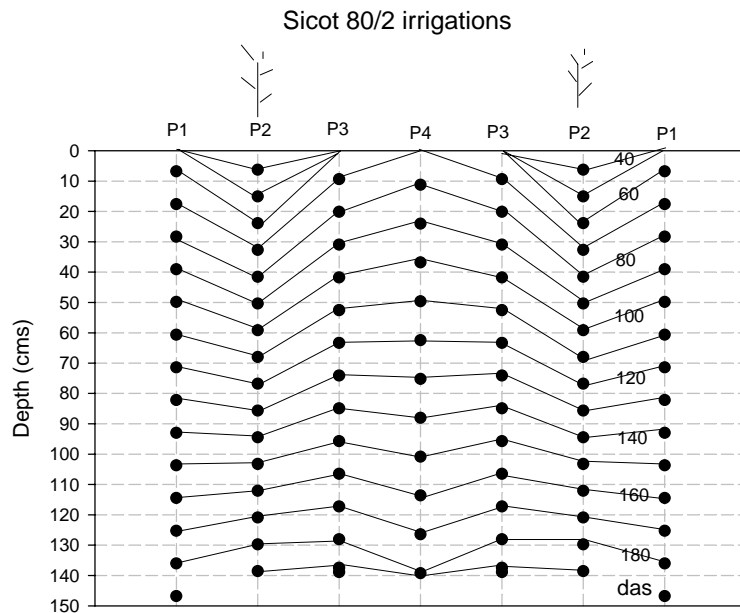


Figure 14. Contd.

The Sicot 80/ 1 irrigation pattern is unusual and not what was expected. Further investigation is necessary. Appendix 5 shows patterns of extraction for year 2.

In addition to the extraction of soil water down the soil profile , the rate of extraction diagonally across the profile from the plant line (P2), as shown in figure 15, was investigated.

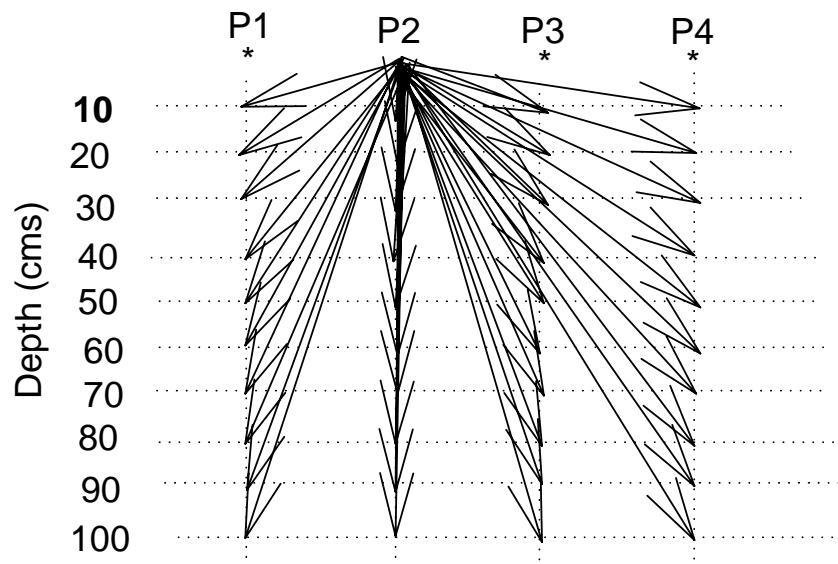


Figure 15. Diagrammatic representation of soil water extraction (extraction front-EF) diagonally across the profile from the plant line (P2) including the vertical extraction from P2.

Rates of travel of the extraction front relative to the directions shown in figure 15 are represented in the graphs of figure 16 (2003-04):

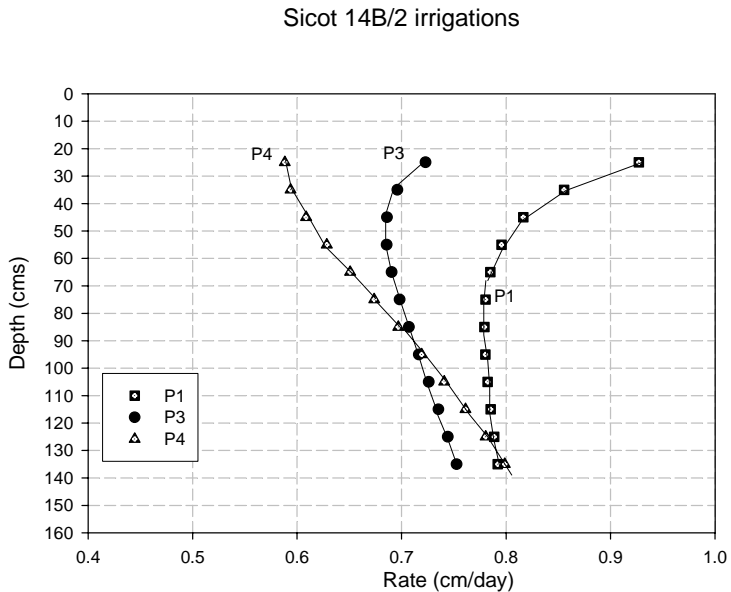
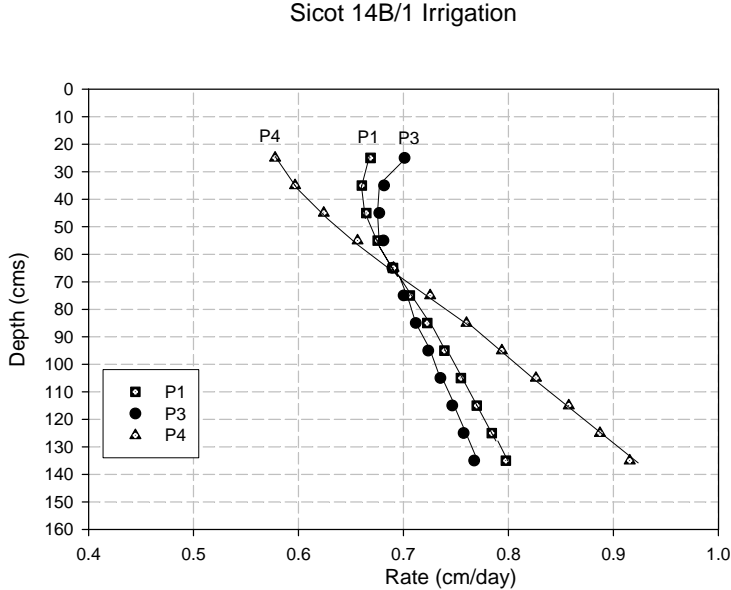
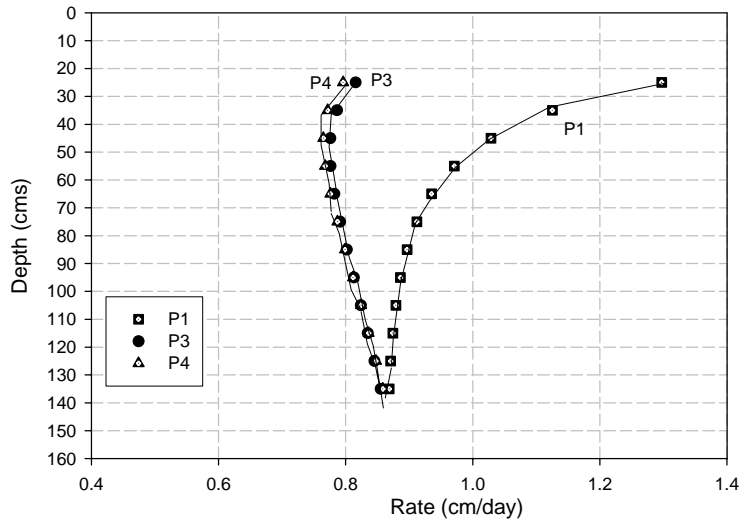


Figure 16. Rate of travel of the Extraction front (EF) from the plant line to the position shown.

Sicot 80/ 1 irrigation



Sicot 80/ 2 irrigations

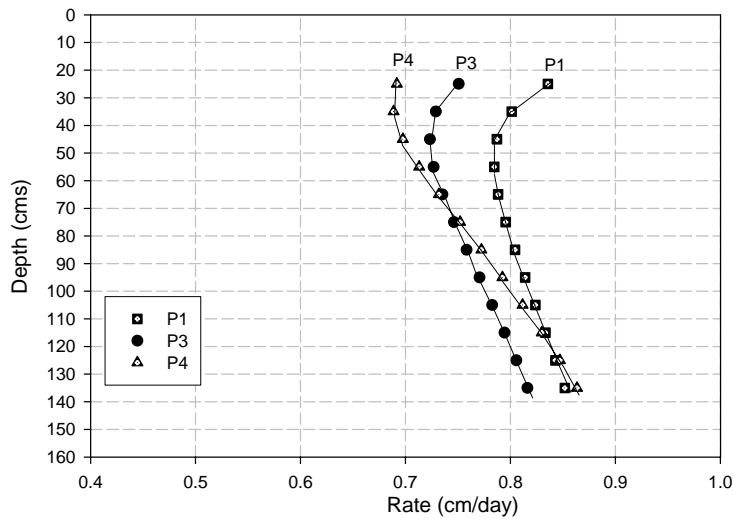


Figure 16. Contd.

Conclusions and Recommendations

The Year 2 trial, in addition to expanding the data set on soil moisture extraction dynamics, provided the opportunity to compare Bollgard II and conventional cotton, as Sicot 80B and its “equivalent”, Sicot 80, were planted.

Given the same irrigation treatment Bollgard II and conventional were similar in yield (lint bales/ha) and fibre quality, although Bollgard II was earlier maturing and appeared to use less soil moisture than conventional.

In both seasons soil moisture was used in and close to the plant line before the middle of the skip, where its use down the profile was rapid, as shown by the higher extraction front velocity. There is some evidence (Goyne 2000) that the roots position themselves into the

skip area and wait for a plant signal before water extraction commences in the mid-skip area. Further evidence of this is required and investigation and would be assisted by the use of mini-rhizotrons. If this theory is correct then the search for the switch (critical fraction of transpirable water in the plant line ?) could be conducted.

In addition, further trials need to be carried out so the data set can encompass various climatic conditions and soil types. Then Ozcot can be enhanced and management scenarios investigated.

Impact on Cotton Industry

The data obtained from this project will be added to data resulting from a new project which has been proposed to the Cotton Catchment Communities CRC for funding:

'Determining strategies for irrigated and dryland farming systems which maximize WUE to enhance environmental and economic benefits for new and existing cotton growing regions'.

It is envisaged by the completion of this project:

- 3) An improved cotton crop model will be developed to enable determination of optimum crop management and farming system irrigation practises to increase WUE.
- 4) Reliable climatic forecasting indicators will be identified for existing and future proposed growing regions.

A decision support package, using the enhanced cotton crop model and climatic forecasting, as a risk management tool will then be available. It will evaluate the probability of achieving a given level of economic return for a range of farming system practises, given cropping area and water availability for a given seasonal outlook. The proposed project will be addressing the CCC CRC objectives of a 20% increase in WUE. This could equate to an extra \$89 million per year (at \$500 per bale) for Queensland alone- an extra \$1000 per ha profit .

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Robertson, M.J., Fukai, S., Ludlow, M.M. and Hammer, G.L. (1993). Water extraction by grain sorghum in a sub-humid environment. I. Analysis of the water extraction pattern. *Field Crops Research*, 33:81-97.

Presentations and Public Relations

A poster (“Comparison of single skip Bollgard II[®] and conventional cotton with limited irrigation”) representing this research was displayed at the 2005 Cotton Trade Show , Moree.

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Sincere thanks to Neville Walton and Bruce Holdicott whose excellent cooperation resulted in the smooth running of these trials; John Marshall of Cotton Seed Distributors for supplying the seed; Simon White for his excellent assistance with the field work; Dr Nicole Goyne also assisted with soil moisture monitoring; David Wigginton for assistance with monitoring equipment; Rachael Russell for the lab work; Jenelle Hare for mapping the progress of the crop in year 1 and assistance with equipment supply; Kellie Cooper , ACRI, for fibre testing; Joanne De Faveri, QDPI&F, for statistical analysis; Julie O’halloran ,Aust. Cotton CRC Farming Systems focus team, for poster preparation and display; CRDC and the Australian Cotton CRC for partly funding the project; Hermitage Research Station field staff for assistance with field work and machinery operation; QDPI&F management and colleagues for their support. Ian Broad loaned some of the equipment used.

APPENDIX 1

Trial Site Soil Analysis: 2003-04

| Depth cm | pH | EC mS/cm | NO3-N mg/kg | Cl mg/kg | Bicarb.P mg/kg |
|--------------------|-----------|--------------------|-----------------------|--------------------|--------------------------|
| 0 -15 | 7.8 | 0.14 | 32.4 | 19.4 | 54.0 |
| 15 - 30 | 8.4 | 0.14 | 22.4 | 17.2 | |
| 30 - 60 | 8.6 | 0.21 | 23.5 | 52.3 | |
| 60 - 120 | 8.8 | 0.55 | 12.5 | 405.3 | |
| 120 - 150 | 8.8 | 0.76 | 2.1 | 805.4 | |
| 150 - 180 | 8.8 | 0.68 | 1.3 | 709.7 | |

| Depth cm | Exch.Ca meq/100g | Exch.Mg meq/100g | Exch.Na meq/100g | Exch.K meq/100g | CEC meq/100g |
|--------------------|----------------------------|----------------------------|----------------------------|---------------------------|------------------------|
| 0 -15 | 25.5 | 15.0 | 1.6 | 1.5 | 44 |
| 15 - 30 | 21.8 | 15.2 | 2.3 | 0.7 | 40 |
| 30 - 60 | 20.0 | 16.2 | 4.1 | 0.6 | 41 |
| 60 - 120 | 18.7 | 18.4 | 6.4 | 0.9 | 44 |
| 120 - 150 | 19.0 | 18.5 | 7.3 | 0.8 | 46 |
| 150 - 180 | 19.2 | 18.4 | 7.0 | 0.8 | 45 |

| Depth cm | DTPA extr. Cu (mg/kg) | DTPA extr. Zn (mg/kg) | DTPA extr. Mn (mg/kg) | DTPA extr. Fe (mg/kg) |
|--------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| 0 -15 | 1.3 | 1.3 | 16.6 | 12.8 |

Trial Site Soil Analysis: 2004-05

| Depth cm | pH | EC mS/cm | NO3-N mg/kg | Cl mg/kg | Bicarb.P mg/kg |
|--------------------|-----------|--------------------|-----------------------|--------------------|--------------------------|
| 0 -15 | 7.6 | 0.29 | 91.4 | 48 | 57.0 |
| 15 - 30 | 8.4 | 0.25 | 33.6 | 35 | |
| 30 - 60 | 8.7 | 0.55 | 12.2 | 441 | |
| 60 - 120 | 8.6 | 1.07 | 1.9 | 1269 | |
| 120 - 150 | 8.6 | 1.16 | 1.3 | 1410 | |
| 150 - 180 | 8.6 | 1.11 | 1.3 | 1335 | |

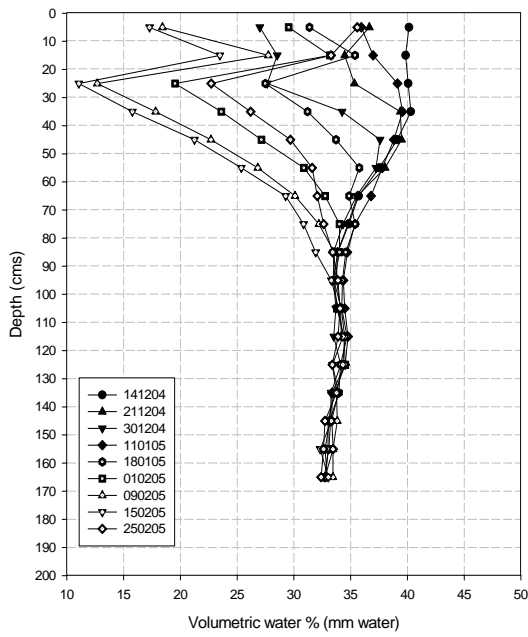
| Depth cm | Exch.Ca meq/100g | Exch.Mg meq/100g | Exch.K meq/100g | Exch.Na meq/100g | CEC meq/100g |
|--------------------|----------------------------|----------------------------|---------------------------|----------------------------|------------------------|
| 0 -15 | 20.0 | 12.7 | 1.4 | 0.9 | 35 |
| 15 - 30 | 20.7 | 15.3 | 0.9 | 2.6 | 39 |
| 30 - 60 | 18.3 | 17.6 | 1.0 | 5.2 | 43 |
| 60 - 120 | 16.8 | 18.9 | 0.8 | 6.9 | 42 |
| 120 - 150 | 15.5 | 16.9 | 1.3 | 6.4 | 40 |
| 150 - 180 | 15.2 | 16.7 | 0.7 | 6.7 | 37 |

| Depth cm | DTPA extr. Cu (mg/kg) | DTPA extr. Zn (mg/kg) | DTPA extr. Mn (mg/kg) | DTPA extr. Fe (mg/kg) |
|--------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| 0 -15 | 1.6 | 12.1 | 35.0 | 17.0 |

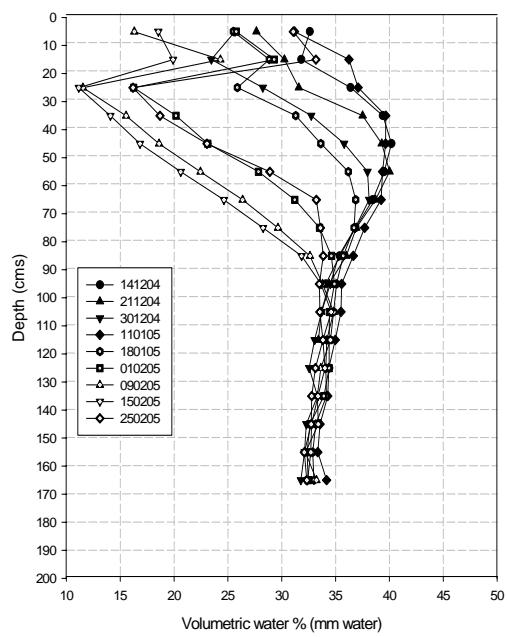
APPENDIX 2

Year 2 profile soil moisture

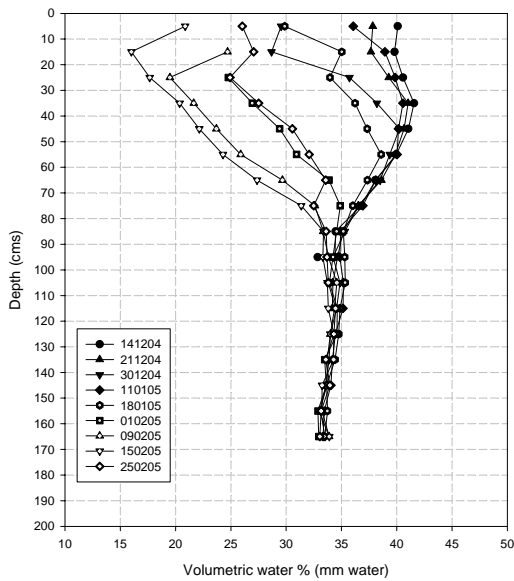
Sicot 80B P1 1 irrigation 2004-05



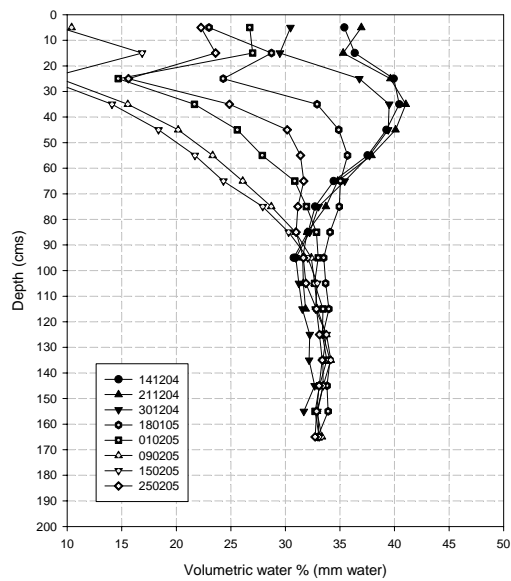
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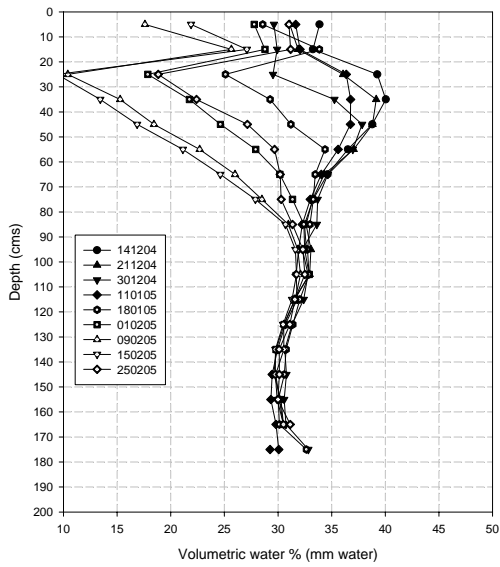


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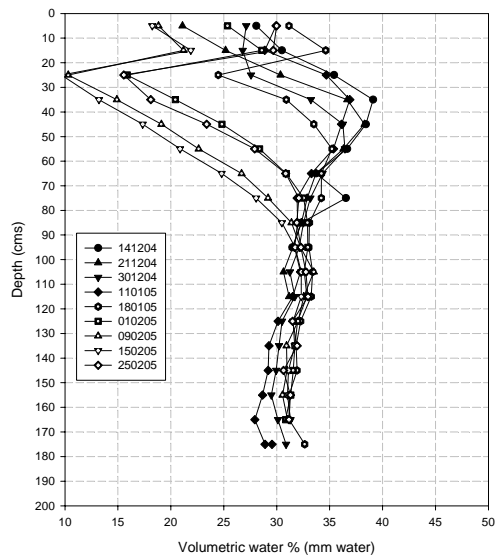


APPENDIX 2 (contd)

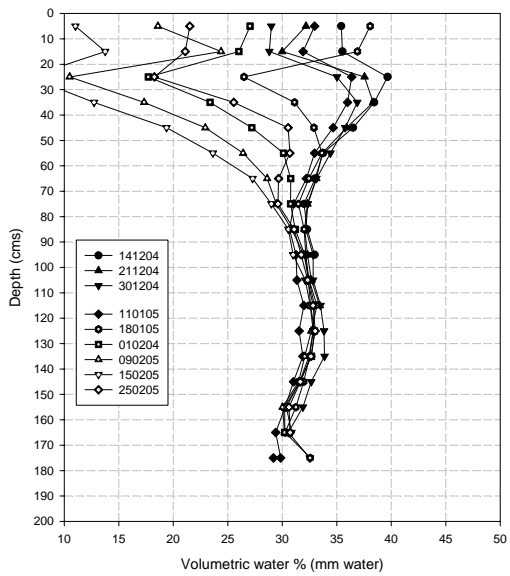
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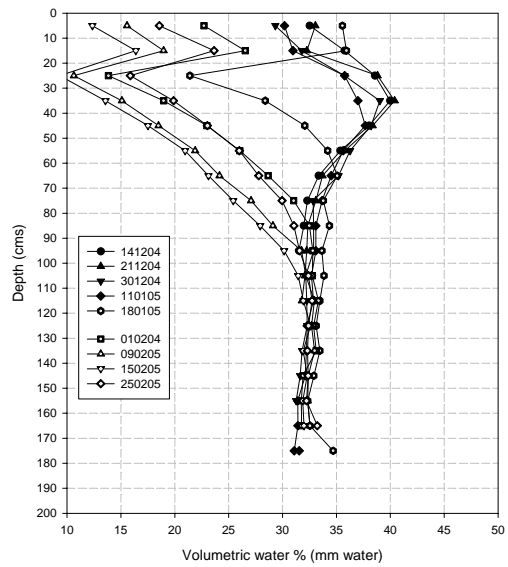
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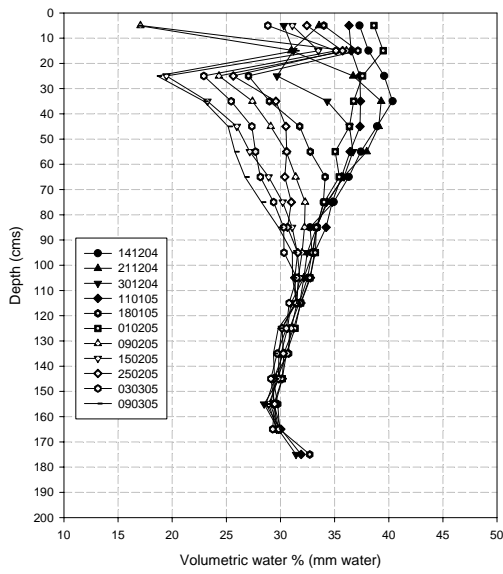


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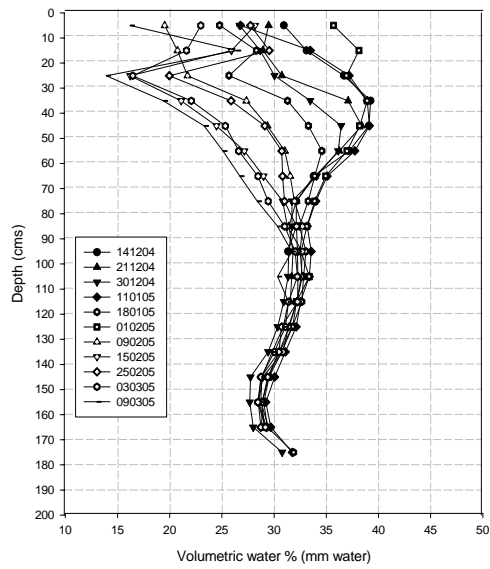


APPENDIX 2 (contd)

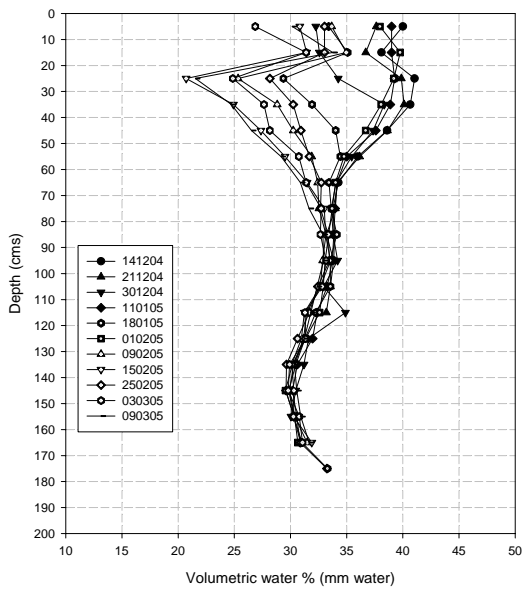
Sicot 80B P1 2 Irrigations 04-05



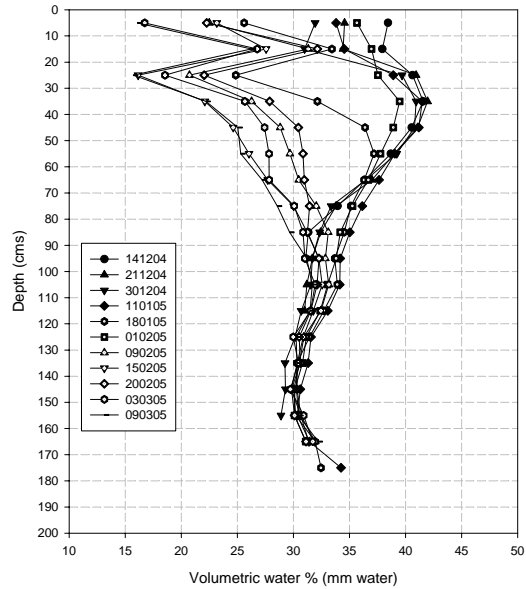
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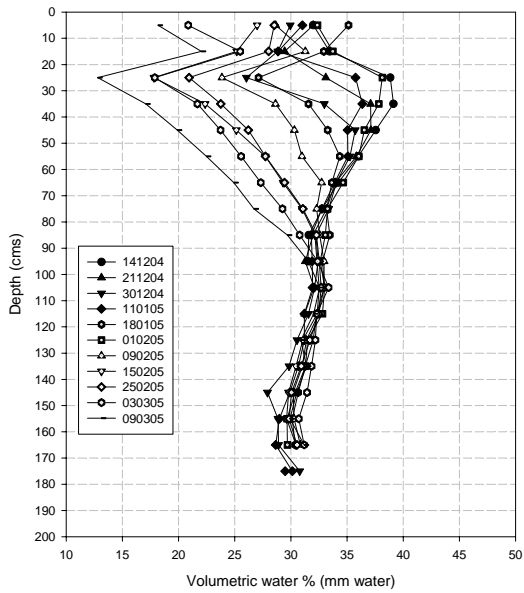


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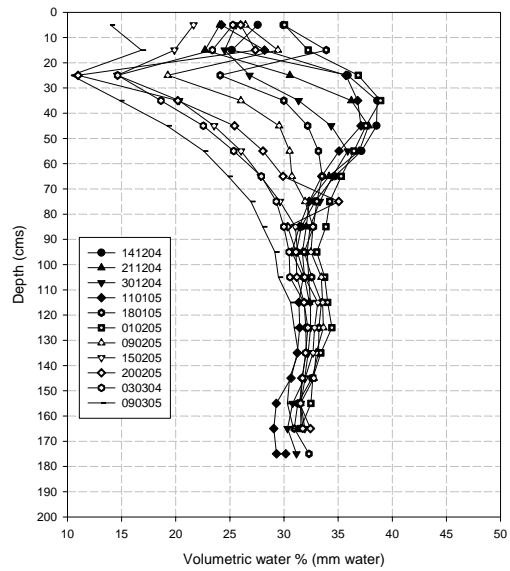


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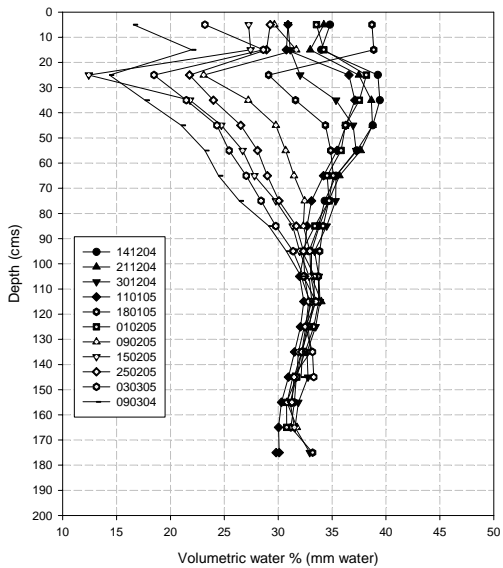
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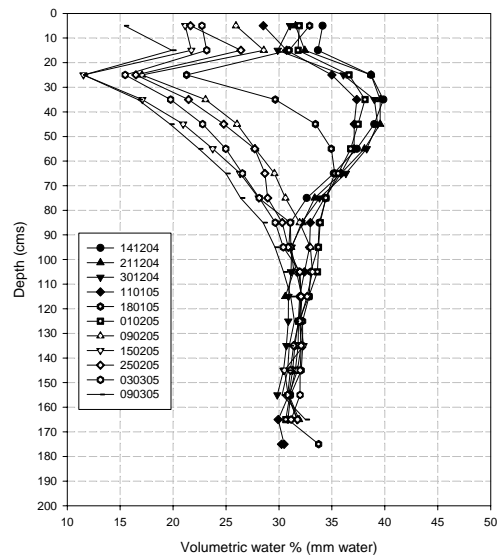
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Sicot 80 P3 2 Irrigations 04-05



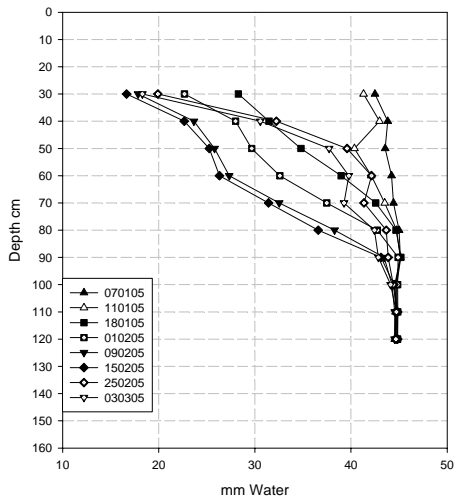
Sicot 80 P4 2 Irrigations 04-05



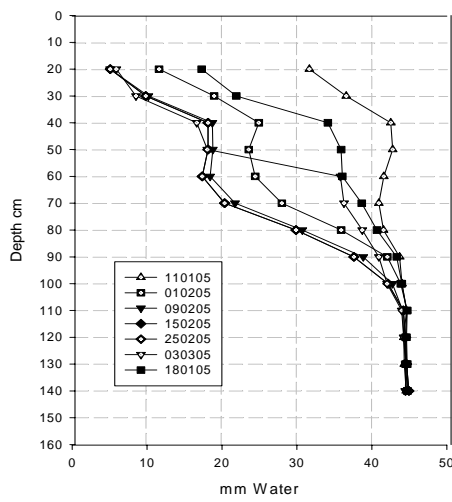
APPENDIX 3

Year 2 Diviner data for 1 Irrigation treatment

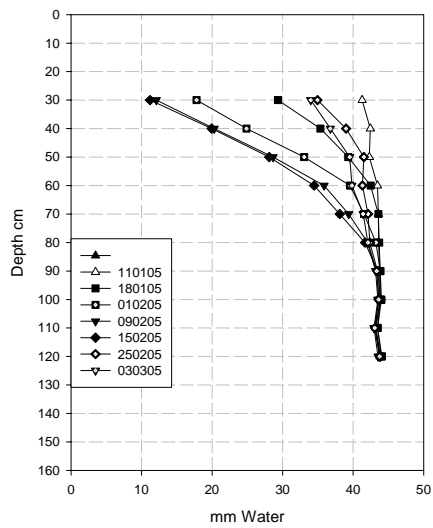
Sicot 80 B P1 1 Irrigation



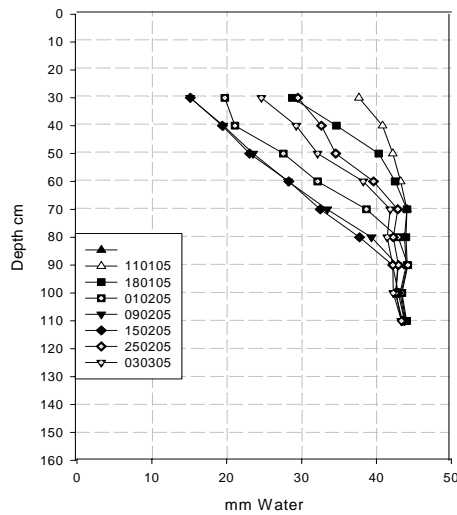
Sicot 80B P2 1 Irrigation



Sicot 80B P3 1 Irrigation

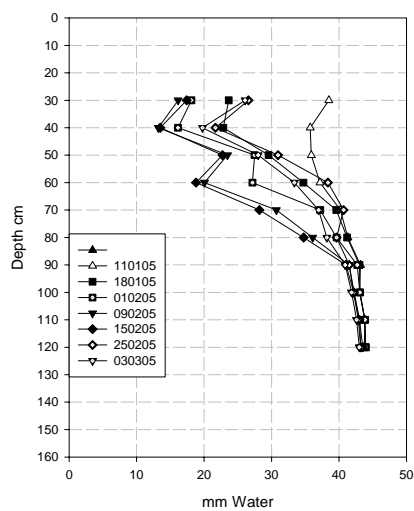


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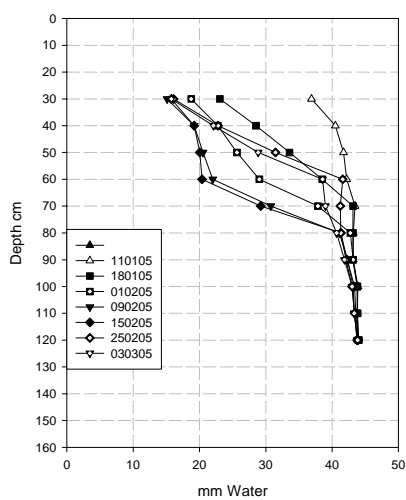


APPENDIX 3 (contd)

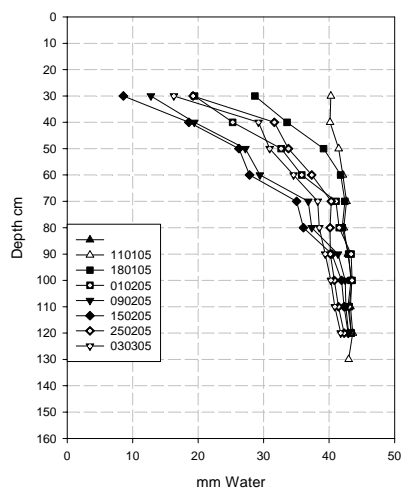
Sicot 80 P1 1 Irrigation



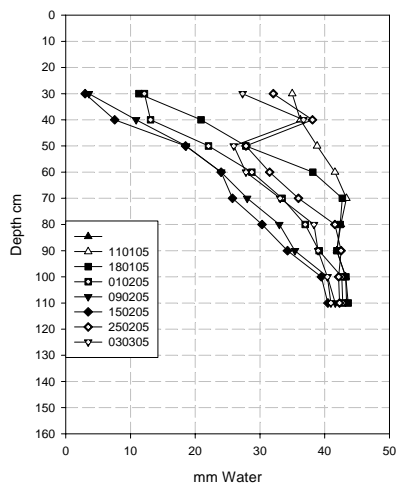
Sicot 80 P2 1 Irrigation



Sicot 80 P3 1 Irrigation

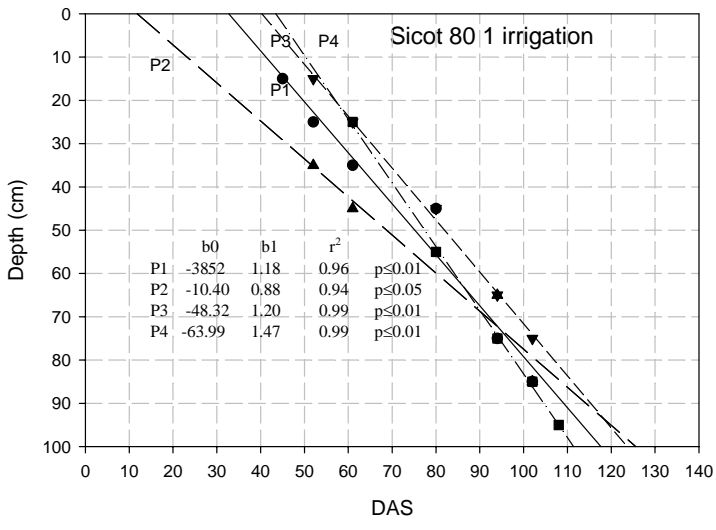
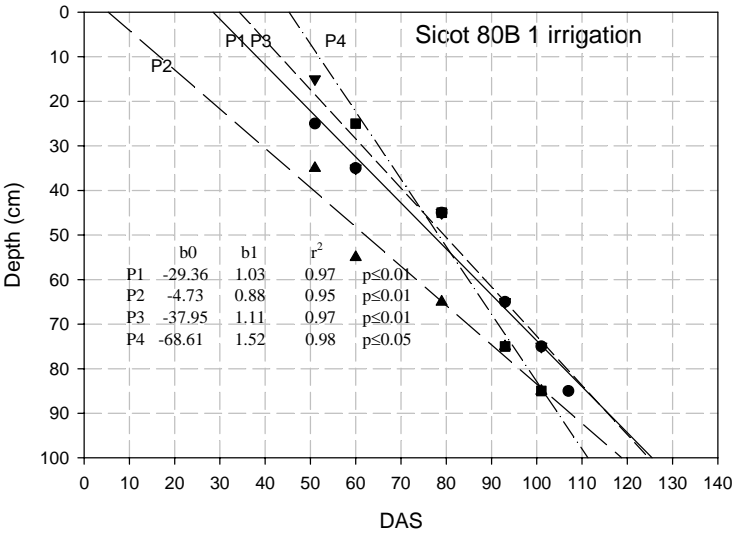


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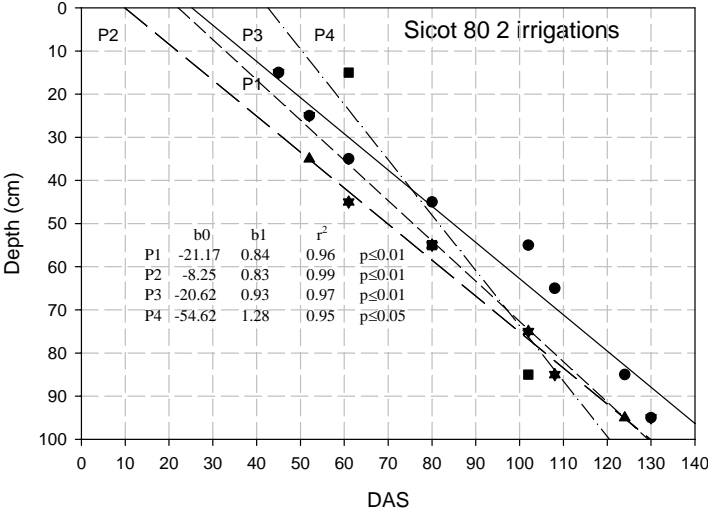
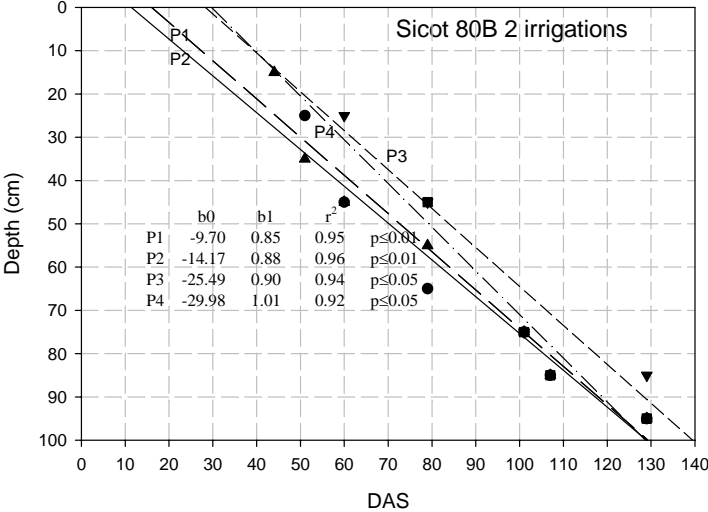


APPENDIX 4

Year 2 Days after sowing vs depth of extraction

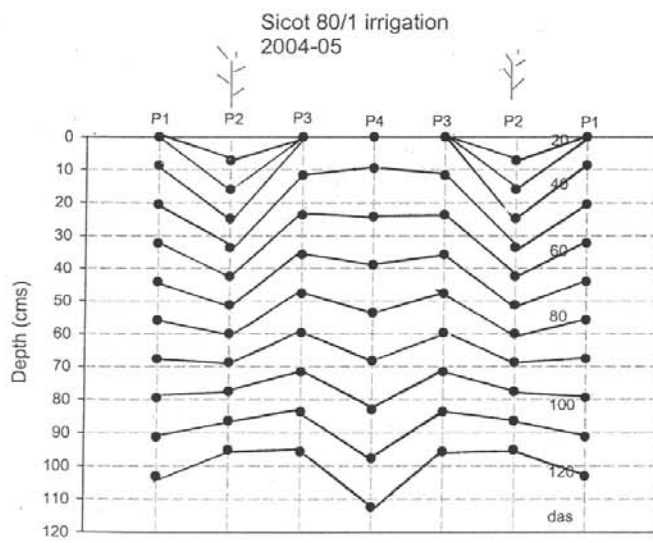
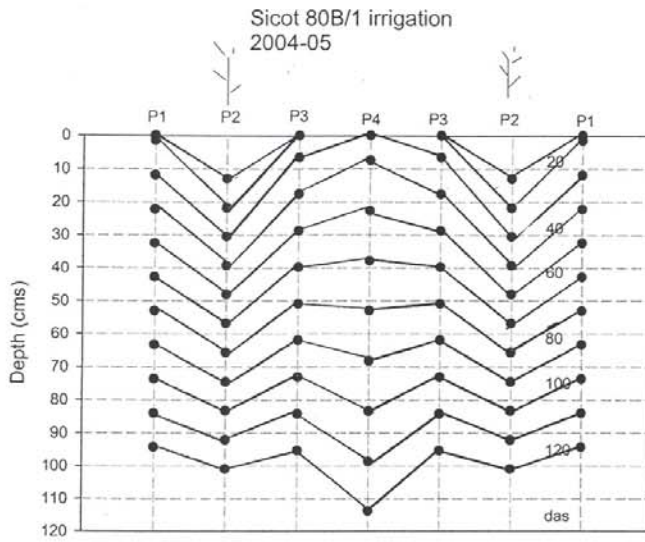


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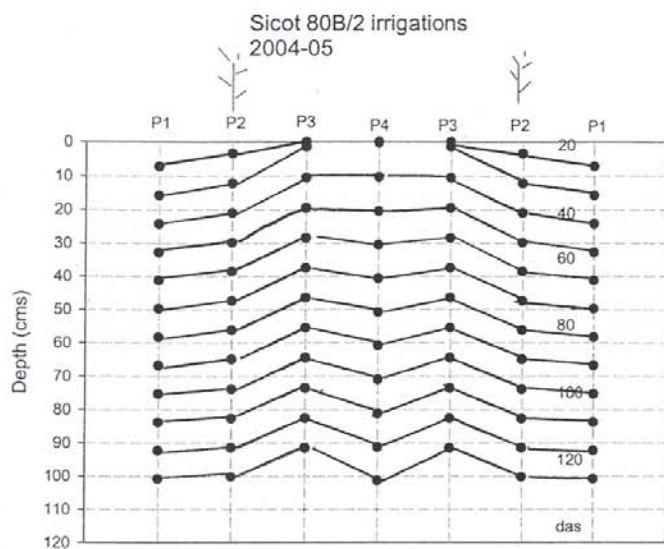


APPENDIX 5

Timing of soil water extraction down the profile 2004-05



APPENDIX 5 (contd)





Installing neutron moisture access tubes using hydraulic soil sampler ('Moonbuggy') 2003-04



View of trial plot 2003-04 showing EnviroSCAN access tubes (with flags).



View of experimental site 2004-05.



Typical plants and fist yield picks 2004-05. Left to right: Sicot 80B 1 irrigation, Sicot 80 1 Irrigation, Sicot 80B 2 Irrigations, Sicot 80 2 Irrigations.