Improved understanding of cotton water use for better management in water limited environments

(originally titled ' Optimising management strategies for profitable cotton production in water limited environments')

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Executive Summary

Raingrown cotton production in Queensland has been expanding in recent years and in the 1998/99 season reached 33% of hectares planted (irrigated plus raingrown) and represented 20% of Queensland's cotton production (Dowling 1999).

Recent developments in the application of crop models indicate that the use of models would enhance the advice given to growers for the production of raingrown crops. However improvements need to be made in their ability to cope with the water balance associated with various row configurations. This project was designed to provide data to achieve this improvement and to investigate the response of cotton to row configurations on a number of major soil types and over various environments.

Row configuration (no skip, single and double skips) by variety experiments were conducted on Waco and Box soils on the inner Darling Downs (Pirrinuan and Nandi - Daandine areas) in 1995/96 and 1996/97. Experiments in 1997/98 were conducted on Waco, Box and Grey Clay soils. In 1998/99 experiments were established on Waco Grey Clay and Mywybilla soils at Pirrinuan, Warra and Macalister respectively. In addition to these inner Darling Downs experiments plantings were made at Hermitage Research Station on the eastern Downs in 1995/96 and 1996/97, but with minimal data being retrieved.

Row configurations were based on 1.0m spacing. In some experiments a no skip treatment with 0.76m or 0.75m row spacing was included. In 1996/97 additional plant densities were trialed and in 1997/98 a configuration referred to as an alternate skip (rows 2m apart) was included at the Warra site. The cotton cultivars included varied over the experiment series and in later experiments were Siokra V15i.

Crop development, biomass accumulation, leaf area accumulation and root length density were monitored in addition to yield and fibre quality. The time course of soil water depletion within the plant row, between rows and at intervals of 0.5m from the plant line to the middle of the skip, was followed with a neutron probe.

Significant yield advantages from skip row configurations were not found in these trials but fibre quality was enhanced. Superior gross margins from skip row cotton can be achieved due to savings in variable costs and improved fibre quality resulting from the extra soil water available for developing bolls. Neither plant densities nor varieties significantly altered these outcomes. The crops on the Eastern Downs indicated that good yields can be achieved in this region and that a narrow row configuration was favoured.

The experiments provided new insights into the extraction of water from the soil profiles which will enable the redevelopment of water supply routines in the cotton predictive models.

Technical Summary

Aims

- To quantify the relationship between cotton plant spatial arrangement and soil water dynamics, and its effect on raingrown cotton yield and quality.
- Provide data to assist the further development of cotton simulation models, to enable the outcome of various management scenarios relating to row configuration to be determined.

Background

Recent developments in the application of crop models indicate that the use of models would enhance the advice given to growers. However improvements need to be made in their ability to cope with the water balance associated with various row configurations. This project was designed to provide data to achieve this improvement and to investigate the response of cotton to row configurations on a number of major soil types and over various environments.

Methodology

Row configuration (no skip, single and double skips) by variety experiments were conducted on Waco and Box soils on the inner Darling Downs (Pirrinuan and Nandi - Daandine areas) in 1995/96 and 1996/97. Experiments in 1997/98 were conducted on Waco, Box and Grey Clay soils. In 1998/99 experiments were established on Waco Grey Clay and Mywybilla soils at Pirrinuan, Warra and Macalister respectively. In addition to these inner Darling Downs experiments plantings were made at Hermitage Research Station on the eastern Downs in 1995/96 and 1996/97, but with minimal data being retrieved.

Row configurations were based on 1.0m spacing. Within row plant spacing was 6 plants/m which represents 60 000, 42 800 and 30 000 plants/ha for no skip, single skip and double skip configurations respectively. In some experiments a no skip treatment with 0.76m or 0.75m row spacing was included. In 1996/97 additional plant densities were trialed and in 1997/98 a configuration referred to as an alternate skip (rows 2m apart) was included at the Warra site. The cotton cultivars included varied over the experiment series and in later experiments were Siokra V15i.

Crop development, biomass accumulation, leaf area accumulation and root length density were monitored in addition to yield and fibre quality. Meteorological conditions were recorded with automatic weather stations located 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, P5), was followed, weekly where possible, to a depth of 1.8m with a neutron probe.

Results and Conclusions

Yield and Fibre Quality:

Significant yield advantages from skip row configurations were not found in these trials but fibre quality was enhanced. Depending on current cotton prices superior gross margins from skip row cotton can be achieved due to savings in variable costs, such as spraying and improved fibre quality resulting from the extra soil water available for developing bolls.

It appears that if the expected no skip yield is below about 3.5 bales/ha the best option would be to plant a double skip configuration. Single skip also will outyield the no skip in this situation. Above 3.5 bales/ha the no skip option would need to be considered. Model output, when available, will assist in determining the best option for any one year and test these findings in other regions.

Neither plant densities nor varieties significantly altered these outcomes. The crops on the Eastern Downs indicated that good yields can be achieved in this location and that a narrow row configuration was favoured.

Soil Water Extraction:

There is an underlying pattern (but with notable exceptions) with respect to the EFVs (extraction front velocities). On the plant row (P2) and within 0.5m either side (P1 and P3) the EFV is slower than further out into the skip areas (P4 and P5). The wider the skip the slower the EFVs at P1, P2 and P3. By the end of the season the soil moisture at all positions can be depleted to within the lower limit of plant available water capacity.

The EFVs for P1, P2 P3 are in agreement with the "effective rooting depth" rate of progression reported by Lacape et.al. (1998) for cotton which ranged from 1.8 to 3.0 cm per day. It seems that the crops can have very high EFVs when extracting from the middle of the skip and these can reach up to twice the rate of the other positions. Robertson et. al., (1989) reported similar findings with sorghum planted in wide rows compared with narrow. The wide row crop took longer to become supply limited resulting in a higher t_0 (time of commencement of the descent of the extraction front) but once commenced, the front descended more rapidly to reach the root front and EFV was therefore greater.

Implications and Recommendations

The findings with respect to the position of the extraction front relative to the number of days from sowing have important implications for the management of the nutrition and optimisation of the yield of raingrown crops. This would impact on the placement and rate of application of nitrogenous fertiliser. Ample must be available to supply the needs of developing bolls so the grower can capture the yield potential and premiums for quality. The timing of the placement of nitrogen in the skip area may be inefficient and needs to be assessed in relation to the expect position of the extraction front.

No information is available on plant responses to early season insect damage for cotton grown on different planting configurations under raingrown conditions. Insect damage could alter the rooting patterns with respect to configurations. Clarification of this issue is of particular significance because of the problems of insecticide resistance which the industry faces.

Further work is required to quantify the determinants of the EFV (extraction front velocity)and t_0 (time of commencement of the descent of the extraction front). Robertson et al. (1993) found that for sorghum EFV is insensitive to soil properties and was stable across experiments differing in evaporative demand and population density. Meinke et al. (1993) found that t_0 was longer for soils with greater maximum available water capacity in the surface. These aspects require clarification for cotton.

Although the extraction parameters could not be quantified in all cases, the experiments have provided sufficient data for the testing of Monteith's (1986) technique for determining water supply, in the cotton predictive models and it is expected that improvements in the models' predictive abilities will be enhanced. *The redevelopment of the water balance routines in the models should now proceed.*

Project Title

Improved understanding of cotton water use for better management in water limited environments

Aims

- To quantify the relationship between cotton plant spatial arrangement and soil water dynamics, and its effect on raingrown cotton yield and quality.

- Provide data to assist the further development of cotton simulation models, to enable the outcome of various management scenarios relating to row configuration to be determined.

Background

Raingrown cotton production in Queensland has been expanding in recent years and in the 1998/99 season reached 33% of hectares planted (irrigated plus raingrown) and represented 20% of Queensland's cotton production (Dowling 1999).

A number of investigations have been conducted into management options available to growers for raingrown cotton production a common one being to skip some rows. Guidelines to determine the best row spacing configurations to use were developed by Marshall et al. (1994). Recent developments in the application of crop models indicate that the use of models would enhance the advice given to growers. However improvements need to be made in their ability to cope with the water balance associated with various row configurations. This project was designed to provide data to achieve this improvement and to investigate the response of cotton to row configurations on a number of major soil types and over various environments.

Methodology

Row configuration (no skip, single and double skips) by variety experiments were conducted on Waco (Black Vertosol, PAWC 300mm to 1.8m, BD 1.09-1.22) and Box (PAWC 290 mm to 1.8m, BD 1.46- 1.53) soils on the inner Darling Downs (Pirrinuan and Nandi - Daandine areas) in 1995/96 and 1996/97. Experiments in 1997/98 were conducted on the Waco, Box and Grey Clay (Grey Vertosol, PAWC 250mm to 1.8m, BD 1.52-1.61) soils. In 1998/99 experiments were established on Waco, Grey Clay and Mywybilla soils (PAWC 280mm to 1.8m), at Pirrinuan, Warra and Macalister respectively. In addition to these inner Darling Downs experiments plantings were made at Hermitage Research Station on the eastern Downs in 1995/96 and 1996/97, but with minimal data being retrieved.

Row configurations were based on 1.0m spacing. Within row plant spacing was 6 plants/m which represents 60 000, 42 800 and 30 000 plants/ha for no skip, single skip and double skip configurations respectively. In some experiments a no skip treatment with 0.76m or 0.75m row spacing was included. In 1996/97 additional plant densities were trialed (see Appendix 16) and in 1997/98 a configuration referred to as an alternate skip (rows 2m apart) was included at the Warra site. Plots were generally 12m in length, of 6 rows with the middle two rows being used for data retrieval. Three or four reps were used per experiment. Harvesting of mature bolls was by hand, at approximately weekly intervals, from the first appearance of open bolls, on the middle two rows of each plot. The cotton cultivars included varied over the experiment series. These are shown in Appendix 15 to 18.

Crop management, such as herbicide and fertiliser application, insect pest control, growth regulator application and defoliation, was applied as per the recommended local guidelines.

Crop development, biomass accumulation, leaf area accumulation and root length density were monitored in addition to yield and fibre quality. Meteorological conditions were recorded with automatic weather stations located 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, P5), was followed, weekly where possible, from 0.15m to a depth of 1.8m with a neutron probe. Figure 1 shows the location of the access tubes in relation to the row configurations. One aluminium access tube was used per sampling position and water extraction data were used to establish parameters relating to soil water extraction dynamics for inclusion into the cotton models (see theory below).

Ideally rainfall should be excluded from the system for these investigations. During 1996/97 an attempt was made to do this in separate experiments by covering the trial site at ground level with plastic sheets. Although seasonal rainfall was low, waterlogging occurred from early falls prior to final sealing of the plastic. Another attempt in 1997/98 was made, on a smaller scale, but with a similar outcome. This approach had to be abandoned but data from some locations within the sites, which were not waterlogged, did reveal that the determination of water supply parameters was not affected by rainfall.

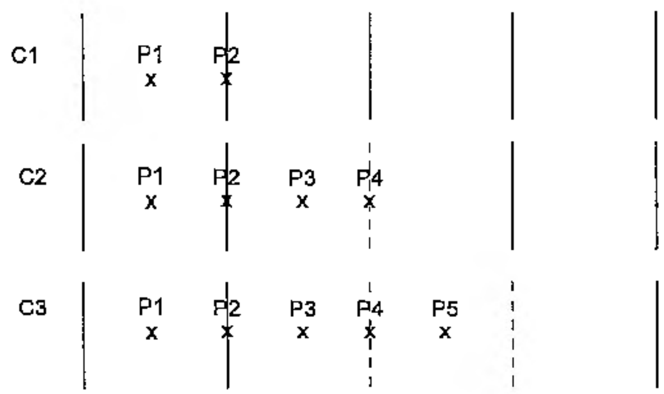

Figure 1. Positions (P1, P2 etc) of the neutron moisture meter access tubes in relation to the planted rows (solid lines) and the skips (broken lines) for each configuration. C1, C2, C3 are solid planted, single skip and double skip respectively.

Yield and Fibre Quality

Results:

Although the primary aim of this project was to gain insights into the dynamics of soil water use, so that planting options can be forecast using models, yield and quality results were examined.

Site soil analyses and climatic data (the rainfall amounts are the mm, in a manually read rain gauge, on the date shown and which fell since the previous date) are shown in Appendices 1 to 14 and full details of yield and fibre quality results including statistical analysis are presented in Appendices 15 to 18. Note the excellent yields obtained at Hermitage Research Station (Appendix 15 and 16), an area considered marginal for cotton due to its eastern location (28 18 S.,152 06 E.).

In Figure 2 yields for the no skip treatment have been regressed against those for single and double skips. All trials have been included. Regressions for fibre length, strength and micronaire are presented in Figures 3,4 and 5.

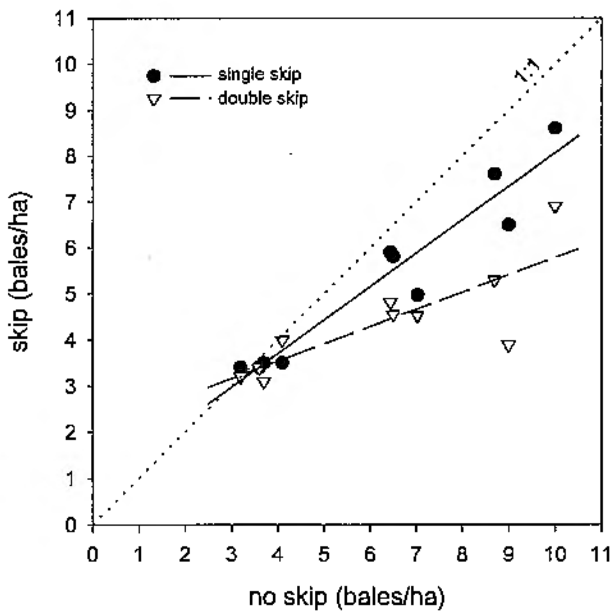

Figure 2. Relationship between no skip yields (bales/ha) and single and double skips.
single skip: Y=0.79+0.73*X r^2=0.89 p<= 0.01
double skip: Y=2.04+0.37*X r^2 =0.57 p<= 0.01

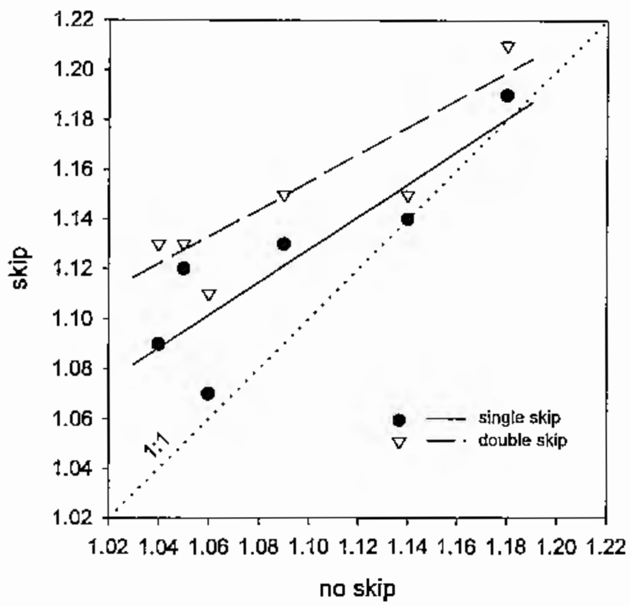

Figure 3. Relationship between no skip fibre length and that for single and double skips.
single skip: Y= 0.40+0.66*X r^2=0.62 p<=0.05
double skip: Y= 0.55+0.55*X r^2=0.63 p<=0.05

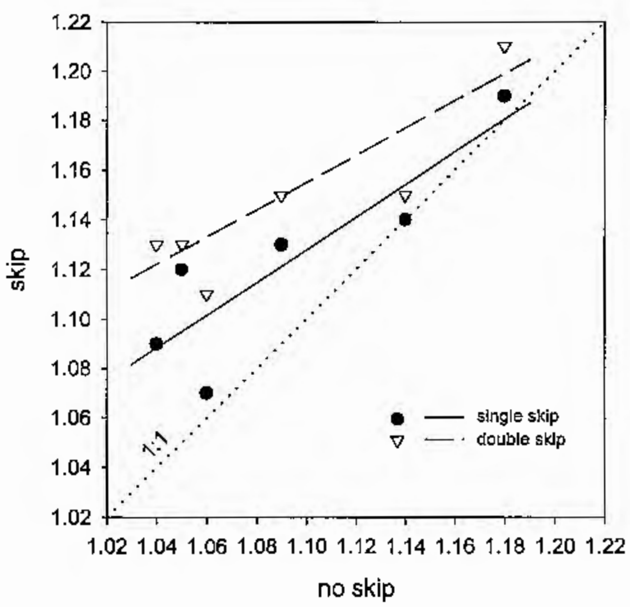

Figure 4. Relationship between no skip fibre strength and that for single and double skips.
Regressions not significant.

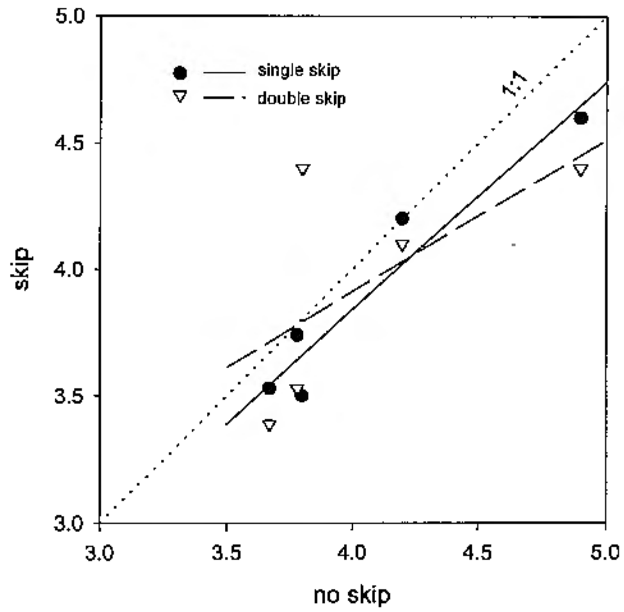

Figure 5. Relationship between no skip fibre micronaire and that for single and double skips.
single skip: Y= 0.24+0.90*X r^2=0.92 p<=0.01
double skip: regression not significant.

Discussion:

It appears that if the no skip yield is below about 3.5 bales/ha the best option would be to plant a double skip configuration. Single skip also will outyield the no skip in this situation. Above 3.5 bales/ha the no skip option would need to be considered. Marshall et al (1994) found 2 to 3 bales/ha to be the critical yield but their data was derived from 30 separate experiments. However model output, when available, will assist in determining the best option for any one year.

Length and strength were generally higher than the no skip treatment for the skip configurations and micronaire lower.

For raingrown cotton yield of 2.5 bales/ha, crop consultants (Michael Castor and Associates, pers commun. 1989), reported that gross margins for single and double skip crops were $532/ha and $604/ha respectively compared with $398/ha for solid planted (no skip) crops. The superior gross margins for skip row configurations were due to savings in variable costs, such as spraying, and the improved fibre quality resulting from the extra soil water available for developing bolls. Hence yield and quality must not be considered alone when making recommendations on which configurations to use.

Soil Water Use

Theory:

Robinson et al., (1993) explain:

- Demand from the atmosphere and supply from the root system determine the extent to which water availability limits crop production.
- The extraction of soil water is controlled mainly by demand when supply is not limiting.
- Extraction becomes limited by supply from the root system as the crop depletes soil water.
- The depth of the root system and the rate and extent to which it can extract water determine its supply to the plant.

The current project was concerned with the supply of water to the plant which is not understood in skip row cotton culture. Monteith (1986) proposed a scheme which is an improvement over the approaches commonly used in modelling. The scheme has been validated for sorghum and millet (Monteith, 1986) and sunflower (Meinke et al., 1993). A full explanation can be found in Meinke et al. (1993) but briefly:

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 following the relationship (Figure 6):

$$AWC = MAWC \quad \text{if } t \leq t_c$$
$$= MAWC \times \exp(-kl(t-t_c)) \quad \text{if } t > t_c \qquad (1)$$

MAWC = maximum plant available volumetric water content in each soil layer
AWC = available water content remaining in each layer at time t (days after sowing)

t = time (days after sowing)
t_c = time of first water extraction in a layer
l = root length density (cm root per cm^3 of soil)
k = constant relating to the diffusivity of water flow (cm^2 per day)

The derivative of equation (1) with respect to time gives the extraction rate:

$$dAWC/dt = 0 \quad \text{if } t \leq t_c$$
$$= (-kl) \times AWC \quad \text{if } t > t_c$$

k and l are not determined individually, but are treated as a combined kl 'plant soil constant' i.e. the rate at which water is extracted within each layer.

tc for each layer can be found from the depth of the extraction front (EF) at any time:

$$EF = EFV \times (t-t_0)$$

EFV = extraction front velocity

t_0 = time (days after sowing) at which the extraction front commences its descent at rate EFV.

t_c = EF/EFV + t_0

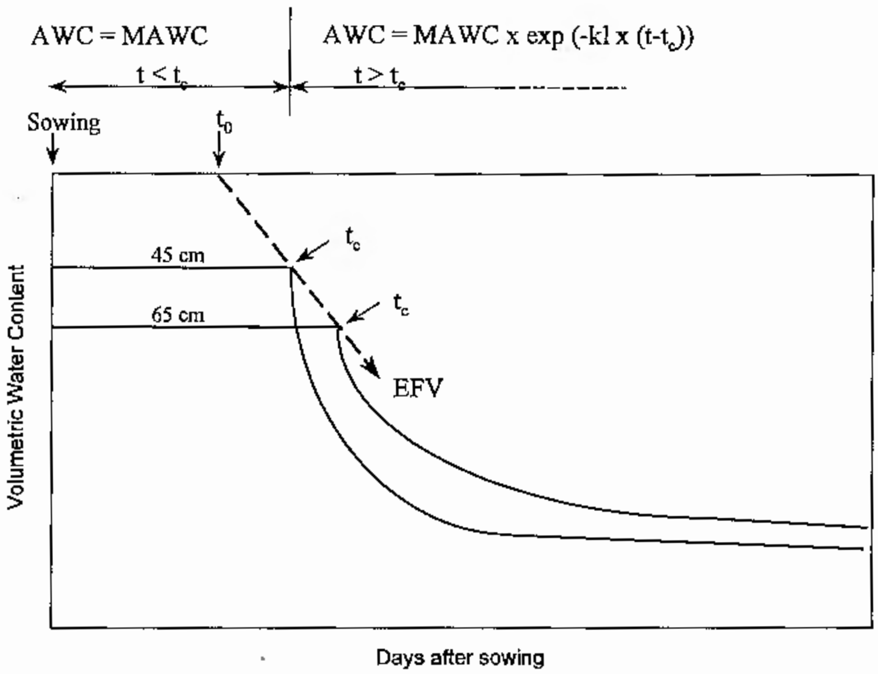

Figure 6. Analytical framework showing the exponential decline of soil water from the 45cm and 65 cm soil layers.

Results:

The soil water extraction data were used to derive values for kl, t_c, EFV and t_0 for 1997/98 and 1998/99 plantings. However, soil water use in 1995/96 and 1996/97 crops is of interest:

The graphs in Appendix 19 show the volumetric moisture % (shaded area) in the soil profile for CS 189+ in the treatments on the dates indicated for the 1995/96 Pirrinuan (Waco soil) trial. Each group of 10 graphs is followed by a diagram showing the planting configuration and the position of the neutron moisture meter access tube where the soil moisture measurement was taken (up arrow). Also shown are the upper and lower soil moisture limits (extreme right and left lines respectively).

The rainfall measured between soil moisture sampling dates was:

Date	Rainfall (mm)
30 Nov - 14 Dec	87
14 Dec - 21 Dec	0
21 Dec - 29 Dec	40
29 Dec - 16 Jan	111
16 Jan - 5 Feb	63
5 Feb - 15 Feb	9
15 Feb - 18 Apr	0

The graphs show the soil profile filling following the rainfall events up to 16 January (early flower) then being rapidly depleted during the remainder of the season which received little rain after early February.

Similar patterns of soil moisture extraction for corresponding dates and positions across configurations are evident from the graphs. It is obvious that extraction occurred well into the skips but to a lesser extent than on the plant line.

The table in Appendix 20 shows that similar total amounts of water (with some exceptions) were used to 1.5m in the profile at the various sampling positions. Note that the single skip values are very similar to the double skip. The mean water use per day over the period 75 days after sowing (das) to 168 das was 2.4mm / day and ranged from 6.0 mm at flowering to 0.3mm / day at maturity.

In 1996/97 the plantings made at the Pirrinuan site (planted October 11) suffered from "long fallow disorder" (zinc deficiency) which resulted in a severe loss of leaf. Foliar application of zinc (November 26, 46 das) resulted in complete recovery which was observed to commence on December 11 (61 das).

In Appendix 21 soil water use is presented in such a way to enable comparisons to be easily made between sampling positions at each sampling date. These water use patterns should be examined along with rainfall events:

Date	Rainfall (mm)	Date	Rainfall (mm)
11 Dec - 17 Dec	26	3 Mar - 10 Mar	23
17 Dec - 23 Dec	0	10 Mar - 17Mar	0
23 Dec - 2 Jan	0	17 Mar - 25 Mar	0
2 Jan - 14 Jan	6		
14 Jan - 21 Jan	0		
21 Jan - 29 Jan	0		
29 Jan - 6 Feb	1		
6 Feb - 13 Feb	12		
13 Feb - 18 Feb	17		
18 Feb - 3 Mar	28		

The maximum extraction depth was approximately 1.05 to 1.1 metres in all configurations and the profiles were depleted of water to about the same amount by the end of the season. Examination of the soil electrical conductivity and chloride levels indicated these to be in the medium to high range at these depths and beyond, probably restricting root growth. This was confirmed from soil sampling for root density determinations which showed little evidence of roots at these depths (Appendix 22). Hence the plant cannot access water in the deeper layers. This was also the case at other sites in other seasons.

The figures in Appendix 21 show that soil water extraction from the middle of the skip in the single skip configuration is first obvious from Jan 2 to Jan 14 (83 to 95 das) whereas in the double skip it was on Jan 21 (102 das) which coincided with the commencement of flowering.

1997/98 & 1998/99 All Soils

Soil water data were analysed for each neutron moisture meter sampling tube position in accordance with Monteith's (1986) theory, for determination of kl, t_c, EFV and t_0. The 1997/98 season data were analysed for each sampling position and the results averaged whereas in 1998/99 soil water data were averaged across reps prior to analysis. Figure 7 shows a typical result from fitting the analytical framework for some selected depths.

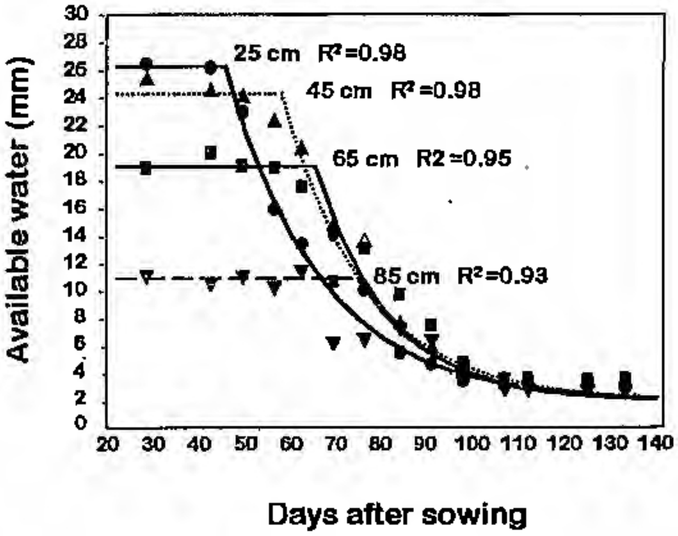

Figure 7. Soil water extraction for four depth intervals at P2 in a single skip configuration, Waco soil 1997/98.

Similar relationships for each depth at each sampling position enabled the evaluation of t_c. Regressing t_c against depth for each sampling time gave t_0 and EFV, (Figures 8 and 9).

kl values relating to these analyses are shown in Appendix 23. The extraction rate (kl) is not a conservative parameter for describing water extraction for a particular combination of species and soil type (Robinson et al. (1993). Consequently the values in Appendix 22 are not consistent for a particular soil type and depth. Variation in root densities (l) (Appendix 22) will influence the kl estimates. Clothier and Green (1997) reported on conditions which result in incorrect output from soil water supply models. These include wide variations in local conditions throughout the root zone causing variations in uptake; very large differences in water content across the root zone following rainfall; differences in local root activity or pockets of rapid root growth. Some or all of these conditions conditions might have been active in the present experiments resulting in the variations in kl values.

Although examination of plots of soil profile water content indicated that extraction appeared to be taking place to at least 1.25 metres in some cases, the extraction parameters could be satisfactorily calculated to only about 0.85 metres. Insufficient data for the exponential decline phase at depth was the reason for this. The result could be improved in future by taking moisture measurements more frequently than once per week during flowering.

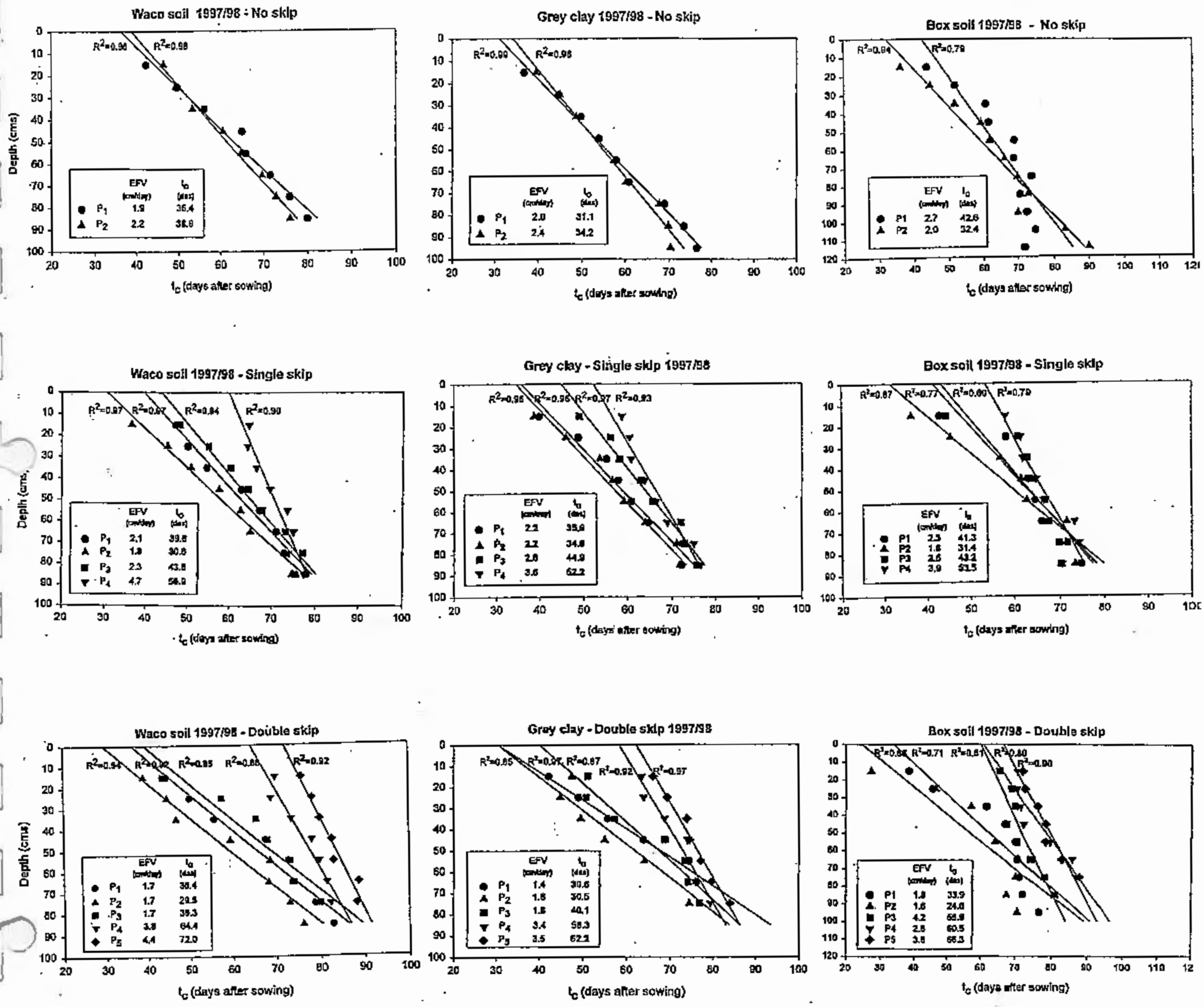

Figure 8. Time of first water extraction in each profile layer (t_c) plotted against depth of layer for various configurations and soil types in 1997/98. Extraction front velocities (EFV) and time of commencement of descent of front (t_0) shown for each sampling position.

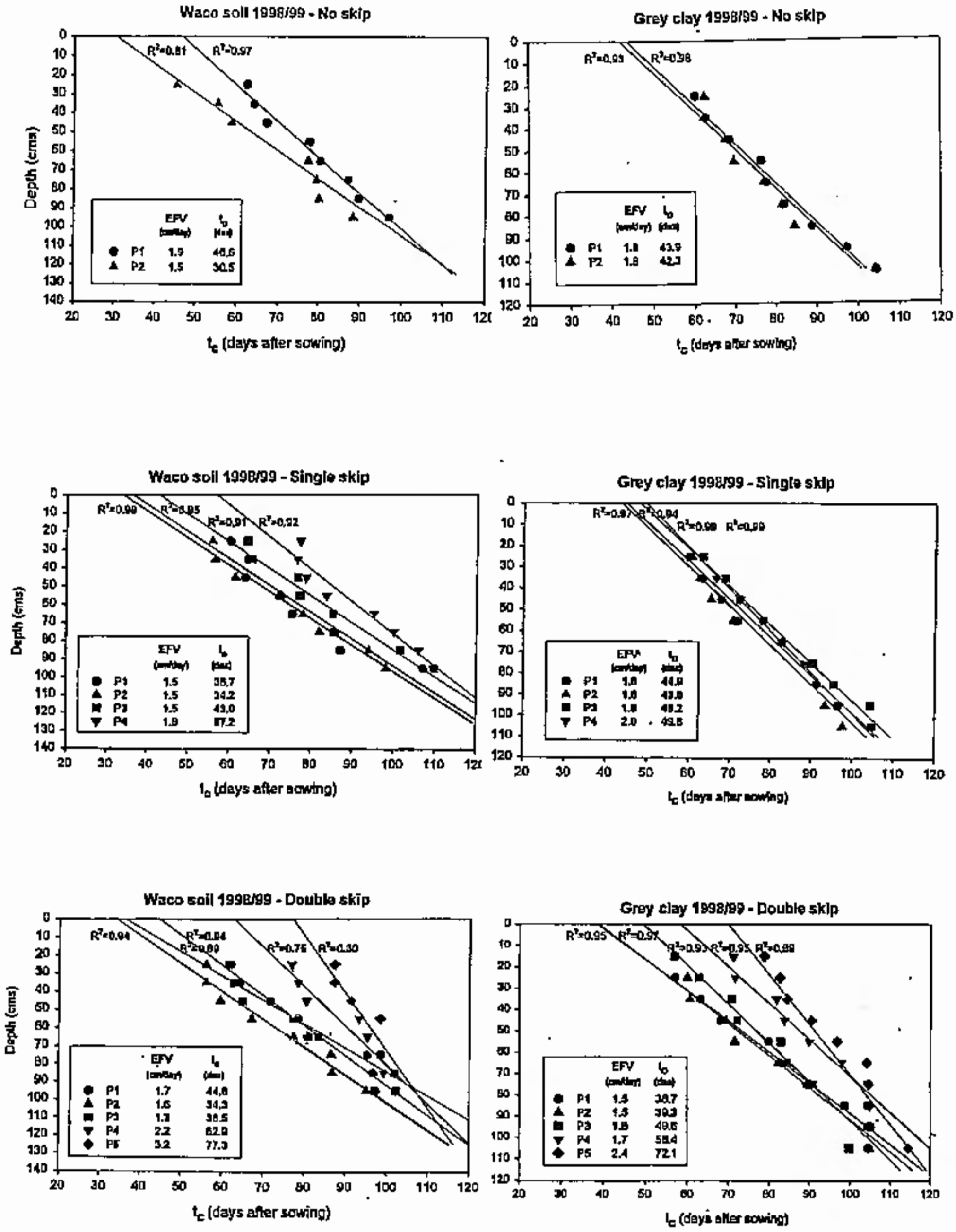

Figure 9. Time of first water extraction in each profile layer (t_c)plotted against depth of layer for various configurations and soil types in 1998/99. Extraction front velocities (EFV) and time of commencement of descent of front (t_0) shown for each sampling position.

In 1997/98 EFV (slope of the regression line) within each configuration was very similar for P1, P2 and P3. Averages are: 2.1,2.2, 2.4 for no skip Waco ,Grey Clay and Box respectively; 2.1, 2.4, and 2.2 for single skip, Waco, Grey Clay and Box respectively; 1.7 and 1.6, double skip, Waco and Grey Clay respectively. The exception is P3 for the Box soil which behaved similarly to P4 and P5. In the skips, P4 and P5 slopes are much steeper indicating higher EFVs in these positions.

Time of the commencement of the descent of the extraction front (das when depth is zero i.e., t_0) when averaged for P1 and P2 was 37.7, 32.7 and 37.5 das for the no skip plantings on the Waco, Grey Clay and Box soils respectively. For the single skip average of P1, P2 and P3 was 38.0, 38.5 and 38.6 das for the Waco, Grey Clay and Box soils respectively. Averages for the double skip were 35.1 and 33.7 das for the Waco and Grey Clay respectively. P3 is again the exception being 59.9 das. Time for commencement of extraction from the middle of the skip (P4 and P5) is seen to be considerably later.

Rainfall distribution in 1998/99 caused difficulty in obtaining meaningful results from some of the extraction analysis. Water extraction in the deeper layers of the soil profile was limited to only a few depth intervals, hence little data for soil water depletion in these deeper layers were available to successfully apply the iterative analysis (hence the missing configurations in Figures 8 and 9). This was particularly the case for the Mywybilla soil which experienced some flooding in the skip areas. This was very evident from plots of moisture content versus depth over time (Appendix 24).

EFV averaged across soil types, configurations and Positions 1, 2 and 3, was 2.0 cm/day in 1997/98 (P3 Box soil double skip omitted) and 1.7 in 1998/99. EFV averages were 36.1 and 41.3 for 1997/98 and 1998/99 respectively. The 1998/99 crops were extracting water from the surface layers and taking longer to commence penetrating the profile particularly in the skip areas.

1997/98 & 1998/99 Waco Soil

The analytical framework fitted well to the Waco soil water extraction data sets in both seasons. Consequently further analyses were undertaken to statistically compare the values of t_0 and EFV across sampling positions:

In the no skip treatment in 1997/98, soil water extraction dynamics were similar for positions P1 and P2. EFV averaged 2.0cm/day and t_0, 37.7 das. However in 1998/99 there were differences in EFV and t_0 between P1 and P2 but only at $p<0.08$. EFV averaged 1.7cm/day and t_0 39.7 das.

In the single skip,1997/97, the extraction front commenced its descent 30.6 das (t_0) in P2, whereas t_0 for P1 and P3 was on the average 11 days later. At P4, t_0 was significantly ($p<0.01$) later (59.9 das) than at the other positions. EFV was similar for P1, P2 and P3 averaging 2.1cm/day but at P4 was significantly faster being greater than twice this rate ($p<0.01$). In 1998/99 t_0 was similar for P1 and P2 averaging 35.5 but significantly different from P2 and P3 ($p<0.01$). In contrast to 1997/98 EFVs were similar in all four positions averaging 1.6 cm/day.

Soil water extraction from the double skip was very similar to the single skip in 1997/98. The extraction front commenced its descent much later in P4 and P5 than at the other three positions (P5 = P4>P1 = P2 = P3, $p<0.05$) and its descent rate in P4 and P5 was greater than twice the rate of the other three positions (P5 = P4>P1 = P2 = P3, $p<0.01$).

In 1998/99 P1 and P3 were similar for t_0 (mean of 40.7 das) but significantly different from P2 ($p<0.01$) which commenced its descent earlier (being on the plant line). EFVs were similar in these positions (1.6 cm/day). t_0 values for P4 and P5 were remarkably similar to those for the previous season and EFVs indicate that the rate of descent of the extraction front was rapid towards the middle of the skip as was the case the previous season.

Extraction Front Comparisons:

Figure 10 presents a diagramatic representation of the position of the extraction front for selected profiles of the two contrasting soils Waco and Grey clay in two contrasting seasons.

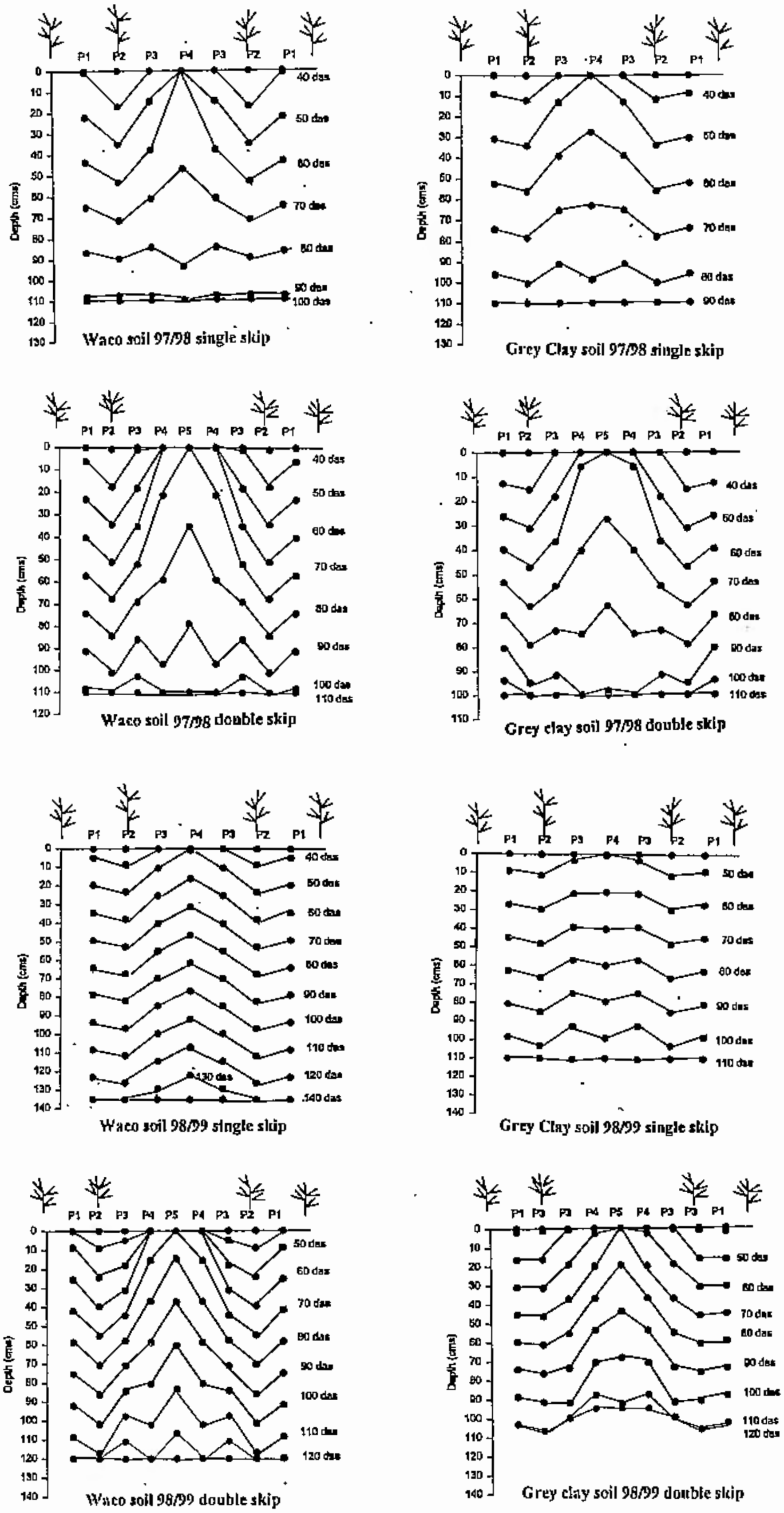

Figure 10. Comparisons of the position of extraction front for the Waco and Grey Clay soils at various times following sowing in 1997/98 and 1998/99.

These data were used to calculate the lateral rate of movement of the extraction front. For example, rates of movement in the direction of the arrows marked A to F in Figure 11 to the point of the arrow heads were: A 2.1, B 2.0, C 2.0, D 2.1, E 2.7, F 2.8 cms per day. This indicates reasonably rapid movement into the skip areas. These calculations assume that lateral movement commenced at the same time as vertical movement through the profile from the plant line.

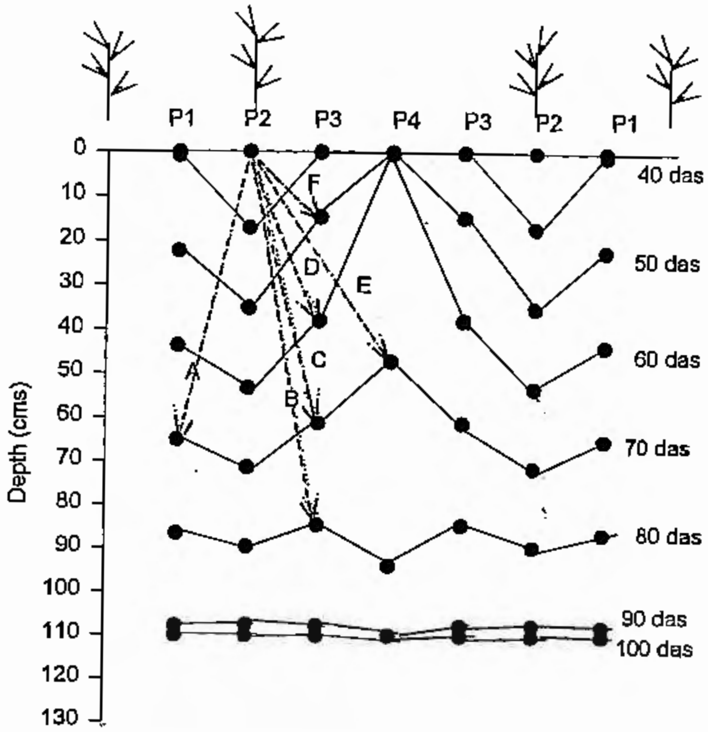

Figure 11. Waco soil, single skip, 1997/98. Arrows depict lateral movement of the extraction front from the plant line (position 2)

Extraction Front and Flowering:

Demand for water is generally at a peak during peak flowering hence management systems should aim to maximise water availability to the crop at this time. Flowering times for the various plantings are shown in Table 1:

Table 1 Flowering dates – 1995/96 CS189+,1996/97 Siokra V15, 1997/98 and 1998/99 Siokra V15i

Year	Soil Type	Start Flowering	Peak Flowering	End Flowering
1995/96				
	Waco	Jan. 14 (73)*	-	Feb. 28 (118)
1996/97				
	Waco	Jan. 21 (102)	Feb. 6 (118)	Feb. 18 (130)
1997/98				
	Waco	Dec. 24 (71)	Jan. 22 (100)	Feb. 3 (112)
	Box	Dec. 24 (67)	Jan. 21 (95)	Feb. 6 (111)
	Grey Clay	Dec. 24 (69)	Jan. 9 (85)	Jan 22 (98)
1998/99				
	Waco	Dec 30 (83)	Jan. 22 (106)	-
	Mywybilla	-	Jan. 22 (103)	-
	Grey Clay	-	Jan. 12 (99)	-

**days after sowing*

The advantage of skip row configurations over no skip in terms of water availability is highlighted in the following example (refer to Figures 8 and 9):

In 1997/98 flowering in the three configurations on the Waco soil was peaking at about 100 das. P1 and P2 in the no skip configuration had an average EFV of 2.0 cm/day and the front commenced its descent 37.7 das. The time at which extraction commenced at 1 m depth was about 88 das. This coincided with peak LAI (Appendix 25) and maximum biomass (Appendix 26). In the double skip configuration a descent rate of 1.7 cm / day for the average of P1, P2 and P3 and commencement of the descent 35 das had extraction from the 1m depth commencing about 94 das, just after peak LAI (Appendix 25). The EF reached 1 m depth in 91 and 94 das for P4 and P5 respectively. Hence the time the EF reached 1m depth in all positions in the double skip configuration was very similar.

The no skip configuration was therefore extracting at depth well before peak flowering and was in danger of exhausting its water supply during flowering. In contrast, because the skip configuration had its EF descending more slowly near and on the plant line, and at a faster rate towards the middle of the skip, extraction at depth was commencing closer to the time of peak flowering.

The skip configuration therefore had water available for a longer time and during the critical stages of growth. Although this did not result in a yield advantage, it did enhance fibre quality.

In 1998/99 on the Waco soil flowering peaked about 106 das. The average time for P1, P2 and P3 to reach 1m was 100 das and for P4 and P5 was 108 and 109 das respectively. The no skip treatment EF reached 1m at about 99 das, one week prior to peak flowering which, under the growing conditions for that season, was not a deterrent to high yield.

Although rainfall in 1997/98 was higher from sowing to peak flowering (290 mm) than in 1998/99 (241 mm), it was better distributed in the latter. The seasonal conditions during 1998/99 were milder and were therefore favouring the no skip yields for that season.

Similar trends in extraction patterns for the Waco soil can be seen in some of the other soils (Figures 8 and 9) but this was not always the case, as prevailing conditions altered the response patterns. For example, in Figure 9 the Grey Clay single skip configuration indicates similar EFVs and t_0 for all positions. In this case the EF arrived at 1m 99 das and flowering peaked at 103 das.

Some Water Use Efficienies:

Comparisons were made of the water use efficiency (WUE) for the crops grown on the Waco and Grey Clay soils in 1998/99. These were calculated using all rainfall received and known soil moisture content, Table 2.

Table 2 Water Use Efficiency (WUE) for Waco and Grey Clay crops 1998/99

	soil water used (mm)	**rainfall** (mm)	**total** (mm)	**yield** (bales/ha)	**WUE** bales/ha/ML	kg lint/ha/mm
Waco Soil						
No skip	154	492	645	9.0	1.4	3.2
Single skip	173	492	670	6.5	1.0	2.2
Double skip	159	492	651	3.9	0.6	1.4
Grey Clay						
No skip	173	565	738	10.0	1.4	3.1
Single skip	169	565	733	8.6	1.2	2.7
Double skip	140	565	705	6.9	1.0	2.2

Under the growing conditions experienced at both sites in 1998/99 the no skip plantings proved the most efficient. These WUEs for the no skip crops are almost equal to some of the best recorded for irrigated crops as reported by Hearn (1994).

Conclusions

Yield and Fibre Quality:

Significant yield advantages from skip row configurations were not found in these trials but fibre quality was enhanced. Depending on current cotton prices superior gross margins from skip row cotton can be achieved due to savings in variable costs, such as spraying and improved fibre quality resulting from the extra soil water available for developing bolls.

It appears that if the no skip yield is expected to be below about 3.5 bales/ha the best option would be to plant a double skip configuration. Single skip also will outyield the no skip in this situation. Above 3.5 bales/ha the no skip option would need to be considered. Model output, when available, will assist in determining the best option for any one year and test these findings in other regions.

Neither plant densities nor varieties significantly altered these outcomes. The crops on the Eastern Downs indicated that good yields can be achieved in this location and that a narrow row configuration was favoured.

Soil Water Extraction:

The EFVs (extraction front velocities) for P1, P2 P3 are in agreement with the "effective rooting depth" rate of progression reported by Lacape et. al. (1998) for cotton which ranged from 1.8 to 3.0 cm per day. It appears that the crops can have very high EFVs when extracting from the middle of the skip and these can reach up to twice the rate of the other positions. Robertson et.al., (1989) reported similar findings with sorghum planted in wide rows compared with narrow. The wide row crop took longer to become supply limited resulting in a higher t_0 (time of commencement of the descent of the extraction front) but once commenced, the front descended more rapidly to reach the root front and EFV was therefore greater.

There is an underlying pattern (but with notable exceptions) with respect to the EFVs. On the plant row (P2) and within 0.5m either side (P1 and P3) the EFV is slower than further out into the skip areas (P4 and P5). The wider the skip the slower the EFVs at P1, P2 and P3. By the end of the season the soil moisture at all positions can be depleted to within the lower limit of plant available water capacity.

Implications and Recommendations

Raingrown cotton production continues to expand each season. Skip row plantings are an important component of the raingrown production system and are specifically used to minimise variation in yield and quality. This leads to more stable production over time as well as providing a reduction in input costs. Soil moisture and nitrogen reserves at planting, coupled with expected rainfall for the season, will determine the most appropriate management options in terms of row configuration, and the rate and timing of fertilizer application. However, no information is available on the capacity of raingrown cotton to extract nitrogen from the skip area.

The findings with respect to the position of the extraction front relative to the number of days from sowing have important implications for the management of the nutrition and optimisation of the yield of raingrown crops. Observations on double skip row crops in the Goondiwindi area, suggest that although the crop uses soil water from the middle of the skip row, nitrogen can be left behind. It is hypothesised that by the time the roots begin to access water from the middle of the skip it is too late for the plant to take up nitrogen, leaving the plant with an inadequate supply for boll filling.

Although scientific evidence is lacking, there are ways which could be suggested by which the plant could achieve this. This would impact on the placement and rate of application of nitrogenous fertiliser. Ample must be available to supply the needs of developing bolls so the grower can capture the yield potential and premiums for quality. Placement of nitrogen in the skip area may be inefficient if it is not available to the crop. Hearn (1999) in his attempts to improve the performance of the cotton model OZCOT identified the extraction of water and nitrogen from the skip as a research and development need.

No information is available on plant responses to early season insect damage for cotton grown on different planting configurations under raingrown conditions. Insect damage could alter the rooting patterns with respect to configurations. Clarification of this issue is of particular significance because of the problems of insecticide resistance which the industry faces.

Further work is required to quantify the determinants of the EFV and t_0. Robertson et al. (1993) found that for sorghum EFV is insensitive to soil properties and was stable across experiments differing in evaporative demand and population density. Meinke et al. (1993) found that t_0 was longer for soils with greater maximum available water capacity in the surface. These aspects require further clarification for cotton.

Although the extraction parameters could not be quantified in all cases, the experiments have provided sufficient data for the testing of Monteith's (1986) technique for determining water supply, in the cotton predictive models and it is expected that improvements in the models' predictive abilities will be enhanced. *The redevelopment of the water balance routines in the models should now proceed.*

Publications Arising From The Project

Goyne,P.J. and Hare, J.M. (1998) Revisiting water use in raingrown skip row cotton. *The Australian Cotton Grower 19: 88-89.*

Goyne, P.J. and Hare, J.M. (1999) Soil water extraction dynamics of dryland cotton in various row configurations. *Proceedings of the Beltwide Cotton Conferences, Orlando Florida pp1280-1282.*

In addition a paper will be prepared for publication in The Australian Journal of Agricultural Research.

Extension Activities associated with the project

16-3-96	Hermitage Research Station field walk and discussions with Eastern Downs growers.
3-2-97	Pirrinuan site- Visit by Dr Warren Hoey (D.G. of QDPI) and Dr Terry DeLacey (CRDC board member).
20-3-97	Open Day Hermitage Research Station.

15-5-97 Cotton Day Hermitage Research Station.

27-11-97 Presentation of project objectives and progress to QDPI/FSI board at Hermitage Research Station.

11 to 14-8-98 Cotton Growers Conference- presentation of poster on project.

3-9-98 Presentation of research findings to Cotton Grower's meetings at Goondiwindi and Dalby

4 to 8-1-99 Presentation of paper on the project to Beltwide Cotton Conference, Orlando Florida.

11-1-99 Presented seminar on project findings to a gathering of scientists at Texas A&M University Blackland Research Centre Temple Texas.

17-3-99 Presented talk to growers at the McIntyre Valley Cotton Field day.

22-3-99 Presented talk on project a Gunnedah/Mullaley growers' field day.

17-6-99 Presented findings to Goondiwindi and Dalby growers at a CSD gathering.

21 to 22-7-99 Paper in proceedings of Cotton CRC conference Narrabri.

In addition to the above there have been numerous informal discussions with growers, consultants and fellow researchers.

References

Clothier, B.C. and Green, S.R. (1997) Roots: The big movers of water and chemical in soil. *Soil Science* 162:534-543.

Dowling, D., (Ed) 1999 'Cotton Year Book". (Australian Cotton Grower, Toowoomba).

Hammer, G.L., Goyne, P.J. and Woodruff, D.R., 1982. Phenology of sunflower cultivars. III Models for prediction in field environments. *Aust. J. Agric. Res.*, 33:263-274.

Hearn, A.B. (1994). Principles of cotton water relations and their application in management. Proc. World Cotton Conf. Aust Feb.14-19.

Hearn, A.B. (1999) Validation of OZCOT for skip-row configurations. Consultancy Services report to CSIRO for contract dated 1 July 1998.

Lacape, M.J., Wery, J. and Annerose, D.J.M. (1998). Relationships between plant and soil water status in five field-grown cotton (*Gossypium hirsutum* L.) cultivars. *Field Crops Research* 57:29-43.

Marshall, J., Pyke, B. and Caster, P. (1994). Managing risk with row configuration and plant density in raingrown cotton. Proceedings 7th Australian Cotton Conference. ACGRA pp.221-228.

Meinke, H., Hammer, G.L. and Want, P. (1993). Potential soil water extraction by sunflower on a range of soils. *Field Crops Research* 32:59-81.

Monteith, J.L. (1986). How do crops manipulate water supply and demand? Phil. Trans. R. Soc. London A., 316:245-289.

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.

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- Seed was supplied by Adam Kay, CSD.
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- Thanks to grower cooperators, Pat McVeigh (Waco soil), Jeff Bidstrup (Grey Clay soil), Ross Skerman (Box soil) and Roly Schmelzer (Mywybilla soil) for their interest and help.
- We thank John Marshall, CSD, for the many helpful discussions during the course of this project and the advice given by Drs Greg Constable and Steve Milroy.
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of: 3

Agricultural Chemistry Laboratory Analytical Information Management System

Printed: 29-AUG-96

FINAL RESULTS REPORT
Investigative and Miscellaneous Samples

Reference: SOI95/844

Subject: Cotton Water Use Efficiency Officer: J.M. Hare District Experimentalist Hermitage Research Station, Warwick	Client: Cotton Water Use Efficiency C/- J Hare Unknown Contact: J Hare	Category: Nonapproved Prj Date registered: 15-NOV-95 Number of samples: 8 Number of profiles: 1

Labno	Rl	Depth	Prof Description	pH	EC	Cl	NO3-N	P	P	SO4-S	Cu	Zn	Mn	ADMC	C. Sand
			Method #	1	1	1	1	1	2	1	1	1	1	1	1
				-	mS/cm	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	%	%
9896	0	0-.10	1	8.40	.19	21.000	22.00	43.00	534.00	-IS-	1.30	2.10	9.80	6.77	-IS-
9897	0	.10-.30	1	8.90	.26	26.000	32.00							14.62	-IS-
9898	0	.30-.60	1	9.10	.35	64.000	33.00							16.72	-IS-
9899	0	.60-.90	1	9.20	.48	222.000	16.00							10.52	-IS-
9900	0	.90-1.20	1	9.20	.70	520.000	9.00							12.19	1
9901	0	1.20-1.50	1	9.10	.95	744.000	13.00								
9902	0	1.50-1.80	1	8.90	1.15	921.000	15.00								
9903	0	1.80-2.00	1	8.90	1.24	1067.000	14.00								

Labno	Rl	Depth	Prof Description	F. Sand	Silt	Clay	15 Bar	R1	P	K	S	OC	N	NH4-N	Fe
			Method #	1	1	1	1	1	3	3	3	1	1	2	1
				%	%	%	%	-	%	%	%	%	%	mg/kg	mg/kg
9896	0	0-.10	1	-IS-	-IS-	-IS-	36	-IS-	.129 VH	1.290 H	.021 M	1.80 M	.08 L	2.00 NL	22.00
9897	0	.10-.30	1	-IS-	-IS-	-IS-	37	-IS-	.122 VH	1.170 H	.018 L			-BQ-	
9898	0	.30-.60	1	-IS-	-IS-	-IS-	37	-IS-	.129 VH	1.190 H	.016 L			-BQ-	
9899	0	.60-.90	1	-IS-	-IS-	-IS-	36	-IS-	.167 VH	1.290 H	.016 L			-BQ-	
9900	0	.90-1.20	1	6	15	77	36	-IS-	.169 VH	1.390 H	.018 L			-BQ-	
9901	0	1.20-1.50	1											-BQ-	
9902	0	1.50-1.80	1											-BQ-	
9903	0	1.80-2.00	1											-BQ-	

Labno	Rl	Depth	Prof Description	K	NO3-N
			Method #	5	2
				meq/100g	mg/kg
9896	0	0-.10	1	-IS-	7.00
9897	0	.10-.30	1		17.00
9898	0	.30-.60	1		15.00
9899	0	.60-.90	1		4.00
9900	0	.90-1.20	1		4.00
9901	0	1.20-1.50	1		1.00
9902	0	1.50-1.80	1		1.00
9903	0	1.80-2.00	1		16.00

*__APPENDIX 2__ **Soil Chemical Analysis 96/97***
Hermitage Research Station

Alluvial Grey Clay – Hermitage Research Station

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of: 2

Agricultural Chemistry Laboratory Analytical Information Management System

Printed: 25-OCT-96

FINAL RESULTS REPORT
Investigative and Miscellaneous Samples

Reference: SOI96/703

Subject: Cotton Water Use Improvement
Officer: P.J. Goyne
Principal Agronomist
Hermitage Research Station, Warwick

Category: Nonapproved Prj
Date registered: 11-OCT-96
Number of samples: 5
Number of profiles: 1

Labno	Rl	Depth	Prof	Description (Analyte / Method #)	pH 1 -	EC 1 mS/cm	Cl 1 mg/kg	NO3-N 1 mg/kg	Cu 1 mg/kg	Zn 1 mg/kg	Mn 1 mg/kg	Fe 1 mg/kg
9884	0	0-.10	1	Paddock D5-D11	8.50	.18	15.000	14.00	1.05	24.80	20.30	10.90
9885	0	.10-.30	1	Paddock D5-D11	8.90	.22	11.000	12.00	1.06	36.90	9.40	11.30
9886	0	.30-.60	1	Paddock D5-D11	9.20	.42	48.000	26.00	1.56	3.89	6.20	16.10
9887	0	.60-.90	1	Paddock D5-D11	9.40	.70	181.000	46.00	1.58	17.50	4.40	15.70
9888	0	.90-1.20	1	Paddock D5-D11	9.70	.67	150.000	32.00	1.44	25.30	2.86	14.40

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of: 3

Agricultural Chemistry Laboratory Analytical Information Management System

Printed: 19-JUN-97

FINAL RESULTS REPORT
Investigative and Miscellaneous Samples

Reference: SOI97/298

Subject: Cotton Water Use Improvement
Officer: P.J. Goyne
Principal Agronomist
Hermitage Research Station, Warwick

Category: Nonapproved Pri
Date registered: 18-APR-97
Number of samples: 16
Number of profiles: 2

Labno	Rl	Depth	Prof	Description	pH (Method 1) -	EC (Method 1) mS/cm	Cl (Method 1) mg/kg	NO3-N (Method 1) mg/kg	Ca (Method 1) meq/100g	Mg (Method 1) meq/100g	Na (Method 1) meq/100g	K (Method 1) meq/100g	CEC (Method 2) meq/100g	ADMC (Method 1) %	C. Sand (Method 1) %	F. Sand (Method 1) %
2631	0	0-.10	1	Site 1 P McVeig	6.10	.20	11.000	53.00	25.00	25.00	2.20	1.90	62.00	7.84	3	11
2632	0	.10-.30	1	Site 1 P McVeig	9.20	.36	46.000	16.00	24.00	29.00	3.90	1.10	64.00	12.94	3	11
2633	0	.30-.60	1	Site 1 P McVeig	9.60	.39	24.000	12.00	19.00	35.00	8.30	.91	66.00	7.08	3	10
2634	0	.60-.90	1	Site 1 P McVeig	9.80	.61	237.000	22.00	15.00	35.00	12.00	.98	62.00	8.86	3	10
2635	0	.90-1.20	1	Site 1 P McVeig	9.60	1.08	723.000	8.00	14.00	35.00	14.00	1.40	66.00	8.49	2	8
2636	0	1.20-1.50	1	Site 1 P McVeig	9.50	1.32	916.000	2.00	13.00	34.00	15.00	1.60	62.00	8.38	2	8
2637	0	1.50-1.80	1	Site 1 P McVeig	9.60	.96	558.000	-BQ-	15.00	34.00	13.00	1.50	63.00	10.50	3	8
2638	0	1.80-2.00	1	Site 1 P McVeig	9.40	1.42	995.000	1.00	14.00	35.00	14.00	1.10	64.00	7.99	3	9
2639	0	0-.10	2	Site 2 R Skerma	8.60	.14	4.000	31.00	17.00	8.50	1.20	.41	31.00	3.08	17	28
2640	0	.10-.30	2	Site 2 R Skerma	8.60	.12	7.000	14.00	22.00	13.00	2.80	.24	42.00	5.05	11	20
2641	0	.30-.60	2	Site 2 R Skerma	8.70	.29	156.000	17.00	18.00	15.00	4.40	.20	42.00	6.63	10	14
2642	0	.60-.90	2	Site 2 R Skerma	9.10	.68	592.000	17.00	17.00	17.00	5.90	.23	42.00	4.48	12	15
2643	0	.90-1.20	2	Site 2 R Skerma	9.00	.97	957.000	6.00	21.00	17.00	6.30	.28	46.00	4.22	11	15
2644	0	1.20-1.50	2	Site 2 R Skerma	9.00	.66	907.000	-BQ-	16.00	17.00	6.60	.28	42.00	4.38	10	18
2645	0	1.50-1.80	2	Site 2 R Skerma	9.10	1.05	1064.000	-BQ-	18.00	18.00	7.20	.31	46.00	4.24	10	17
2646	0	1.80-2.00	2	Site 2 R Skerma	9.20	1.03	949.000	-BQ-	19.00	19.00	7.50	.30	48.00	5.32	6	17

Labno	Rl	Depth	Prof	Description	Silt (Method 1) %	Clay (Method 1) %	15 Bar (Method 1) %	R1 (Method 1) -	P (Method 3) %	K (Method 3) %	S (Method 3) %
2631	0	0-.10	1	Site 1 P McVeig	11	71	34	.53	.061	.986	.021
2632	0	.10-.30	1	Site 1 P McVeig	12	71	38	.66	.056	.906	.037
2633	0	.30-.60	1	Site 1 P McVeig	11	73	42	.74	.059	.931	.021
2634	0	.60-.90	1	Site 1 P McVeig	13	73	41	.86	.071	1.000	.026
2635	0	.90-1.20	1	Site 1 P McVeig	10	78	44	.84	.087	1.160	.042
2636	0	1.20-1.50	1	Site 1 P McVeig	10	78	43	.78	.099	1.190	.048
2637	0	1.50-1.80	1	Site 1 P McVeig	8	79	43	.84	.083	1.200	.037
2638	0	1.80-2.00	1	Site 1 P McVeig	10	78	42	.77	.071	1.140	.047
2639	0	0-.10	2	Site 2 R Skerma	13	40	18	.74	.023	.367	.017
2640	0	.10-.30	2	Site 2 R Skerma	16	51	24	.77	.022	.369	.020
2641	0	.30-.60	2	Site 2 R Skerma	20	53	25	.90	.016	.332	.022
2642	0	.60-.90	2	Site 2 R Skerma	18	54	25	.84	.016	.346	.033
2643	0	.90-1.20	2	Site 2 R Skerma	16	57	26	.82	.015	.412	.029
2644	0	1.20-1.50	2	Site 2 R Skerma	13	57	26	.88	.016	.456	.027
2645	0	1.50-1.80	2	Site 2 R Skerma	13	57	25	.80	.021	.461	.026
2646	0	1.80-2.00	2	Site 2 R Skerma	17	57	26	.79	.037	.629	.020

<u>APPENDIX 4</u> Soil Chemical Analysis 97/98
Waco, Box, Grey Soil

Waco – Pirrinuan (P.McVeigh)
Box – Nandi Daandine (R.Skerman) 1997/98

Page: 1 of: 5

Analytical Centre Laboratory Analytical Information Management System

Printed: 17-AUG-1998

Reference: SOI98/226

FINAL RESULTS REPORT
Investigative and Miscellaneous Samples

Subject: Improved Understanding of Cotton Water Use
Officer: P.J. Goyne
Principal Agronomist
Hermitage Research Station, Warwick

Category: Nonapproved Prj
Date registered: 23-MAR-98
Number of samples: 24
Number of profiles: 3

Labno	Rl	Depth	Prof	Description	pH 1 -	EC 1 mS/cm	Cl 1 mg/kg	NO3-N 1 mg/kg	P 1 mg/kg	P 2 mg/kg	SO4-S 1 mg/kg	Ca 1 meq/100g	Mg 1 meq/100g	Na 1 meq/100g	K 1 meq/100g	CEC 1 meq/100g
3420	0	0-.10	1	P Mc Veigh	7.80	.17	51.200	29.50	29.00	230.00	6.00	36.00	31.00	1.40	3.10	73.00
3421	0	.10-.30	1	P Mc Veigh	8.70	.21	111.000	2.10				32.00	34.00	2.80	1.90	77.00
3422	0	.30-.60	1	P Mc Veigh	9.10	.29	68.500	15.40				28.00	40.00	6.00	1.40	77.00
3423	0	.60-.90	1	P Mc Veigh	9.30	.41	213.000	12.40				22.00	41.00	9.40	1.50	72.00
3424	0	.90-1.20	1	P Mc Veigh	9.20	.83	615.000	24.00				20.00	41.00	11.00	1.80	60.00
3425	0	1.20-1.50	1	P Mc Veigh	9.10	1.10	1140.000	16.40				17.00	42.00	13.00	2.00	72.00
3426	0	1.50-1.80	1	P Mc Veigh	9.00	1.22	1740.000	68.60				17.00	44.00	12.00	1.80	72.00
3427	0	1.80-2.00	1	P Mc Veigh	-NR-	-NR-	-NR-	-NR-				-IS-	-IS-	-IS-	-IS-	-IS-
3428	0	0-.10	2	R Skerman	8.20	.10	23.100	26.50	13.00	21.00	4.00	24.00	12.00	1.40	.61	43.00
3429	0	.10-.30	2	R Skerman	8.50	.09	32.700	4.80				28.00	13.00	2.40	.45	46.00
3430	0	.30-.60	2	R Skerman	8.10	.20	122.000	10.30				23.00	17.00	4.00	.35	36.00
3431	0	.60-.90	2	R Skerman	8.30	.48	530.000	16.00				21.00	18.00	5.80	.35	45.00
3432	0	.90-1.20	2	R Skerman	8.50	.89	1220.000	6.80				20.00	19.00	6.40	.40	40.00
3433	0	1.20-1.50	2	R Skerman	8.60	1.02	1430.000	1.60				20.00	20.00	6.70	.43	42.00
3434	0	1.50-1.80	2	R Skerman	8.60	1.05	1470.000	1.40				20.00	23.00	7.50	.49	48.00
3435	0	1.80-2.00	2	R Skerman	-NR-	-NR-	-NR-	-NR-				-IS-	-IS-	-IS-	-IS-	-IS-
3436	0	0-.10	3	J Bidstrup	8.80	.14	78.700	1.60	31.00	47.00	8.00	30.00	7.10	.85	.70	35.00
3437	0	.10-.30	3	J Bidstrup	8.90	.15	32.000	15.50				28.00	9.20	1.40	.22	35.00
3438	0	.30-.60	3	J Bidstrup	9.10	.22	58.500	8.00				23.00	12.00	3.00	.16	35.00
3439	0	.60-.90	3	J Bidstrup	9.10	.44	275.000	16.30				15.00	16.00	5.20	.15	38.00
3440	0	.90-1.20	3	J Bidstrup	8.40	.71	625.000	12.40				13.00	18.00	6.60	.19	35.00
3441	0	1.20-1.50	3	J Bidstrup	5.60	1.02	1240.000	8.40				12.00	16.00	6.40	.18	37.00
3442	0	1.50-1.80	3	J Bidstrup	4.70	1.01	1330.000	6.40				9.60	16.00	6.20	.17	38.00
3443	0	1.80-2.00	3	J Bidstrup	4.90	.93	1270.000	4.00				11.00	17.00	6.60	.23	38.00

APPENDIX 4 Continued *Soil Chemical Analysis 97/98*

Waco, Box, Grey Soil

1997/98

Analytical Centre Laboratory Analytical Information Management System

Printed: 17-AUG-1998

FINAL RESULTS REPORT
Investigative and Miscellaneous Samples

Reference: SOI98/226

Labno	Rl	Depth	Prof	Description	Cu 1 mg/kg	Zn 1 mg/kg	Mn 1 mg/kg	ADMO 1 %	C. Sand 1 %	F. Sand 1 %	Silt 1 %	Clay 1 %	15 Bar 1 %	Rl 1 -	P 3 %	K 3 %
3420	0	0-.10	1	P Mc Veigh	1.17	.87	12.80									
3421	0	.10-.30	1	P Mc Veigh				10.32	3	11	13	75	36	.72	.069	1.750
3422	0	.30-.60	1	P Mc Veigh				7.35	1	11	13	73	36	.73	.064	1.090
3423	0	.60-.90	1	P Mc Veigh				8.48	3	11	11	74	16	.80	.073	1.060
3424	0	.90-1.20	1	P Mc Veigh				8.99	3	10	13	74	37	.81	.089	1.170
3425	0	1.20-1.50	1	P Mc Veigh				8.14	3	9	10	76	18	.76	.096	1.240
3426	0	1.50-1.80	1	P Mc Veigh				8.54	2	9	12	75	38	.80	.093	1.250
3427	0	1.80-2.00	1	P Mc Veigh				-NR-	-NR-	-NR-	-NR-	-NR-	-IS-	-NR-	-IS-	-IS-
3428	0	0-.10	2	R Skerman	1.10	.46	8.90									
3429	0	.10-.30	2	R Skerman				4.51	11	21	17	53	22	.75	.018	.406
3430	0	.30-.60	2	R Skerman				4.77	8	16	17	60	24	.84	.018	.392
3431	0	.60-.90	2	R Skerman				4.74	7	12	20	61	25	.86	.013	.386
3432	0	.90-1.20	2	R Skerman				5.06	8	15	19	58	24	.85	.014	.485
3433	0	1.20-1.50	2	R Skerman				5.11	8	18	15	61	25	.96	.014	.503
3434	0	1.50-1.80	2	R Skerman				4.77	6	19	16	61	27	.87	.017	.532
3435	0	1.80-2.00	2	R Skerman				-NR-	-NR-	-NR-	-NR-	-NR-	-IS-	-NR-	-IS-	-IS-
3436	0	0-.10	3	J Bidstrup	1.34	.82	31.45									
3437	0	.10-.30	3	J Bidstrup				3.76	15	23	15	46	19	.67	.020	.177
3438	0	.30-.60	3	J Bidstrup				3.78	21	14	16	50	20	.78	.016	.163
3439	0	.60-.90	3	J Bidstrup				3.79	12	17	19	53	21	.83	.014	.137
3440	0	.90-1.20	3	J Bidstrup				3.79	9	17	16	57	22	.97	.011	.149
3441	0	1.20-1.50	3	J Bidstrup				4.58	8	16	16	61	24	.95	.010	.156
3442	0	1.50-1.80	3	J Bidstrup				4.35	9	19	15	57	24	.86	.011	.198
3443	0	1.80-2.00	3	J Bidstrup				5.58	7	16	15	61	26	.96	.011	.226

__APPENDIX 4 Continued__ ***Soil Chemical Analysis 97/98***

Waco, Box, Grey Soil

1997/98

Analytical Centre Laboratory Analytical Information Management System

Printed: 17-AUG-1998

FINAL RESULTS REPORT

Reference: SOI98/226

Investigative and Miscellaneous Samples

Labno	Rl	Depth	Prof	Description	S 3 %	pH 2 -	OC 1 %	N 8 %	NH4-N 1 mg/kg	Fe 1 mg/kg	K 5 meq/100g	NO3-N 1 mg/kg
3420	0	0-.10	1	P Mc Veigh		7.00	1.35	.09	1.80	19.64	2.20	22.10
3421	0	.10-.30	1	P Mc Veigh	.028	7.70			3.00			1.20
3422	0	.30-.60	1	P Mc Veigh	.027	7.90			2.90			7.80
3423	0	.60-.90	1	P Mc Veigh	.040	8.20			1.60			7.50
3424	0	.90-1.20	1	P Mc Veigh	.043	8.30			1.30			13.60
3425	0	1.20-1.50	1	P Mc Veigh	.050	8.30			2.00			9.70
3426	0	1.50-1.80	1	P Mc Veigh	.044	8.30			4.40			18.80
3427	0	1.80-2.00	1	P Mc Veigh	-IS-	-NR-			-NR-			-NR-
3428	0	0-.10	2	R Skerman		7.30	.70	.05	3.10	15.33	.50	20.30
3429	0	.10-.30	2	R Skerman	.025	7.30			37.10			40.50
3430	0	.30-.60	2	R Skerman	.032	7.20			2.30			6.50
3431	0	.60-.90	2	R Skerman	.032	7.50			2.00			9.50
3432	0	.90-1.20	2	R Skerman	.034	7.80			1.60			4.10
3433	0	1.20-1.50	2	R Skerman	.039	7.80			2.00			.90
3434	0	1.50-1.80	2	R Skerman	.038	7.90			2.40			.90
3435	0	1.80-2.00	2	R Skerman	-IS-	-NR-			-NR-			-NR-
3436	0	0-.10	3	J Bidstrup		7.60	1.00	.09	2.30	13.11	.52	.80
3437	0	.10-.30	3	J Bidstrup	.022	7.80			1.60			11.10
3438	0	.30-.60	3	J Bidstrup	.027	7.90			1.70			11.10
3439	0	.60-.90	3	J Bidstrup	.035	8.00			37.80			40.80
3440	0	.90-1.20	3	J Bidstrup	.042	7.70			2.00			9.00
3441	0	1.20-1.50	3	J Bidstrup	.048	5.10			1.80			5.70
3442	0	1.50-1.80	3	J Bidstrup	.042	4.20			2.00			4.70
3443	0	1.80-2.00	3	J Bidstrup	.042	4.40			2.00			2.90

<u>*APPENDIX 5*</u> ***Soil Chemical Analysis 98/99***

Waco, Grey Soil, Mywybilla

Waco – Pirrinuan (McVeigh)
Grey Clay – Warra (Bidstrup) 1998/99

Analytical Centre Laboratory Analytical Information Management System

Printed: 31-03-1999

FINAL RESULTS REPORT
Investigative and Miscellaneous Samples

Reference: SOI99/47

Subject: DAQ 77C
Officer: P.J. Goyne
Principal Agronomist
Hermitage Research Station, Warwick

Category: Nonapproved Prj
Date registered: 29-01-1999
Number of samples: 24
Number of profiles: 3

Labno	Rl	Depth	Prof	Description	pH (Method 1) -	EC (Method 1) mS/cm	Cl (Method 1) mg/kg	N (Method 1) mg/kg	P (Method 1) mg/kg	P (Method 2) mg/kg	SO4-S (Method 1) mg/kg	Ca (Method 1) meq/100g	Mg (Method 1) meq/100g	Na (Method 1) meq/100g	K (Method 1) meq/100g	CEC (Method 1) meq/100g
344	0	0-.10	1	1 McVeigh	8.10	.13	15.200	12.20	34.00	366.00	4.12	36.00	21.80	2.20	.82	57.20
345	0	.10-.30	1	2 McVeigh	8.70	.23	11.700	38.70				33.00	23.50	3.80	.42	57.70
346	0	.30-.60	1	3 McVeigh	9.00	.28	45.900	30.90				34.00	23.20	6.00	.34	59.60
347	0	.60-.90	1	4 McVeigh	9.30	.39	82.400	21.10				20.70	26.50	10.60	.44	57.70
348	0	.90-1.20	1	5 McVeigh	9.30	.66	425.400	11.10				19.30	27.50	13.40	.58	53.10
349	0	1.20-1.50	1	6 McVeigh	9.00	1.00	789.700	3.50				16.20	26.50	13.40	.58	57.60
350	0	1.50-1.80	1	7 McVeigh	9.00	1.31	1364.000	1.10				16.70	26.50	14.50	.58	55.20
351	0	1.80-2.00	1	8 McVeigh	8.90	1.51	1756.300	-BQ-				15.30	27.20	14.90	.36	58.80
352	0	0-.10	2	9 Bidstrup	8.70	.15	52.700	.90	25.00	43.00	2.01	39.50	6.90	.94	.32	31.40
353	0	.10-.30	2	10 Bidstrup	8.90	.16	18.100	2.10				23.40	8.30	1.30	.08	32.90
354	0	.30-.60	2	11 Bidstrup	9.10	.21	19.500	5.00				18.10	11.90	2.40	.14	30.30
355	0	.60-.90	2	12 Bidstrup	9.10	.23	33.400	6.30				9.90	13.20	4.30	.08	33.20
356	0	.90-1.20	2	13 Bidstrup	7.80	.42	161.400	15.30				11.50	13.80	6.20	.08	32.90
357	0	1.20-1.50	2	14 Bidstrup	5.10	.82	528.300	27.10				9.60	12.50	6.10	.09	33.80
358	0	1.50-1.80	2	15 Bidstrup	4.50	1.19	1408.600	21.80				7.10	14.50	7.20	.08	37.10
359	0	1.80-2.00	2	16 Bidstrup	4.40	1.19	1538.900	14.70				7.90	15.20	7.40	.09	36.30
360	0	0-.10	3	17 Rolly Schmei	7.10	.08	34.800	7.50	28.00	29.00	25.86	26.20	23.00	2.10	.55	59.60
361	0	.10-.30	3	18 Rolly Schmei	8.00	.10	21.600	8.50				26.40	23.00	3.50	.30	57.40
362	0	.30-.60	3	19 Rolly Schmei	8.50	.13	33.400	10.50				34.50	25.30	5.60	.23	58.80
363	0	.60-.90	3	20 Rolly Schmei	8.90	.21	93.000	8.40				21.50	27.20	7.40	.26	59.10
364	0	.90-1.20	3	21 Rolly Schmei	8.80	.64	470.600	9.90				21.90	25.40	10.20	.23	58.70
365	0	1.20-1.50	3	22 Rolly Schmei	8.70	.98	1253.000	-BQ-				21.40	29.40	8.60	.39	58.60
366	0	1.50-1.80	3	23 Rolly Schmei	8.60	1.19	1520.300	-BQ-				17.90	26.80	9.00	.40	58.20
367	0	1.80-2.00	3	24 Rolly Schmei	8.60	1.26	1583.700	-BQ-				19.80	29.20	9.00	.35	59.40

Labno	Rl	Depth	Prof	Description	Cu (Method 1) mg/kg	Zn (Method 2) mg/kg	Mn (Method 1) mg/kg	ADMC (Method 1) %	C. Sand (Method 1) %	F. Sand (Method 1) %	Silt (Method 1) %	Clay (Method 1) %	15 Bar (Method 1) %	R1 (Method 1) -	P (Method 3) %	K (Method 3) %
344	0	0-.10	1	1 McVeigh	1.00	1.00	6.50	10.89	3	10	14	73	35	.49	.098	1.250
345	0	.10-.30	1	2 McVeigh				11.79	3	9	11	77	38	.65	.090	1.130
346	0	.30-.60	1	3 McVeigh				11.67	3	9	11	77	39	.75	.096	1.140
347	0	.60-.90	1	4 McVeigh				13.53	3	9	10	75	40	.92	.105	1.180
348	0	.90-1.20	1	5 McVeigh				13.34	3	8	12	78	39	.90	.125	1.310
349	0	1.20-1.50	1	6 McVeigh				13.51	2	7	12	79	38	.88	.137	1.370
350	0	1.50-1.80	1	7 McVeigh				13.63	2	6	14	79	38	.84	.138	1.380
351	0	1.80-2.00	1	8 McVeigh				9.93	2	5	13	80	-BQ-	.75	.139	1.380

APPENDIX 5 Continued *Soil Chemical Analysis 98/99* 1998/99

Waco, Grey Soil, Mywybilla

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of: 5

Analytical Centre Laboratory Analytical Information Management System

Printed: 31-03-1999

FINAL RESULTS REPORT
Investigative and Miscellaneous Samples

Reference: SOI99/47

Labno	R1	Depth	Prof	Description	Cu	Zn	Mn	ADMC	C. Sand	F. Sand	Silt	Clay	15 Bar	R1	P	K
				Method #	1	1	1	1	1	1	1	1	1	1	3	3
					mg/kg	mg/kg	mg/kg	%	%	%	%	%	%	-	%	%
352	0	0-.10	2	9 Bidstrup	.96	.83	3.20	3.69	13	23	17	51	17	.48	.036	.198
353	0	.10-.30	2	10 Bidstrup				5.70	12	21	17	52	19	.57	.024	.172
354	0	.30-.60	2	11 Bidstrup				5.55	13	23	16	49	19	.70	.018	.121
355	0	.60-.90	2	12 Bidstrup				5.19	11	22	15	55	-BQ-	.81	.016	.112
356	0	.90-1.20	2	13 Bidstrup				5.88	10	19	13	59	20	.92	.011	.103
357	0	1.20-1.50	2	14 Bidstrup				5.89	10	19	16	56	20	.90	.010	.101
358	0	1.50-1.80	2	15 Bidstrup				5.65	8	18	14	62	24	.88	.010	.139
359	0	1.80-2.00	2	16 Bidstrup				7.31	8	17	14	63	25	.85	.010	.151
360	0	0-.10	3	17 Rolly Schmei	1.90	1.50	21.00	8.93	4	13	14	69	31	.60	.033	.568
361	0	.10-.30	3	18 Rolly Schmei				12.01	4	13	12	73	33	.78	.023	.488
362	0	.30-.60	3	19 Rolly Schmei				11.23	3	12	13	73	33	.78	.021	.494
363	0	.60-.90	3	20 Rolly Schmei				11.91	3	11	13	74	35	.85	.029	.550
364	0	.90-1.20	3	21 Rolly Schmei				9.92	3	11	12	75	35	.82	.039	.665
365	0	1.20-1.50	3	22 Rolly Schmei				12.65	3	10	14	74	34	.76	.049	.724
366	0	1.50-1.80	3	23 Rolly Schmei				12.02	3	10	9	77	33	.74	.052	.739
367	0	1.80-2.00	3	24 Rolly Schmei				13.35	3	10	13	78	33	.69	.057	.719

Labno	R1	Depth	Prof	Description	S	OC	N	Fe	K
				Method #	3	1	2	1	5
					%	%	%	mg/Kg	meq/100g
344	0	0-.10	1	1 McVeigh	.023	1.80	.06	3.50	2.10
345	0	.10-.30	1	2 McVeigh	.019				
346	0	.30-.60	1	3 McVeigh	.019				
347	0	.60-.90	1	4 McVeigh	.021				
348	0	.90-1.20	1	5 McVeigh	.028				
349	0	1.20-1.50	1	6 McVeigh	.038				
350	0	1.50-1.80	1	7 McVeigh	.044				
351	0	1.80-2.00	1	8 McVeigh	.044				
352	0	0-.10	2	9 Bidstrup	.023	1.50	.06	4.30	.50
353	0	.10-.30	2	10 Bidstrup	.029				
354	0	.30-.60	2	11 Bidstrup	.027				
355	0	.60-.90	2	12 Bidstrup	.027				
356	0	.90-1.20	2	13 Bidstrup	.035				
357	0	1.20-1.50	2	14 Bidstrup	.053				
358	0	1.50-1.80	2	15 Bidstrup	.046				
359	0	1.80-2.00	2	16 Bidstrup	.043				
360	0	0-.10	3	17 Rolly Schmei	.021	1.55	.05	13.00	1.40
361	0	.10-.30	3	18 Rolly Schmei	.020				
362	0	.30-.60	3	19 Rolly Schmei	.021				
363	0	.60-.90	3	20 Rolly Schmei	.024				
364	0	.90-1.20	3	21 Rolly Schmei	.029				
965	0	1.20-1.50	3	22 Rolly Schmei	.035				

__APPENDIX 5 Continued__ Soil Chemical Analysis 98/99
Waco, Grey Soil, Mywybilla

1998/99

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of: 5

Analytical Centre Laboratory Analytical Information Management System

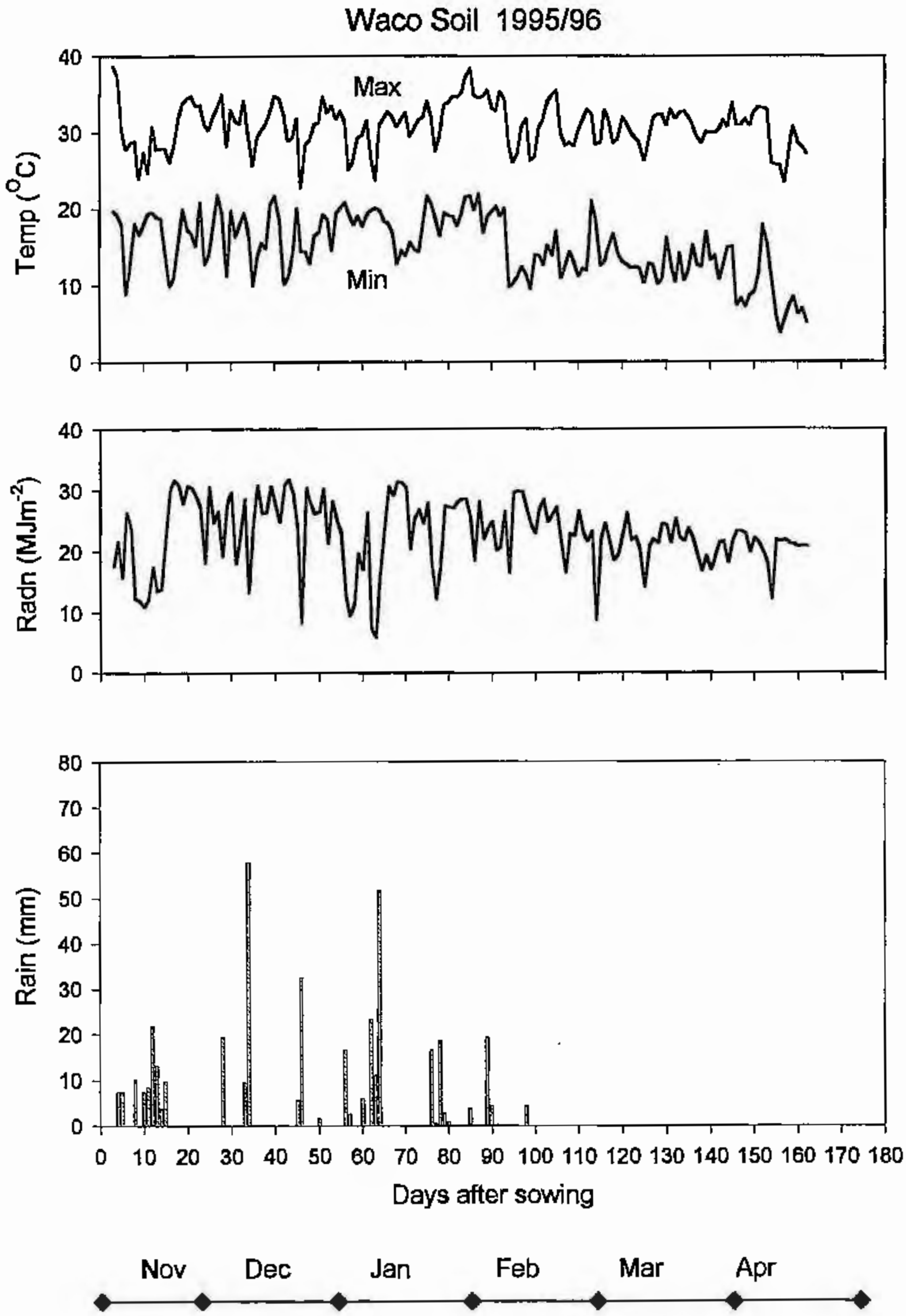
Printed: 31-03-1999

Reference: SOI99/47

FINAL RESULTS REPORT
Investigative and Miscellaneous Samples

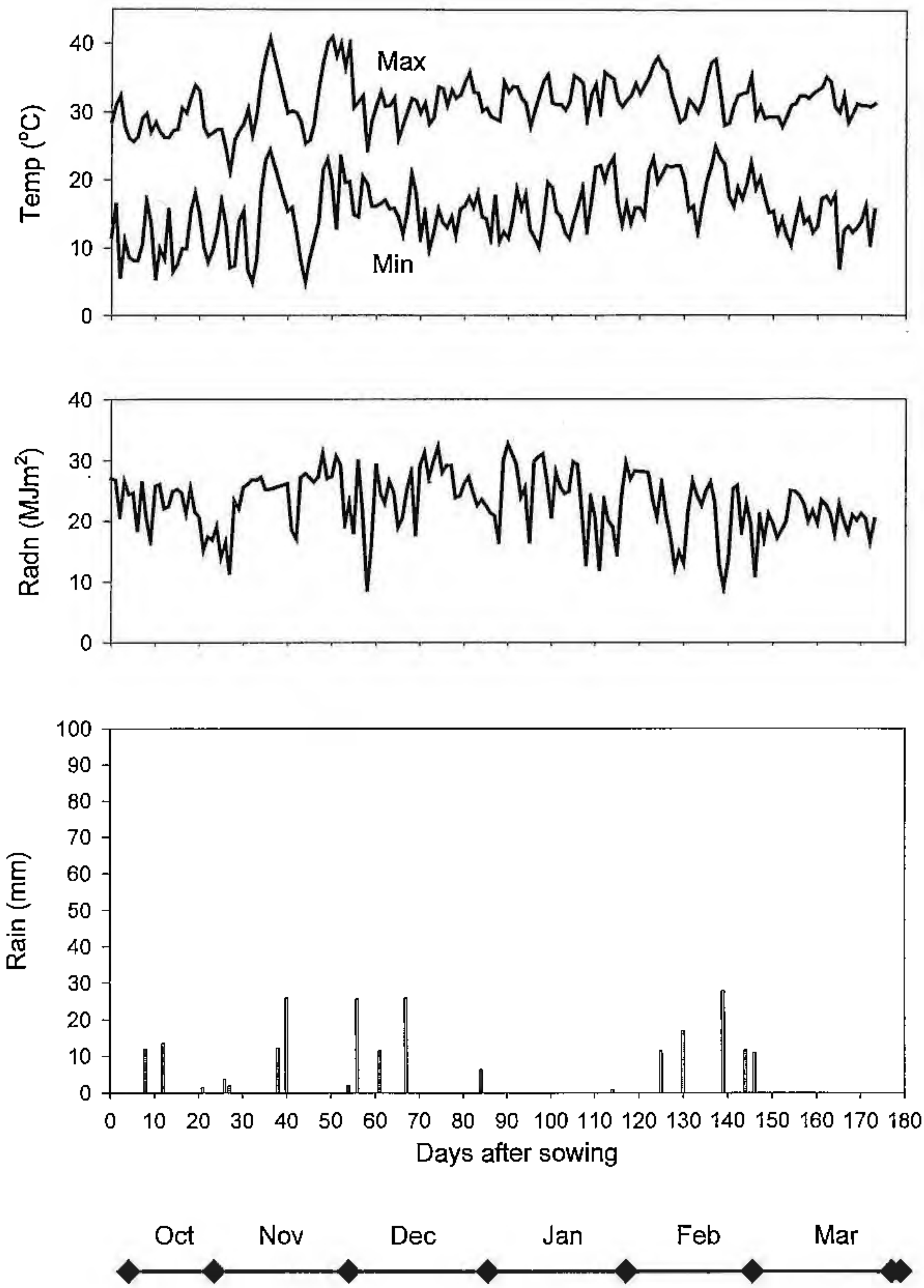
Labno	Rl	Depth	Prof	Description	S	OC	N	Fe	K
				Analyte	S	OC	N	Fe	K
				Method #	3	1	2	1	5
					%	%	%	mg/kg	meq/100g
366	0	1.50-1.80	3	23 Rolly Schmei	.036				
367	0	1.80-2.00	3	24 Rolly Schmei	.037				

APPENDIX 6


Waco Soil 1995/96
Max
Min
Temp (°C)
0
10
20
30
40
Radn (MJm-2)
Rain (mm)
50
60
70
80
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
Days after sowing
Nov
Dec
Jan
Feb
Mar
Apr

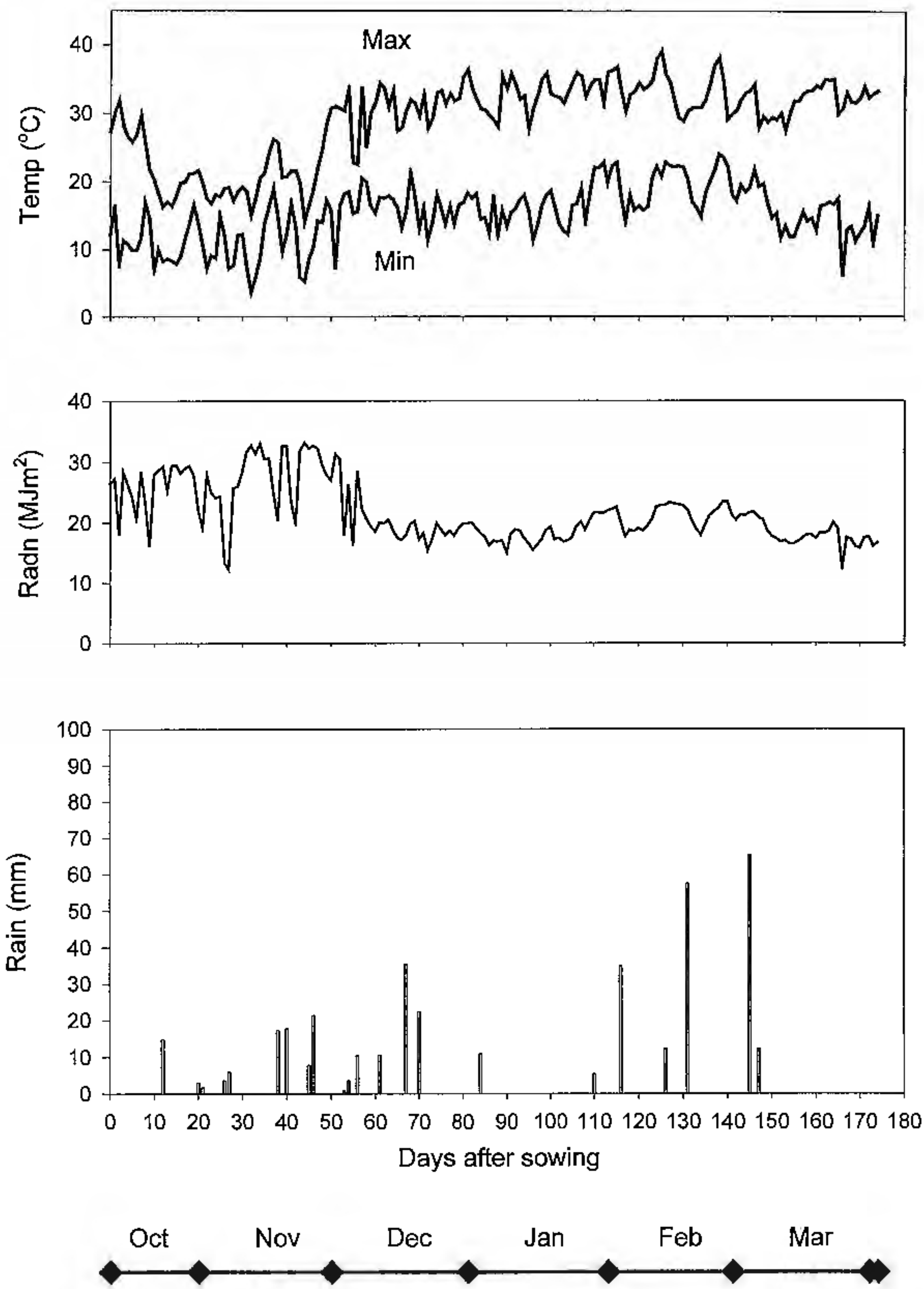
APPENDIX 7

Waco Soil 1996/97



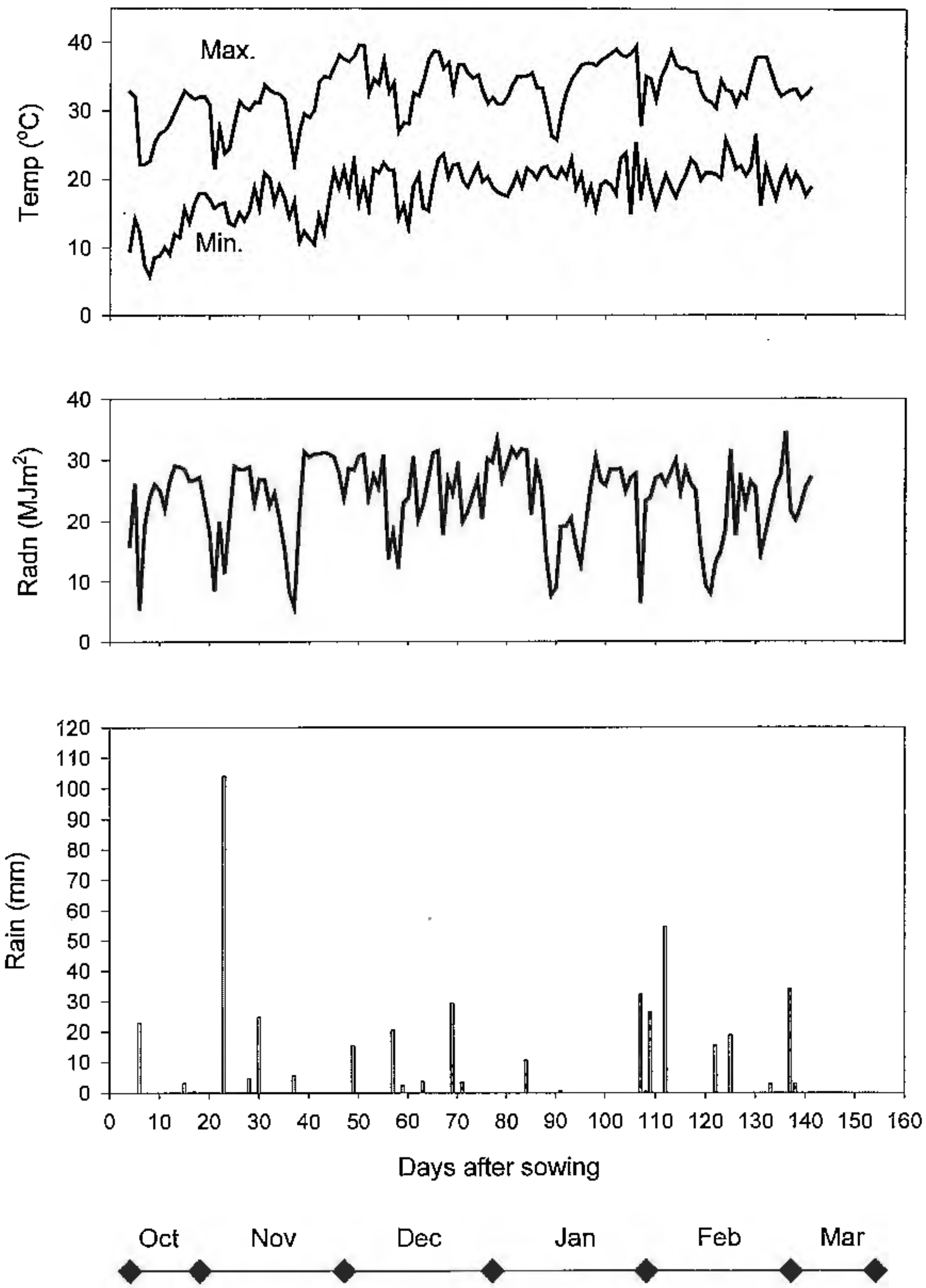
APPENDIX 8

Box Soil 1996/97

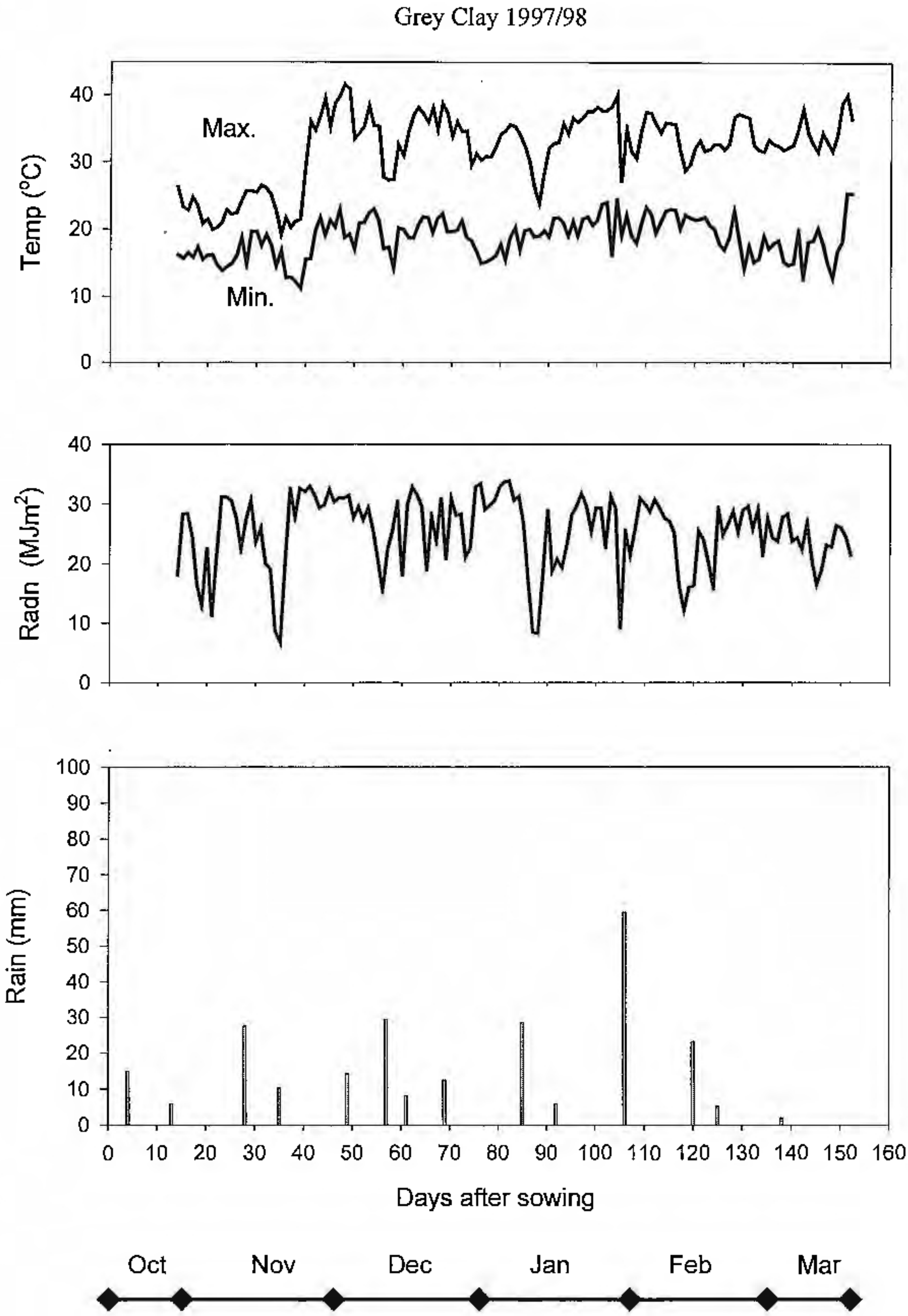


APPENDIX 9

Waco Soil 1997/98

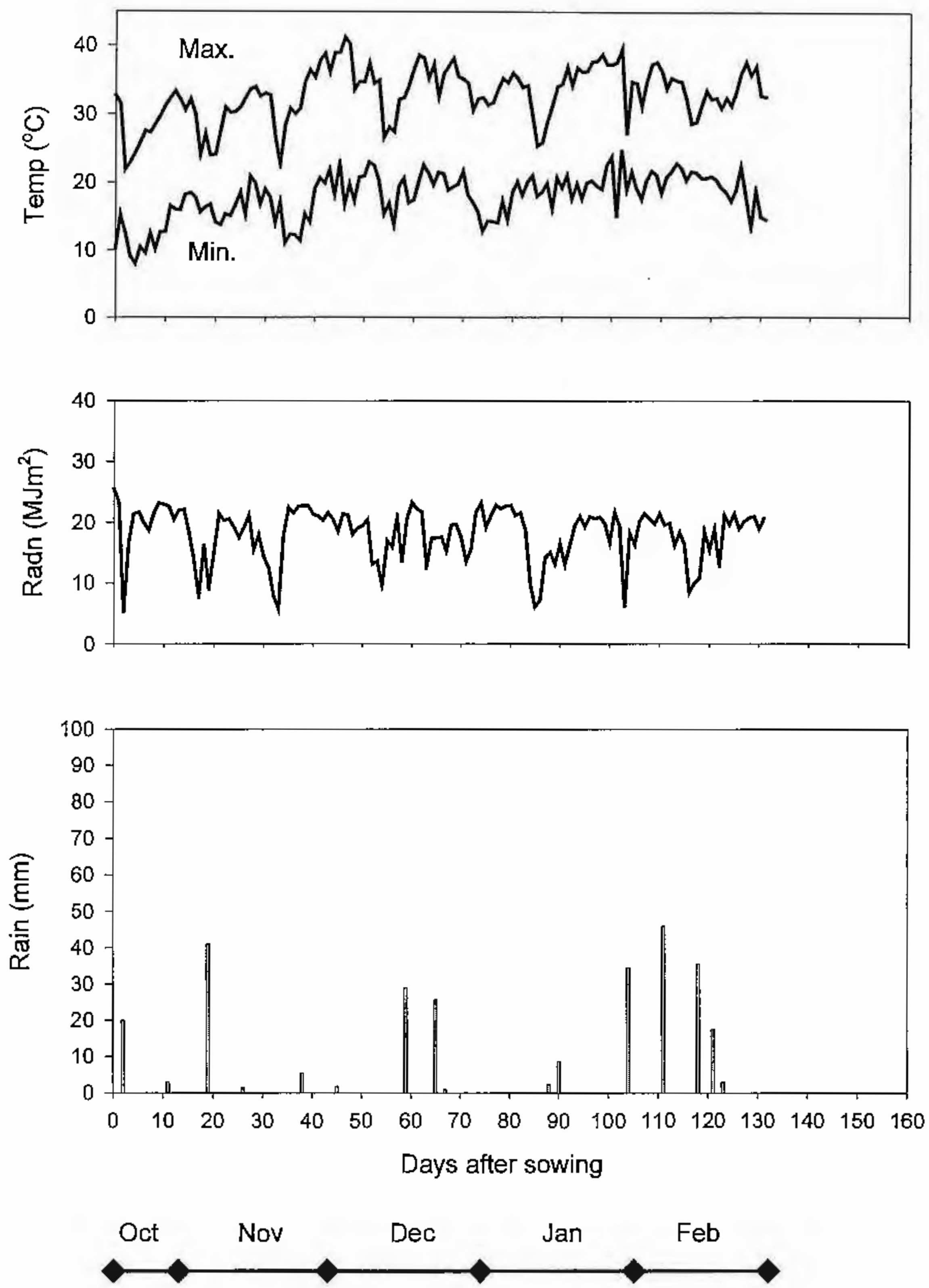


APPENDIX 10

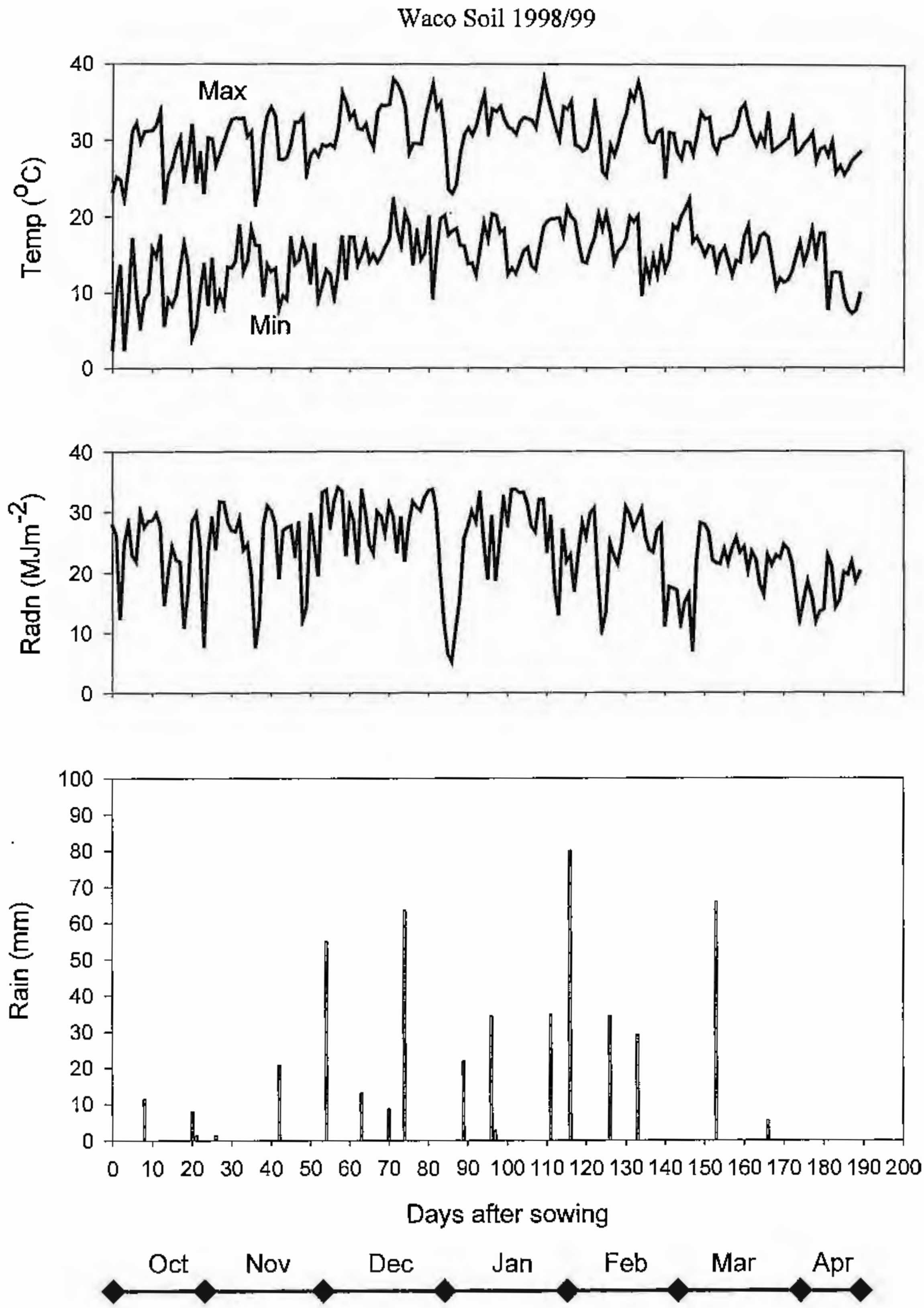

Grey Clay 1997/98
Max.
Min.
Temp (°C)
Radn (MJm²)
Rain (mm)
Days after sowing
Oct
Nov
Dec
Jan
Feb
Mar

APPENDIX 11

Box Soil 1997/98



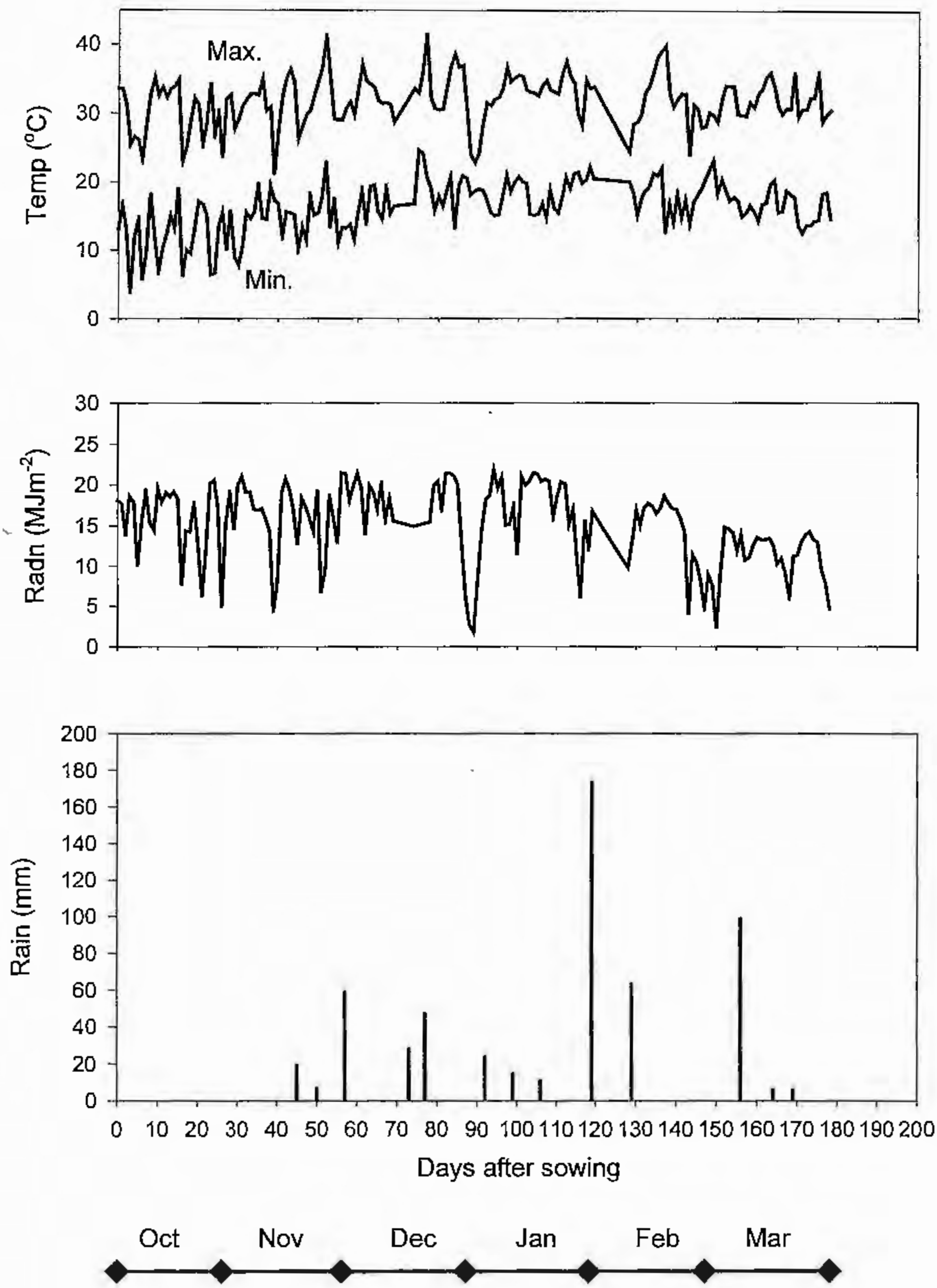
APPENDIX 12



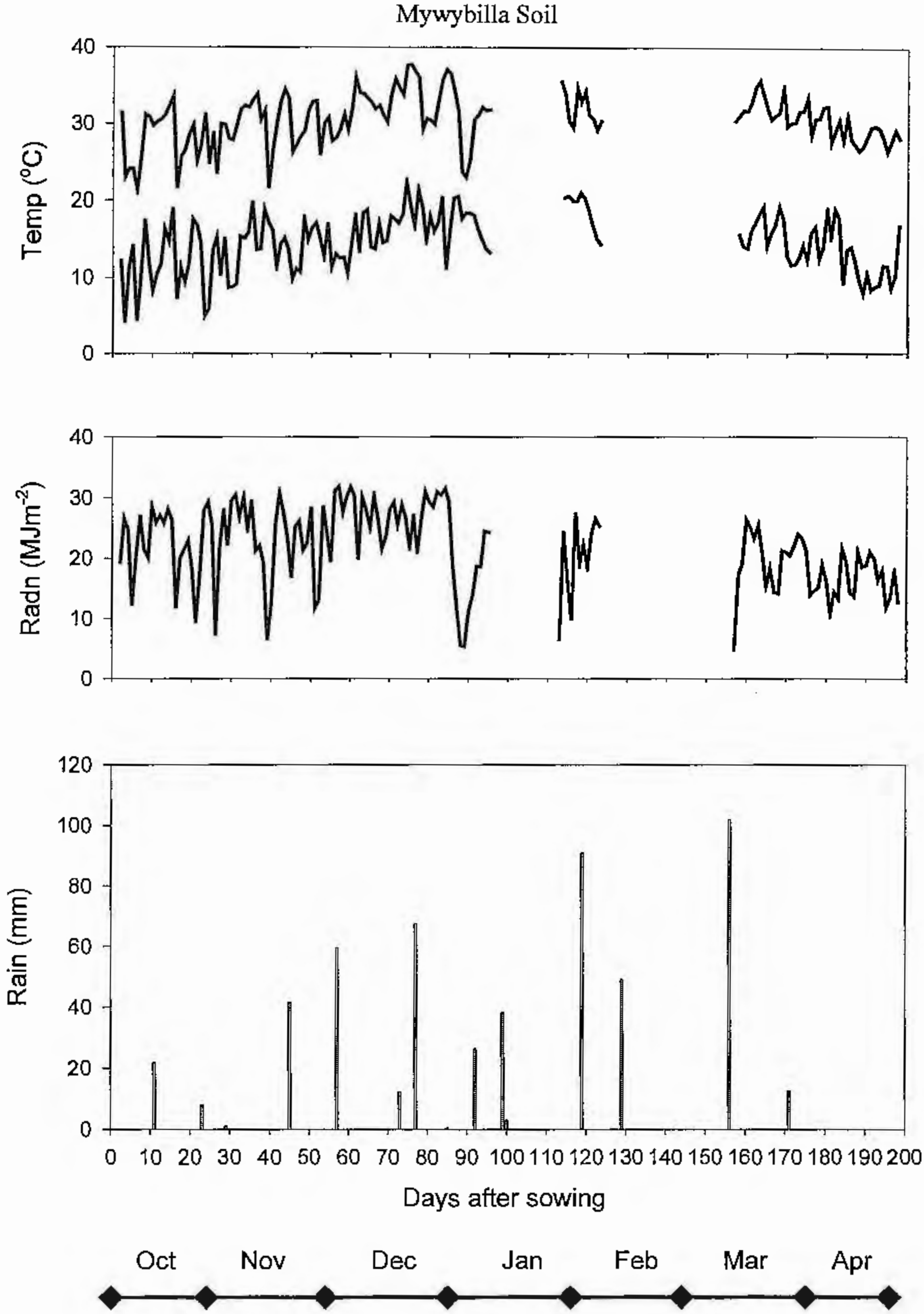
Waco Soil 1998/99
Max
Min
Temp (°C)
Radn (MJm-2)
Rain (mm)
Days after sowing
Oct
Nov
Dec
Jan
Feb
Mar
Apr

APPENDIX 13

Grey Clay Soil 1998/99



APPENDIX 14



Mywybilla Soil
Temp (°C)
Radn (MJm-2)
Rain (mm)
Days after sowing
Oct
Nov
Dec
Jan
Feb
Mar
Apr

APPENDIX 15

Waco Soil_1995/96 Pirrinuan Site (Planted 2/11/95)

Yield (bales/ha)

Configuration*	Variety			Configuration Means
	CS8S	CS 189+	SIOKRA L22	
No Skip	6.74	7.08	7.27	7.03 a[†]A
Single Skip	4.67	5.42	4.82	4.97 b B
Double Skip	5.29	4.00	4.31	4.53 b B
Variety Means	5.57	5.50	5.47	

* based on 1 m row spacing

† numbers followed by a different letter are significantly different, lower case = p≤0.05,
upper case = p≤0.01

Significance level of the F statistic for configuration was p≤0.01. Neither variety differences nor the variety x configuration interaction were significant. Results show that under the conditions experienced in 1995/96 skip row plantings were of no advantage and actually reduced yield significantly.

GTO (%)

Configuration	Variety			Configuration Means
	CS8S	CS 189+	SIOKRA L22	
No Skip	40.975	38.900	40.825	40.233 a[†]
Single Skip	40.350	38.075	41.050	39.225 b
Double Skip	40.275	37.625	39.675	39.192 b
Variety Means	40.533 A	38.200 B	40.517 A	

† Numbers followed by a different letter are significantly different within configuration means or within variety means. Lower case = p≤0.05 upper case = p≤0.01

Treatment	Significance levels for F statistic	LSD for comparing means	
		p≤0.05	p≤0.01
Configuration	p≤0.057	0.830	1.257
Variety	p≤0.001	0.382	0.523
Configuration x Variety	p≤0.054	0.988,0.661‡	1.340, 0.906

‡ Use second number when comparing means with the same level of configuration

APPENDIX 15 Continued

Hence the solid plant was superior in GTO and L22 and CS8S were similar and significantly ($p \leq 0.01$) higher than CS189+ across configurations.

The variety x configuration interactions also indicated the superiority of a solid planted configuration with preference for variety CS8S.

Fibre Quality

Configuration and configuration x variety interactions were not significant for any of the fibre quality characteristics at Pirrinuan. However there were differences between varieties for maturity ratio, percent mature fibres, length, strength and micronaire. The significance level for the F statistic was $p<0.001$ for the former three and $p \leq 0.01$ for the latter two quality tests.

Variety	Maturity Ratio	Percent mature Fibres	Length	Strength	Micronaire
CS189+	0.96 A[†]	84.8 A	1.18 b A	31.1 a A	3.45 a
CS8S	0.91 B	80.6 B	1.12 c B	29.0 b B	3.24 b
Siokra L22	0.89 B	79.3 B	1.21 a A	30.5 a AB	3.18 b

† Numbers followed by a different letter within columns are significantly different. Lower case letter = $p \leq 0.05$, upper case = $p \leq 0.01$

Experiment means for other fibre characters which were not significant for treatment effects and their classification were:

Fineness	126.3	very fine
Length Uniformity	84.8	high
Elongation	5.9	average

Grey Alluvial Clay Soil_1995/96 Hermitage Research Station Site

(Planted 12/10/95)

Yield (bales/ha)

Configuration*	Variety			Configuration Means
	CS8S	CS189+	Siokra L22	
No Skip	6.592	5.823	6.905	6.440 b[†] AB
Single Skip	5.927	5.572	6.214	5.904 b B
Double Skip	4.707	4.429	5.313	4.816 c C
Narrow Row‡	7.925	6.845	6.865	7.212 a A
Variety Means	6.288 A	5.667 B	6.324 A	

* Based on 1.0 m row spacing except where stated otherwise.

‡ 0.76 m row spacing

APPENDIX 15 Continued

Treatment	Significance levels for F statistic	LSD for comparing means	
		p≤0.05	p≤0.01
Configuration	p≤0.001	0.6651	1.0076
Variety	p≤0.001	0.3228	0.4699
Configuration x variety	p≤0.014	0.820, 0.592‡	1.194,0.816

‡ Use second number when comparing means with the same level of configuration

The solid narrow treatment was the highest yielding configuration at Hermitage with the double skip the lowest. Varieties CS8S and Siokra L22 were similar in yield but superior to CS189+ (p≤0.01). With regards to variety x configuration interaction, all varieties performed well under the solid narrow configuration but overall the early maturing CS8S appeared best. With wider spacing Siokra L22 performed well.

GTO (%)

Configuration	Mean GTO	Variety	Mean GTO
No Skip	40.000 a†	CS8S	40.158 A
Single Skip	38.533 bc	CS189+	37.417 B
Double Skip	38.211 c	Siokra L22	39.892 A
Narrow Row	39.378 ab		

† Numbers followed by a different letter are significantly different. Lower case = p≤0.05, uppercase = p≤0.01

The solid planted cotton produced the highest GTO as did varieties CS8S and Siokra L22. The configuration x variety interaction was not significant.

Fibre Quality

At Hermitage Research Station the fibre quality measurements: maturity ratio, percent mature fibres, length, strength, elongation and micronaire showed significant differences between configuration treatments and varieties. Fineness was significant for varieties only. Interactions between configurations and varieties were significant for length only. There were no significant treatment differences for uniformity. The general mean for this character was 85.0 which is classified as high.

APPENDIX 15 Continued

Configuration/ Variety	Maturity Ration	Percent Mature Fibres	Fineness	Length	Strength	Micronaire	Elongation
No Skip	1.00 a A[†]	88.5 a	133.1 a A	1.14 b	28.6 a	3.67 a A	NS
Single Skip	0.99 ab AB	87.4 a	128.3 a AB	1.14 b	26.4 bc	3.53 ab A	NS
Double Skip	0.96 b BC	85.0 a	125.8 a AB	1.15 ab	26.8 c	3.39 b AB	NS
Narrow Row	0.90 c C	80.4 b	115.0 b B	1.17 a	26.6 c	3.02 c B	NS
CS8S	0.99 A	87.3 A	130.6 a A	1.11 c B	25.9 b B	3.57 a A	5.79 B
CS 189+	0.97 A	83.5 B	121.2 b B	1.17 b A	27.7 a A	3.27 b B	6.21 A
Siokra L22	0.95 B	85.3 AB	124.8 b AB	1.18 a A	27.7 a A	3.38 b AB	6.23 A

† Numbers followed by a different letter are significantly different. Lower case = $p \leq 0.05$, upper case = $p \leq 0.01$

The solid wide configuration was superior in all quality characteristics (except length) showing significant differences, whereas the solid narrow surprisingly was the reverse. The early variety CS8S was superior to the medium maturing CS 189+ and Siokra L22 for maturity ratio, percent mature fibres, fineness and micronaire. The configuration x variety interaction for length indicated that CS8S produced longer fibre from a solid narrow configuration, configuration did not influence CS 189+ but Siokra L22 had slightly shorter fibre when planted in a single skip configuration.

APPENDIX 16

Waco Soil_1996/97 Pirrinuan Site (Planted 11/10/96)

Yield

Configuration*	bales/ha
Narrow row[ϕ]	3.8 a[†] A
No skip	3.7 ab AB
Single skip	3.5 ab AB
Double skip	3.1 b B

* based on 1 m row spacing
ϕ based on 75 cm row spacing
† Yields followed by same letter are not significantly different. Lower case letter = $p \leq 0.05$, upper case = $p \leq 0.01$.

There were no significant differences for plant density nor variety (Siokra S 101, Siokra V 15).

No interactions were significant.

(Plant densities trialled : plots were split for density treatments as follows: First 5.0m of row- 50 000plants/ha giving within row spacing/m of 5,8,10,4 for no skip, single skip, double skip, narrow row (0.76m) respectively. Second 5.0m of row- 6plants/m giving plants/ha of 60 000, 42 800, 30 000, 75 000 for the respective configurations).

GTO (%)

GTO not significant for configurations and averaged 43.4 % over the four configurations.

Only significant differences were for variety.

Variety	GTO
Siokra S 101	44.3 A[†]
Siokra V 15	42.6 B

† Numbers followed by a different letter are significantly different. Significance level for the F statistic for variety was $p \leq 0.01$.

APPENDIX 16 Continued

Fibre Quality

Configuration	Length	Uniformity	Sfi	Strength	Fineness
No skip	1.09 b[†] B	83.4 b B	8.08 a A	30.33 a A	149.8 a A
Single skip	1.13 a A	83.4 b B	6.87 a AC	30.85 ab A	144.0 bc AB
Double skip	1.15 a A	84.6 a A	6.60 b ACD	31.28 b A	139.0 c B
Narrow row	1.08 b B	83.3 b B	8.14 b BD	28.97 c B	148.1 ab A

Configuration	Micronaire (1)	Micronaire (2)	Maturity	Percent mature fibres
No skip	3.78 a A	3.72 a A	0.92 a A	81.43 a A
Single skip	3.74 aA B	3.52 b AB	0.89 ab AB	79.35 ab AB
Double skip	3.53 b B	3.33 c B	0.86 b B	76.66 b B
Narrow row	3.92 a A	3.71a A	0.92 a A	82.19 a A

[†] Numbers followed by a different letter within columns are significantly different. Lower case letter = p≤0.05, upper case = p≤0.01.

Variety	Sfi	Strength	Elongation
Siokra S 101	7.86 a[†]	29.92 B	14.25 b
Siokra V 15	6.96 b	30.48 A	14.50 a

[†] Numbers followed by a different letter within columns are significantly different. Lower case letter = p≤0.05, upper case = p≤0.01.

APPENDIX 16 Continued

Grey Alluvial Clay Soil_1996/97 Hermitage Research Station Site
(Planted 24-10-96)

Yield

Configuration*	bales/ha
Narrow row[ϕ]	6.76 a[†] A
No skip	6.46 a A
Single skip	5.81 a A
Double skip	4.55 b B

* based on 1 m row spacing
ϕ based on 75 cm row spacing
† Yields followed by same letter are not significantly different. Lower case letter = $p \leq 0.05$, upper case = $p \leq 0.01$.

There were no significant differences for variety.
No interactions were significant. (Lsd 5% = 0.951)

GTO (%)

GTO significant for configurations at $p \geq 0.05$ (Lsd 5% = 1.429). Significant differences for variety at $p \geq 0.05$ (Lsd 5% = 1.010). The configuration x variety interaction was not significant.

Configuration*	GTO
Narrow row[ϕ]	38.75 a†
No skip	38.50 a
Single skip	38.09 a
Double skip	36.64 b

* based on 1 m row spacing
ϕ based on 75 cm row spacing
† Numbers followed by a different letter are significantly different. Significance level for the F statistic for variety was $p \leq 0.05$.

Variety	GTO
Siokra S 101	38.51 a†
Siokra V 15	37.49 b

APPENDIX 16 Continued

† Numbers followed by a different letter are significantly different. Significance level for the F statistic for variety was p≤0.05.

Fibre Quality

Configuration	Length	Fineness
No skip	1.1817 b†	150.2 ab
Single skip	1.1900 ab	141.5 b
Double skip	1.2117 a	140.7 b
Narrow row	1.1683 b	154.7 a

† Numbers followed by a different letter within columns are significantly different.
Lower case letter = p≤0.05.
Length (lsd 5% = 0.2762). Fineness (lsd 5% = 10.13)

Variety	Strength
Siokra S 101	29.44 B†
Siokra V 15	31.02 A

† Numbers followed by a different letter within columns are significantly different.
Upper case letter = p≤0.01.

Variety only significant at p≥0.01. (Lsd 5% = 0.544)

Uniformity not significant and averaged 84.81 over the four configurations.

Super Fibre Index not significant and averaged 5.90.

Elongation not significant, averaging 13.512.

Micronaire_1 not significant and averaged 3.633. (Nearly significant at p≥0.05 level).
Micronaire_2 not significant and averaged 3.571. (Nearly significant at p≥0.05 level).

Maturity not significant and averaged 0.8846.

Percent Mature Fibres not significant and averaged 79.06.

APPENDIX 17

Yield and GTO (%)

Waco Soil_1997/98 Pirrinuan Site (Planted 14/10/97)

Variety Siokra V15i

Configuration*	Yield (bales/ha)	GTO%
No skip	3.2 a[†]	44.2 a
Single skip	3.4 a	43.8 a
Double skip	3.2 a	42.8 a

* based on 1 m row spacing
[†] Numbers followed by a different letter are significantly different at $p \leq 0.05$ level.

No significant differences between configurations for yield or ginning %.

Box Soil_1997/98 Nandi-Dannedine Site
(Planted 18/10/97)

Configuration	Yield (bales/ha)	GTO %
No skip	3.6 a[†]	44.6 a
Single skip	3.4 a	43.6 b
Double skip	3.4 a	42.6 c

[†] Numbers followed by a different letter are significantly different at $p \leq 0.05$ level.

No significant differences between configurations for yield.

Grey Clay Soil_1997/98 Warra Site
(Planted 16/10/97)

Configuration	Yield (bales/ha)	GTO %
No skip	4.1 a[†]	43.6 a
Single skip	3.5 a	44.6 a
Double skip	4.0 a	44.9 a
Alternate skip[ϕ]	3.8 a	45.7 a

[†] Numbers followed by a different letter are significantly different at $p \leq 0.05$ level.
[ϕϕ] based on 2 m row spacing

No significant differences between configurations for yield or ginning %.

APPENDIX 17 Continued

Fibre Quality

Waco Soil

Configuration	Length	Uniformity	Strength	Elongation	Micronaire
No skip	1.05 b[†]	81.8 a	30.4 b	5.4 a	4.2 a
Single skip	1.12 a	83.0 a	32.9 a	5.5 a	4.2 a
Double skip	1.13 a	83.5 a	32.9 a	5.5 a	4.1 a

† Numbers followed by a different letter within columns are significantly different. (Lsd for significant differences $p \leq 0.05$ level).

Significant differences with Length and Strength.

Box Soil

Configuration	Length	Uniformity	Strength	Elongation	Micronaire
No skip	1.04 a[†]	81.3 a	29.6 a	5.2 a	4.9 a
Single skip	1.09 a	82.9 a	31.5 a	5.3 a	4.6 b
Double skip	1.13 a	83.1 a	32.2 a	5.4 a	4.4 b

† Numbers followed by a different letter within columns are significantly different. (Lsd for significant differences $p \leq 0.05$ level).

Significant differences with Micronaire.

Grey Clay Soil

Configuration	Length	Uniformity	Strength	Elongation	Micronaire
No skip	1.06 a[†]	81.2 a	27.8 a	5.1 b	3.8 a
Single skip	1.07 a	81.6 a	29.0 a	5.3 a	3.5 b
Double skip	1.11 a	82.4 a	30.5 a	5.3 a	4.4 a
Alternate skip[ϕ]	1.09 a	81.9 a	31.2 a	5.4 a	4.2 a

† Numbers followed by a different letter within columns are significantly different. (Lsd for significant differences $p \leq 0.05$ level).

ϕϕ based on 2 m row spacing

Significant differences only with Elongation.

APPENDIX 18

1998/99

Prior to 1998/99 there was no clear yield advantage from either single or double ship over solid (no skip) planted cotton. However longer, stronger and more uniform fibre resulted from the skip configurations. Yield differences were obtained in 98/99 but favoured the solid configuration.
Planting Dates: Pirrinuan 8/10/98 Macalister and Warra 5/10/98
Variety: Siokra V15i

Yield (bales/ha)

Configuration	Pirrinuan **Waco Soil**	Macalister **Mywybilla Soil**	Warra **Grey Clay Soil**
No Skip	9.0 a†	8.7 a	10.0 a
Single Skip	6.5 b	7.6 a	8.6 b
Double Skip	3.9 c	5.3 b	6.9 c

† Yields followed by the same letter are not significantly different (5% level) within sites.

GTO (%)

Configuration	Pirrinuan **Waco Soil**	Macalister **Mywybilla Soil**	Warra **Grey Clay Soil**
No Skip	40.1 a	42.4 a	42.1 a
Single Skip	39.7 ab	41.2 b	41.3 b
Double Skip	39.2 b	40.4 c	41.1 b

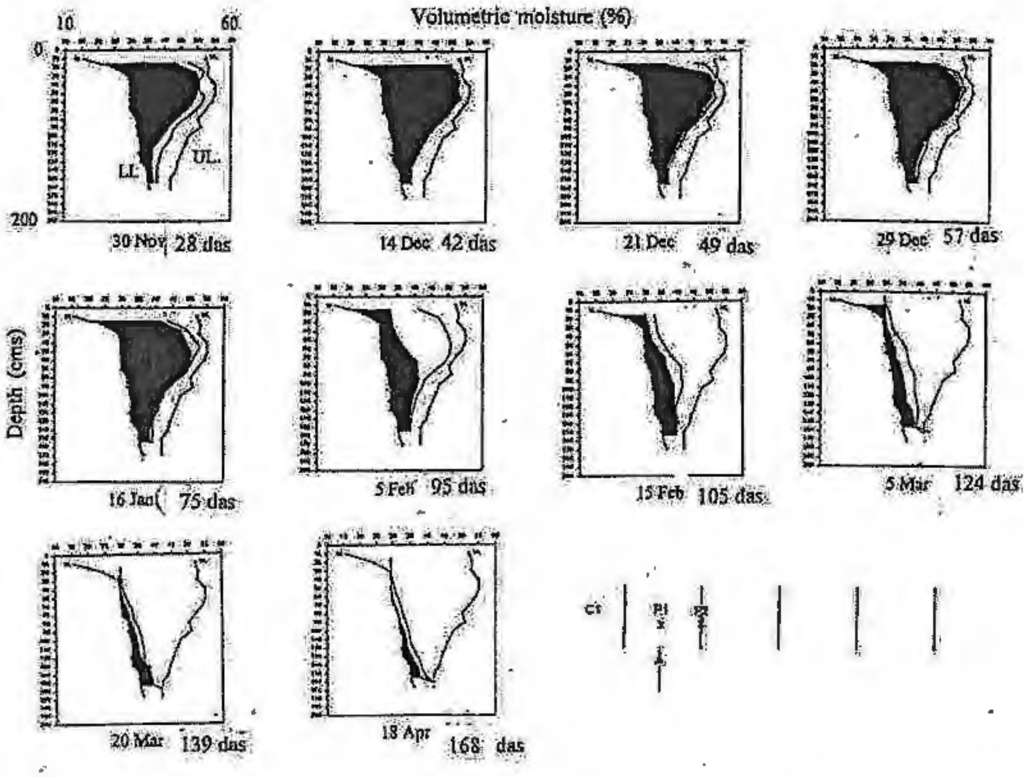
Fibre quality testing for 1998/99 revealed no significant differences between configurations, but there were significant differences between sites. The grey clay site (Warra) had longer, stronger and more uniform fibre than the other two sites but lower Micronaire.

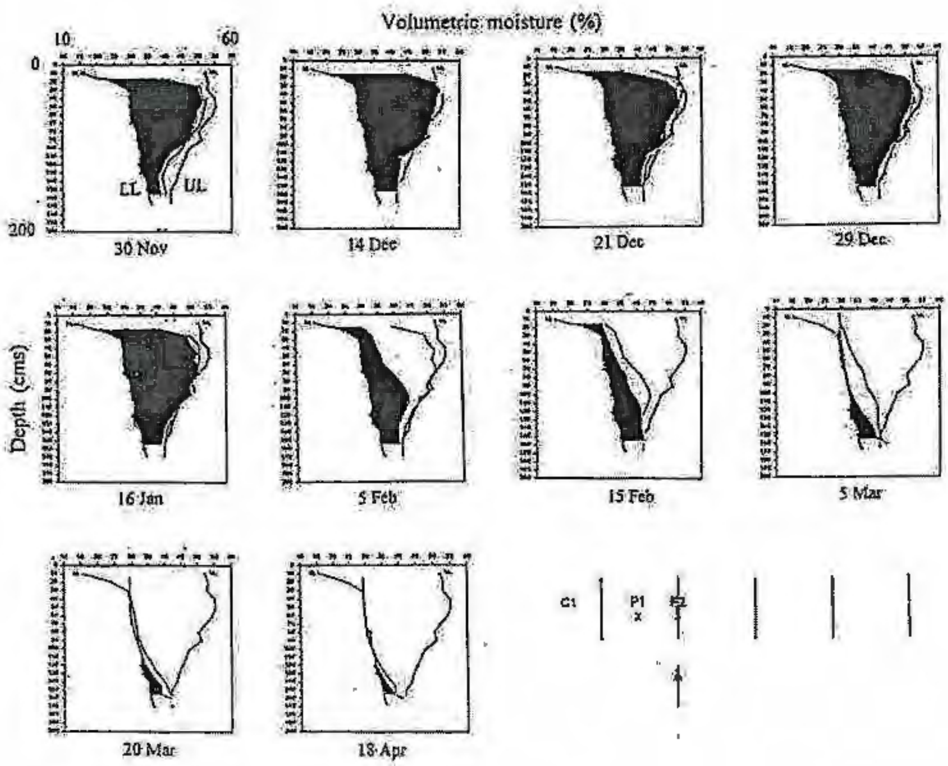
Fibre Quality

Site	Length	Uniformity	Strength	Micronaire
Warra **Grey clay soil**	1.16 a	83.4 a	31.4 a	3.9 b
Macalistar **Mywybilla soil**	1.07 b	81.5 b	28.6 b	4.2 a
Pirrinuan **Waco soil**	1.05 b	80.9 b	28.3 b	4.0 ab

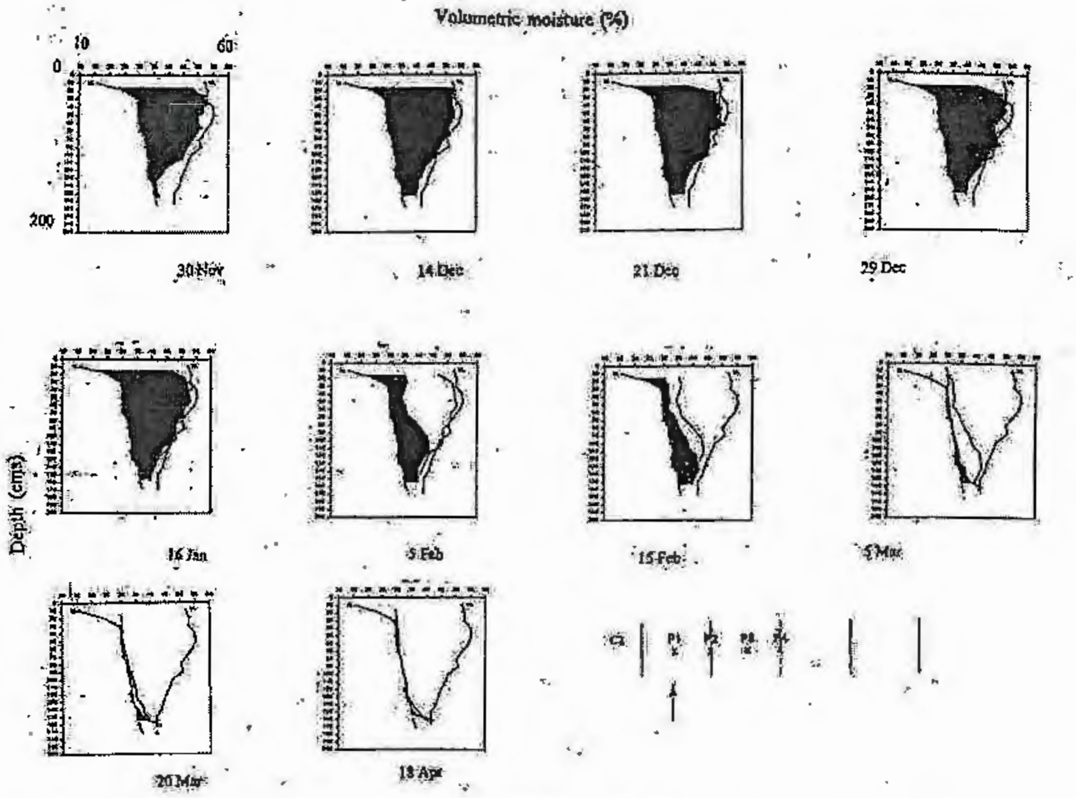
APPENDIX 19

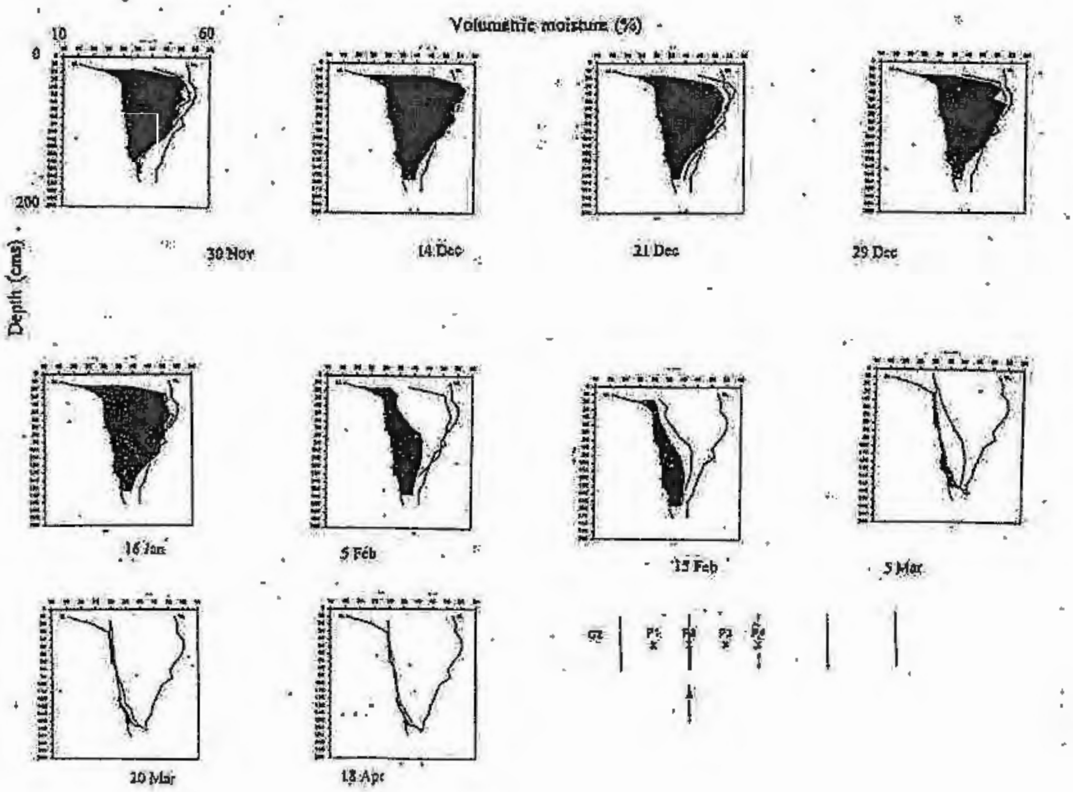
1995/96
Water in Profile on date shown (shaded)
Position of access tube shown by arrow
Data are mean of 3 reps
Variety is CS189+



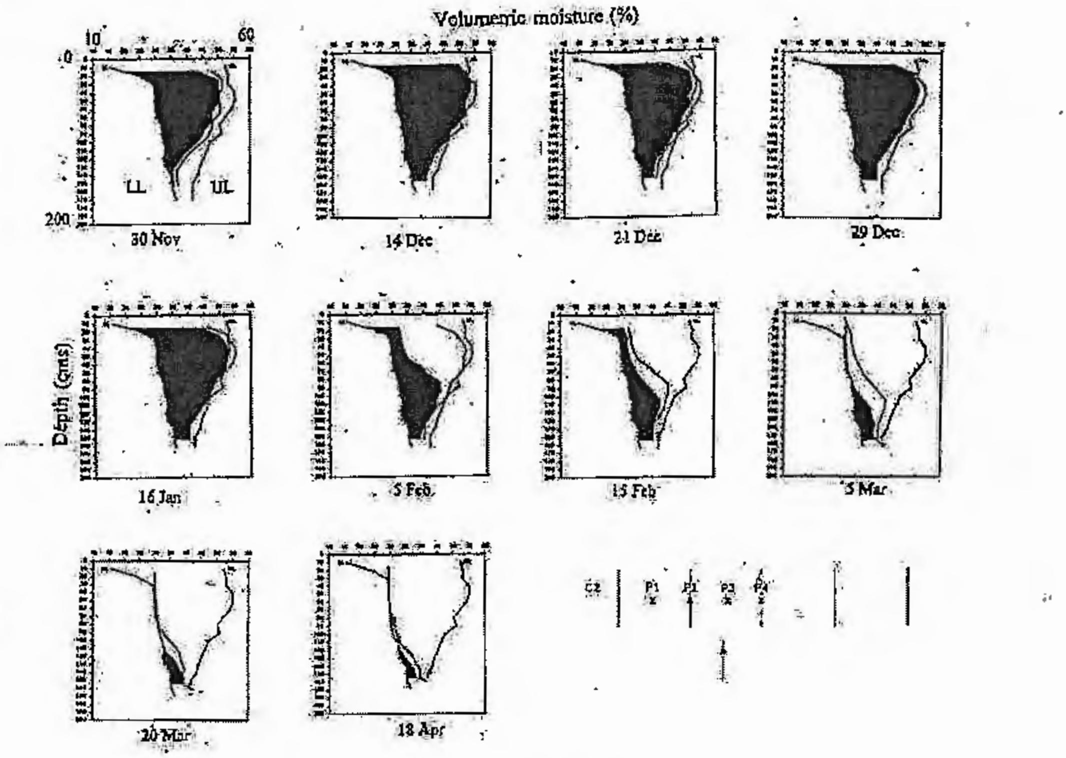


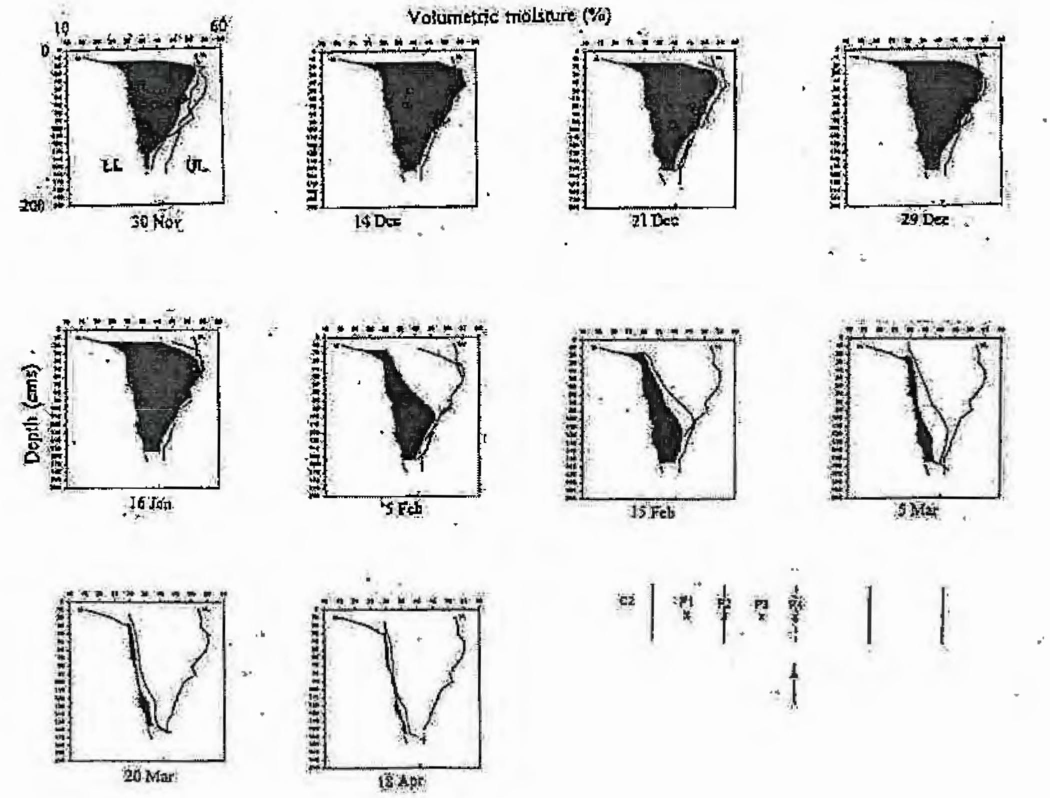
APPENDIX 19 Continued



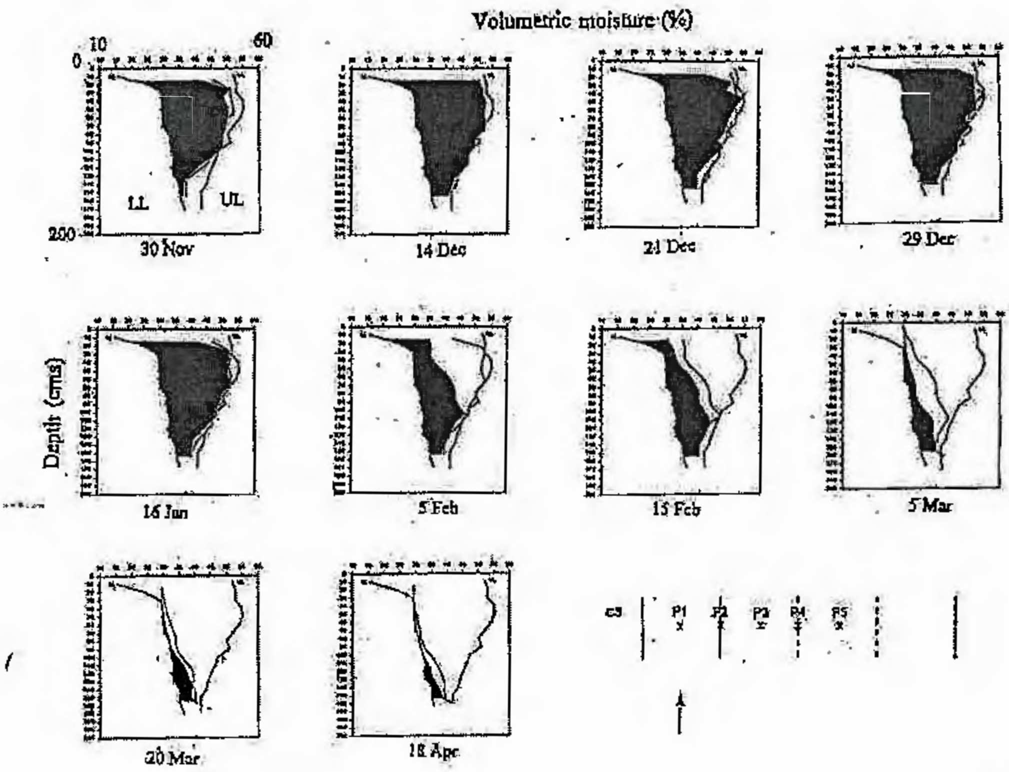


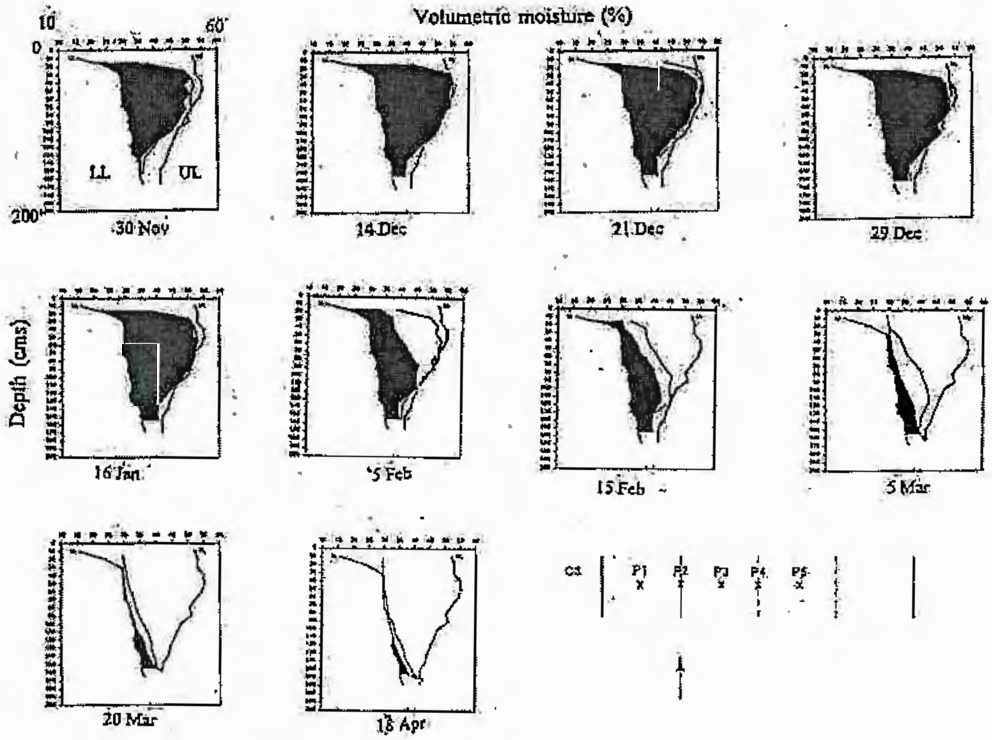
APPENDIX 19 Continued



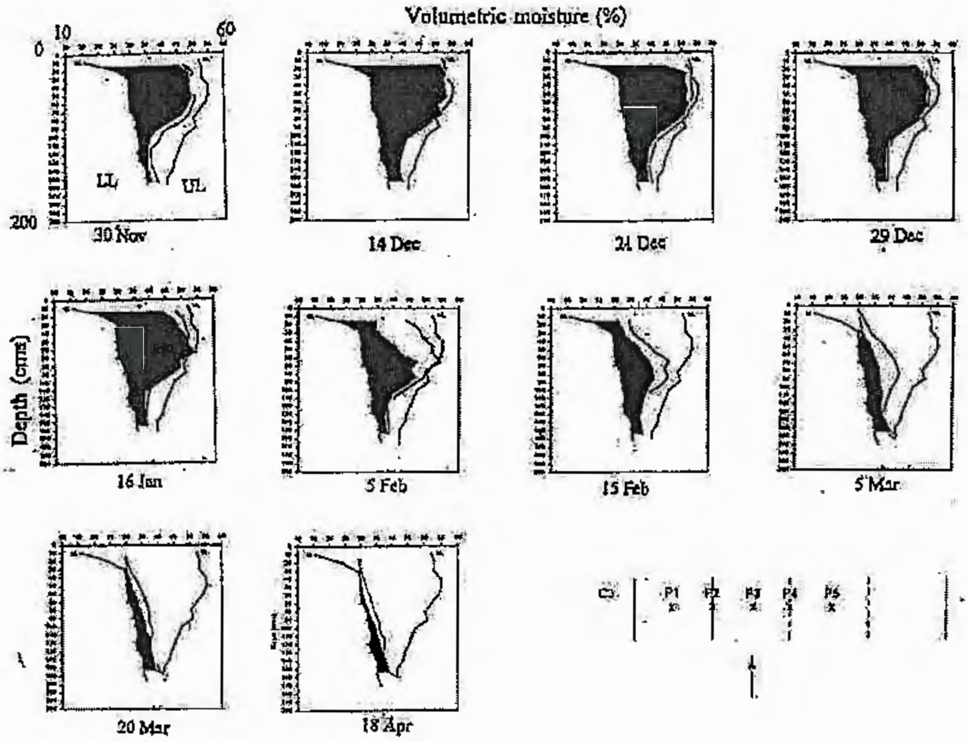


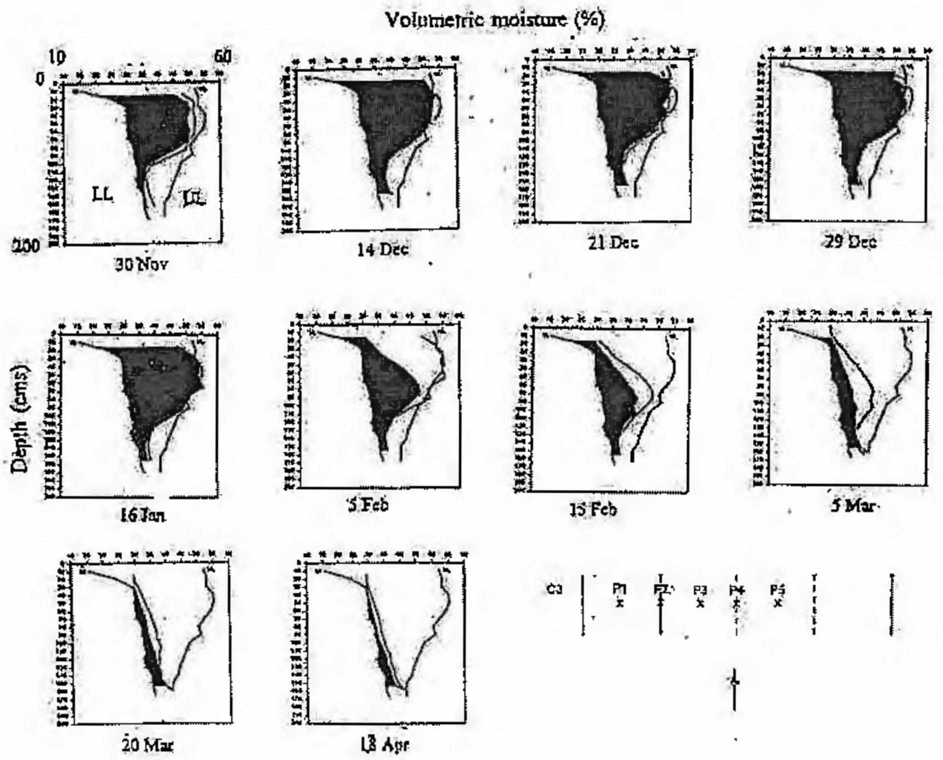
APPENDIX 19 Continued



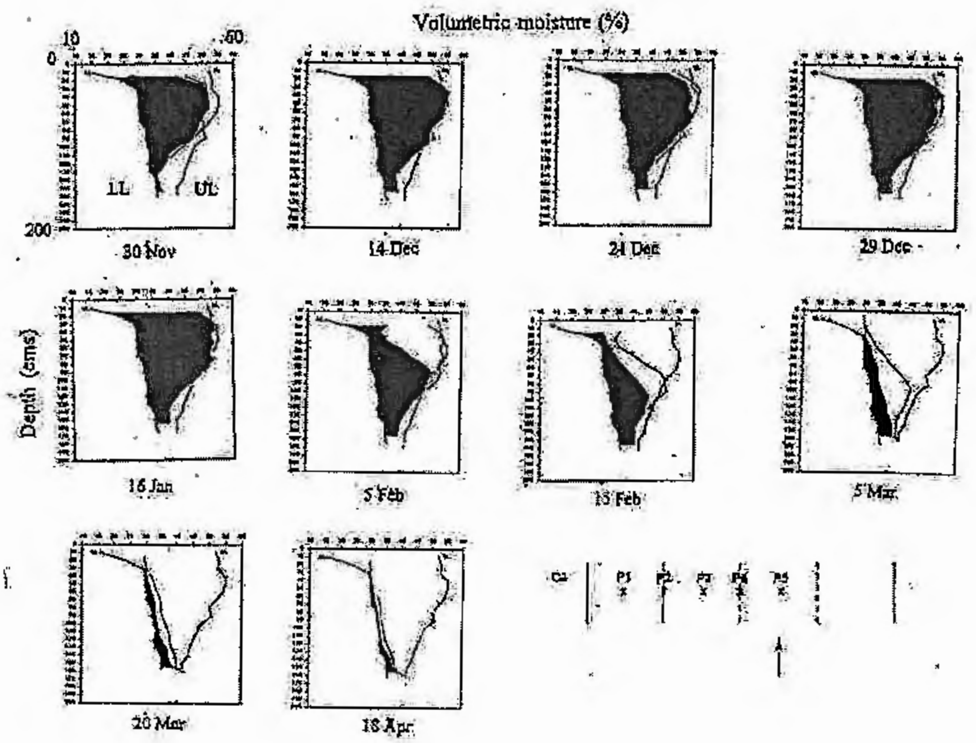


APPENDIX 19 Continued





APPENDIX 19 Continued

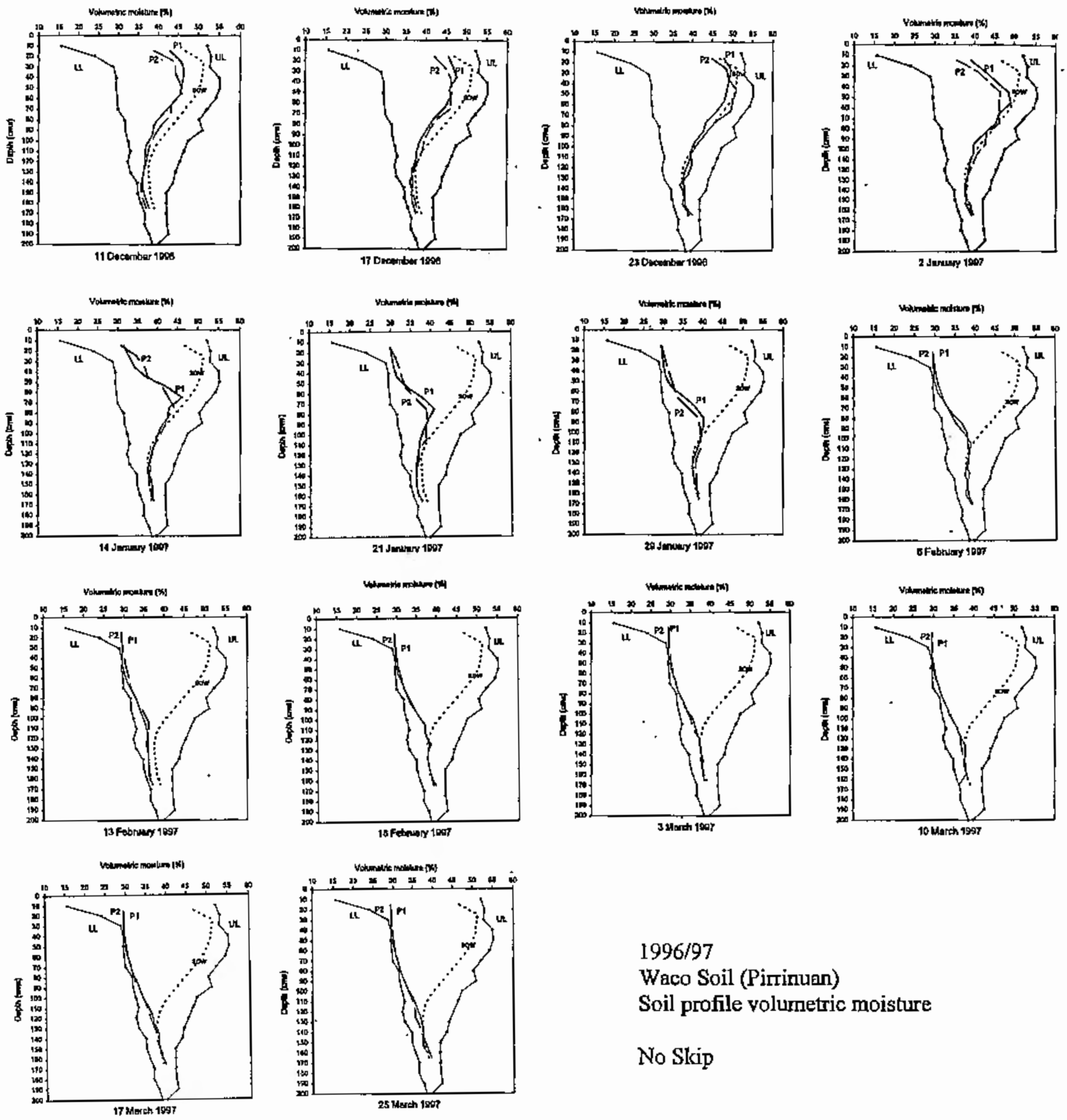


<u>APPENDIX 20</u> Soil Water Used
Waco Soil 95/96

1995/96 Waco Soil – Pirrinuan
Soil water used (mm) (from 0.15 to 1.5m) for period shown (variety CS189+)

Configuration	*Sample Position*	*Jan. 16 – Feb. 5 (75 – 95 das)*	*Feb. 5 – Feb. 15 (95 – 105 das)*	*Feb. 15 – Mar. 5 (105 – 124 das)*	*Mar. 5 – Mar. 20 (124 – 139 das)*	*Mar. 20 – Apr. 18 (139 – 168 das)*	*Total*	*mm/day*
No Skip	1	99	28	30	11	14	182	2.0
	2	121	37	48	17	9	232	2.5
Single Skip	1	127	41	50	11	6	235	2.6
	2	118	37	52	11	9	227	2.5
	3	118	36	45	18	12	229	2.5
	4	122	28	52	18	11	231	2.5
Double Skip	1	100	35	56	18	18	227	2.5
	2	92	46	55	21	14	228	2.5
	3	74	33	40	18	14	179	1.9
	4	102	34	45	18	13	212	2.3
	5	85	55	59	23	10	232	2.5

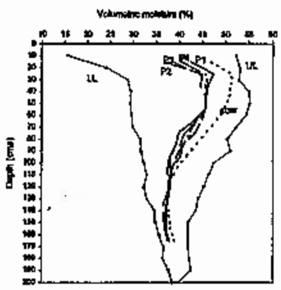
APPENDIX 21



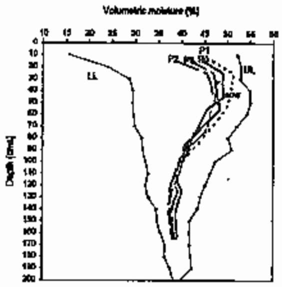
1996/97
Waco Soil (Pirrinuan)
Soil profile volumetric moisture

No Skip

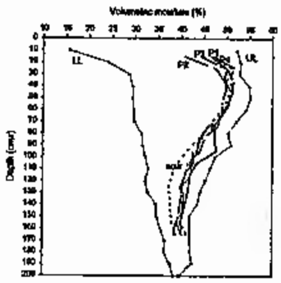
APPENDIX 21 Continued



11 December 1996



17 December 1996



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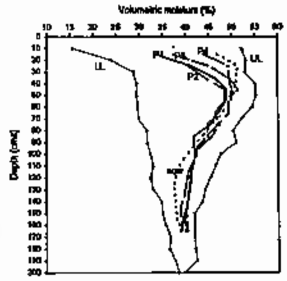
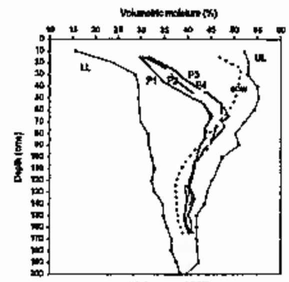
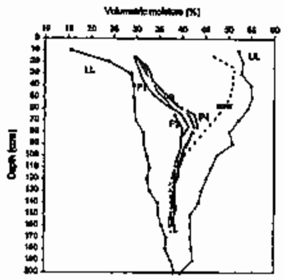


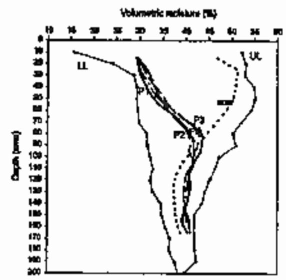
2 January 1997



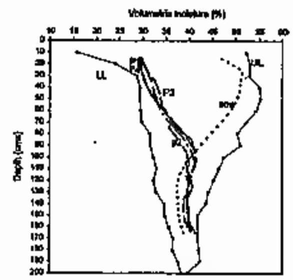
14 January 1997



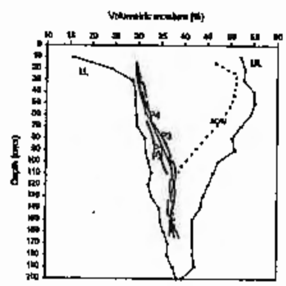
21 January 1997



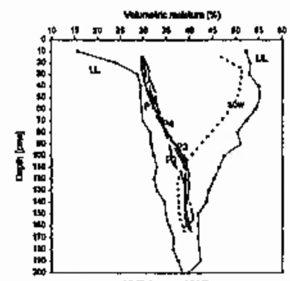
29 January 1997



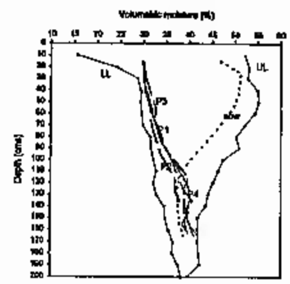
5 February 1997



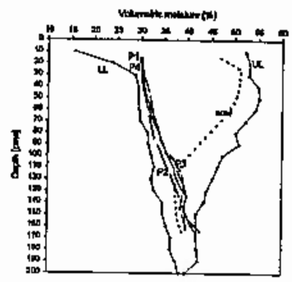
13 February 1997



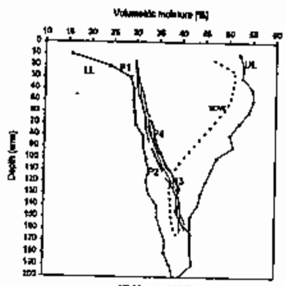
18 February 1997



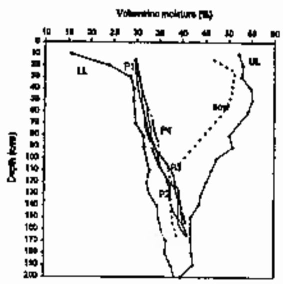
3 March 1997



10 March 1997



17 March 1997

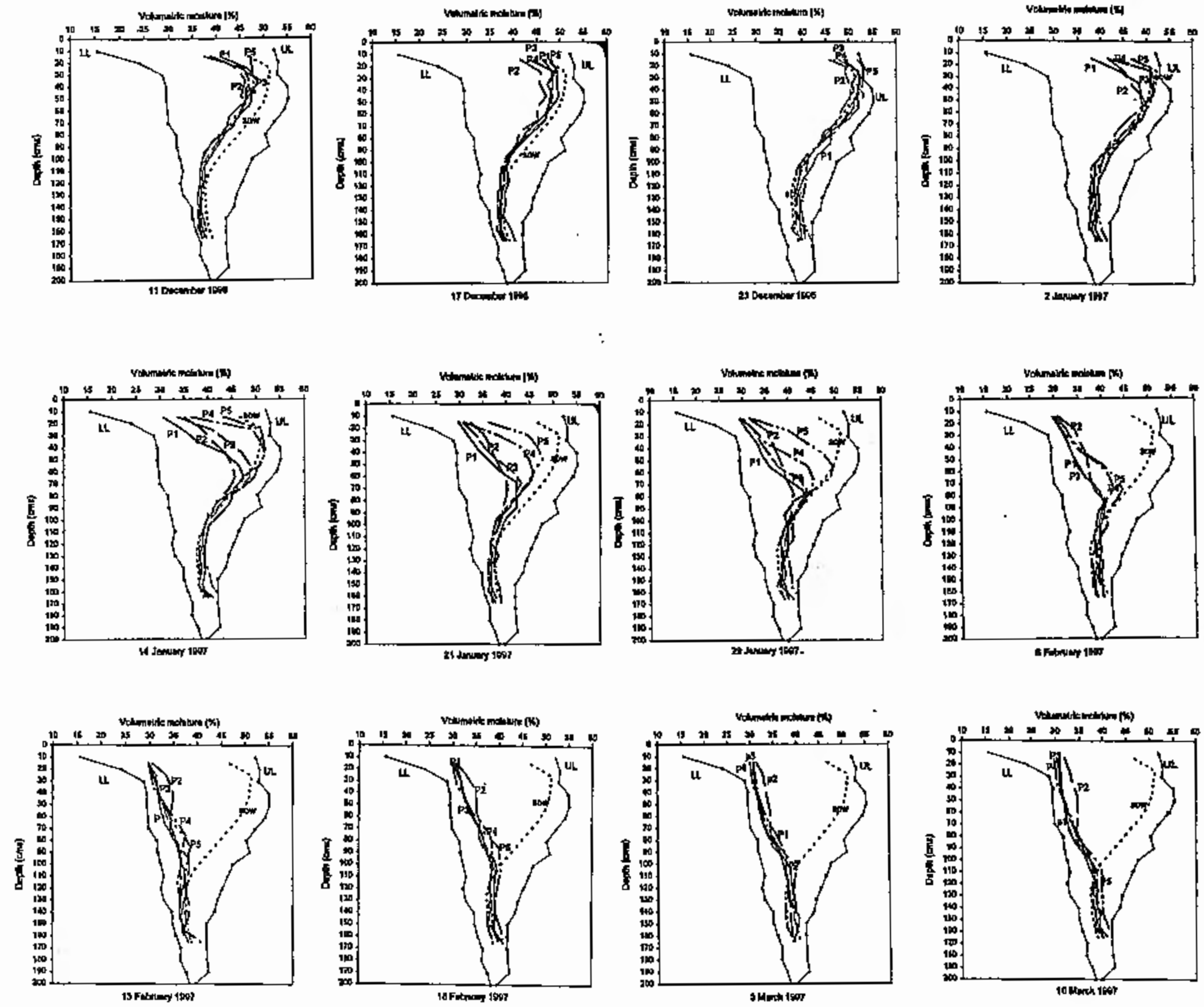


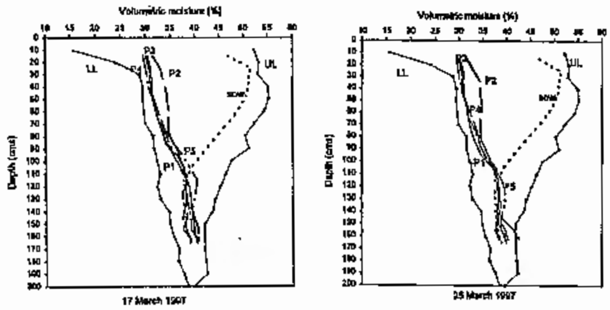
25 March 1997

1996/97
Waco Soil (Pirrinuan)
Soil profile volumetric moisture

Single Skip

APPENDIX 21 Continued



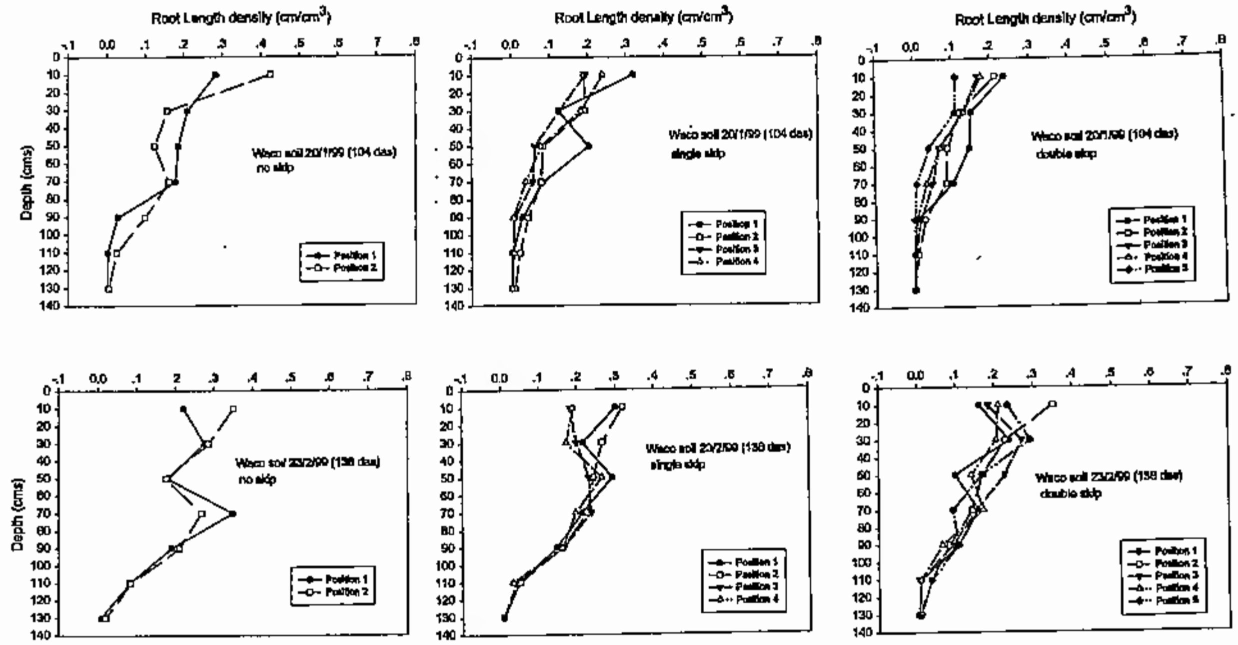


1996/97
Waco soil (Pirrinuan)
Soil profile volumetric moisture

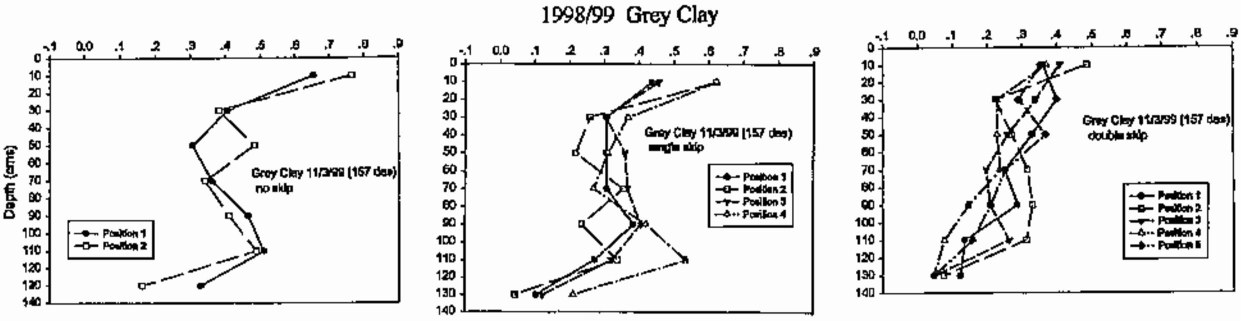
Double skip

APPENDIX 22 Root Length Densities

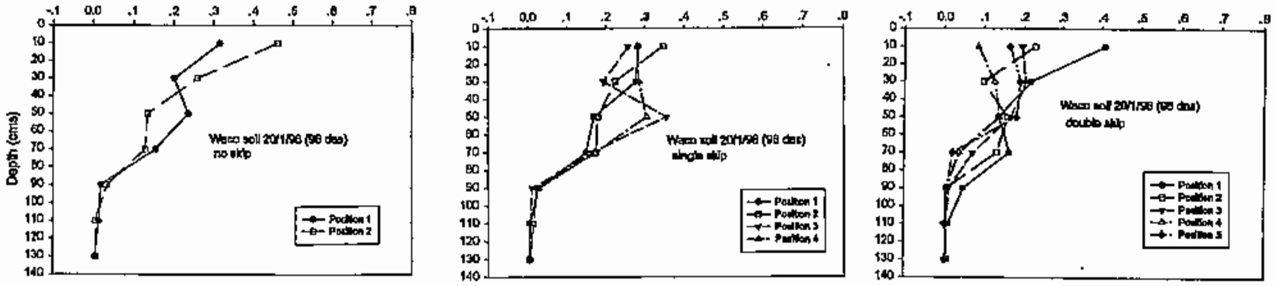
1998/99 Waco



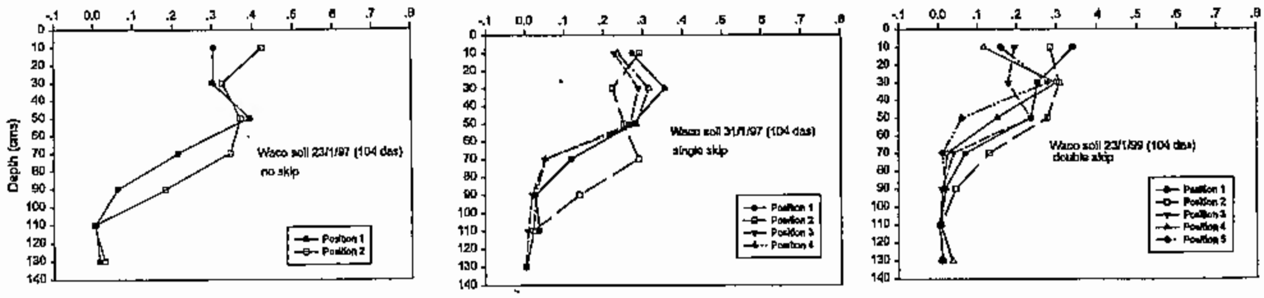
1998/99 Grey Clay



1997/98 Waco



1996/97 Waco



APPENDIX 23

Soil Year Config Posn			K1 ($days^{-1}$) for Depths (cms)										
			15	25	35	45	55	65	75	85	95	105	115
WACO 1997/98	**NS**	**P_1**	.128 (.039)*	.059 (.009)	.080 (.021)	.138 (.013)	.103 (.007)	.019 (.019)	.084 (.009)	.089 (.002)	.038 (.008)	.033 (.014)	-
		P_2	.069 (.022)	.060 (.008)	.057 (.003)	.086 (.015)	.092 (.004)	.091 (.009)	.074 (.005)	.074 (.012)	.075 (.042)	.030 (.009)	-
	SS	**P_1**	.106 (.023)	.065 (.009)	.053 (.011)	.080 (.007)	.083 (.003)	.101 (.033)	.059 (.006)	.073 (.009)	.059 (.006)	.090 (.034)	-
		P_2	.069 (.034)	.047 (.008)	.042 (.006)	.053 (.009)	.054 (.009)	.061 (.009)	.065 (.006)	.058 (.008)	.041 (.012)	.039 (.013)	-
		P_3	.069 (.009)	.073 (.010)	.087 (.009)	.093 (.007)	.093 (.015)	.108 (.021)	.087 (.009)	.052 (.003)	.028 (.004)	.033 (.019)	-
		P_4	.199 (.000)	.183 (.013)	.149 (.006)	.124 (.015)	.125 (.023)	.102 (.011)	.054 (.015)	.103 (.035)	.035 (.008)	.054 (.023)	-
	DS	**P_1**	.034 (.004)	.037 (.006)	.055 (.029)	.082 (0)	.114 (.013)	.080 (.003)	.067 (.003)	.067 (.025)	.017 (.006)	.077 (.004)	-
		P_2	.122 (.038)	.032 (.007)	.025 (.006)	.035 (.001)	.066 (.010)	.051 (.003)	.053 (.011)	.064 (.003)	.028 (.011)	.078 (.004)	-
		P_3	.039 (.010)	.044 (.007)	.072 (.012)	.065 (.011)	.051 (.001)	.054 (.003)	.059 (.003)	.037 (.001)	.101 (.089)	.079 (.001)	-
		P_4	.86 (.009)	.069 (.004)	.107 (.009)	.133 (.026)	.121 (.006)	.097 (.003)	.061 (.002)	.036 (.011)	.016 (.006)	.093 (.001)	-
		P_5	.195 (.004)	.198 (.001)	.176 (.024)	.141 (.001)	.092 (.004)	.157 (0)	.107 (.003)	.032 (.012)	.015 (.005)	.089 (.003)	-

* Standard Error

APPENDIX 23 Continued

Soil Year	Config	Posn	Kl (days^{-1}) for Depths (cms) 15	25	35	45	55	65	75	85	95	105	115
GREY CLAY 97/98	**NS**	**P_1**	.048 (.003)	.062 (.004)	.071 (.008)	.077 (.014)	.082 (.009)	.082 (.006)	.193 (.076)	.199 (.049)	.265 (.151)	.075 (.035)	-
		P_2	.042 (.005)	.164 (.096)	.195 (.124)	.083 (.017)	.229 (.150)	.082 (.015)	.134 (.027)	.117 (.012)	.125 (.039)	.056 (.023)	-
	SS	**P_1**	.040 (.001)	.066 (.011)	.084 (.008)	.095 (.014)	.097 (.020)	.101 (.015)	.145 (.012)	.109 (.017)	.125 (.007)	-	-
		P_2	.032 (.002)	.048 (.001)	.067 (.007)	.069 (.008)	.069 (.006)	.079 (.012)	.139 (.039)	.147 (.024)	.113 (.025)	-	-
		P_3	.055 (.008)	.077 (.011)	.072 (.009)	.086 (.009)	.087 (.009)	.153 (.018)	.125 (.011)	.108 (.009)	-	-	-
		P_4	.110 (.018)	.136 (.041)	.105 (.015)	.164 (.062)	.122 (.019)	.197 (.072)	.297 (.125)	.349 (.201)	-	-	-
	DS	**P_1**	.033 (.004)	.044 (.006)	.047 (.003)	.085 (.033)	.137 (.004)	.114 (.029)	.158 (.026)	.09	.017	.017	-
		P_2	.037 (.008)	.035	.040 (.005)	.046 (.003)	.049 (.002)	.130 (.013)	.123 (.009)	.189 (.088)	.019	.019	-
		P_3	.046 (.008)	.048 (.005)	.056 (.000)	.111 (.040)	.163 (.006)	.127 (.004)	.111 (.009)	.081	.036	.008	-
		P_4	.078 (.004)	.082 (.003)	.123 (.049)	.175 (.007)	.152 (.014)	.156 (.027)	.123 (.021)	.077	-	-	-
		P_5	.187 (.049)	.172 (.022)	.159 (.010)	.143 (.009)	.141 (.016)	.114 (.017)	.068	.027	-	-	-

APPENDIX 23 Continued

Soil Year	Config	Posn	Kl (days^{-1}) for Depths (cms)										
			15	25	35	45	55	65	75	85	95	105	115
BOX 97/98	**NS**	**P_1**	.058 (.002)	.079 (.008)	.153 (.021)	.153 (.029)	.179 (.020)	.165 (.037)	.176 (.036)	.092 (.021)	.051 (.009)	.032 (.001)	-
		P_2	.057 (.011)	.063 (.004)	.081 (.017)	.118 (.014)	.112 (.013)	.166 (.046)	.139 (.019)	.111 (.002)	.059 (.009)	.049 (.009)	-
	SS	**P_1**	.047 (.014)	.161 (.023)	.243 (.008)	.187 (.005)	.194 (.003)	.195 (.002)	.125 (.025)	.087 (.017)	.017 (.005)	.038 (.018)	-
		P_2	.076 (.010)	.066 (.005)	.166 (.047)	.186 (.026)	.172 (.059)	.198 (.038)	.099 (.036)	.075 (.057)	.055 (.018)	.018 (.004)	-
		P_3	.119 (.034)	.184 (.037)	.224 (.024)	.243 (.007)	.189 (.005)	.127 (.023)	.126 (.045)	.075 (.032)	.126 (.057)	.014 (.003)	-
		P_4	.255 (.029)	.211 (.035)	.254 (.015)	.274 (.014)	.248 (.001)	.179 (.032)	.149 (.035)	.065 (.025)	.112 (.052)	-	-
	DS	**P_1**	.040 (.009)	.042 (.003)	.077 (.013)	.101 (.003)	.088 (.045)	.070 (.022)	.053 (.025)	.034 (.003)	-	-	-
		P_2	.029 (.0005)	.039 (.004)	.067 (.028)	.111 (.013)	.057 (.024)	.072 (.011)	.054 (.022)	.036 (.002)	.040 (.0003)	-	-
		P_3	.119 (.002)	.153 (.013)	.125 (.017)	.084 (.048)	.066 (.032)	.069 (.032)	.055 (.011)	.039 (.002)	-	-	-
		P_4	.186 (.009)	.152 (.005)	.138 (.004)	.103 (.002)	.142 (.024)	.184 (.045)	.136 (.037)	-	-	-	-
		P_5	.193 (.004)	.177 (.009)	.189 (.016)	.167 (.042)	.127 (.027)	.154 (.060)	.169 (.031)	-	-	-	-

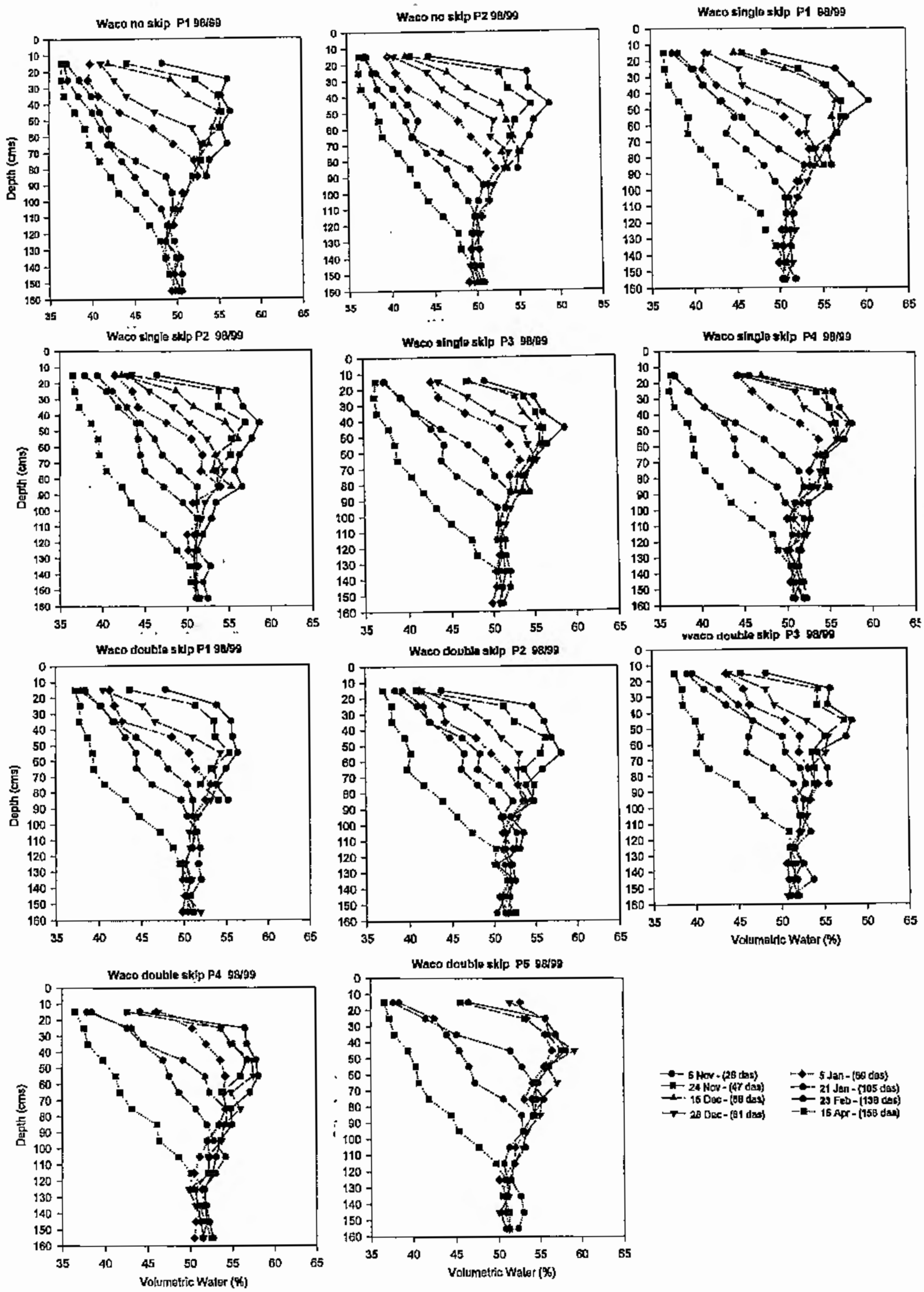
APPENDIX 23 Continued

Soil Year	Config	Posn	K1 (days^{-1}) for Depths (cms) 15	25	35	45	55	65	75	85	95	105	115
WACO 98/99	NS	P_1		.064	.057	.052	.069	.062	.059	.038	.033	-	-
		P_2		.030	.039	.030	.055	.050	.044	.028	.022	-	-
	SS	P_1		.041	.047	.035	.032	.029	.027	.021	.029	-	-
		P_2		.029	.026	.027	.029	.029	.027	.030	.023	.021	-
		P_3		.041	.032	.039	.029	.031	.024	.027	.024	-	-
		P_4		.062	.049	.039	.033	.034	.033	.030	.027	-	-
	DS	P_1		.044	.039	.033	.032	.026	.029	.023	.021	-	-
		P_2		.032	.024	.022	.021	.021	.020	.016	.019	-	-
		P_3		.034	.027	.025	.025	.022	.026	.023	.018	-	-
		P_4		.036	.030	.025	.029	.027	.029	.023	.017	-	-
		P_5		.064	.038	.033	.033	-	.029	-	-	-	-

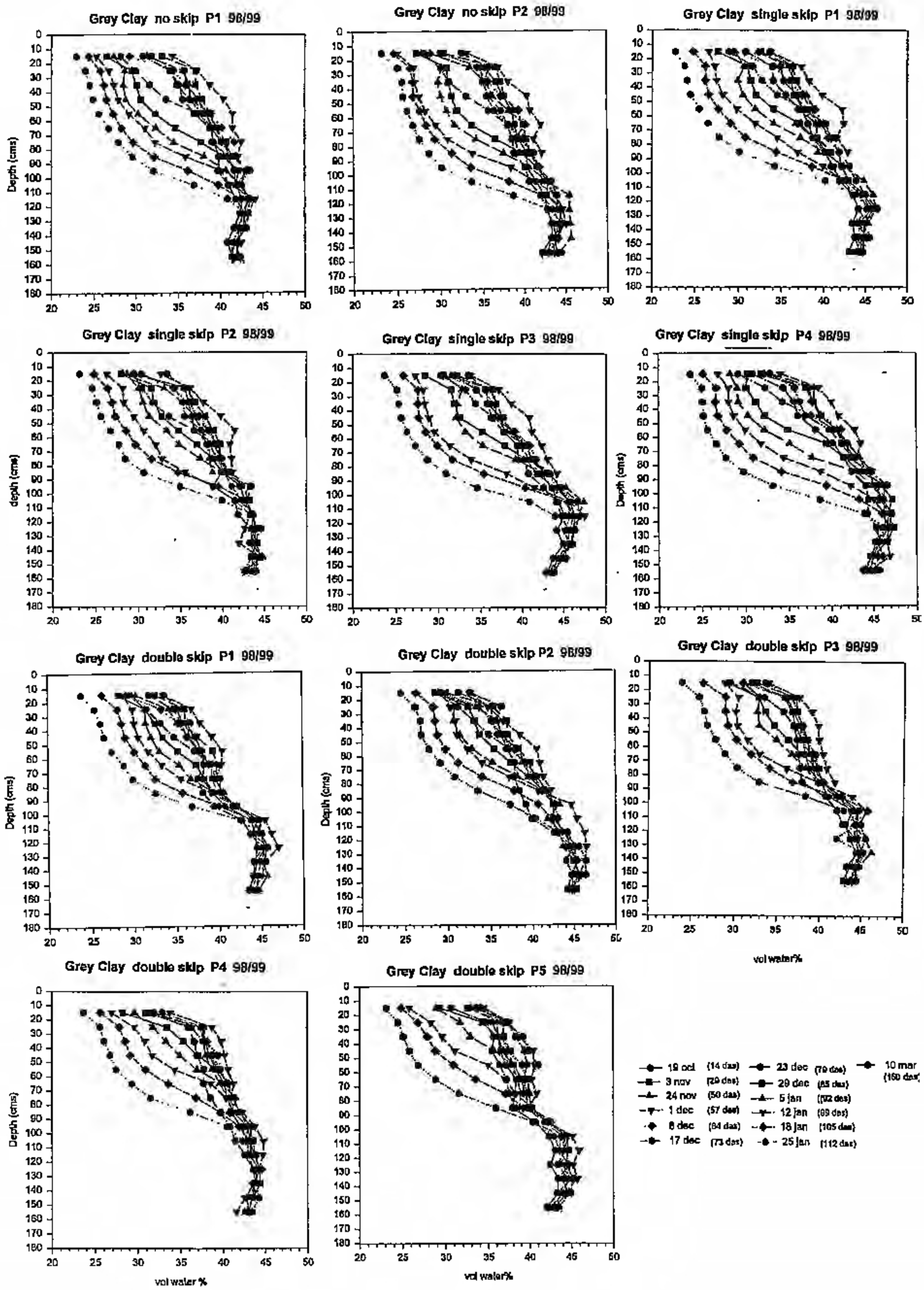
APPENDIX 23 Continued

Soil Year Config Posn			Kl ($days^{-1}$) for Depths (cms)										
			15	25	35	45	55	65	75	85	95	105	115
GREY CLAY 98/99	**NS**	**P_1**		.035	.038	.049	.072	.067	.075	.090	.153	-	-
		P_2		.033	.038	.048	.053	.076	.077	.068	.177	-	-
	SS	**P_1**	.026	.030	.036	.043	.046	.068	.091	.083	.114	-	-
		P_2		.031	.035	.038	.041	.069	.104	.093	.083	-	-
		P_3		.031	.039	.047	.061	.073	.111	.133	-	-	-
		P_4		.046	.049	.055	.068	.077	.094	.091	.125	-	-
	DS	**P_1**	.021	.025	.029	.036	.060	.063	.080	-	-	-	-
		P_2	.026	.031	.038	.031	.041	.064	.076	-	-	-	-
		P_3	.024	.031	.039	.043	.067	.064	.078	-	-	-	-
		P_4	.044	.043	.065	.068	.086	.163	-	-	-	-	-
		P_5	.065	.074	.073	.105	.156	-	-	-	-	-	-

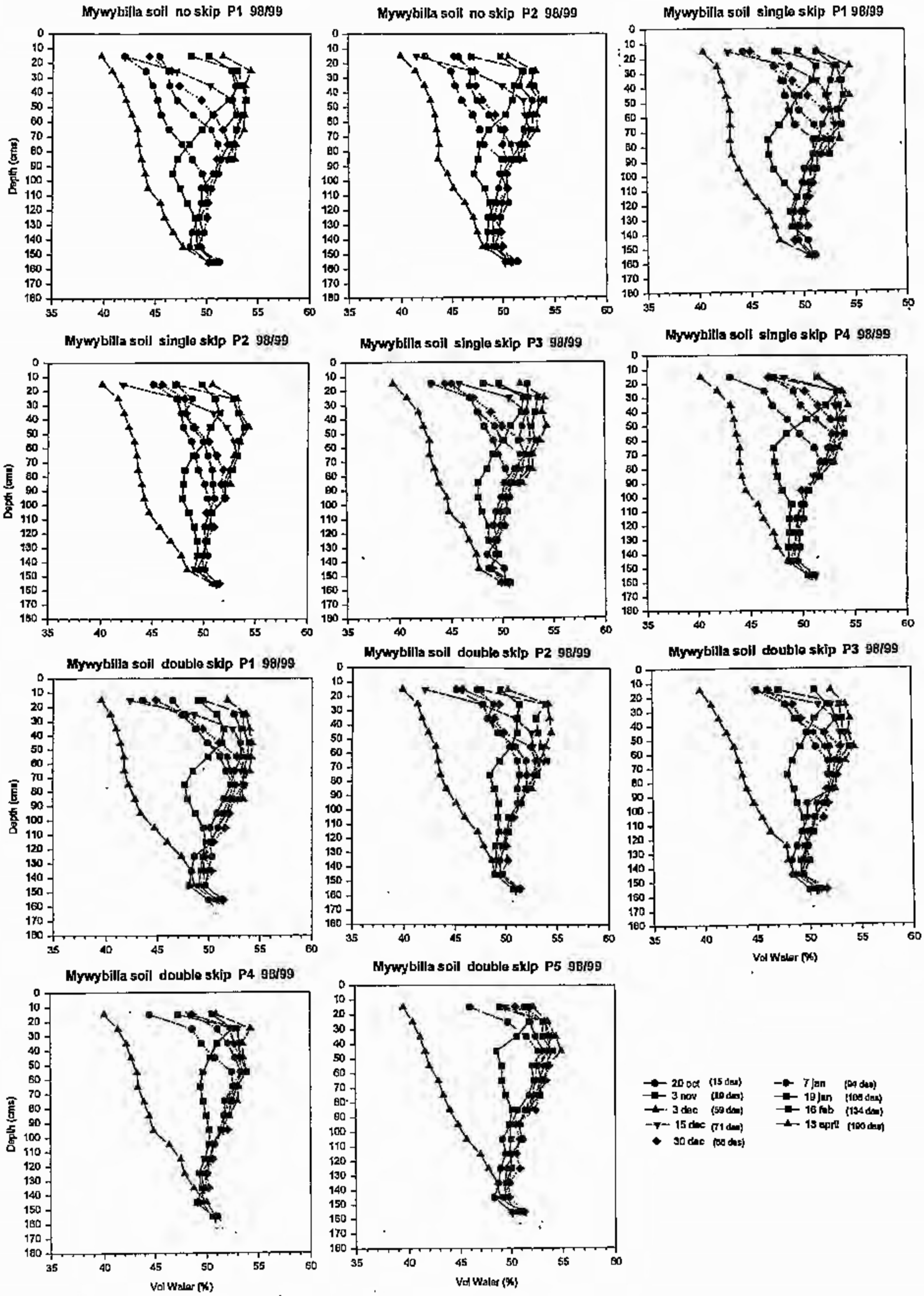
APPENDIX 24 Volumeric Water Content 1998/99



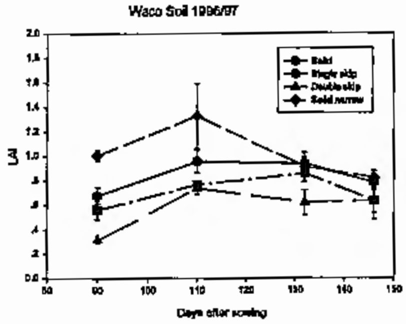
<u>APPENDIX 24 Continued</u> *Volumeric Water Content 1998/99*



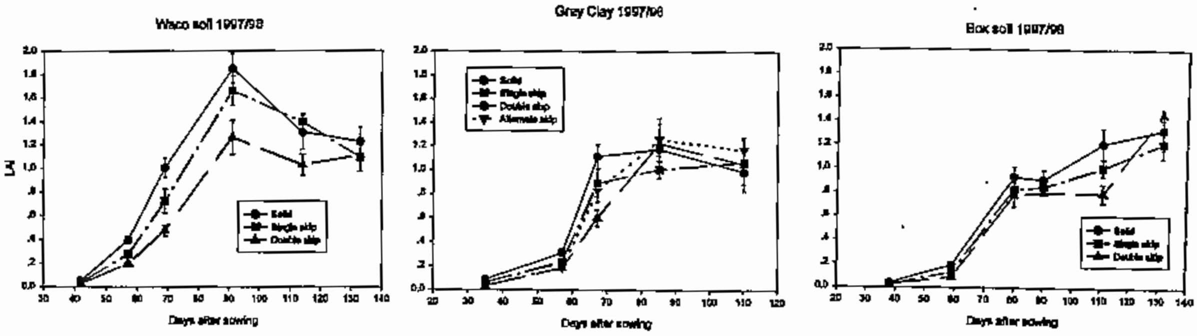
APPENDIX 24 Continued *Volumeric Water Content 1998/99*



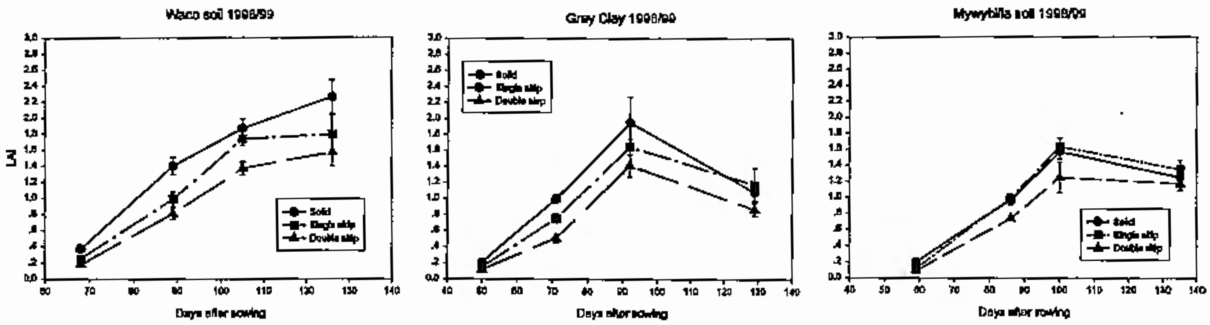
APPENDIX 25 Leaf Area Index



Siokra V15

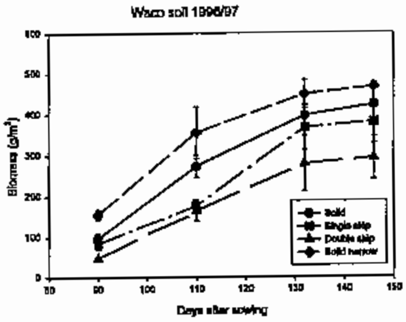


Siokra V15i

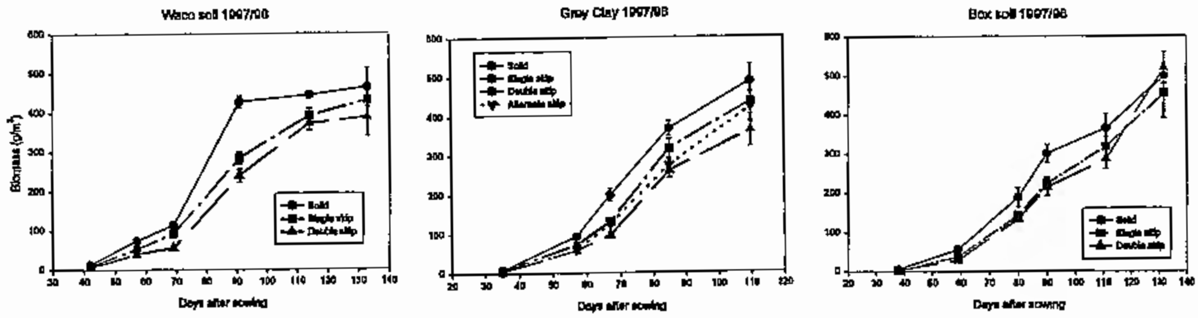


Siokra V15i

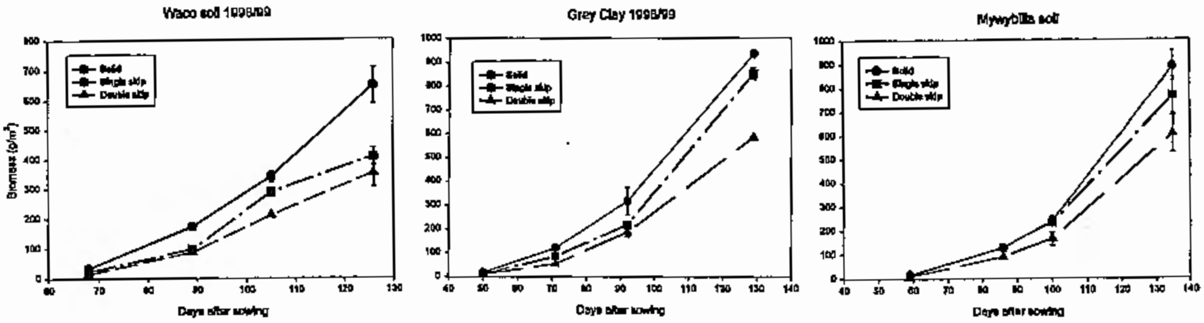
APPENDIX 26 Biomass



Siokra V15



Siokra V15i



Siokra V15i