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Disclaimer

Acknowledgments

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Abstract

Transpiration, leaf water potential and stomatal conductance were measured on several days during the irrigation season on 2% year old peach trees (*Prunus persica* var. Golden Queen) subjected to different irrigation treatments. Diurnal patterns of these variables were consistent with observations by other workers. Transpiration daily totals were about 16 L/tree for a day in December, and 22 and 36 L for two days in February. These figures are lower than for other reported work, but examination of transpiration, leaf water potential and stomatal conductance comparisons between two irrigation treatments, in combination with measurements of soil water potential suggests no significant water stress due to irrigation treatment. Consideration of the stage of fruit growth in relation to irrigation management needs careful consideration.

Leaf water potential (LWP) was approximately linearly related to transpiration at LWP less than -2000 kPa. Stomatal closure seems to occur in the LWP range -1500 to -2000 kPa. At vapour pressure deficit above 25 mb there appears to be partial stomatal closure.

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1. Introduction

Numerous studies on the water requirements of various horticultural crops have been undertaken.

It is generally recognized that under-watering leads to crop water stress resulting in a yield reduction. Over-watering can also result in yield penalties and is wasteful of an often valuable resource.

The processes and mechanisms involved in water use, water stress and yield reduction are the subject of many papers. Teare and Peet (1983) provide examples of how these processes and mechanisms affect a range of agricultural plant species.

Mitchell and Chalmers (1982) demonstrated that strategic periods of water stress could be used to increase fruit yields in peach trees. They reduced the vigor of peach trees without adversely affecting fruit development by applying reduced rates of irrigation during a nominated stage of fruit growth, and increased irrigation during the initial and final, fruit growth stages. Their work emphasized the importance of understanding the effects of water stress on horticultural crops in relation to their stage of growth. Mitchell (1979) gave recommendations for crop factors according to pan evaporation rates and the size (as measured by butt circumference) of peach trees. These recommendations were used in a trial to assess the potential of the Golden Queen variety of peaches, at Manjimup, Western Australia. In order to assess whether water stress was occurring due to differences in irrigation rates, transpiration, stomatal conductance and leaf water potential were measured on several days in 1985 and 1986. This was made opportune by the availability of the ventilated chamber system owned by the Western Australian Department of Agriculture, and developed by Dr R.A. Nulsen, Mr I.N. Baxter, Mr R. Engel and Mr M. Eales. The need to familiarise new operators with the system was combined with the opportunity to gather data on peach tree transpiration.

2. Materials And Methods

Sites

Measurements were conducted (in summer 1985/86) on the Golden Queen Peach Management Trial (82Mn15) on the Middlesex Road Research Station. The Station is located near Manjimup in the south-west corner of Western Australia. Average annual rainfall is 1,053 mm and average annual Class A pan evaporation is about 1,300 mm.

The trial site was on a hillslope with deep fine sandy loam soil, known locally as Karri loam (Northcote Classification Gn 2.12).

Trees

The peach trees (*Prunus persica* var. Golden Queen) were planted in July 1983. The trees were 2% years old and about 2.5 m high when measurements were taken. They were planted on a 6 x 4 m spacing so that each tree had an available ground area of 24 m^2. The trees used for transpiration measurements were winter pruned and trained as McKenzie central leader trees. The trees sampled for conductance and leaf water potential were guard trees, winter pruned to the four leader Hawkesbury system.

Irrigation

Water was applied using a drip irrigation system with two drippers per tree located about 0.7 m on either side of the trunk. Irrigation was based on evaporation from a class A pan, using a crop factor indexed to the mean butt circumference of the trees. The trees used in this study were irrigated to replace either 100% or 50% of the crop factor suggested by Mitchell (1979) (see Paulin, 1984) according to butt circumference. These rates were calculated to be 61% and 31% replacement of Class A pan evaporation during the period of these measurements.

Ventilated Chamber System

The ventilated chamber system measures transpiration by sampling the vapour pressure of air entering and leaving a plastic chamber enclosing a tree. The difference in vapour pressure between the two samples in used to calculate the transpiration rate (Tr, L/hr) using the formula:

$$Tr = \frac{0.21668 \times \Delta mb \times V \times A}{T} \quad (1)$$

Δmb = difference in vapour pressure (mb).

V = air velocity through the chamber.

A = cross sectional area of the chamber.

T = ambient air temperature (K).

0.21668 is the conversion factor of units to give Tr in L/hr.

The ventilated chambers (Figure 1) were constructed using a Dexion® aluminium framework to support Visqueen® plastic sheeting. The plastic was sown and glued to the shape of the chamber and bound to the frame with rope. The chambers were 1.84 x 1.84 m wide and 2.5 in high. A single 45 cm diameter, 0.4 kw industrial fan forced air into each chamber resulting in an air speed through the chamber of 0.4 m/s. Air entering and exiting the chamber was sampled with pairs of aquarium pumps. Sampled air was homogenized in a 3.5 L mixing chamber before being transported via plastic tubing to an ANRI Instruments Infra-red Gas Analyzer (IRGA). The plastic tubing was heated with low voltage teflon wire and insulated to prevent condensation. A solenoid connected to an automatic timer switched the air samples entering the IRGA for analysis. The IRGA was calibrated and operated in the differential mode using air of known vapour pressure in the reference cell. The IRGA output was recorded on a chart recorder. This system has been successfully employed by Nulsen (1984) and Greenwood et al. (1985) and its accuracy discussed by Foster and Leuning (1987), Dunin and Greenwood (1986) and Dunin et al. (1989).

For the ventilated chamber used equation 1 can be simplified to:

$$\text{Tr (L/hr)} = \frac{1{,}057.74 \times \Delta\text{mb}}{T} \quad (2)$$

Ventilated Chamber Measurements

Two ventilated chambers were set up on December 3 and 4, 1985, and again on February 18, 19 and 20, 1986. On each occasion one chamber measured transpiration from a single tree receiving a given irrigation treatment. Plastic was placed over the ground around the tree base to prevent soil evaporation.

Stomatal Conductance Measurements

Stomatal conductance measurements were taken using a LICOR LI 700 transient porometer. Samples were taken from guard trees under the 61% and 31% irrigation treatments. Six fully exposed and expanded leaves were sampled for each time from each treatment, (two from each of the top, middle and bottom of the canopy).

Figure 1. Ventilated Chamber on a 2% year old Golden Queen Peach Tree.

Leaf Water Potential Measurements

Leaf water potential was measured using a portable pressure bomb. The sampling pattern used was the same as for the stomatal conductance measurements.

Tensiometer Measurements

A single tensiometer was installed at 30, 60 and 90 cm depth beneath one tree in each irrigation treatment. Measurements were taken daily from December until mid-February.

3. Results

These results are presented graphically in this section. See Appendix 1 for the numerical tabulation of results.

December 4, 1985

Transpiration

The recorded transpiration rates for peach trees receiving irrigation replacement rates of 31% and 61% are shown in Figure 2. Each point is the mean of 15 air samples taken during a 30 minute period. Equipment problems prevented some measurements being taken. On 4/12/1985 the peak transpiration rate was about 2.4 L/hr at about 0930. The low transpiration rate on this day was due to cloud cover and occasional drizzle. Total transpiration for the day was less than 16 L.

Leaf water potential (LWP)

The recorded diurnal pattern of leaf water potential for the 4/12/1985 is shown in Figure 3. A minimum value of about -800 KPa was reached by 1200 hrs and sustained until about 1500 hours. There appears to be no significant difference in LWP between the two irrigation treatments. At 0930 hours a comparison of LWP between leaves from the top and the bottom of the canopy of the same tree revealed no significant difference.

February 18, 1986

Transpiration

The transpiration rates of the two trees measured follow the same diurnal pattern (Figure 4). The peak transpiration rate of 5.8 L/hour occurred at about 1530 hours. Maximum temperature for the day was 32°C and the relative humidity remained between 23% and 30% for the measurement period.

Leaf water potential and stomatal conductance were not measured.

February 19, 1986

Transpiration

The diurnal course of transpiration rates and ambient conditions for 19/2/1986 are shown in Figure 5. Transpiration can be seen to generally follow the course of solar radiation, but the high vapour pressure deficit (VPD) and temperature in the evening may have extended the declining phase of transpiration in the afternoon. The peak transpiration rate of 5.1 L/hr was recorded at about 1530 hours. The integrated daily value of transpiration was about 36 L for the 11 hours between 0800 and 1900. The small amount of condensation overnight “burnt off” by about 0900 hours as solar radiation increased rapidly. This led to a sharp peak in transpiration that amounts to about 0.5 L.

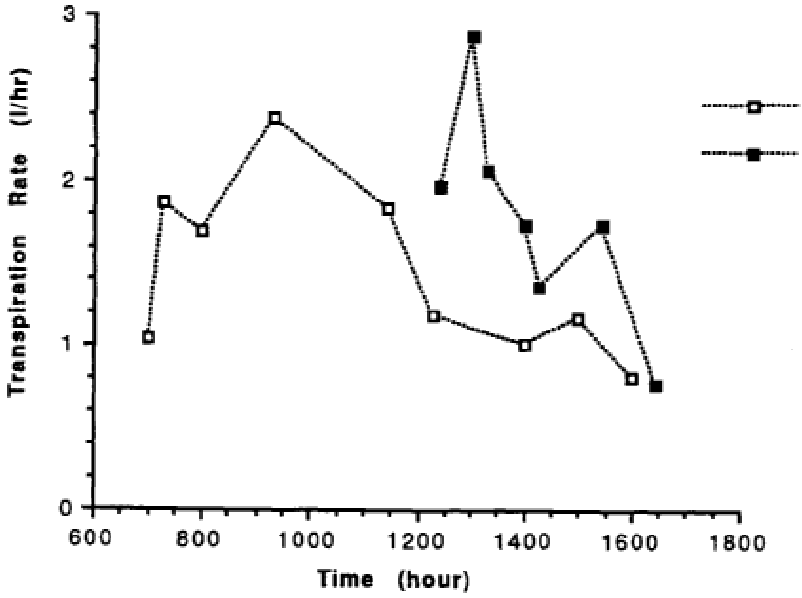

Figure 2. Peach tree transpiration rates for two irrigation treatments on 4/12/85.

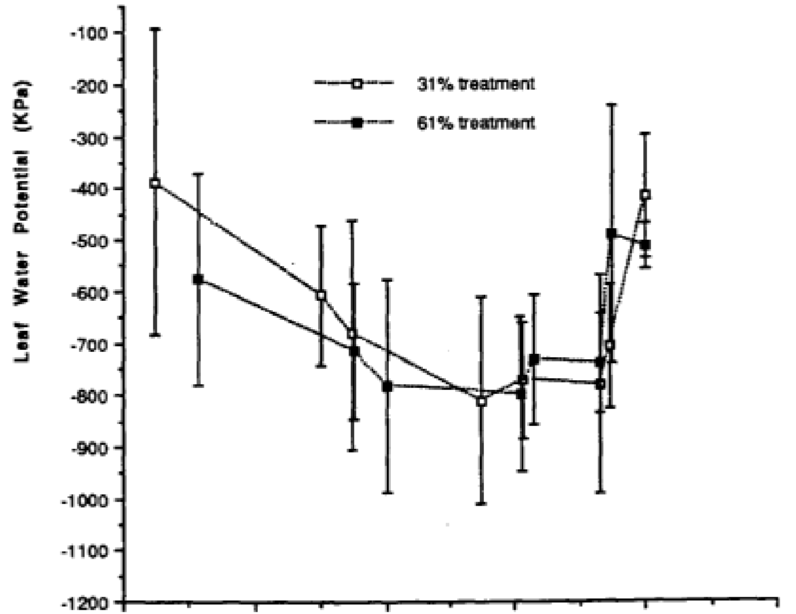

Figure 3. Leaf water potential for two irrigation treatments on 4/12/85. Standard deviations shown as error bars.

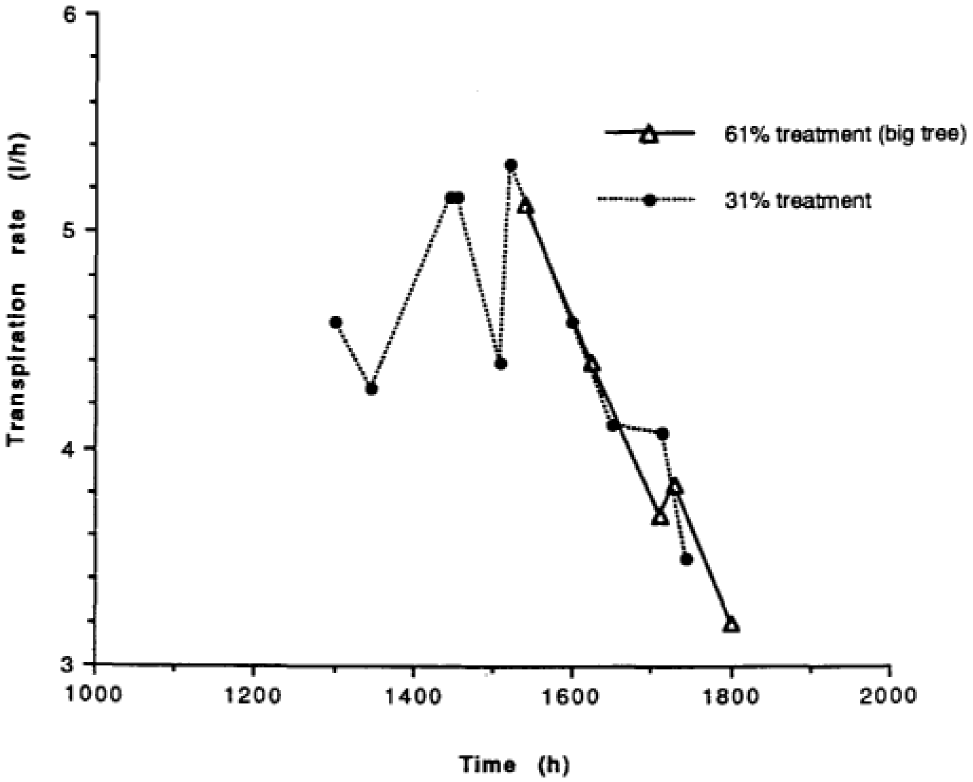

Figure 4. Transpiration rates for two irrigation treatments on 18/2/86.

Transpiration measurements on the 61% treatment did not begin until after 1100 hours and continued until 1800 hours. The diurnal course of transpiration is similar for both treatments. Large differences in transpiration rate only occur at around 1400 and 1700 hours. The 31% IR tree does not appear to be under transpiration stress due to reduced soil moisture. Most trees in the orchard appeared to be slightly wilted in the mid-afternoon, but their transpiration rates have been maintained.

Conditions were hot (maximum temperature = 35°C) and a high evaporative demand (maximum VPD = 43 mb) extended throughout the afternoon and well beyond sunset (Figure 5a).

Measurements on the 61% treatment continued overnight (Figures 5b and 7b) revealing a transpiration rate of about 0.1 L/hr for about 6 hours until 0130 hours. Thus 0.6 L of water was transpired overnight. Condensation formed between 0130 and 0700 (see February 20, 1986).

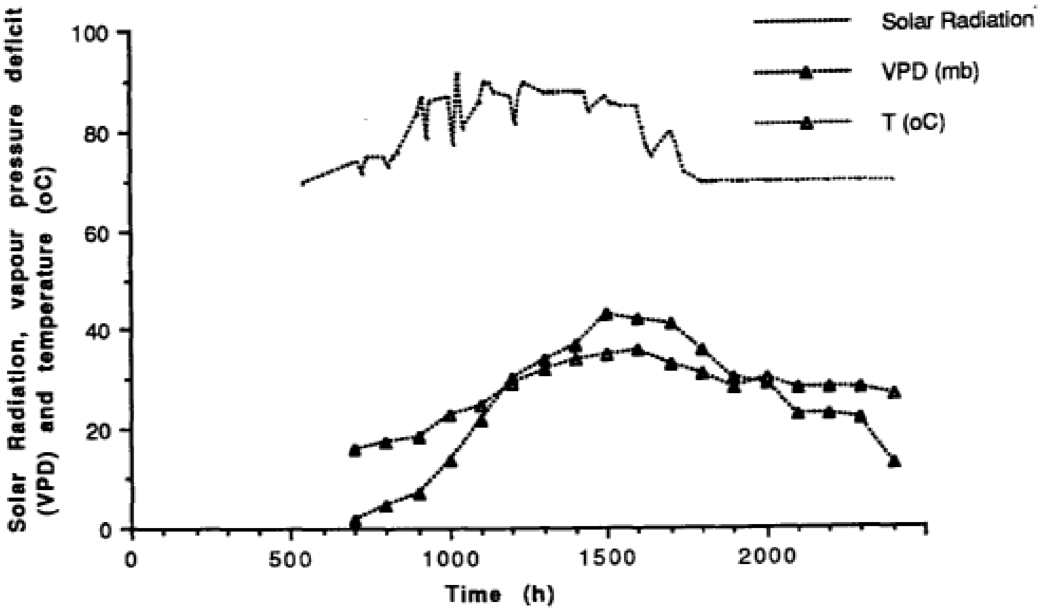

Figure 5(a). Solar radiation (uncalibrated), vapour pressure deficit and temperature on 19/2/86.

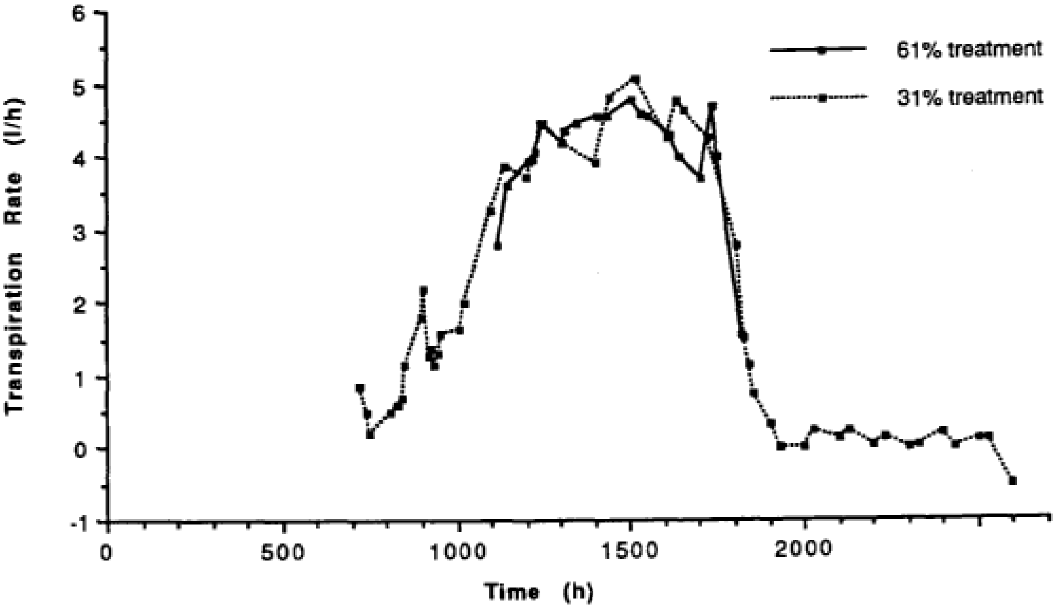

Figure 5(b). Transpiration rate for two irrigation treatments on 19/2/86.

Leaf water potential

Figure 6a shows the diurnal course of LWP measured on pairs of guard trees (at the end of each row) for each treatment. The 61% treatment reaches a minimum LWP of -1,800 KPa at about 1500 hours. The 31% treatment, reaches a minimum LWP of -2,400 KPa at about 1130 hours. There was some variation in the LWP of the pair of trees receiving 31% evaporation replacement. There were no significant differences (0.05 probability level) between the two treatments throughout the day.

Stomatal conductance

Stomatal conductance ranged from about 0.65 cm/s at 1100 hours on the 61% treatment down to about 0.2 cm/s at 1500 hours on the 61% treatment. The only major anomaly the apparent difference in stomatal conductance before 1200 hours. This difference was not supported by the transpiration or LWP data and was most likely due to the time difference or sampling problems. A visual inspection of the data revealed that leaf aspect influenced stomatal conductance by shading effects. East facing leaves had relatively higher conductances in the morning, and west facing leaves higher in the afternoon (data not presented here). This feature has also been recorded by Chalmers et al. (1983).

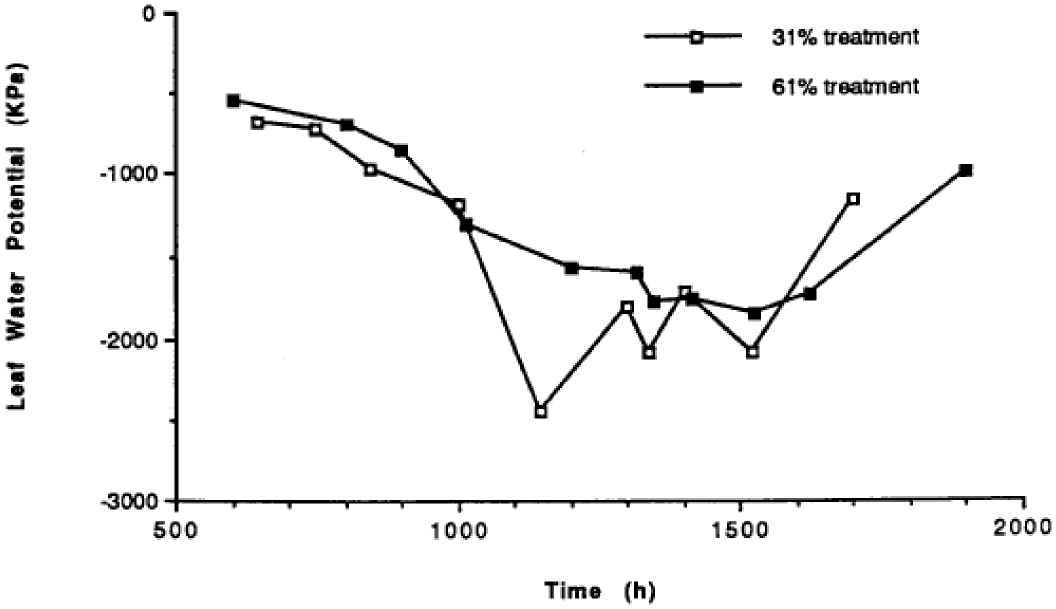

Figure 6(a). Leaf water potential for two irrigation treatments on 19/2/86.

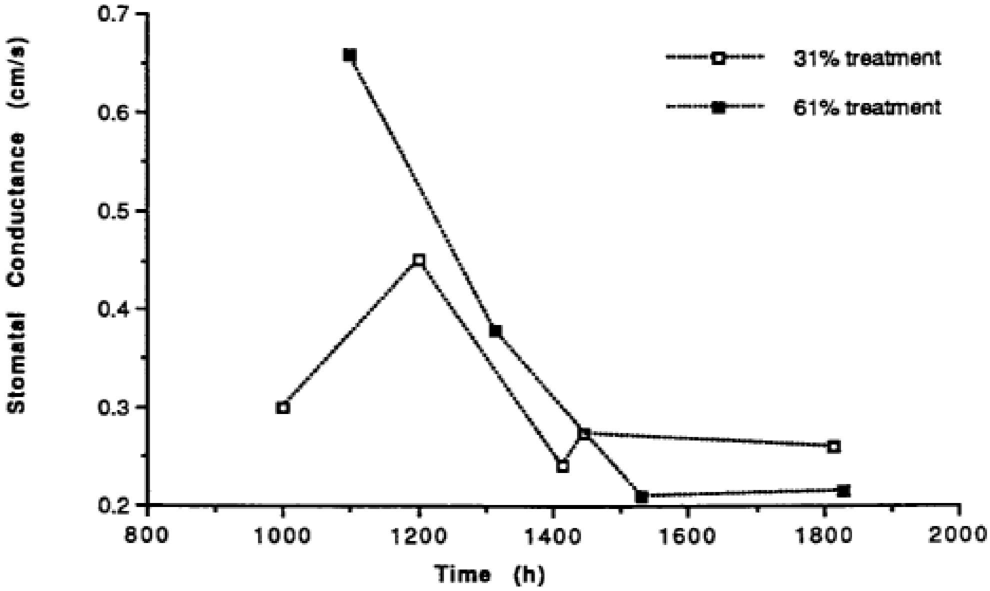

Figure 6(b). Stomatal conductance for two irrigation treatments on 19/2/86.

February 20. 1986

Conditions

Although conditions remained warm overnight, there was a considerable amount of condensation (VPD was 2 mb from 0400 to 0700 hours) deposited in the chamber overnight. The day was warm and humid with increasing cloud and a maximum VPD of 27 mb at 1500 hours. This coincided with the maximum temperature of 34°C. Heavy rain began to fall at 1630 hours when measurements were abandoned. The course of VPD, temperature and solar radiation is shown in Figure 7a.

Transpiration

The diurnal course of transpiration is shown by Figure 7b. A considerable amount of condensation (10.3 L) overnight is shown as negative transpiration. The bulk of this was seen to “burn off” rapidly between 0715 and 0900. After allowing for the condensation, total daily transpiration until the rainstorm was about 22 L.

Transpiration peaked at 5.1 L/hr at 1500 hours (the same time as solar radiation, VPD and temperature peaked). There is little difference between the transpiration rate of the two trees except between 1100 and 1300 hours when the 61% treatment is transpiring less than the 31% treatment. Again, there appears to be no depression of transpiration rate according to irrigation treatment.

Leaf water potential

Measurements of LWP were taken between 1000 and 1600 (Figure 8) revealing no significant difference between treatments. All samples were taken from a pair of guard trees. LWP reached a minimum of -2,000 KPa at about 1400 hours.

Stomatal conductance

Stomatal conductance was measured on the same pair of guard trees (Figure 9). Stomatal conductance appeared to be lower in the 31% treatment tree from 1200 to 1330 hours despite their being no difference in LWP between the trees. Reference to Figure 7a also conflicts with this result as the transpiration rate of the 31% treatment was actually higher than the 61% treatment for this period.

Tensiometer measurements

Soil moisture levels as recorded by a single tensiometer at each of three depths are shown in Figures 10, 11 and 12. For the 30 and 90 cm depths the 31% treatment appears to be frequently drier than the 61%. At 60 cm, however, the trend is reversed, with the 61% treatment appearing to be drier. The 31% tensiometer at 60 cm depth broke down near the end of January. The soil moistures for both treatments were maintained above field capacity (approximately -15 kPa).

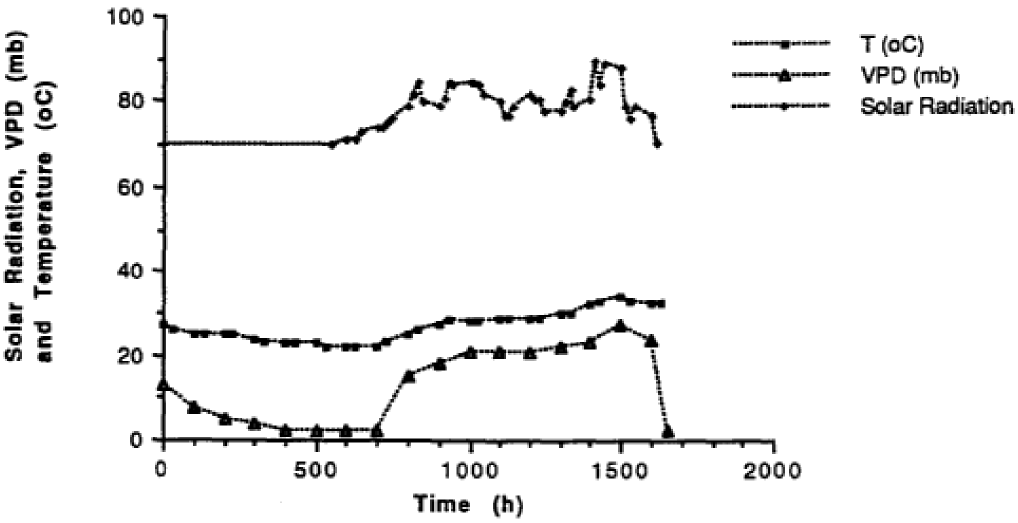

Figure 7(a). Solar radiation (uncalibrated), vapour pressure deficit and temperature on 20/2/86.

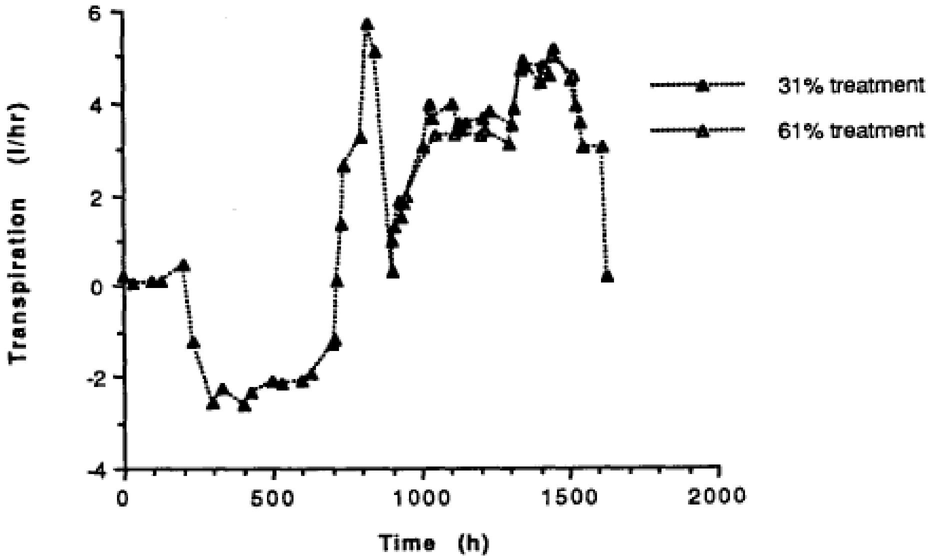

Figure 7(b). Transpiration rate for two irrigation treatments on 20/2/86.

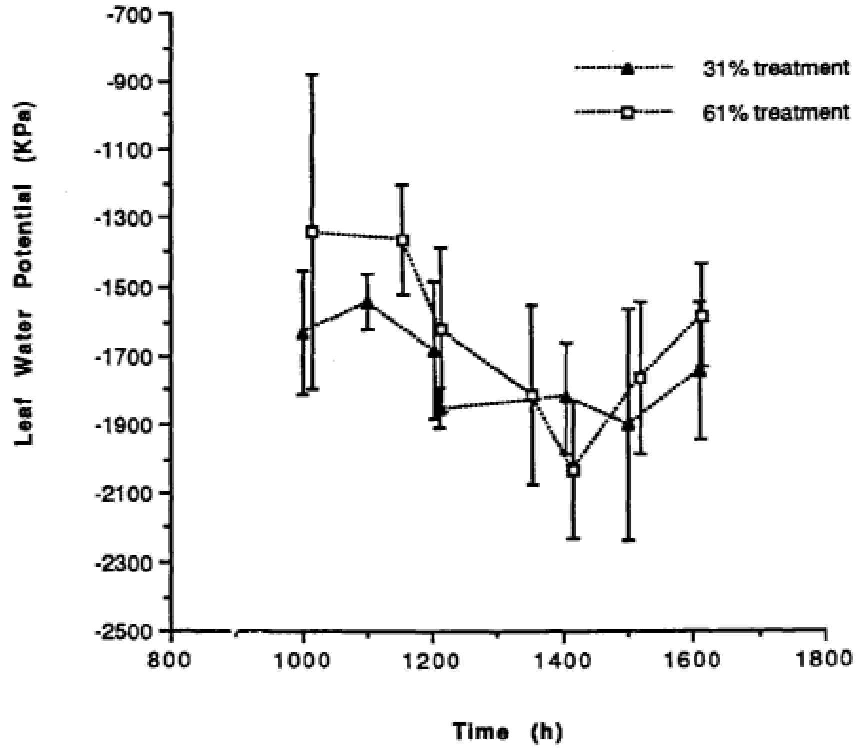

Figure 8. Leaf water potential for two irrigation treatments on 20/2/86. Standard deviations shown as error bars.

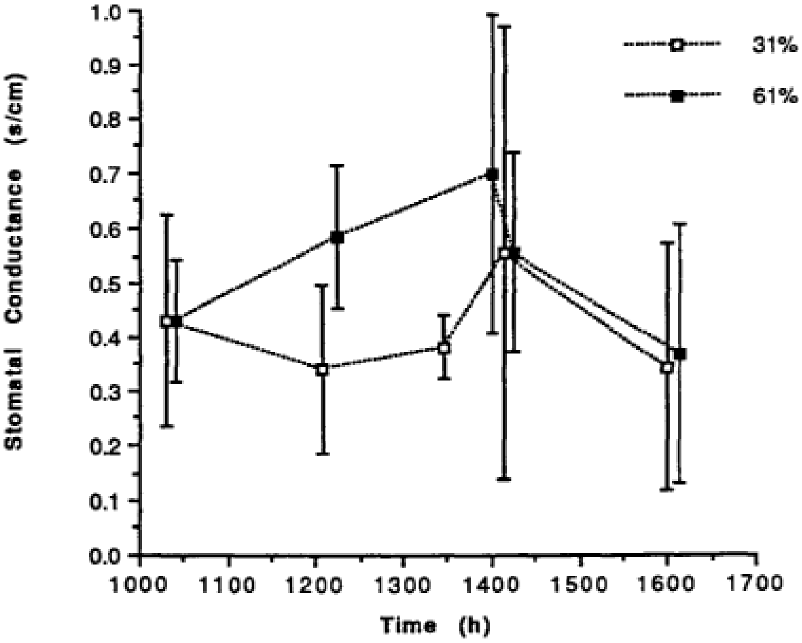

Figure 9. Stomatal conductance for two irrigation treatments on 20/2/86. Standard deviations shown as error bars.

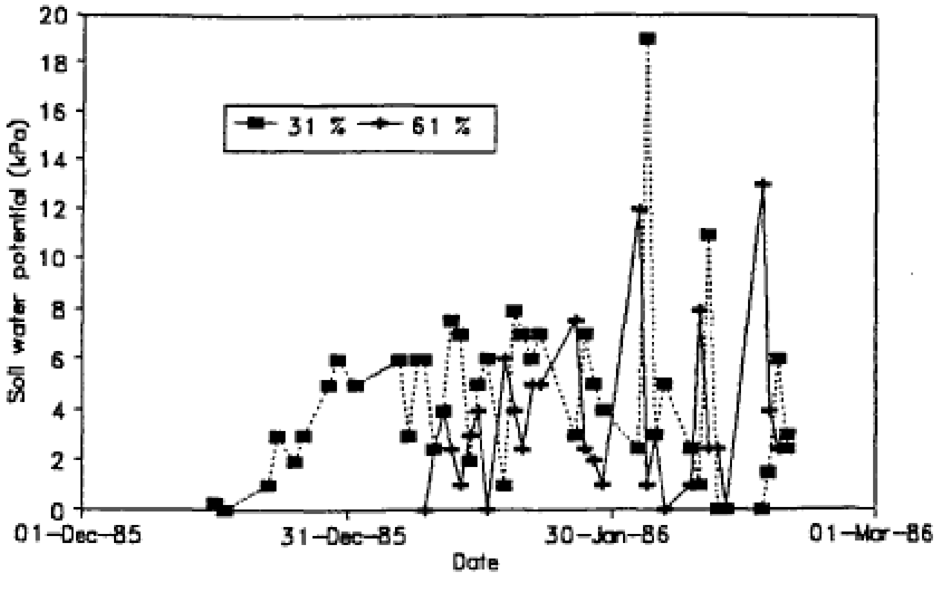

Figure 10. Tensiometer readings for two irrigation treatments over the course of the irrigation season. Depth = 30 cm.

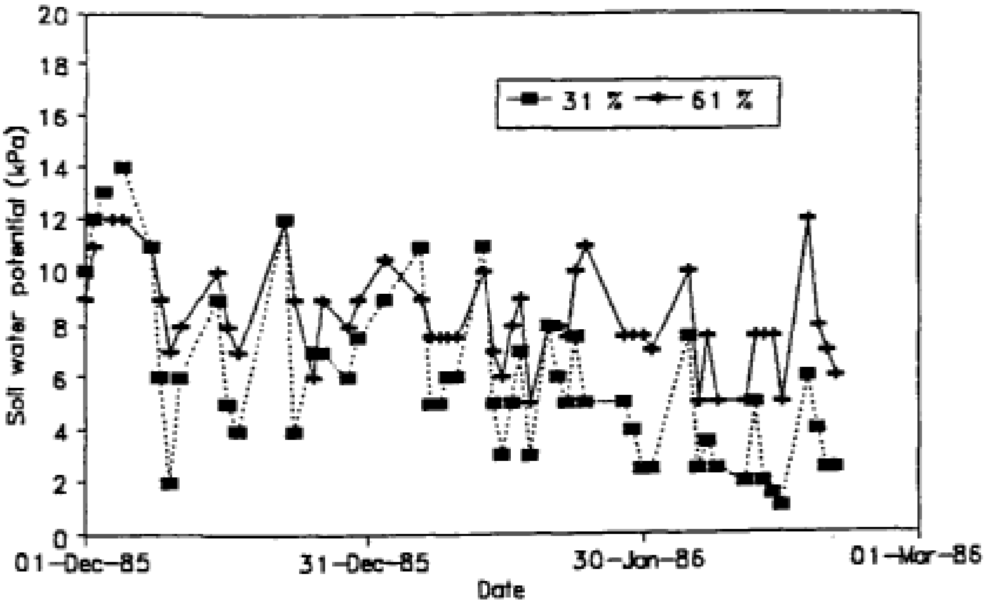

Figure 11. Tensiometer readings for two irrigation treatments over the course of the irrigation season. Depth = 60 cm.

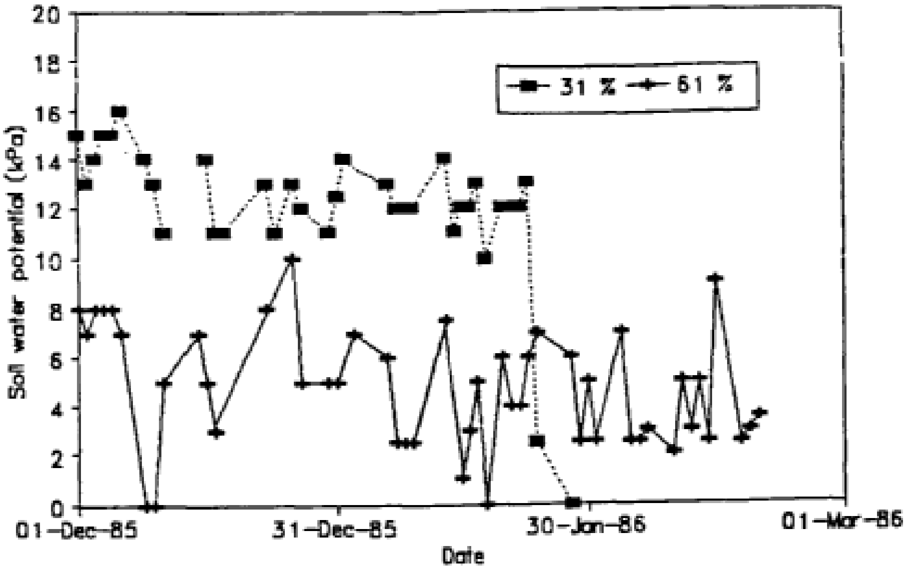

Figure 12. Tensiometer readings for two irrigation treatments over the course of the irrigation season. Depth = 90 cm.

4. Discussion

Transpiration

The formula for calculating transpiration is very sensitive to the windspeed term. Therefore, the absolute accuracy of the transpiration measurements is very dependent upon the measurement of windspeed. This was measured only once for these chambers. Assuming there was no change in the performance of the fans (subsequent measurements suggest that this would be true) the comparative transpiration rates are valid.

Dunin and Greenwood (1986), Foster and Leuning (1987) and Dunin et al. (1989) have discussed the possible effects of ventilated chambers on the transpiration rate of the vegetation within them. Checks of temperatures within the canopies of trees inside and outside the chambers during the middle of the day on 20/2/86 revealed that the temperature difference was never more than 0.5°C. Foster and Leuning (1987) noted that high Et rates recorded using a VC usually caused by higher temperatures within the chamber. It is concluded that in this case the ventilation rate was sufficient to prevent excessive warming within the chamber. The form of the ventilation, however, was different to that ordinarily experienced by a tree within an orchard. Air was introduced to the chamber from one side at the base and allowed to escape through a constriction at the top. Thus the lower limbs received some windblasting while the average air flow through the chamber was only 0.4 m/s. Depression of transpiration rates recorded by the VC when wind speeds external to the VC were greater than those internal, was noted by Foster and Leuning (1987) and the critical nature of ventilation rates when attempting to gather accurate measurements of Et has been discussed by Dunin and Greenwood (1986) and Dunin et al. (1989).

The measurements recorded in this experiment did not include wind speed external to the VC through the orchard. It is uncertain whether or not the conditions for equilibrium evaporation (evaporation rate at which recorded Et is independent of ventilation) were met. Therefore, the absolute accuracy of the Et measurements is not guaranteed, but their relative accuracy is good.

Peak transpiration rates of about 3 L/hr were recorded under low evaporative demand conditions in December 1985, and increased to 5 L/hr under high evaporative demand conditions in January 1986. The integration of the diurnal transpiration curves gives a daily water use of about 16 L/tree for December 4 and 22 L/tree to 36 L/tree for February 19 and 20 respectively. It was not possible to detect the effect of irrigation treatment on transpiration rate or total daily transpiration from the measurements taken. Both irrigation treatments appear to have received sufficient water, and no water stress would be expected.

Several other workers have measured evapotranspiration from peach orchards. Fereres and Goldhammer (1990) report average daily Et values for a peach orchard as 4.8 mm/day for flood irrigation, 3.9 mm/day for 100% Epan replacement using drippers and

2.6 mm/day for 33% replacement using drippers. Corresponding soil moisture extractions (approximately transpiration) were:

0.9, 1.1 and 1.8 mm/day respectively. Gamier, et al. (1986) report orchard Et for 3 year old peach trees in France ranging from 1.8 mm/day to 3.5 mm/day. Worthington, et al. (1984) measured 5 year old peach tree Et in Texas ranging from 61 L/tree/day to 136 L/day/tree. Chalmers et al. (1983) estimated that a fully grown peach tree would have a peak water demand of 150 L/day. From the measurements taken in this study, it would appear that total daily transpiration from these 2% year old trees can range from 16 L/tree/day in December, to about 36 L/tree/day in February depending upon environmental conditions. At the spacings in the Manjimup orchard, this translates to between 0.7 mm/day and 1.5 mm/day on an area basis. The age of the trees, and the exclusion of soil evaporation in this study have no doubt contributed to the lower transpiration rates than those found by other workers. The size, or more correctly, the leaf area of the trees will have a significant effect on total tree transpiration - the pruning system adopted in this trial may have resulted in lower leaf areas than for similar aged trees.

The average daily evaporation for Manjimup in December is 6.4 mm and 6.2 mm for February. At replacement rates of 61% this translates to 94 L/tree/day in December and 91 L/tree/day in February. For the 31% replacement rate this would be 48 L/tree/day in December and 46 L/day/tree in February. If the trees had access to all of the water delivered (i.e. no soil evaporation or drainage loss) then even the lower replacement rate would have been adequate to replace water transpired by the trees. The assumptions made in this study, make it unwise to offer recommendations on the basis of the above information alone.

The double sigmoid growth curve of peach fruit outlined by Chalmers et al. (1981) is critical to decisions regarding the irrigation management of peach trees. They identified the periods September 25 to December 6, and January 3 to March 3 as being periods of rapid increase of fruit dry weight (consequently called DW1 and DWIII) and thus assimilate demand. Luxury levels of soil moisture are required at these times otherwise water stress will adversely affect the production of assimilates for fruit production. The measurements taken at Manjimup roughly coincide with periods DWI and DWIII when luxury watering levels should be maintained. Allowing for soil evaporation and measurement errors, the transpiration data suggests that both irrigation treatments were receiving sufficient water to replace evaporation. The 31% treatment in February, where measured tree water use was up to 36 1L/tree/day, and water applied was about 46 1./tree/day, may be cutting the margin rather fine given that no allowance has been made for soil evaporation, drainage, or measurement error. The soil moisture measurements, however, suggest that ample moisture is stored in the soil for transpiration.

The DWII period defined by Chalmers et al. (1981) as December 6 to January 3, is a period where the fruit do not gain dry weight, and assimilate production is directed towards vegetative matter. Water stress, it is argued, during this period does not adversley affect fruit production, but reduces the production of vegetative material. The tree does not then suffer the burden of maintaining this extra vegetative material during the DWIII period. In their study, fruit yields were increased by reducing the amount of water applied in DWII to a maintenance amount.

A simple stress index would be of great benefit to any grower attempting to manage his orchard according to the recommendations of Chalmers et al (1981). Ensuring adequate water is available during the DWI and DWIII periods is essential, and being able to observe the onset of stress during the DWII period would be beneficial. Hsiao (1973) showed that leaf enlargement is very sensitive to water stress. It is one of the first growth processes to be affected by a decrease in LWP. It is suggested that measurements of leaf, trunk and fruit expansion may be valuable in defining not only the onset of water stress, but also the three growth phases previously mentioned.

Leaf Water Potential and Stomatal Conductance

Xiloyannis et al. (1980) recorded mid-afternoon IMP’s of about 2500 KPa in well watered (100% replacement of Et) peach trees in California with only small, but consistent differences compared to 50% replacement of Et and unwatered treatments. Pre-dawn LWP’s showed little difference between 50% and 100% treatments, but were substantially different to the unwatered treatment over the course of the season. This difference became noticeable when about half of the available water in the top 90 cm was depleted. The LWP’s recorded in this study were not pre-dawn and according to Xiloyannis’ data, may not be the best indication of the effect of irrigation treatment on water stress. Unfortunately, Xiloyannis et al. did not present data on the effects of irrigation treatment on fruit yield. Similar diurnal patterns of LWP have been observed in pear and apricot trees (Klepper, 1968) and apple trees (Goode and Higgs, 1973, Landsberg et al. 1975). The high resistance to water flow in peach trees results in lower LWP than for many other woody species (Chalmers et al. 1983).

The relationship between LWP and transpiration is shown in Figure 13. There is an apparently linear relationship between LWP and transpiration for LWP greater than -2000 kPa. The regression on this data (excluding the data point at LWP = 2,500 kPa) is T = (-0.00309 LWP) -1.36271 (R^2 = 0.84) where T = L/hr and LWP = kPa. This compares well to a similar regression by Landsberg et al. 1975 where LWP and transpiration rate were related in apple trees. The lower transpiration rate recorded at -2,500 kPa LWP is probably due to stomatal closure at low LWP.

Stomatal closure due to low leaf turgor has been observed in apples at -1400 kPa (1.andsbemg et al. 1975). Xiloyannis et al. (1980) found that stomatal closure was linked with pre-dawn LWP’s of less than -1000 kPa in peach trees. With the exception of the morning of February 20 (for which there is no data), the first LWP’s are all above -1000 KPa and suggest that there is little likelihood of stomatal closure due to insufficient soil moisture availability. From the data in Figure 14 it is difficult to postulate any stomatal reaction at daytime LWP greater than about -1,900 kPa. Unfortunately data points do not coincide at LWP less than -2,000 kPa, making it impossible to decide what is the critical LWP for stomatal closure in peach trees from this data set. Data collected by Olsson (1977) showed that stomatal conductance was reduced by about 40 per cent over the range of LWP -1,200 to -1,800 kPa in early January (stage DW11 of fruit growth). During the DW111 stage of fruit growth however, there was evidence that stomatal conductance remained high for a longer period during the day (and hence over a wide range of LW?) before decreasing. The fruit in this trial was in the DW111 stage and the maximum stomatal conductance observed was at LWP = -1,800 kPa.

The minimum and maximum daytime stomatal conductance was measured at approximately the same LWP. This indicates some variability in the response of individual trees, or sampling error. It is interesting to note that On 19/2/86 (a day of high solar radiation and VPD) that the maximum recorded stomatal conductance was at a LWP of -1,500 kPa and dropped as LWP dropped beneath that level. The 20/2/86, by contrast, was cloudy and had a lower maximum VPD. From this limited data set, it seems that the proposal of Xiloyannis et al. (198) is true; that daytime stomatal conductance is dependant upon the interaction of several factors including temperature, relative humidity, solar radiation and soil moisture. Fereres and Goldhaxnmer (1990) found in a long term soil moisture deficit experiment on peach trees, that after some time LWP does not reflect the level of water stress experienced by the tree. After three years of deficit irrigation there was no differences in LWP between treatments, but stomatal conductance was higher in well watered treatments.

The stomatal conductance measurements are considerably higher than those recorded by Xiloyannis et al. but compare favourably with those recorded by Gamier et al. (1986) and Fereres and Goldhammer (1990). The maximum stomatal conductance measurements recorded are similar to those found in apples by Landsberg et al. The stomatal conductance measurements presented here were taken on fully expanded and exposed leaves, and consequently would be expected to be the above the canopy average. Our experience highlights the difficulty of determining canopy conductance from small samples of individual leaves. Landsberg .et al. (1975) provides a good review of stomatal conductance measurements.

Figure 15 shows stomatal conductance apparently peaking at a VPD of about 25 mb. For VPD greater than 25 mb, the stomatal conductance appears to be reduced. Luke (1987) made similar observations on irrigated grape vines and Fereres and Goldhammer (1990) on several other species, regardless of soil moisture status. LWP appears to level out at around -2,000 kPa at a VPD of about 25 mb (Figure 16), slightly lower than the -1,700 kPa noted in grapevines by Luke (1989). Landsberg et al. (1975) recorded a nearly linear response of LWP to VPD in apples, but only in the VPD range up to 13 mb. Combining the information contained in Figures 14, 15 and 16 suggests that stomatal closure occurs somewhere in the LWP range -1,500 to -2,000 kPa according to soil moisture, VPD and solar radiation conditions.

The fact that transpiration can continue through partially closed stomates is demonstrated in Figure 17. At low stomatal conductance values a range of transpiration rates were recorded. At high evaporative demand (high VPD), considerable moisture loss is occurring from the leaves. This is confirmed by the night time transpiration rates (when stomates are partially closed) during high VPD conditions (19/2/86). This can be seen as the line of descending points at VPD 32-43 mb on Figure 18. The remaining points are daytime transpiration and show an almost linear relationship to VPD. The effect of partial stomatal closure at VPD greater than 25 mb is difficult to see in terms of transpiration rate (Figure 18). However, by splitting the data at 25 mb and doing separate linear regressions, a significant change of slope is apparent. For VPD conditions less than 25 mb the regression is T = 0.162 VPD -0.090 ($R^2 = 0.74$), and for conditions greater than 25 mb the regression is T = 0.061 VPD + 1.983 ($R^2 = 0.45$).

There is little to suggest, from this data set, that the peach trees were under water stress as a result of soil moisture deficit from irrigation treatment. The measurements are however, patchy, and conclusions should be drawn from them only with caution.

The data set does point out the difficulty that peach trees have coping with hot, dry weather (high evaporative demand) even when soil moisture is adequate. This difficulty would only become worse if soil moisture was limiting. It is advisable, therefore, for growers to consider bringing forward a scheduled irrigation if very hot weather is forecast towards the end of an irrigation cycle.

Tensiometer Measurements

The tensiometer measurements suggest that the amount of soil moisture in the 31% treatment was frequently less than in the 61% treatment at the 30 and 90 cm depths. The anomaly at 60 cm (where the trend is reversed) may be due to poor tensiometer or dripper placement. Worthington et al. (1984) suggest that water use of peach trees is not affected until soil water potentials drop below -400 kPa. For the period of this trial the peach trees were never exposed to soil water potentials of less than -20 kPa bars at any of the three depths and can be considered to be well watered. Given, therefore, that soil moisture was unlikely to be limiting transpiration in this trial, the lack of difference in transpiration rate, LWP and stomatal conductance between the two irrigation treatments is to be expected. The assumptions made in this study, and the complexity of plant water relations and fruit growth make it difficult to make recommendations from this data set. However, any water stress experienced was due to the tree’s inability to cope with high evaporative demand conditions.

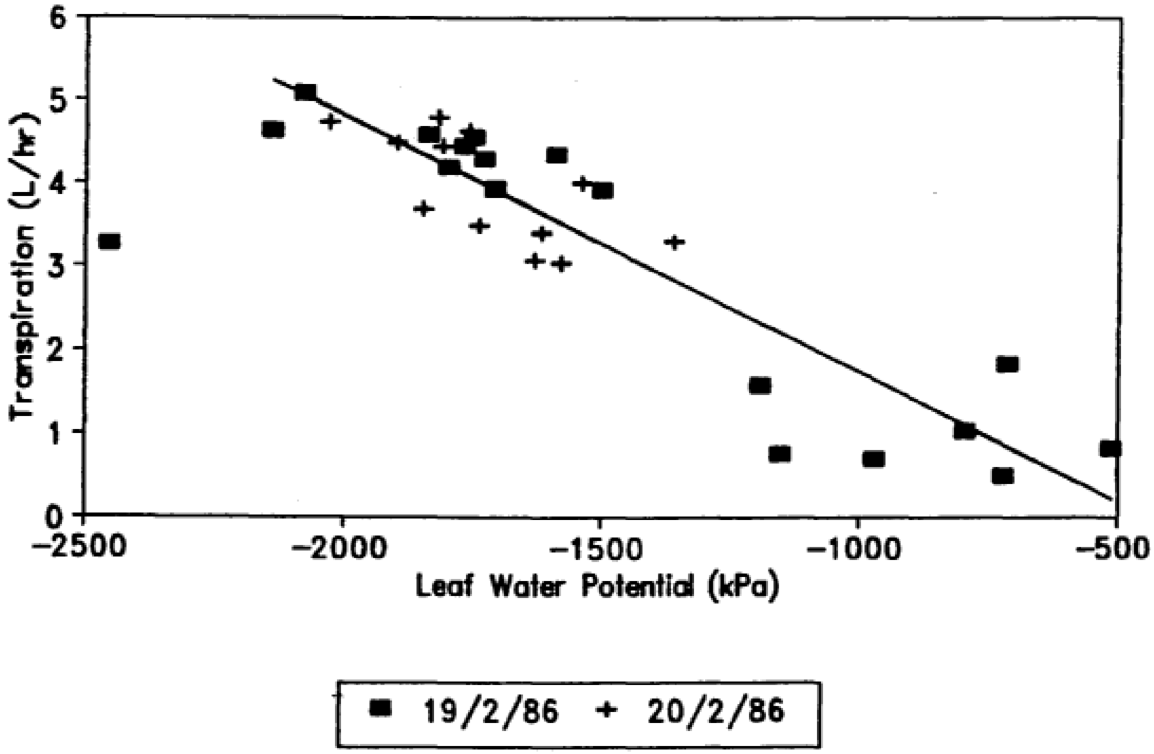

Figure 13. The relationship between leaf water potential and transpiration for two days in February 1986.

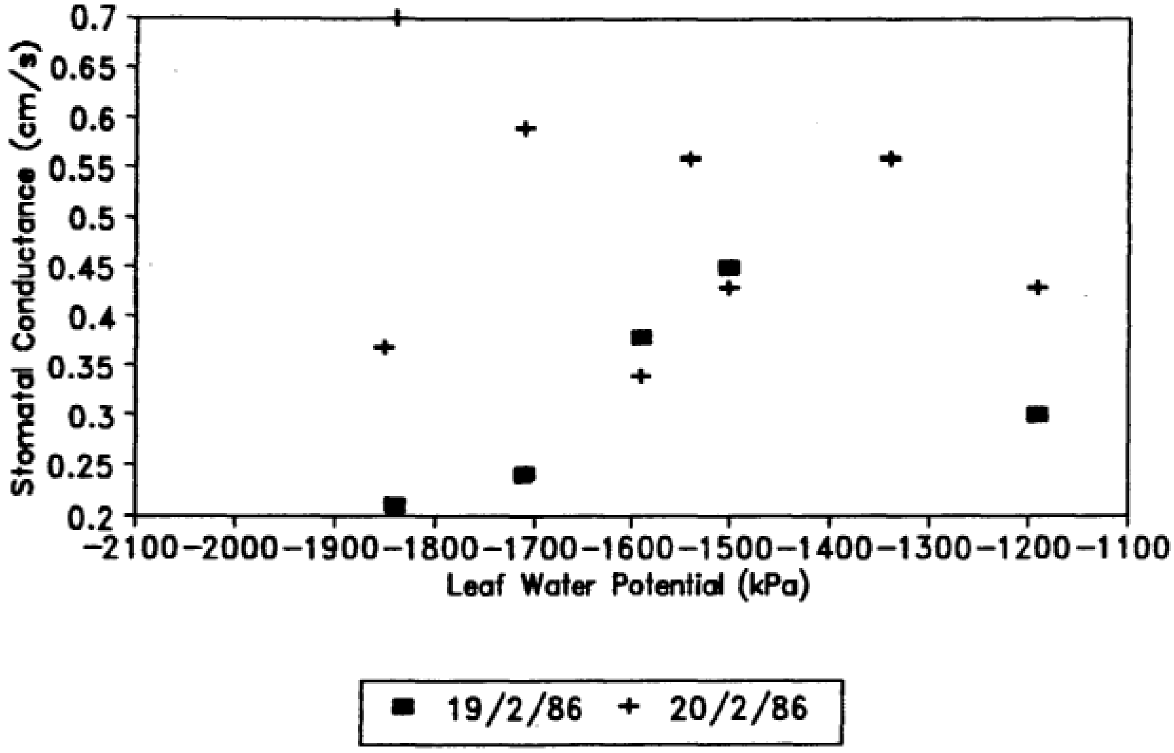

Figure 14. The relationship between stomatal conductance and leaf water potential for two days in February 1986.

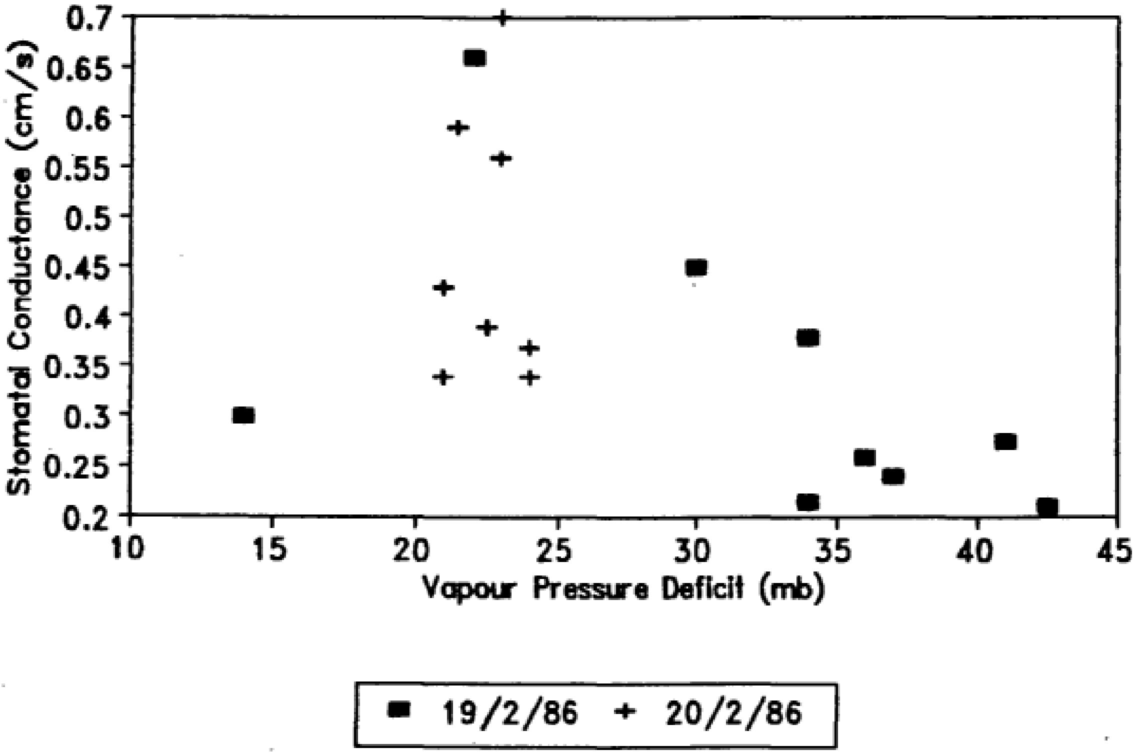

Figure 15. The relationship between stomatal conductance and vapour pressure deficit for two days in February 1986.

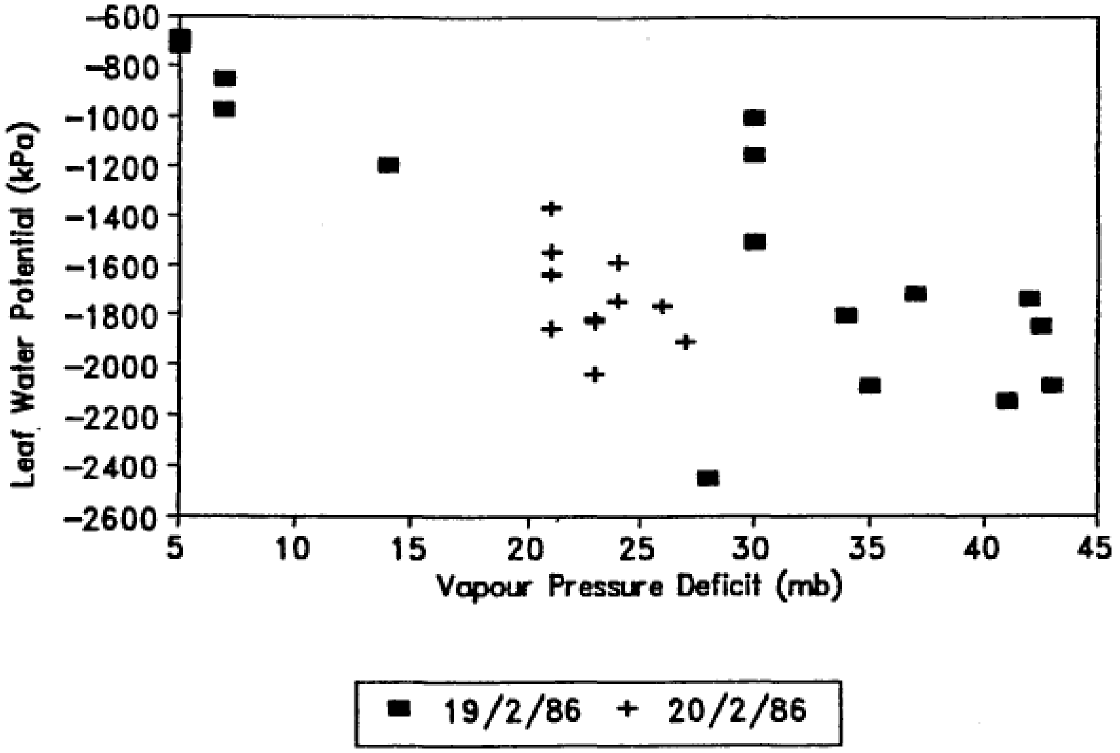

Figure 16. The relationship between leaf water potential and vapour pressure deficit for two days in February 1986.

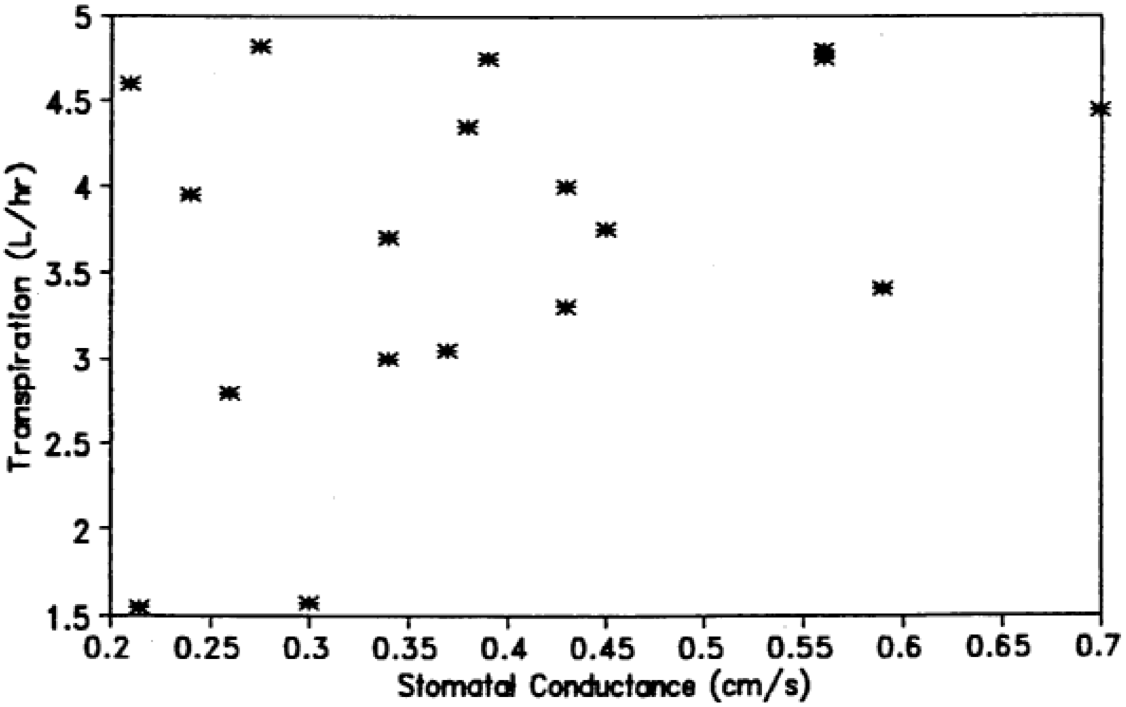

Figure 17. The relationship between stomatal conductance and transpiration.

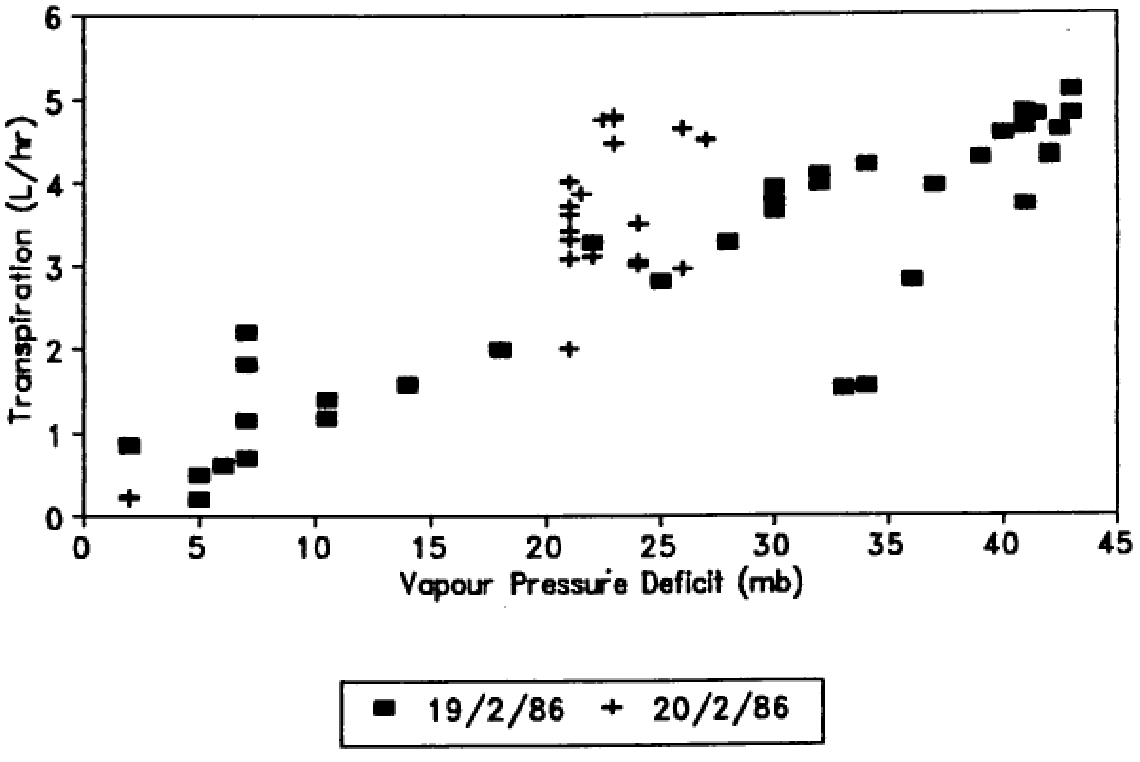

Figure 18. The relationship between transpiration and vapour pressure deficit for two days in February 1986.

5. Conclusion

Measurements of transpiration, stomatal conductance and leaf water potential carried out in December 1985 and February 1986 suggest that different irrigation treatments probably did not cause significant plant water stress in Golden Queen peach trees. Any stress encountered was more likely due to high evaporative demand conditions encountered in February.

Data analysis shows that LWP is linearly related to transpiration, and that stomatal closure occurs in the range -1,500 to -2,000 kPa in these trees with fruit at the DW111 stage. Changes in LWP and stomatal conductance appear to occur at VPD greater than 25 mb.

Management of water stress in peach trees can result in yield differences according to the timing and extent of the stress. More detailed measurements would have been necessary to investigate the role of planned water stress management. This was beyond the scope of this opportunistic study. Future studies should include more intensive irrigation management and detailed analysis of the plant’s physiological processes based on work conducted elsewhere. Substantial savings in irrigation water may be possible.

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7. Appendix 1

Time, transpiration (TRANSP), leaf water potential (LWP), vapour pressure deficit (VPD), stomatal conductance (STOM CON), solar radiation (SOLAR RAD), temperature (TEMP) for the two irrigation treatments (IRR. TMT) on peach trees at Manjimup.

Note:

a) Some data interpolation has been necessary to assemble this data set.

b) The solarimeter was not calibrated.

c) Measurements were opportunistic, and therefore not to any set schedule.

DATE	TIME Hrs	TRANSP L/hr	LWP KPa	VPD Mb	STOM CON Cm/s	SOLAR RAD Uncalib.	TEMP C	IRR. TMT. E Replac.
31285	1240	1.97						0.31
	1300	2.89						0.31
	1330	2.07						0.31
	1400	1.73						0.31
	1430	1.36						0.31
	1500	0.95						0.61
	1545	1.77						0.31
	1615	0.78						0.61
	1645	0.78						0.31
41285	848		-388					0.31
	915		-575					0.61
	930	2.38						0.61
	1100		-605					0.31
	1145	1.84	-713					0.61
	1148		-680					0.31
	1200		-780					0.61
	1230	1.19						0.61
	1348		-810					0.31
	1400	1.02	-794					0.61
	1415		-770					0.31
	1430		-730					0.61
	1500	1.19						0.61
	1530		-780					0.31
	1530		-738					0.61
	1545		-706					0.31
	1548		-488					0.61
	1600		-412					0.31
	1600	1.19	-510					0.61

DATE	TIME Hrs	TRANSP L/hr	LWP KPa	VPD Mb	STOM CON Cm/s	SOLAR RAD Uncalib.	TEMP C	IRR. TMT. E Replac.
180286	1300	4.59						0.31
	1345	4.28						0.31
	1445	5.17						0.31
	1455	5.17						0.31
	1509	4.4						0.31
	1521	5.32						0.31
	1539	5.13						0.61
	1600	4.59						0.31
	1624	4.4						0.61
	1650	4.11						0.31
	1710	3.71						0.61
	1715	4.08						0.31
	1730	3.84						0.61
	1745	3.5						0.31
	1800	3.2						0.61
190286	600		-540					0.61
	645		-670					0.31
	724	0.85		2		72	16.5	0.31
	745	0.5	-720	5		75	17.5	0.31
	750	0.2		5		75	17.5	0.31
	800		-690	5		73	17.5	0.61
	810	0.5		5		73	17.5	0.31
	830	0.6		6		75	18	0.31
	845	0.7	-970	7		76	18.5	0.31
	855	1.15		7		84	18.5	0.31
	900	1.825		7		73.5	18.5	0.31
	900		-850	7		73.5	18.5	0.61
	910	2.2		7		87	18.5	0.31
	918	1.275				87		0.31
	930	1.4		10.5		79	20.5	0.31

DATE	TIME	TRANSP	LWP	VPD	STOM CON	SOLAR RAD	TEMP	IRR. TMT.
	Hrs	L/hr	KPa	Mb	Cm/s	Uncalib.	C	E Replac.
190286 ctd.	936	1.175		10.5		79	20.5	0.31
	948	1.325				86		0.31
	1000	1.575	-1190	14	0.3	87	23	0.31
	1010	1.65				77.5		0.31
	1015		-1300			77.5		0.61
	1024	2		18		92	24	0.31
	1100	3.275		22		86	25	0.31
	1100			22	0.66	86	25	0.61
	1120	2.8		25		90	26	0.61
	1140	3.275	-2450	28		88	28	0.31
	1150	3.625		30		88	29	0.61
	1200	3.75		30	0.45	87	29	0.31
	1210	3.925	-1500	30		87	29	0.61
	1224	3.975		32		88	30	0.31
	1230	4.075		32		88	30	0.61
	1245	4.45				90		0.31
	1250	4.475				90		0.61
	1303	4.2		34		88	32	0.61
	1306	4.2	-1800	34		88	32	0.31
	1315	4.35	-1590		0.38	88		0.61
	1336		-2080	35		88	33	0.31
	1345	4.45	-1770			88		0.61
	1400	3.92	-1710	37	0.24	88	34	0.31
	1415	4.55	-1750			88		0.61
	1430	4.55		40		88	34.5	0.61
	1445	4.825		41	0.275	84	35	0.31
	1500	4.8		43		87	35	0.61
	1515	5.075	-2080	43		85.5	35	0.31
	1530	4.6	-1840	42.5	0.21	85.5	35.5	0.61
	1550	4.55				85		0.61

DATE	TIME	TRANSP	LWP	VPD	STOM CON	SOLAR RAD	TEMP	IRR. TMT.
	Hrs	L/hr	KPa	Mb	Cm/s	Uncalib.	C	E Replac.
190286 ctd.	1606	4.275		42		85	36	0.31
	1615	4.3	-1730	42		81	35	0.61
	1633	4.775		41.5		77	34.5	0.31
	1645	4				75		0.61
	1655	4.65	-2140	41		80	33	0.31
	1706	3.7		41		80	33	0.61
	1724	4.275		39		76	32	0.31
	1740	4.7				72		0.61
	1750	4				72		0.61
	1805	2.8		36	0.26	70	31	0.31
	1818	1.55		34	0.215	70	29	0.61
	1830	1.525		33		70	29	0.31
	1840	1.15				70		0.31
	1854	0.75	-1150	30		70	28	0.31
	1900		-1000	30		70	28	0.61
	1906	0.35				70		0.31
	1950	0				70		0.31
	2000	0		29		70	30	0.31
	2030	0.25				70		0.31
	2100	0.15		23		70	28	0.31
	2130	0.25				70		0.31
	2200	0.05		23		70	28	0.31
	2230	0.15				70		0.31
200286	0	0.25		13		70	27	0.31
	30	0.05				70	26	0.31
	100	0.1		8		70	25	0.31
	130	0.1				70	25	0.31
	200	0.5		5		70	25	0.31
	230	-1.2				70	25	0.31

DATE	TIME	TRANSP	LWP	VPD	STOM CON	SOLAR RAD	TEMP	IRR. TMT.
	Hrs	L/hr	KPa	Mb	Cm/s	Uncalib.	C	E Replac.
200286 ctd.	300	-2.55		4		70	24	0.31
	330	-2.25				70	23	0.31
	400	-2.6		2		70	23	0.31
	430	-2.35				70	23	0.31
	500	-2.1		2		70	23	0.31
	530	-2.15				70	22	0.31
	600	-2.1		2		71	22	0.31
	630	-1.95				71	22	0.31
	700	-1.25		2		74	22	0.31
	710	-1.15				74		0.31
	718	0.1				74		0.31
	736	1.375				75	23	0.31
	745	2.65				76		0.31
	800	3.25		15		79	25	0.31
	820	5.75				82	26	0.31
	850	5.1				80		0.31
	900	0.35		18		79	27	0.31
	906	1				79		0.31
	915	1.3				81		0.31
	925	1.9				85	28	0.31
	935	1.5				84	28	0.31
	945	1.85				84	28	0.31
	950	2		21		84	28	0.61
	1005	3.075	-1630	21		84	28	0.31
	1015		-1340			84.5		0.61
	1035	4		21	0.43	84	28	0.31
	1042	3.7						0.31
	1050	3.3		21	0.43	82	28.5	0.61
	1105	4	-1540	21		80	29	0.31
	1115	3.3		21			29	0.61

DATE	TIME	TRANSP	LWP	VPD	STOM CON	SOLAR RAD	TEMP	IRR. TMT.
	Hrs	L/hr	KPa	Mb	Cm/s	Uncalib.	C	E Replac.
200286 ctd.	1125	3.6		21		77	29	0.31
	1135	3.4		21		77	29	0.31
	1150	3.6		21		79	29	0.31
	1200	3.3	-1360	21		82	29	0.61
	1203		-1680					0.31
	1210	3.7	-1850	21	0.34	81	29	0.31
	1220	3.4	-1620		0.59			0.61
	1230	3.85		21.5		81	29	0.31
	1300	3.1		22		78	30	0.61
	1306	3.55						0.31
	1318	3.875				80		0.61
	1335	4.75		22.5	0.39	83	30	0.31
	1345	4.9				79		0.61
	1355	4.8				80		0.31
	1400	4.45	-1810	23	0.7	81	32	0.61
	1415	4.8	-1820	23	0.56	90	32	0.31
	1420	4.75	-2030	23	0.56	90	32	0.61
	1436	4.6				84		0.31
	1445	5				89		0.61
	1455	5.15				88		0.31
	1505	4.5	-1900	27			34	0.31
	1520	4.625	-1760	26		79	34	0.61
	1525	3.925						0.31
	1535	2.95		26		76	33	0.31
	1542	3.6				79		0.61
	1550	3.05		24		77	32	0.61
	1555	3		24	0.34	77	32	0.31
	1610	3.05	-1580	24	0.34		32	0.61
	1615	3.5	-1740	24		71	32	0.31
	1620	1.6				71	32	0.31