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# DIURNAL CHANGES IN STEM DIAMETER AND PLANT WATER CONTENT IN PEACH TREES.

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## Abstract

Three to five year-old peach trees (*Prunus Persica* L. Batsch cv. 'Maycrest') grafted on *Prunus* 'Damas 1869' grown in a sand trench were removed in the spring and grown hydroponically from then on for several months. The growing system comprised 2 balances continuously recording the mass of the nutrient solution and that of the tree, in order to estimate separately both transpiration and water uptake rates. Diurnal variation in plant water content (transpiration minus water uptake) was observed, with rapidly decreasing values when the solar radiation increased, while the reverse occurred when radiation decreased. Changes in stem diameter were continuously recorded using Linear Variable Differential Transformers. Data collected over several days of well contrasted climatic conditions revealed that rapid changes in the stem diameter occurred throughout the day and were closely related to plant water content without any important lag.

## 1. Introduction

Li and Huguet (1990) stressed the advantages in scheduling irrigation by controlling plant water status rather than soil water content, or climate. Li *et al.* (1989) developed the micromorphometric technique, based on stem shrinkage, for use in irrigation systems and showed the benefits for management of peach tree orchards (Li and Huguet, 1990). The method involves determining threshold values which are non-limiting for plant growth.

Our aim was to define the relationship between trunk diameter and water storage in the tree using experiments performed on peach trees where the micromorphometric method was used concomitantly with measurements of whole plant water content. Moreover, we determined the amount of water stored in the shoots which may contribute to the transpiration stream. To our knowledge, this has never been measured for such plants.

## 2. Materials and methods

Experiments were conducted at the Montfavet INRA Center in southern France. Young peach trees (*Prunus persica* L. Batsch, cv. 'Maycrest') grafted on *Prunus* 'Damas 1869' were

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first cultivated in a sand trench and then in sand containers as described by Simonneau and Habib (1991). In february 1991, some of these trees were removed from containers and grown hydroponically in a greenhouse from then on for several months.

At the start of the experiment trees were transferred to a high precision load cell (10g accuracy) weighing a 35dm<sup>3</sup> pot of nutrient solution. Each tree was suspended over the pot with its roots bathing in the solution. The support holding the tree was put on a balance (5g accuracy). Changes in stem diameter were continuously recorded using Linear Variable Differential Transformers (LVDT). The sensor and its holder (5µm accuracy) have been described by Li *et al.* (1989). All of the sensors were connected to an automatic data acquisition system (Lecomte *et al.*, 1989).

The upper level of the solution was kept within a narrow range to cover main roots close to the collar. The volume changes of this root fraction were not significant, whatever water status they exhibited (Simonneau, 1992). Nevertheless, as the emerged fraction of the roots varied with the quantity of solution, mass changes recorded by the load cell were not exactly the same as the mass of solution withdrawn. After correcting for the differences due to changes in Archimedes forces, flow rate through the root collar (Ab) was calculated. In the following, it has been termed absorption for simplicity, but may differ from water uptake since non steady state conditions have been observed for roots. Transpiration rate (Tr) was more easily assessed by summing masses from the load cell and the balance. Transpiration minus absorption gave St, the flow rate of water stored in or lost from the aboveground plant reservoirs. Data were logged every 5min and water flows were calculated by smoothing the values over 30min intervals.

The main results presented here (Figs. 2 and 3) concerned a 5-year-old tree. The LVDT was placed 55cm above the root collar on the trunk (65cm tall) to monitor changes in diameter (initial value : 6.0cm). At the end of the experiment total fresh and oven dried weights were respectively 8730g and 4320g for shoots, and 2970g and 660g for roots.

### 3. Results

#### 3.1. Transpiration versus water uptake

The direct relationship between transpiration and water uptake rates (Fig. 1a) showed a slight lag. As classically found, when transpiration increased in the morning, it was slightly higher than uptake (points over the bisecting line in Fig. 1) and slightly lower when transpiration decreased in the afternoon (points under the bisecting line). During cloudy days (Fig. 1b), the previous scheme was respected with the following periods

alternating very quickly : Tr higher (respectively lower) than Ab while Tr increasing (resp. decreasing).

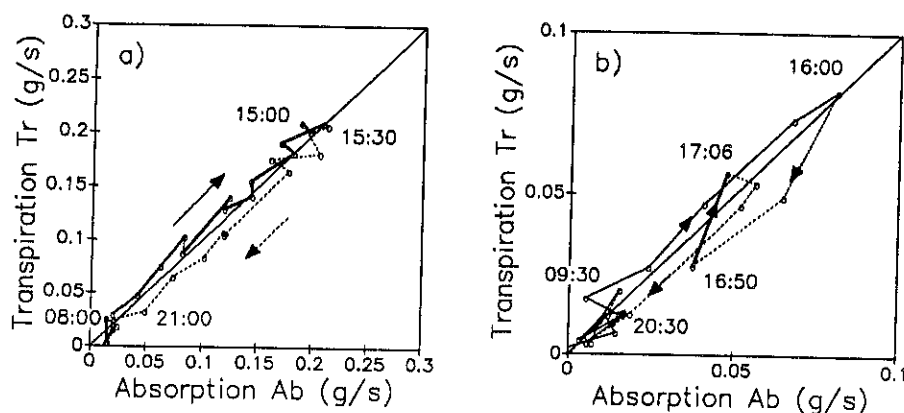


Figure 1 - Relationship between water uptake and transpiration rates by 3-year-old peach trees during (a) a bright sunny day (18 May 1989) and (b) a cloudy day (21 Apr 1989). The bisecting line corresponds to steady state (constant water content) in the emerged part (above the nutrient solution) of the peach trees.

### 3.2. Diurnal changes in the shoot mass balance

The fresh weight of the tree increased during the experiment with an average daily fresh matter gain of about 60g for the shoots (Fig. 2b). Regardless of this growth phenomena, water reserves in the shoots were rarely constant either becoming depleted by contributing to the transpiration stream (mainly in the morning) or restored by using a part of the water absorbed (mainly in the afternoon). However, values calculated for St were never high, typically ranging from  $-0.03\text{g}\cdot\text{s}^{-1}$  to  $0.03\text{g}\cdot\text{s}^{-1}$ , which are lower than transpiration or absorption rates.

### 3.3. Diurnal changes in trunk diameter

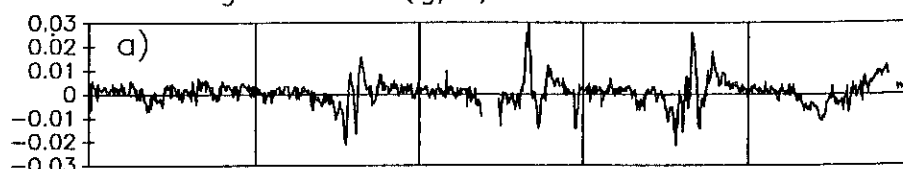
Trunk diameter showed a net increase over the 5-day period in Fig. 2c as reported previously without a limited water availability (Li and Huguet, 1990). An average daily increase in diameter of 0.014mm was due to trunk secondary growth. More rapid changes occurred within each day due to changes in water status. As for flow rates, trunk diameter varied almost simultaneously with solar radiation (data not presented).

### 3.4. Shoot mass balance in relation to diameter changes of the trunk

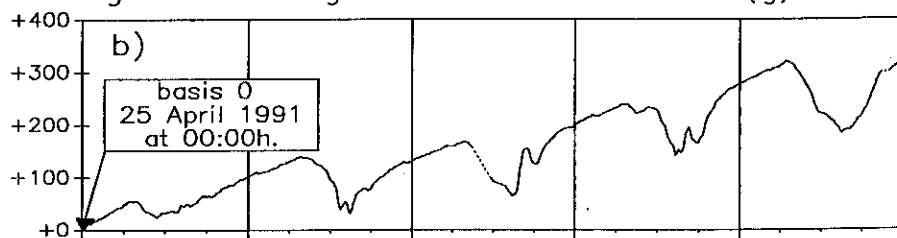
There were diurnal changes in both the trunk diameter and internal water balance of the shoots (Fig. 2b,c). However, integration of St to calculate mass evolution led to summation of errors on St. Therefore, direct comparison

of  $St$  versus rate of change in trunk diameter was preferred.

Water storage rate  $St$  (g/s)



Changes in aboveground mass of the tree (g)



Changes in trunk diameter (mm)

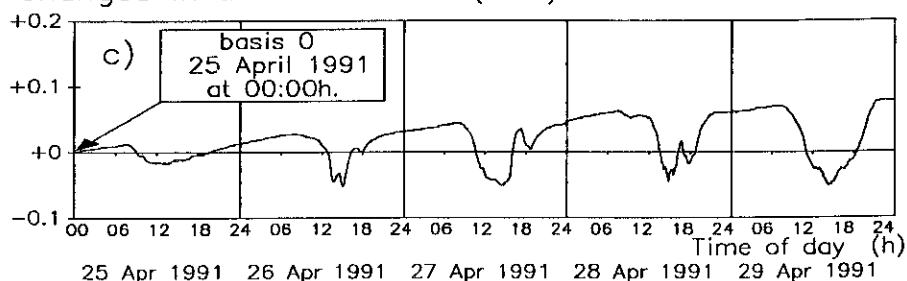


Figure 2 - (a) Flow rate of water stored in or lost from the emerged part of a 5-year-old peach tree; fluctuations of (b) the weight of the emerged part of the tree, and of (c) trunk diameter with time.

Globally, the relation was linear. For the 5-day period of Fig. 2, including the case of Fig. 3 (26 April 1991), Y-axis intercept of the regression line was not different from zero, and its slope was  $0.7 \mu\text{m} \cdot \text{g}^{-1}$  ( $n = 983$ ;  $r = 0.84$ ). This confirmed the similar relationship previously reported by Klepper *et al.* (1971) and Jordan and Ritchie (1971) on cotton.

#### 4. Discussion

The relationship between trunk diameter and plant water status may not be caused solely by dehydration effect. The occurrence of growth processes are superimposed on the hydration-dehydration effects on trunk diameter. Data may

be corrected to eliminate expansion effect (Huck and Klepper, 1977; So *et al.*, 1979). However, it is not known whether diurnal expansion and hydration-dehydration phenomena occur concomitantly as both processes may vary with turgor pressure (Turner, 1986). In addition, certain mechanisms of adaptation to water deficits, such as osmotic adjustment or increase in tissue elasticity (Turner, 1986) may alter stem diameter. Therefore, trunk diameter changes cannot be of general use to continuously monitor the amount of water stored in the tree.

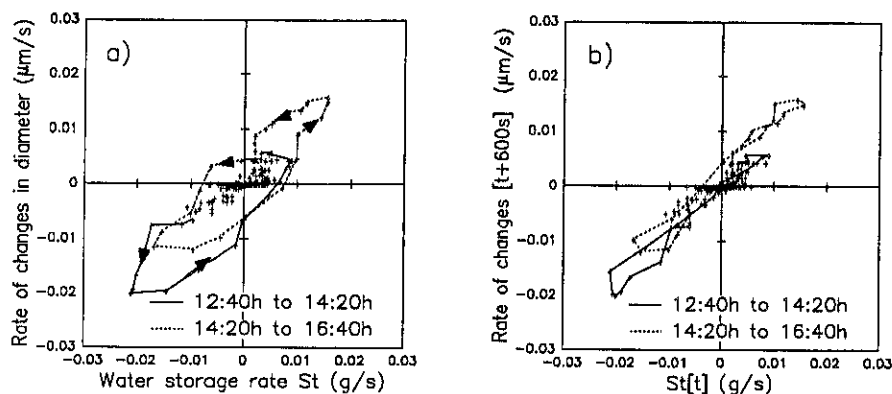


Figure 3 - (a) flow rates of water stored in or lost from the emerged part of the peach tree, versus rate of changes in trunk diameter (26 Apr. data set of Fig. 2); (b) same data but with a 10 minutes advance for diameter changes rate. This corrected the lag behind storage rate data.

Lags up to 2 hours (Parlange *et al.*, 1975; Klepper *et al.*, 1971) between changes in diameter and in leaf water potential, or lags in diameter changes down tree stems have been reported (Wronski *et al.*, 1985). This may affect the diameter-water status relation due to radial resistance to water diffusion between conducting and reservoir tissues. This resistance could be maximized on the basis of the time lag (about 10 minutes) stressed in Fig. 3. Very low values were suggested, and rapid equilibrium was more easily achieved as diurnal decreases in shoot mass never exceeded 150g, which was far lower than the 4410g of water stored in the emerged parts of the tree.

Irrigation can be decided when the daily increase in trunk diameter falls below a threshold value (0 mm.day<sup>-1</sup> is often pertinent) and when water availability is identified as the limiting factor. This is revealed by high daily shrinkages of the trunk. Moreover, water can be supplied several times a day; we demonstrated that maintaining the trunk diameter above a critical level was equivalent to maintain a sufficient amount of water in the shoots. Responses of fruit tree orchards to such irrigation

management are discussed elsewhere (e.g. Huguet et al., 1992).

To summarize, since Klepper et al. (1971) and Jordan and Ritchie (1971) obtained a poor correlation between water content and stem diameter of cotton plants, no clear relation has been drawn up. Results obtained here on 3 to 5 year-old peach trees clearly demonstrated that stem diameter changed in close relation to the total water stored in the shoots without any important lag.

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