Dendrometers: Multi-Purpose Sensors

Dendrometers are a multi-purpose sensor for measuring plant growth and water use. They are a precision sensor to measure small variations in plant tissues which is then directly related to how a plant grows and its water use.

As dendrometers are a non-destructive, easy to install and maintain sensor, they are favoured by growers as a plant monitoring tool.

Data from a dendrometer

Dendrometers measure changes in stem or fruit diameter. Over a 24-hour period, values cycle between a maximum and a minimum that is correlated with daily transpiration (Figure 1A).

Over periods of weeks and months, values from a dendrometer should increase as the stem or fruit grows to maturity (Figure 1B). Dendrometers, therefore, provide a direct, and continuous, measurement of plant growth over the growing season.

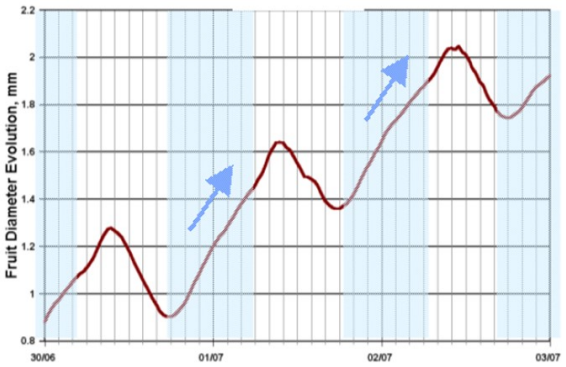

Figure 1A. Three days of dendrometer data.

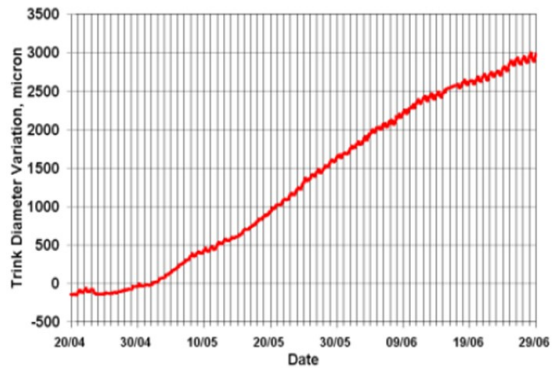

Figure 1B. Three months of dendrometer data.

DG and MDS

Two useful ways to view dendrometer data are Daily Growth (DG) and Maximum Daily Shrinkage (MDS) (Figure 2).

DG is how much a stem or fruit has expanded between days—i.e. a measure of growth. Healthy, well irrigated plants, show high DG values. An unhealthy plant shows low, or negative values.

MDS is how much a stem or fruit contracts over a 24-hour cycle. A well irrigated, or hydrated plant, will have a lower MDS value than a stressed plant.

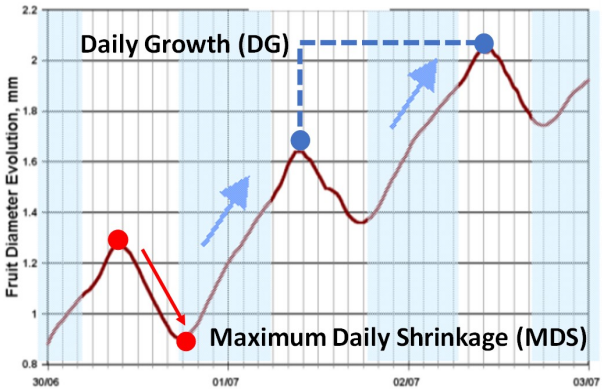

Figure 2. DG and MDS explained.

Dendrometers & Fruit Physiology

The Phyto-Sensor Group's range of dendrometers are suitable for installing directly onto fruits. The dendrometers do not damage or harm the fruit during measurement.

Dendrometers can directly measure the growth of fruits, as well as how solutes move into, and out of, fruits during the growing season.

Management strategies can be employed to increase the growth rate and size of fruits based on dendrometer monitoring.

Data from a dendrometer

A well irrigated and managed crop will show a consistent, and high, rate of fruit growth, when measured over several days to weeks (Figure 3).

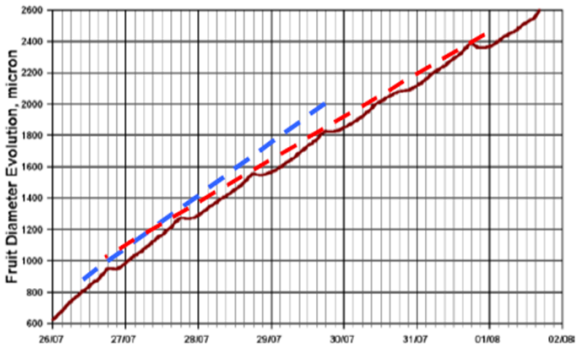

Figure 3. Healthy fruit growth over one week.

A stressed fruit will show negative growth over several days of monitoring (Figure 4). In this scenario, other plant tissues, particularly leaves, have a stronger demand for water and are extracting solutes from the fruit. This scenario will negatively impact fruit yield, size and, possibly, quality.

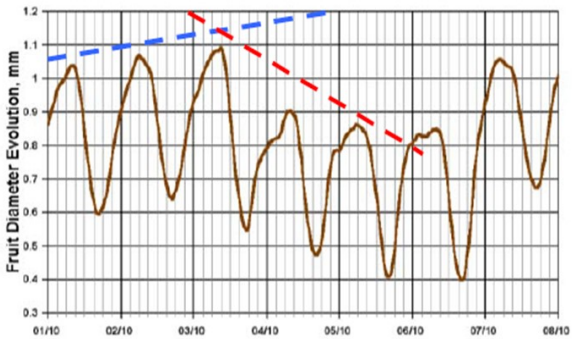

Figure 4. A fruit experiencing stress.

BRIX / Sugar Accumulation

Dendrometer measurements have been shown to have a direct correlation with BRIX accumulation in grape fruits (Figure 5).

During the post-veraison period, the MDS values from a dendrometer were shown to have a direct correlation with BRIX accumulation in Chardonnay.

The correlation is negative, indicating that when the vine daily expansion is small (or negative), then BRIX accumulation is high.

Growers can use the information from the dendrometers to monitor BRIX indirectly without taking destructive, lab measurements.

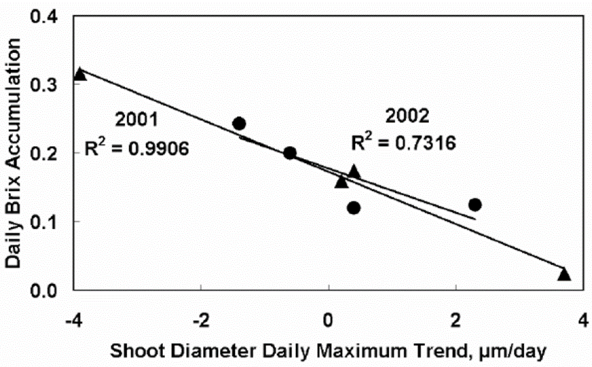

Figure 5. The correlation between BRIX accumulation and dendrometer measurements. Image source: Ton & Kopyt (2003), Acta Hort, 652.

Dendrometers & Irrigation

Dendrometers have been widely used for irrigation scheduling, monitoring and management. The dendrometer provides greater information than the traditional soil moisture sensor, such as a capacitance sensor or tensiometer, as it is a direct measure of the plant's current water status.

Save on water and energy costs

Dendrometers can be used to determine whether the amount of irrigation is sufficient for plants. A grower can assess whether decreasing irrigation by 10%, 20% or more will have no or a negative impact on plant growth and yield.

For example, a grower was irrigating every day. However, when the valves were closed, the plants did not respond to the decrease (Table 1).

Therefore, this grower can potentially irrigate less than every day, saving on costs such as water and electricity, without having a negative impact on the growth and water use of the crop.

Table 1. The results of an analysis of growth, water use and water use efficiency before and after irrigation was stopped.

	With Irrigation	Without Irrigation
Daily Growth (mm)	0.12	0.11
Daily Water Use (Litres)	10.87	10.16
Water Use Efficiency (µm/L)	10.99	10.98

The best time of day to irrigate

A dendrometer can determine which time of the day is best for irrigation. Therefore, growers can adjust their timing to night, day, evening, etc, to maximise crop growth.

For example, a vine grower in Israel was irrigating his crop at midnight (Figure 6). Under this irrigation schedule, the vine was showing positive growth. The grower then switched to a midday irrigation schedule. The vine showed a negative growth rate during this midday schedule. Therefore, the grower switched back to the midnight schedule and the growth rate of the vine returned to normal.

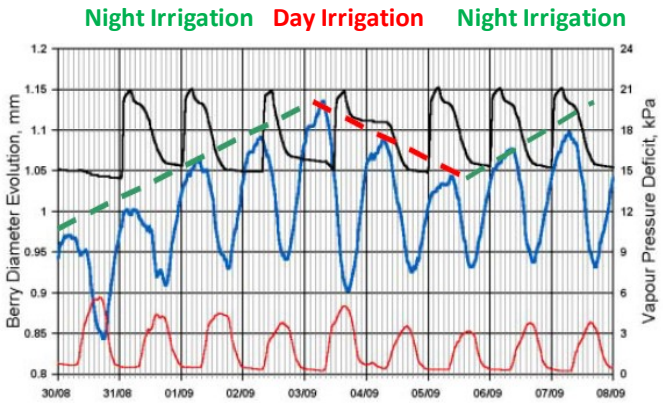

Figure 6. Soil moisture (black line), dendrometer (blue line) and VPD (red line) data. The dashed green line is period of midnight irrigation (positive growth) and dashed red line is midday irrigation. (negative growth).

Dendrometers & Plant Water Potential

Plant water potential is extremely important for growers as it is a measurement of water status. Yet, measuring plant, or leaf, water potential is very expensive, difficult and time consuming.

A large amount of research has demonstrated that dendrometers can be calibrated to measure plant water potential.

As dendrometers are low cost, and easy to install and maintain, they provide an excellent alternative to existing methods to measure water potential.

How does it work?

The Maximum Daily Shrinkage (MDS) has been demonstrated, on a large number of crops, to have a direct correlation with leaf water potential.

When soil moisture availability declines, stem contraction (shrinkage) increases as water storage in stem tissues decrease and effort to absorbed water from the soil increases.

A dendrometer needs to be calibrated against leaf water potential for a crop. But, once calibrated, a dendrometer can continuously measure plant water potential over many weeks and months.

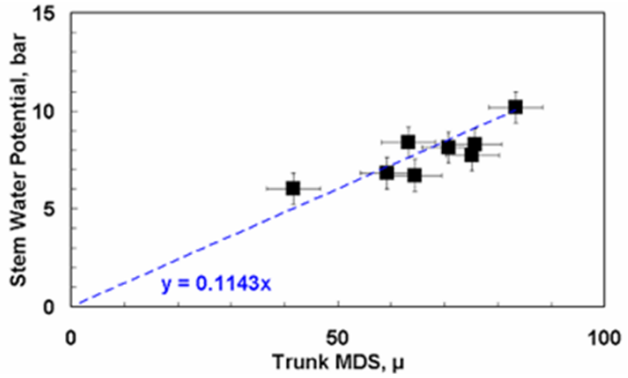

Figure 7. An example of the strong correlation between plant water potential and MDS.

Example water potential data

A dendrometer was calibrated against leaf water potential, as measured with a pressure chamber, for a grapevine species (Figure 7).

By using a simple linear equation, which can be found using Excel, it is possible to convert values from a dendrometer into plant water potential.

Figure 8 shows plant water potential data over a three week period. Subsequent checking of these data, with a pressure chamber, found a high degree of accuracy. Therefore, it is possible to use a dendrometer as a plant water potential monitor.

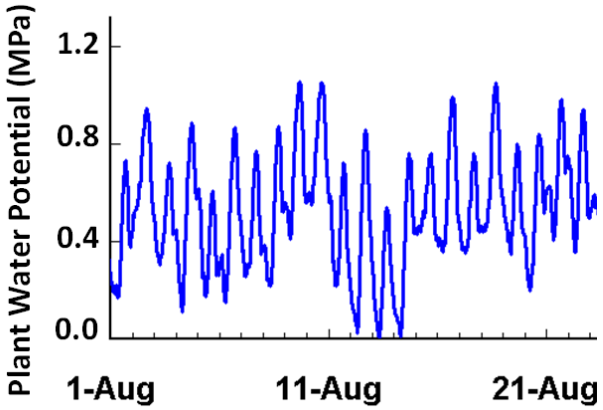

Figure 8. An example of 3 weeks of plant water potential data that was measured via a calibrated dendrometer.