

The Scientific Background of Leaf-Sen innovating irrigation System

The introduction of drip irrigation systems ushered in a new era in irrigation due mainly to its contribution to our understanding of root and whole plant physiology interactions. Unfortunately, the full potential of this revolutionary technology has not yet been realized and most drip irrigation systems are not utilized to their full potential. Despite the novel solutions made possible by drip irrigation, for the most part, the irrigation community has related to the dripper as a miniature sprinkler, and implemented dripper irrigation according to traditional strategies. The conventional wisdom relates to the soil as a reservoir from which the rooted plant makes withdrawals. The primary task of the irrigator is to estimate the accumulated water deficit, and to replenish the soil when this deficit reaches a maximum safe level calculated according to plant and soil parameters. This approach was well adapted to the state of irrigation technology in the period when it was expounded. It was claimed that a regime of periodic wetting mimicked nature and that evolutionary development had ensured optimum plant function. However, evolution has supplied plants with survival mechanisms that can efficiently be used by intelligent farmers for improving production, quality and water use efficiency of various ornamentals and agricultural commodities. The major conceptual approaches that lead to the agricultural revolution associated with micro irrigation are:

1. Application of frequent partial root and soil irrigation and fertigation in order to develop an efficient rootlet system for water and mineral uptake. The tremendous capability for water and mineral transfer between roots and other plant organs will then develop root and canopy systems as dictated by the genetic traits of each plant species.
2. Control of water potential and mineral concentration and composition at the immediate vicinity of the roots, enables applying a hydroponics approach to field grown plants.

Unlike the commonly accepted view, partial root wetting has a minor effect on the basic structure of the roots system. Genetic traits are producing roots of different structure and size adopted for functions such as water and mineral absorption, for holding the plant in place under varying environmental conditions, storing food and prevent soil erosion. All these traits are consequences of an evolution process. An intensive rootlet system that develops in the onion shaped wetted soil volume under the drippers creates a tremendous root surface area for water and mineral absorption with numerous active root tips that produce plant hormones involved in the reproductive and vegetative functions of the whole plant. Drip irrigation systems are based on frequent irrigations aimed at replenishing the water that is depleted by the plants. The rate of depletion is dependent on two major factors; the evaporative demand of the atmosphere and canopy dimension and characteristics. In order to keep high water and mineral availability in the immediate vicinity of the roots it is essential to adjust the frequency of the irrigation to the rate of the water uptake by the plant and thereby maintain leaf turgidity that is essential for stomatal functioning, photosynthetic rate, and growth via cell elongation and multiplication. Due to the many factors involved in the process of plant water consumption, automation seems essential for optimizing the irrigation system. Since the plants are the target object in the Soil-Plant Atmosphere Continuum (SPAC), Leaf-Sen chose to concentrate on

monitoring plant water status and controlling it by precise irrigation. Among all plant organs we chose to monitor the leaf turgor for online irrigation operation. Obviously the leaf is the organ through which the plant is exchanging water and carbon dioxide to the atmosphere via the stomata and is the first one to sense water deficit. To the best of our knowledge, commercial online irrigation systems solely based on plant water status monitoring was never reported so far. The commercial online soil water monitoring systems suffer from a serious deficiency since they monitor the average soil water potential rather than at the immediate vicinity of the roots. Studies have shown that under high evaporative demand conditions, leaves may lose turgor and undergo incipient wilting even when soil water sensors show high water potentials corresponding to field capacity. Gradients of soil water potentials of up to -3.0Mpa between the root surface and the surrounding soil were reported in the literature. Leaf-Sen has developed a method that requires immediate and accurate sensing of changes in plant water status. We have demonstrated that leaf thickness varies almost immediately, linearly and with a high degree of correlation with leaf turgor and, further that the reactions of other plant organs, not only lag behind the reaction in the leaf proportionate to their distance from the leaf, but do not consistently or accurately reflect plant water status. For example, changes in the diameter of a trunk of a mature tree will occur from one to two hours after the response of leaf thickness. Furthermore, trunk shrinkage cannot serve for online irrigation due to redistribution of water among the various plant tissues involved during weather variations along the day. Soil moisture device may not register any change in response to meaningful short term variations in plant water status. Our research has proven that reduced water application delivered during maximum evaporative demand with frequent short pulses is preferable to a 30 % higher total volume delivered at infrequent intervals. The Leaf-Sen system maintains high water (and mineral) availability by applying precise amounts of water at the right timing. The timing is determined by the magnitude of shrinkage whereas the amount of water of each pulse is a product of the rate of leaf shrinkage (slope) and the official daily recommended water amounts as determined by evaporative demands and the crop factor.

Some Results of Irrigating with Leaf-Sen:

<i>Crop</i>	<i>Water Savings</i>	<i>Addition to Yield</i>
<i>“Sweetie” Grapefruit</i>	40%	15%
<i>Shamouti Oranges</i>	40%	12%
<i>Avocado</i>	20%	5%
<i>Corn</i>	24%	5%
<i>Cotton</i>	20%	5%
<i>Tomatoes</i>	35%	21%
<i>Peppers</i>	60%	5%
<i>Grapes</i>	33%	6%