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My Professional Testament: Dr. Yoseph Shoub " Gerbera Breeding" Ganey Am, December 2024

Since 2005, for 19 years, irrigation on our farm in Ganey Am has been managed using an Israeli irrigation control system called "AutoAgronom". Starting in 2024, the Fertigation on our farm has been operated by a new advanced Israeli system, named "Roots Talk", developed based on the "AutoAgronom", the prototype of the previous system. The first new" Roots TalK" system, was tested in our greenhouse in Ganey Am, on wide range of plants.

The "Roots Talk" system, like the "AutoAgronom system", based on real-time monitoring of physical and chemical changes in the Soil Solution. The system consists of a smart controller with dedicated software and sensors placed in the root environment.

Water and Soil Solution Dynamics in the Root Zone Under Precise Drip Fertigation

Plants in nature operate for their survival and benefit, adapting to the environmental conditions of their habitats. Agricultural plants, in addition, are influenced by the management decisions of farmers and agricultural research recommendations. Every practice employed in the irrigation of intensive crops has an immediate impact on the root growth conditions and a lasting-positive or negative-effect on the activities of all plant tissues.
Environmental changes in the atmosphere, such as cloud cover, radiation, temperature, humidity, and others, even if brief, are reflected in plant responses. Similarly, changes occurring in the root zone as a result of farmers' actions in their fields, such as **Water Tension***, **Saturation Points**, **excess Fertilizers**, **Salinity**, and more, manifest in either positive or negative ways. (See Page 5: "Stages of Agricultural Salinity Development.")

The roots are the first to respond to environmental changes. Their initial response is to decrease or increase the uptake of the "**soil solution**"**. **For example**, the development of light cloud cover, which reduces light radiation, slows the photosynthetic activity of plants and reduces the need for soil solution absorption. With increased radiation levels and the fulfillment of other growth conditions necessary for photosynthesis, the uptake of soil solution intensifies.
Agricultural plants similarly respond to environmental changes caused by farmers themselves, such as irrigation that does not match the water absorption capacity of the roots or the timing of actual water consumption during plant activities. These agricultural missteps reduce or even halt photosynthesis processes and the transport of assimilates to growth areas.
The computerized sensors of the Roots Talk system work continuously (24/7) to create and maintain optimal conditions for water absorption from the root zone, both in open fields and greenhouses. The system's sensors quickly respond to real-time changes in "water tension," resuming or stopping the

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fertigation*** in real-time, adjusting the fertigation dose to the amount consumed (approximately 20–25 cm^3) by a "leading plant" in the monitoring system, measured in the water-absorbing root zone, by a highly sensitive Tensiometer with millibar values.
This prevents water excess or deficiency in the root zone, avoiding salinity conditions and their damages, ensuring uninterrupted root activity and growth, and significantly shortening the cultivation period****.

One important advantage of the computerized control is that during each Fertigation-cycle, the wetting volume is consistent. In this optimal volume, root hairs and absorptive rootlets develop and function efficiently, easily absorbing the available soil solution.

Let us note <u>the unique method of the plants to absorb and use the oxygen</u>:
1. The porosity structure of the soil holds the atmospheric air. 2. The free oxygen molecules in the air dissolves into the soil-solution. 3. The soil solution absorbed by the root's organelles is transported to above-ground plant organs through the plant's water systems, supplying the oxygen and all other minerals.
This method is entirely different from the direct absorption of free oxygen molecules from the air by other biological entities (except for fish).

And these are the Physiological Facts in Plants:
1. During Photosynthesis Procedures, a unique process in the plant cells, releases oxygen by splitting water molecules. The free oxygen released into the atmosphere through the leaves' stomata, enriching the vital existing air, **including the soil air**.
2. A small portion of the oxygen in the capillary spaces of the soil dissolves in the soil solution, it's about (8 – 10 ppm. in water at 20°C).
3. The low solubility of oxygen in water corresponds to the level suitable for biochemical activities in plants.
4. Roots absorb the "soil solution" (soil water containing dissolved minerals, fertilizers, and oxygen).

Since this is the unique way of the plants to absorb the soil solution, and transport it to aboveground organs, the plant growth and its' activities depend on the continuous presence of air in the water-absorbing roots' zone. This fact necessitates soil aeration by the farmers.

And these are the Essential Reasons for Absorbing the "Soil Solution" that Nourishes Plant Tissues:
>Absorption of the soil solution to nourish plants with oxygen and minerals: This process occurs continuously throughout the day and night.
>Absorption of water for photosynthesis: Takes place during daylight hours.
>Daily synthesized photosynthesis products move from the leaves to growth zones and development sites: This movement occurs both day and night.
>Water absorption by leaf tissues: Occurs day and night to dilute the concentration of synthesized products that accumulate in leaf cells during the day.

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>Movement in the vascular system is bidirectional: Upward to the canopy and downward to the root systems.
>**Water evaporation from leaves during the day: This is a constant and essential process for cooling plant tissues exposed to sunlight**. It is also a physical mechanism that facilitates the upward movement of the nutrient-rich soil solution through the vascular system with minimal energy expenditure in both tall and short plants.

In Extreme Climate Conditions in all seasons, when leaf evaporation (" *Of healthy plants*"**!**) exceeds the roots' ability to supply water for the evaporation, it activates a mechanism that stop the evaporation by closing the stomata in the leaves. This halts water movement and prevents the dissolved oxygen presented in the water, and prevents the entry of the atmospheric CO_2, the vital components for the photosynthesis. In contrast, under the controlled conditions of the Roots Talk system, evaporation continues even during extreme temperatures and air dryness. Thus, water movement, oxygen supply, and CO_2 uptake proceed uninterrupted, ensuring continuous photosynthesis processes.

Monitoring Water Tension and Movement in Natural Soils and in Drip Irrigated Substrates:
In natural soils (at depths of -5 cm to -40 cm): The rate at which roots absorb the "soil solution" exceeds the rate of water movement within the soil. Therefore, the "**water tension**" measured at these depths using Tensiometers (in centibar values; 1 centibar = 1/100th of atmospheric pressure) does not accurately reflect the rapid changes in water tension caused by plant activity in real-time.
In artificial substrates used in modern agriculture: Water movement is significantly faster, both vertically and in drainage, compared to natural soils. Water evaporation from the upper layer of these substrates is also more rapid, leading to quick changes in water tension and increasing the risk of salinity development in the upper substrate layers. This requires real-time monitoring to ensure optimal water tension levels.
With the **Roots Talk system**, water tension values are measured in decimillibars (0.1/1000th of atmospheric pressure). **The system's immediate and proportional real-time response** to rapid changes in water tension stabilizes optimal conditions for soil solution absorption, synchronizing with plants' water consumption in intensive agricultural practices.

<u>Optimal Conditions for Absorbing the Soil Solution:</u>
The primary absorbers of the soil solution are the fine **Root Hairs**, which must remain in constant contact with the soil solution to function. These delicate and sensitive structures are unprotected and vulnerable to dryness, water excess, oxygen deficiency, high concentrations of fertilizers that lead to salinity, and other substrate disturbances.
To support plant growth and development, farmers must ensure that sensitive root activity occurs in the upper soil layers. This includes **maintaining a consistent presence of air around the roots and ensuring that the soil solution contains minerals and dissolved oxygen at optimal levels.**

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The desired conditions for the soil solution are the same as the optimal conditions for root hair activity and are controlled by the system:
>Fertilizer solution with low to medium concentrations (including trace elements): 200–400 grams per 1,000 liters of water.
>Water tension near saturation point: Always slightly above the saturation point, specific to each soil or root substrate.
>Optimal pH values of the nutrient solution: Between 5.5 and 6.5 for most plants, with lower values monitored for specific crops.

Advantages of Micro-Drip Irrigation:
Increased oxygen dissolution in the soil solution: Achieved through low-flow drip emitters that release water in separate drops (~6,000 drops per liter) at intervals of 1.5 to 2 seconds.
1. The total surface area of the separated drops exposed to soil air is large, increasing oxygen dissolution in the soil solution.
2. Low water flow creates capillary water movement: Horizontally and vertically, wetting broad soil volumes without wasting the fertilizer solution at unnecessary depths.
- **For example, regulated low-flow emitters**: 250–500 cc/hour (manufactured in Israel).
In contrast, when nutrient solutions are delivered using high-flow-rate drippers, without separation between the droplets, the level of dissolved oxygen is lower compared to the oxygen dissolution achieved with the "micro-drip" method.
3. High water flow rates create gravitational (vertical) water movement that pushes the nutrient solution deeper than the active root zone and beyond the saturation point. This method is therefore wasteful, unnecessary, and harmful to plant roots. Additionally, it leads to contamination of aquifers in areas of intensive agriculture, primarily due to the leaching of fertilizer surpluses with large volumes of water, as officially recommended in irrigation guidelines for growers in Israel.

Dr. Yoseph Shoub
Ganey Am
December 1, 2024

Notes:
* "**Water tension**": Measured using tensiometers, indicating moisture changes in root substrates. The Roots Talk tensiometer stabilizes water tension in real-time with short irrigation cycles (3–4 minutes delivering ~20–25 cc) without reaching saturation.
** "**Soil solution**": Water available in the root zone, including oxygen and minerals.
*** "**Fertigation**": Drip irrigation with water containing fertilizers and oxygen.
**** See verified details in the list of relevant presentations on our website:
https://www.gerberaisrael.com/

See presentations on the website: https://www.roots-talk.com/

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Developmental Stages of Salinity Damage and Low Humidity in Intensive Crops

Under Salinity Conditions

Accumulation of Salts in the Growing Media

↓

The root tips become scorched, and their growth is halted.

↓

Disruption in water uptake from the growing media

↓

Under conditions of salinity and low humidity

The rate of water evaporation from the leaves exceeds the rate of water uptake by the roots.

↓

The plant regulates water evaporation by closing its stomata.

↓

When the stomata close, the following processes occur in the plant:

A decrease in humidity in the leaf area	Prevention of CO_2 absorption
↓	↓
Leaf warming	Stop sugar production
↓	↓
Increase in salt concentration in the leaves	The level of salts increases in relation to sugars.

→ ←

Final result

There is no energy supply for growth, and growth stops.

Accompanying result

Accumulation of growth-inhibiting substances in the leaves

The economic damage to the grower

The cessation of sprout awakening,

No new branches will develop,

There will be no flowers.