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FACT SHEET

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MANAGING CROPS IN SOILLESS SUBSTRATE

Introduction:

Soilless substrates are used across the world, offering a solution to those with difficult soil conditions, or those who are looking to increase production efficiencies. These substrates are comprised of non-soil components, but still provide structural support for plant growth. For more information on alternative growing media, check out Perennia's fact sheet titled '**Soilless Substrates**'

Managing Soilless Substrate

The shift from soil to substrate production is more involved than simply swapping out soil for a soilless medium. It is crucial to adopt the following management recommendations to maximize performance and yield in a substrate-based production system. Proper attention to the growing medium will allow for optimal plant growth and a more seamless transition into the new production method.

1. Irrigation management is crucial for a substrate-based production system.

Traditional production in soil allows for a much wider root range, and a much larger volume of growing media to hold water and nutrients compared to a pot. A crop that would require one daily watering in soil is going to require multiple waterings per day in a containerized setup to meet the water demand of the plant. The water demand for a containerized crop is also going to change throughout the day as a result of fluctuating temperatures and solar radiation levels. The plant water use requirements at 2pm are going to be vastly different compared to what it needs at 10 am or 10 pm, so irrigation events will have to cater to growing conditions throughout the day to maximize plant productivity and health.

Figure 1. A photo of a containerized long cane raspberry crop grown in soilless substrate. Notice how each crop has a limited volume of grow media to hold moisture and nutrients. This is sufficient for production, as long as the producer can keep up with the water and fertilizer requirements of the plant. Photo credit: Amber Dort.

One of the most effective ways to monitor an irrigation system is to track the volume of irrigation water going into the pot, and the volume of water coming out the bottom of the pot. Comparing these values over the same 24-hour period will be indicative of the water status of the plant, and the growing media.

Leachate, or drain, are used interchangeably to refer to the fertigation solution that leaches out of the bottom of the pot following an irrigation event. This excess nutrient solution is a necessary evil for maintaining a healthy root zone, however there are limits as to how much leachate is actually beneficial to the crop. Past a certain percentage, the drainage becomes excessive and does not provide any additional benefit to the plant. 'In protected spaces, excess leachate is linked to an increased risk of root disease, and contributes to overall humidity levels as well. Excess humidity results in increased severity of disease and pest infestations in the production space. By maintaining a tight balance on the amount of water leaving the system, fertilizer and water loss can be minimized while still allowing for the maintenance of healthy and productive roots.

2. Inherent nutritional value of substrate compared to soil.

Soil has some inherent nutritional content which the plants can draw from throughout the season, whereas substrate has very little to offer in terms of baseline nutrition. Fertilizer should be provided to substrate-grown crops with every irrigation event throughout the day to make sure that the plants are getting everything that they need. Inadequate nutrition results in poor plant growth and crops that are not meeting their full yield potential.

This nutritional baseline differs depending on what the base growing material is, meaning that the fertilizer recipes are not 'one size fits all'. Submitting substrate samples for nutritional analysis before planting will show which nutrients are present and to what degree. Regular nutrient analysis of substrate throughout the growing season is recommended to ensure that nutrients are present in their appropriate proportions and not accumulating over time.

3. Adjustment of the target values relating to substrate.

Maintaining the growing media in a production system is reliant on measuring and maintaining key parameters within a range of target values. As the base material of the substrate changes, so do its physical and chemical properties of the growing media. This translates to inconsistencies in those target values when across different base materials.

Substrate pH is an excellent example of this (see Figure 2). Where the target pH in soil production sits around 6.5, certain soilless substrate requires a more acidic pH of 5.5. Nutrient availability is highly reliant on the base material of the substrate, so it makes sense to see differences in what that target number is for pH.

It is also important to remember that all substrates are not created equal. While a pH of 5.8 might satisfy the maximum nutrient availability in one growing media, it does not mean that it will be the target value when growing in another.

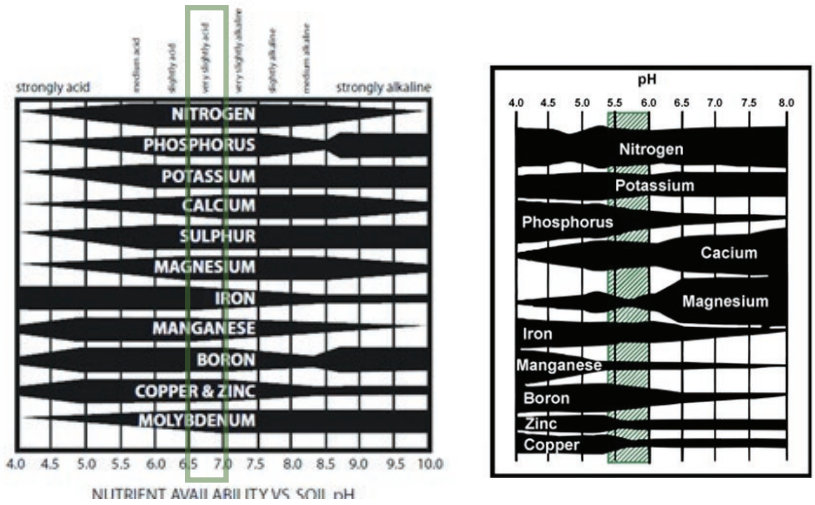

Figure 2. A side-by-side schematic showing nutrient availability according to the pH of the growing media. The left diagram shows the nutrient availability in a soil-based system (ideal range is 6.5-7.0), and the right one depicts a substrate-based system (ideal range is 5.4-6.0). Each nutrient has a range of availability and capturing the best-case availability for each nutrient is the goal in assigning a target pH. Notice how these nutrients availabilities change depending on the growing media in question. Photo credit: South Dakota State University (left) and the University of Georgia Extension (right).

Another target range that shifts w substrate production is the optimum moisture tension (kPa). Moisture tension is a measurement reflecting the availability of water in the matrix, and the amount of effort required to pull water from the pores. Smaller pores are created by small particles, will hold onto water more tightly compared to larger pores created by larger particles. Plants grown in soil have a much larger volume of root material, which allows for a higher capacity to extract water from pores in the ground. By growing a plant in a containerized, substrate-based system, you are miniaturizing this root system. This reduction in root volume results in a lessened ability to pull water from high-tension pore spaces. Containerized crops must be treated more gently in that regard, as they will not bounce back from a dry period as well as a crop that is grown in soil.

- **The ideal moisture tension for tomatoes grown in a peat-based substrate is 1 to -5kPa.**
    - Within this range, water is easily accessible by the roots, and transpiration and yield are maximized. Running a moisture tension higher than this will result in lower transpiration rates and smaller fruits, both of which are major symptoms of moisture stress.
- **A moisture tension reading of 0 to -1 kPa indicates that the substrate is overly saturated.**
    - This is a result of too much water being added to the substrate, or not allowing the pot enough time to drain before the next irrigation event. Too much water leads to a reduction in air spaces in the soil and can result in root dieback.
- **A moisture tension that reads >-10 kPa is associated with a substrate that is much too dry.**
    - The substrate is lacking in water content and is not able to sustain plant growth or high yields. While the plant might not wilt right away, water should be added to the substrate immediately. The substrate should be closely managed until it approaches the ideal moisture tension range to sustain a healthy, growing crop.

Monitoring Water Content in Substrate

Water content can be assessed in a handful of ways. It is important to be aware of what the reading from the monitoring equipment means – moisture tension and moisture content are two different things. A substrate can have a high moisture content, but that does not necessarily mean that the water is readily available to the root system.

1. **Basic squeeze test:**

This is not the most accurate method for testing moisture tension in the substrate, but it can give some indication on where the moisture tension of the media sits on the tension scale. This will help create familiarity with the substrate and develop a feel for the ideal substrate moisture level.

- Take a representative handful of substrate from the growing container and give it a squeeze.
    - If the substrate is dripping wet without any pressure, or after the application of a very low amount of pressure, the substrate is much too wet. This translates to a low moisture tension reading
    - If after applying medium amount of pressure to the substrate sample and you start to see water dripping out of the substrate, the moisture tension is around the target level
    - A high degree of pressure applied to the substrate that results in little – to- no solution dripping out of the media indicates that the substrate is too dry. This translates to a high moisture tension reading

2. **Tensiometers**

- Moisture sensors that measure the tension between soil particles and water molecules
- Relatively simple and inexpensive
- Require some maintenance through the growing

Figure 3. An example of a tensiometer used to measure the tension that exists amongst water-filled pores in the substrate. Photo taken from soilmoisture.com (**https://www.soilmoisture.com/JET-FILL-TENSIOMETER-60-1-2-BAR-GAUGE/**)

season

3. **Capacitance probes**

- Measures soil moisture along the length of the probe
- Accuracy is debated, mostly due to lack of substrate calibrations
    - Would have to establish this before installing in the crop
- Typically used as a stationary monitoring tool – cannot be easily moved through the crop on a regular basis
- Expensive to purchase, site of installation should be chosen wisely

4. **Time Domain Reflectometry (TDR) probes**

- Measures water content and electrical conductivity in the substrate of container crops
- Manually inserted into substrate, and will give an average reading across the length of the rods
- Can be used in a permanent monitoring location or as a roving device
- There are some existing calibrations for substrate

Figure 4. An example of a WET sensor. Having a mobile sensor can be helpful throughout the facility to account for microclimates that exist within the space. These devices can also help classifying moisture across a single pot/bag to see how that profile changes within a fairly restricted volume. Photo from Delta-T Devices (**https://delta-t.co.uk/product/wet-2-horticulture/**)

- Most expensive soil moisture sensor to purchase

5. **Weigh Stations**

- Specialized troughs that are able to measure the weight of the growing container/slab as an indication of water content
- Real time data is used to determine the next irrigation event

Figure 5. An example of a weigh station used for monitoring irrigation. When the slab is fully saturated with water, the higher weights will prompt the system to hold off on delivering additional water. As the slab dries out and the weight decreases, the scale will send information to the irrigation computer to deliver more water once a target weight has been hit. Photo from Agrofim (**https://www.agrofim.pl/en/19-oferta/szklarnie/158-root-optimizer**)

Concluding Remarks

While the switch from a soil-based system to a soilless substrate system might be daunting, it can open doors to maximizing year-round production. Making small adjustments to the daily crop routine are crucial for ensuring success of the containerized substrate system. Monitoring water tension, ensuring the crop is receiving adequate nutrition, and adjusting the target management values to be most suitable for the substrate are very important pieces to the substrate cropping system. Failing to do so will directly impact plant yield and overall crop health and productivity.

For more information on managing a substrate-based crop, check out Perennia's follow-up fact sheet which focuses on irrigation management for substrate-based production systems. There are a handful of resources on substrate that are worth exploring, including Perennia's 'Getting Into the Weeds' Webinars which are currently available on our Youtube channel:

- 2020-2021 'Getting Into the Weeds' session '**Making the Switch to Soilless Substrate**'
- 2020-2021 'Getting Into the Weeds' session '**Irrigating my Soilless Substrate**'

Stay tuned to Perennia's blogs for information on upcoming workshops, webinars, or fact sheets. If you have any questions on growing in substrate, don't hesitate to reach out to our Protected Crop Specialist, Talia Plaskett.