Irrigating a Container Crop: Checks and Balances

Substrate-based crops grown in tunnels or greenhouses are completely reliant on irrigation systems to provide water throughout the day. Plant transpiration is the major avenue for water consumption in containerized systems, as compared to soil-based systems where water can be lost more readily to evaporation, seepage, etc. This means that water management can be focused on how much water a plant needs, and when.

Daily irrigation cycles should correspond to the environmental conditions the crop is experiencing. Solar radiation, wind, relative humidity, temperature, etc. will impact plant transpiration and determine the frequency and volume that water should be delivered to the crop to maintain a healthy root system. When there are low levels of transpiration, the substrate should be allowed to dry back slightly with less frequent or shorter waterings. Similarly, when high levels of transpiration occur it is important to increase the frequency or duration of irrigation.

IRRIGATION SCHEDULING

Containers hold a limited quantity of growing medium, which restricts the amount of water that is held in reserve (figure 1). As a result, containers require significant volumes of water throughout the day to prevent the substrate from drying out and meet the plant's water demand. Delivery of the daily allotted water all at once will see a significant loss of water and nutrients due to the limited water holding capacity of the containerized substrate and should be avoided. As a result, containerized crops require 'many and often' irrigation cycles throughout the day to ensure water and nutrients are readily available to the plant.

Figure 1. Containerized strawberry plants grown under cover.

- Crop
- Humidity
- Plant age
- Container Size
- Time of Year
- Growing Media
- Temperature
- Time of Day
- Solar Radiation
- Wind

Deciding the appropriate volume and frequency of water delivery is going to depend on the following:

Figure 2 shows a newly planted long cane raspberry crop next to a well-developed crop canopy. Ideally, two crops with different planting dates would be in different irrigation zones because their irrigation needs are very different.

Figure 2. Mature versus newly planted long cane raspberry crop on the right side of the photo, both requiring different levels of irrigation.

Irrigation scheduling should consider the irrigation system's capacity, the substrate's water-holding capacity and the growing container as well. Most container crops are irrigated using drip irrigation. Drippers allow water to be fed directly to the root zone of each plant. Each pot can accommodate multiple drippers, which will facilitate even water spread throughout the growing medium (as opposed to a singular delivery point). Water volumes can be easily quantified, minimizing loss to the surrounding environment. Drip irrigation does not contribute to the humidity in the tunnel when managed properly, which limits potential disease spread. Important considerations with any type of irrigation are the maintenance of pressure at various points through the tunnel, as well as allowing for shut-off points in multiple positions that allow for increased control over each row if necessary.

PLANNING YOUR IRRIGATION SCHEDULE

The following concepts on crop water demand will create a framework for developing an irrigation schedule from scratch:

- Peak parts of the day (10 am – 4 pm) are characterized by having maximum temperature readings and levels of solar radiation. During this window, the plant is actively photosynthesizing, and multiple irrigation events per hour will be necessary to meet the crop demand and maintain ideal moisture availability in the substrate.
- Wait until after sunrise to apply the first rounds of irrigation: one to two hours after the sun rises is approximately when plants will begin transpiring in response to increasing sunlight and temperature.
- Plan to end the irrigation for the day two to three hours before sunset. This should provide enough time for the plant to utilize, or pot to drain, the remaining water in the substrate without putting the plant at risk of root and crown rots. Do not completely dry out the substrate over night as re-wetting can be quite difficult and creates a high degree of stress on the crop.
- The generally recommended irrigation volume for containerized crops is around 2-4% of the container volume. This volume of water should be sufficient to wet the substrate without overwhelming it, resulting in a large degree of running-through and loss to the environment.

MONITORING (AND TWEAKING) YOUR IRRIGATION SCHEDULE

Once a baseline schedule is created, adjustments can be made using information gathered from monitoring feed and leachate solutions.

The feed refers to the nutrient solution that is delivered to the crop through emitters

Leachate, or drainage, is the water that drains through the bottom of the growing container following the application of a fertilizer solution

Leachate is necessary to draw salts down and out of the substrate, preventing them from building up around the root system. Excess salt build-up in the substrate will cause issues with nutrient uptake and can result in disease development throughout the roots and the crown. However, there is a limit as to how much leachate is beneficial to the system. Supplying excess nutrient solution into the crop, where high percentages (>40%) of the solution is bleeding out of the pots, is problematic in the wrong conditions. From a cost of production standpoint, there is unnecessary loss of water and fertilizer in this scenario. From a crop health perspective, this will cause humidity in the production space to rise, which can be linked to increased disease and pest pressure. Increased pressure results in increased use of preventative/management sprays, which will also impact production costs. Maintaining percent drain in the ideal range will limit the damage done to the crop while managing the rootzone. The ideal percent drain depends on the time of day and is reviewed in detail below.

Figure 3. The ideal setup for a drip and drain monitoring station in a long cane raspberry crop. Image provided by Delphy UK.

As modelled in Figure 3, the ideal monitoring station has a collection pail located under a representative number of pots for the tunnel. Including multiple irrigation monitoring stations throughout the production space leads to higher accuracy when understanding average plant water and nutrient use. Pots used for irrigation management are ideally set at the same level as the rest of the crop – raising them would expose them to conditions which are not consistent with many of the plants on site (ex., increased airflow). These select pots are going to be our reference points on irrigation and management decisions, so they should be set up the same as the rest of the crop. To accommodate this, the collection container can be placed be in the ground, with easy access for taking measurements and dumping. In addition to collecting leachate, we need to include a spot to measure and collect the drip feed. This can happen anywhere in the production space, though close to our leachate monitoring station is highly convenient.

Leachate reflects plant demand and allows for a high degree of control over how the crop grows. The key leachate variables that should be monitored are EC (electrical conductivity), pH and volume.

ELECTRICAL CONDUCTIVITY (EC):

Electrical conductivity (EC) is an indication of the concentration of the nutrient solution being delivered to the plants. This should be checked daily to account for abiotic and biotic changes happening in the production space.

- Drip EC is a good way to stay on top of the feed solution. Issues with pump functionality or ratios of injection into the source water are not uncommon in hydroponic setups. This is a quick way to ensure the system works properly and fine-tune the dilution ratio if necessary.
- Drain EC, especially when compared to the drip EC, will give a sense of what is happening from the moment it touches the substrate to when it drains out the bottom of the container.
    - » A significantly lower drain EC (compared to the feed EC) indicates that the plants are removing a lot of nutrients from the system. This typically means that an increase in the concentration of the feed solution is necessary to support a heavy-feeding crop.
    - » A significantly higher drain EC implies that salts are accumulating in the substrate, which can result in an unbalanced root zone. If this occurs, the EC of the feed solution should be reduced to prevent over-supplementation to the crop and allow the substrate to balance itself out. Depending on how high this EC value is, a flush of raw water may also be warranted.

Colour can be a useful primary indication of EC as well. Looking at Figure 4, the pale colouration of the drain solution indicates that the crop is feeding heavily and has removed a large portion of the nutrients provided in the feed solution. While colour comparisons do not replace actual EC readings and monitoring, it can be a quick indication that the EC of the feed solution should be increased to fully support crop nutrient demand.

Figure 4. On the right side of the image is a bottle of the drip solution fed to the crop, and on the left is a bottle of the fertigation solution that leached out of the bottom of the pot.

PH:

pH impacts the availability of nutrients within the fertilizer solution. If the source water is overly acidic or overly basic, the nutrients may not be available to the plant for uptake, despite them being present in the solution.

- Drip pH is a good checkpoint to make sure that the stock fertilizer tanks are injecting properly and that the target pH is being achieved.
- Drain pH will give an indication, alongside EC, as to what is happening in the growing media. Values that are significantly higher or lower in the drain compared to the feed solution implies an imbalance in the substrate that needs to be resolved to maximize nutrient availability and uptake by the crop.

Regular calibration of pH meters is highly recommended for better accuracy in measured readings. While there is a lot of variation from meter to meter, it should give a reasonable indication of the pH. Sending regular in-season substrate samples for mineral analysis is recommended to make sure that irrigation equipment and dosing pumps are working as they should be. This can also serve as an pH meter calibration: record the pH reading of irrigation samples before sending them off for nutritional analysis and compare it to the lab report findings.

VOLUME:

The comparison of drip volume to drain volume (percent drain) is a highly important metric used to plan irrigation cycles. Target values for drain volume are 10-20% of what was fed to the crop over a 24-hour period. This should allow enough solution to draw excess salts out of the substrate and maintain an ideal wetness of the growing media while

still reducing fertilizer losses. Though the 24-hour period is important to monitor, looking at leachate after each cycle throughout the day will provide valuable feedback on the current schedule and give insight on where more/less water is needed.

Hourly monitoring is very important when getting a sense of irrigation management and ensuring the plants are properly supplemented. It is not uncommon to record high drain volumes in the early and late parts of the day and low to no drainage through the peak parts of the day. Daily monitoring of leachate volume would only capture the overall average, which could still fall in the desired range despite the large fluctuations that occur over a 24-hour period. These leachate trends result in large amounts of fertilizer loss early and late in the day while the crop is underfed (and stressed) through the most active parts of the day.

Percent drain will see a lot of variation on a day-to-day basis depending on crop stage, time of year and the weather. Irrigation schedules can be changed to account for a series of overcast days or a growing canopy, and volume comparison is crucial for making decisions. Irrigation dictates plant growth habits, plant health and fruit quality, and it is worth integrating the appropriate monitoring checks into the daily routine to maximize the impact of all growing inputs. Table 1 outlines the leachate targets at different times of the day so that the substrate is not overly wet during the night, which increases the risk of root and crown rots.

Table 1: Leachate Target for Timing of the day

Cycle	Drain Target	Reason	Solution
First watering of the day	<0%	Indication that the substrate was not allowed to dry out throughout the night. A wet substrate, when the plant is not actively photosynthesizing, puts the roots at risk of disease and will impact water/nutrient uptake ability in the long term.	If > 0% drain, adjust the time of the last watering of the day. By setting that last watering event earlier in the day, the plant has an opportunity to use that water up before it slows down for the night. Other option is to shorten the duration of the last cycle to apply less water.
Second watering of the day	0% drain, to a very low percentage		
Third watering of the day	>0% drain	If there is still no drainage at the third watering of the day, the substrate was run too dry the previous day. The plant roots are going to be struggling to extract the little water that is still present in the substrate as the day picks up, and this can have significant implications for canopy and berry development.	Schedule the last irrigation event of the day closer to sundown so that the substrate can provide the necessary water to the plant as the day runs out.
Peak day (10 am – 4 pm)	observing 10% - 30% leachate during peak periods of the day	Drainage is required to satisfy the water and nutrient requirements for the developing crop and to remove salt from the root zone.	If the drainage volume is too high, reduce the frequency of irrigation to increase the amount of time between watering events. If the drainage volume is too low, increase the frequency of irrigation events.
Evening	Start decreasing percent leachate	Depending on the time of the summer, the percent leachate should be dropped back though the evening in preparation for nightfall	