GROWERS GUIDE TO CROP STEERING

An overview of the concepts, methodologies, and available technology associated with crop steering cannabis

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INTRODUCTION

Recently, the concept of crop steering has become a popular topic amongst cannabis cultivators. With cannabis being the most lucrative crop in the world, it's no surprise that cultivation businesses are drawn to the allure of growing more productive plants with higher yields. While some growers have utilized crop steering techniques for years, others are newly adopting these methodologies in their gardens.

Unfortunately, there's little information published on crop steering in general, and even less for cannabis specifically, making it difficult for both seasoned and new growers to expand their knowledge on the topic. In an effort to demystify the topic of crop steering in the cannabis community, this guide provides an overview of the concepts, methodologies, and available technology

PART 01

CROP STEERING OVERVIEW

WHAT IS CROP STEERING?

Cannabis plants have hormonal systems that regulate their growth in response to external conditions and stresses. These reactions are a result of millions of years of evolution and the plants adaptation to seasonal changes. **Crop Steering** is essentially the exploitation of these hormonal responses through manipulation of a controlled environment. Using climate and irrigation cues, growers are able to induce **vegetative** and **generative** growth to steer their plants to a desired outcome.

Vegetative plants are in a state where most of their energy goes towards leaf growth and very little towards flower production. The opposite is true of generative plants, where the plants put most of their energy into flower growth, and have little left to invest in new leaves or stem growth.

Plant Balance

Growers must maintain proper **plant balance**, which is the balance between leaf and flower production. Plants that are growing overly generatively or vegetatively are considered to be out of balance. If the plant isn't in balance, then it's likely that production and quality will ultimately suffer.

In general, the intent in commercial cannabis production is to maximize yield by optimizing the time plants spend in vegetative growth to ensure they produce only enough foliage and stems to support vigorous flower production.

Vegetative Growth

Vegetative growth is when stems and foliage are the predominant focus of the plant's energy use and resulting growth. As plants grow vegetatively they increase their photosynthetic capacity by increasing their leaf area and mass.

Although cannabis vegetative growth is most notably associated with the phase between clone and flowering, it's possible to use vegetative cues to nudge plants into vegetative growth at any point in their lifecycle. For instance, if you have compact, slow-growing flowering plants you can use climate and irrigation cues to inspire vegetative growth, stretch the plants out, and increase internode spacing. Some growers also use vegetative cues at points during the flowering growth phase to promote hearty bud growth.

Vegetative Steering Characteristics

To inspire vegetative growth you must simulate conditions similar to spring, which allows your plants to thrive and maintain vigor. Conditions that favor vegetative growth include lower electrical conductivity (EC), higher water content (WC), lower vapor pressure deficit (VPD), lower light intensity, and an overall stress-free environment.

The following ranges are examples of conditions that could induce vegetative growth. Actual conditions will vary by grow environment and cultivar. It's critical that you adapt your climate and irrigation strategy to your specific environment and genetics by

VEGETATIVE CLIMATE STEERING

Ambient Temperature	78 - 88 °F
Relative Humidity (RH)	65 - 80%
Vapor Pressure Deficit (VPD)	0.8 - 1.1 kPa
CO2	500 - 800 ppm
Day/Night Temp Differential	0 - 10 °F

VEGETATIVE IRRIGATION STEERING

Shot Size	1 - 3% of substrate volume
Dry Back	10 - 15%
Substrate Temperature	72 - 78 °F
Electrical Conductivity (EC)	2 - 4 dS/m
Water Content (WC)	55 - 70%
Irrigation Frequency	6 - 9+ per lights on period

Generative Growth

In generative growth, the plant's energy is directed toward creating flowers. With this focus on flower production, the plant slows down the growth of new foliage and reduces stretching.

Generative growth cues can be leveraged throughout the plant's lifecycle, not just in the flowering period. For instance, if you have plants that are demonstrating signs of excessive vegetative growth, such as stretching too much with larger internodal spacing, then you can modify your climate

Generative Steering Characteristics

In contrast to the mild conditions that inspire vegetative growth, harsher summer-like conditions are the foundation of generative cues. Lower WC, higher EC, and higher VPD are all examples of ways to motivate generative growth in cannabis plants.

The following ranges are examples of conditions that could induce generative growth. Actual conditions will vary by grow environment and cultivar. It's critical that you adapt your climate and irrigation strategy to your specific environment and

GENERATIVE CLIMATE STEERING

Ambient Temperature	60 - 78 °F
Relative Humidity (RH)	40 - 70%
Vapor Pressure Deficit (VPD)	1.0 - 1.5 kPa
CO2	800 - 1200 ppm
Day/Night Temp Differential	0 - 10 °F

GENERATIVE IRRIGATION STEERING

Shot Size	4 - 8% of substrate volume
Dry Back	15 - 30%+
Substrate Temperature	68 - 76 °F
Electrical Conductivity (EC)	5 - 12 dS/m
Water Content (WC)	25 - 70%
Irrigation Frequency	3 - 9+ per lights on period

PART 02

CROP REGISTRATION

WHAT IS CROP REGISTRATION?

Crop registration, which is the collection of detailed observations about your crop, is arguably the most important aspect of crop steering. Through this method of diligent data collection, you can track how steering actions are driving changes in your plants. Each cultivar is unique, and as a result you should experiment to see how growth

What Should You Track?

Crop registration should occur frequently to ensure you're effectively tracking the impact of steering cues on your crop.

By collecting data on these key performance indicators (KPIs) at a regular frequency for each round, you can begin to make correlations about cause and effect of various steering actions. This historical data becomes a powerful tool in predicting plant performance and enables you to optimize crop yields by making changes to your operational processes

COMMON CROP OBSERVATIONS

- Plant height
- Root development
- Stem diameter
- Internodal spacing
- Leaf color / Stem color
- Flower circumference
- Trichome attributes
- Plant vigor

PART 03

IRRIGATION STEERING

DEVELOPING AN IRRIGATION STRATEGY

Irrigation is a fundamental aspect of cannabis crop steering. In order to successfully steer plants with irrigation, growers must have the ability to sufficiently manage the root zone. Selection of substrate and irrigation equipment, in addition to volume, frequency, and timing of irrigation events, are key considerations during the development of

Considerations for Different Substrates

In commercial cultivation facilities, with numerous grow rooms and thousands of plants in various growth stages, tracking crop data can be a daunting task. Luckily, there's software to help simplify and automate these activities.

Trym is the industry's choice when it comes to crop steering, team management, and Metrc compliance. Our flexible sensor integrations allow you to link your climate and root zone data across all your rooms and facilities. Additionally, you can record all the tasks, plant observations, and measurements in Trym, creating a record of every harvest. Review your data, optimize your processes and improve your yields.

Trym empowers you to:

- Plan crop schedules and track plant inventory
- Log climate and root zone sensor data
- Enable efficient crop registration
- Manage team activities
- Visualize crop results to optimize future runs

Calculating Substrate Irrigation Volumes

Calculating ideal irrigation volumes is simpler than it sounds. The amount of solution you apply to irrigation is a product of how much growing media you have per plant and whether you would like to steer more generatively or vegetatively. For example, if you had 3.5 liters of growing media, to determine shot volume you multiply by the desired shot size.

IRRIGATION VOLUMES

Growth Type	% of Substrate Volume
Vegetative	1 - 3%
Generative	4 - 8%

EXAMPLE: CALCULATING SUBSTRATE VOLUME

Rockwell Cube Size = 6 x 6 x 6 inches

Subtrate Cubic Volume (in^3) = 216 in^3

Inches^3 to Liters Convervsion = 1 in^3 = 0.0163871 liters

Subtrate Cubic Volume (L) = 216 in^3 * 0.0163871 liters = 3.54 liters

EXAMPLE: CALCULATING SHOT SIZE

Substrate Volume = 3.54 liters (3539 ml)

Desired Vegetative Shot Size = 3% of substrate volume

Desired Generative Shot Size = 6% of substrate volume

Vegetative Shot Size (3%) = 3539 x 0.03 = 106 ml

Generative Shot Size (6%) = 3539 x 0.06 = 212 ml

ROOT ZONE MANAGEMENT

Management of your irrigation strategy on a daily basis is critical to successfully steering with irrigation. Utilizing root zone monitoring sensors and measuring drain volumes empowers growers to tailor their irrigation strategy to different plants under changing environmental conditions. By monitoring and adjusting water content (WC), total drain achieved compared to irrigations applied, electrical conductivity (EC), as well as dry back overnight and between irrigations each day,

Daily Irrigation Schedule

Many growers utilize a multi-phase irrigation schedule that was initially popularized by Grodan. When utilizing this methodology there are four distinct phases.

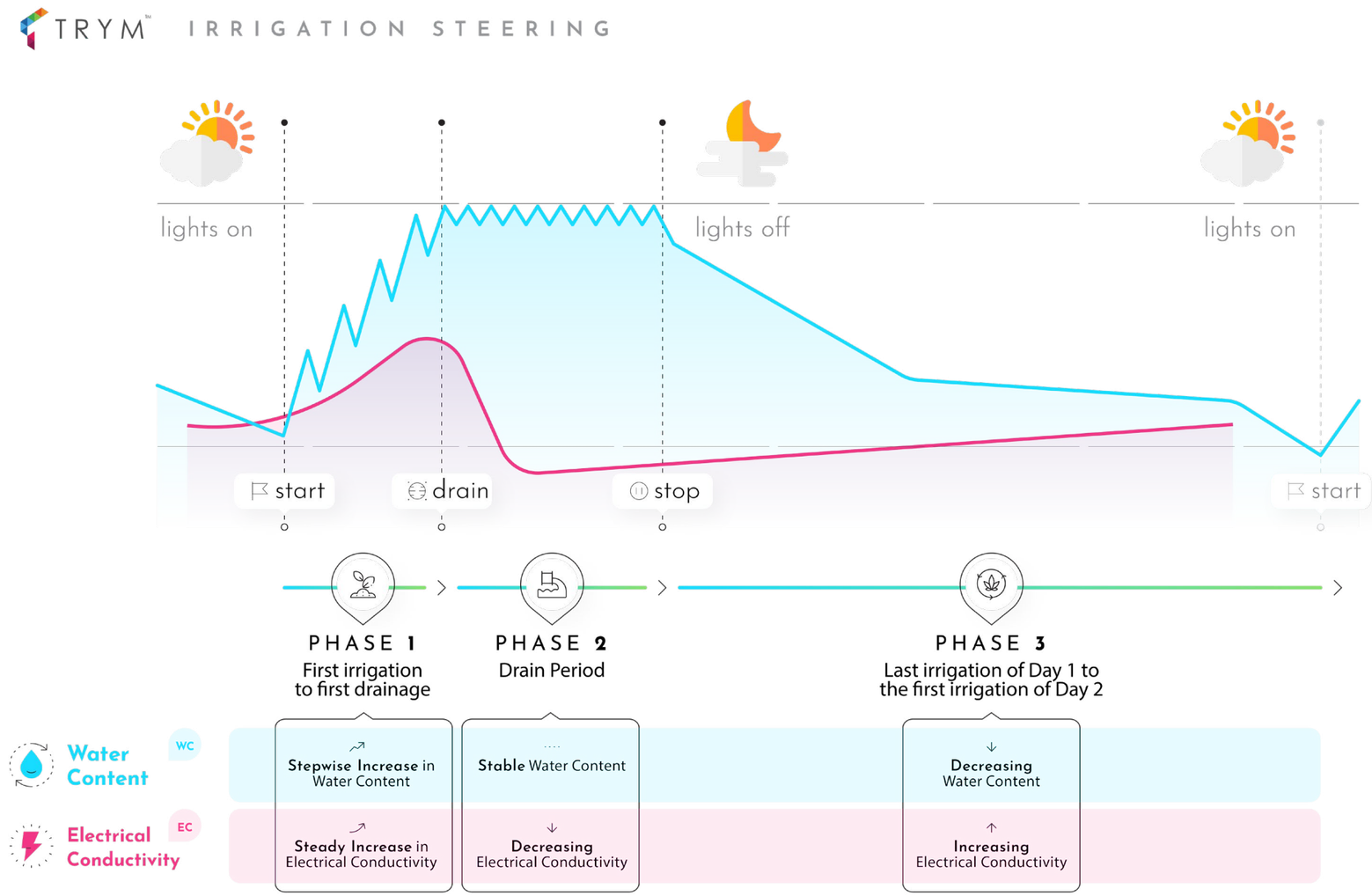
IRRIGATION PHASES

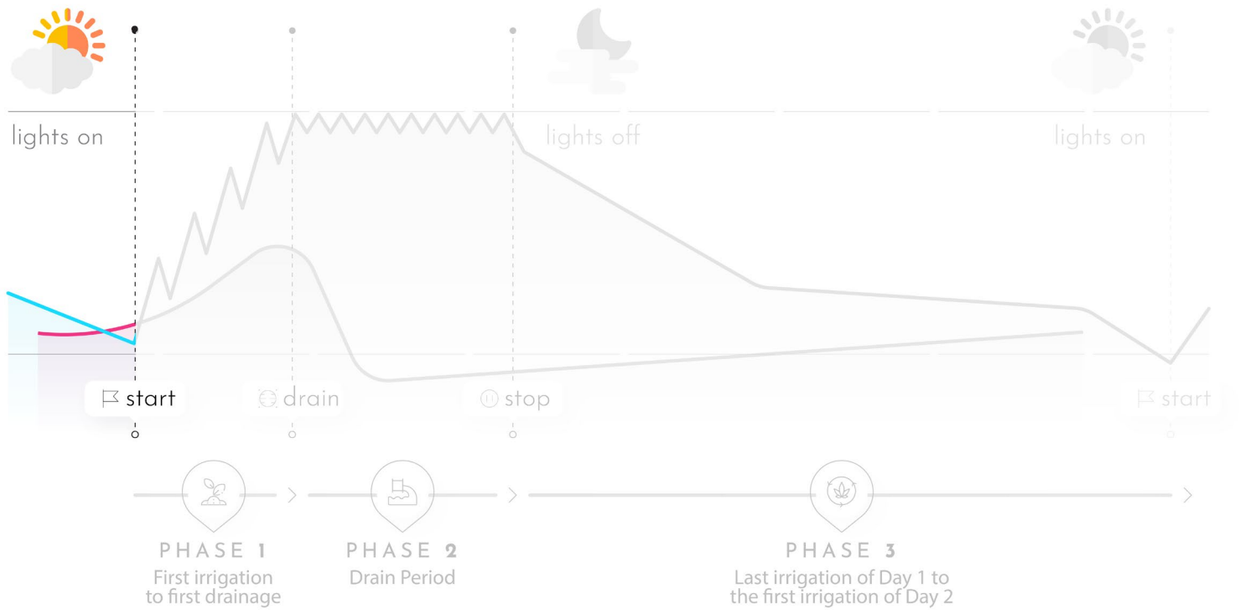
Phase 0: Lights On to First Irrigation

Phase 1: First Irrigation to Runoff

Phase 2: Runoff to Last Irrigation

Phase 3: Last Irrigation to Lights On





Phase 0:

Lights On to First Irrigation

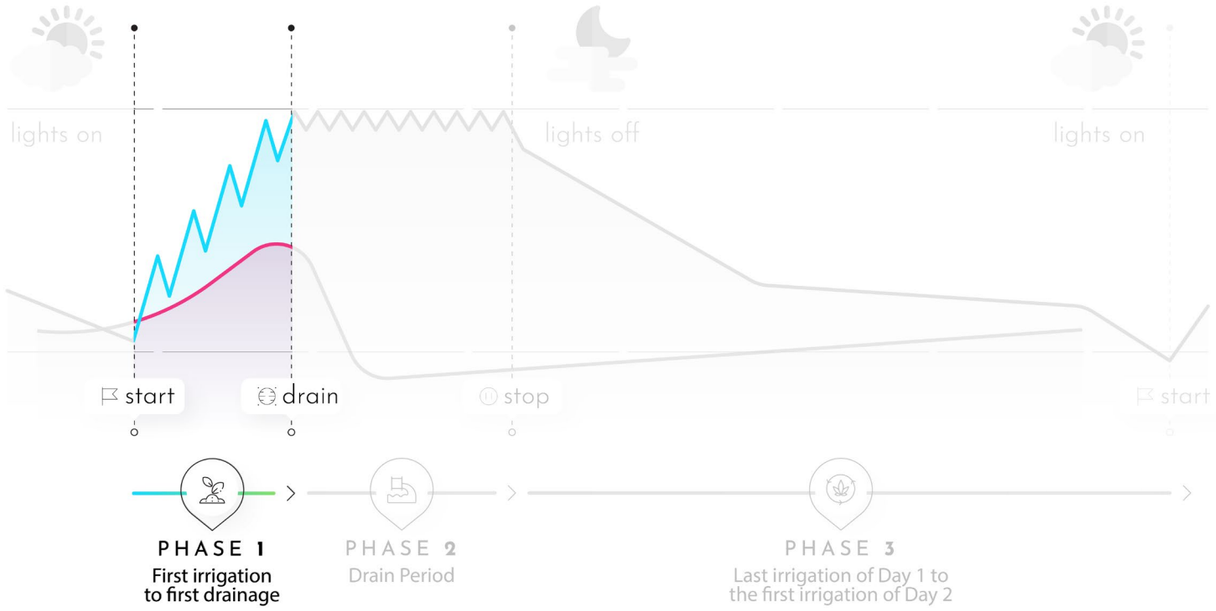
After the lights are on in your room (sunrise), you should wait until your plants are actively transpiring before beginning irrigation for the day. You can verify that they're transpiring by monitoring the water content (WC) in your substrate. As the plants uptake water, the WC in the substrate will decline. You can use varying amounts of dry back from sunrise to your first irrigation in order to steer your plants vegetatively (1 - 4% dry back) or generatively (4 - 6% dry back).

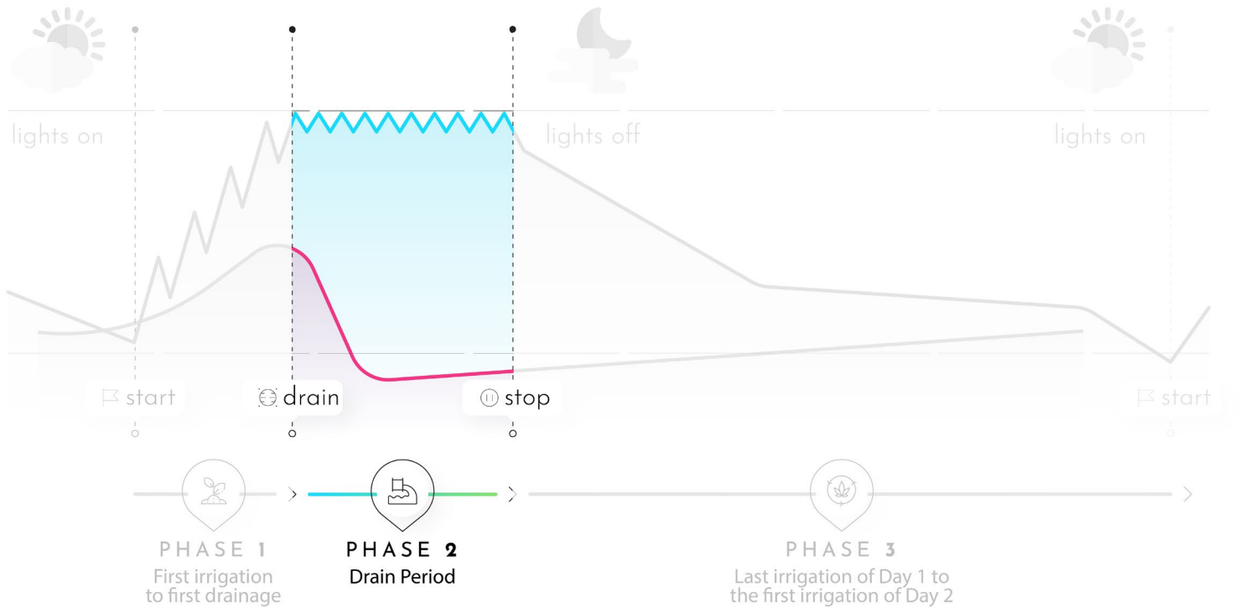
Phase 1:

First Irrigation to Runoff

Once your plants are actively transpiring, your plants are ready for the first irrigation of the day. The goal for this irrigation phase is to reach peak water content (WC) for the day and achieve runoff 1 - 3 hours after your first irrigation.

The number of irrigations required to produce runoff will vary depending on substrate size, starting WC, shot size, and irrigation frequency. Achieving a minimum of 1% dry back between each irrigation is ideal to ensure you're not seeing runoff too quickly. If you're steering more generatively and are applying a larger irrigation shot (6%+), you should aim for a longer dry back of 2% - 3% between feedings to avoid hitting peak WC too early and creating excess drain.





Phase 2:

Runoff to Last Irrigation

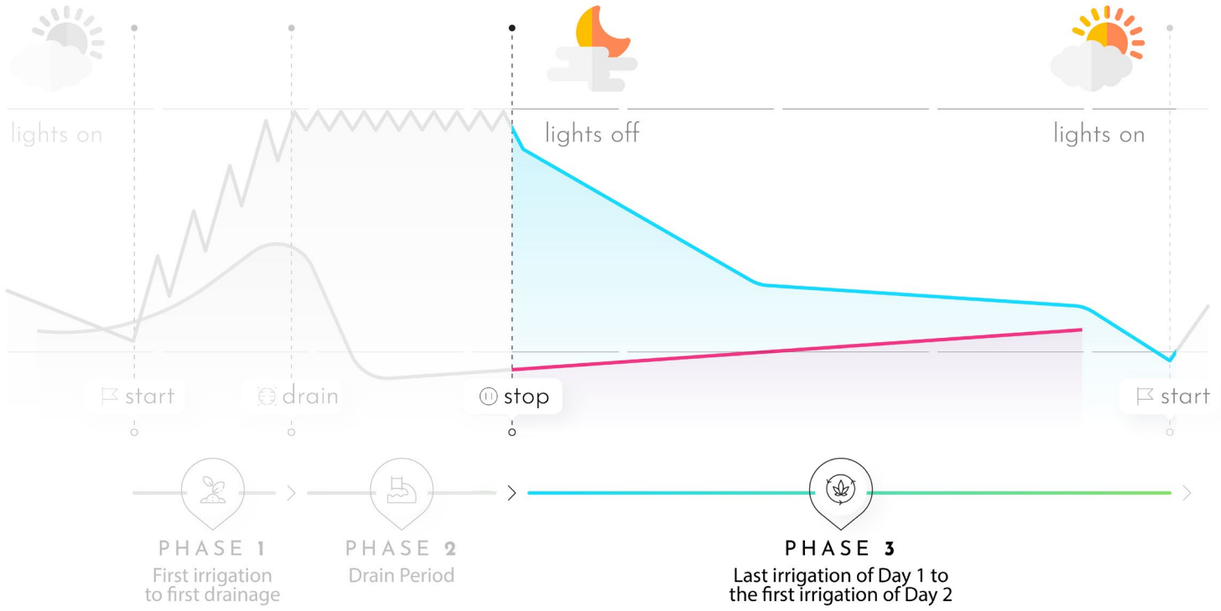
During this phase the goal is to reduce EC to its lowest daily value while light intensity and temperature are at their highest, These conditions require your plants to work their hardest and typically correspond with the midpoint of the day.

Since you've already achieved your desired WC and first drain in Phase 1, during this phase you can tailor the volume and frequency of irrigations to hold WC consistent in your substrate. You can do this by reducing your shot size and adjusting the dry back between shots. You should aim for at least 1% to 3% dry back between each shot if steering more vegetatively. If steering more generativity you should target 3%-6% dry backs during this phase.

Phase 3:

Last Irrigation to Lights On

It's important that you time the last irrigation of the day so that you allow adequate time for proper overnight dry back. Depending on the stage of growth, you should aim to achieve 2% to 6% dry back between the final irrigation and lights off (sunset). If steering vegetatively, you should target dry back from the last irrigation of the day until the first irrigation of the following day between 10% to 15%. For generative, aim for 20 - 30% or more.



IRRIGATION STEERING TECHNOLOGY

A key component of crop steering is management of the root zone through a combination of irrigation events, nutrient dosing, and dry backs. The frequency, duration, and timing of feedings is critically important to provide the appropriate cue to your plants. Because of this, automating your irrigation is nearly essential to be successful with crop steering in large-scale cultivation operations.

Substrate Sensors

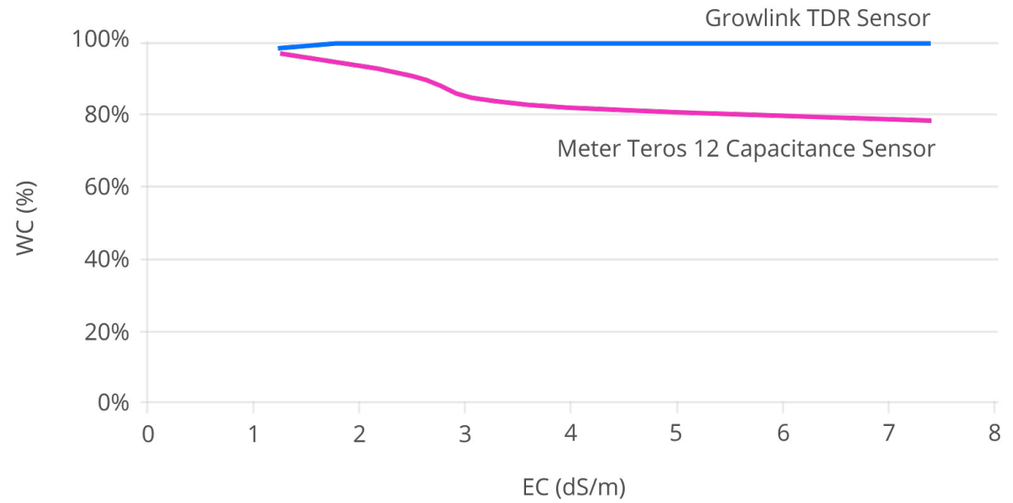
Understanding root zone conditions is key to successful crop steering. Substrate sensors allow you to monitor WC, EC, and temperature in real-time. Deploying substrate sensors throughout your rooms allows you to take a granular approach to irrigation and nutrient delivery.

As a general rule of thumb, it's recommended

TDR vs Capacitance Sensors

The two most common soil moisture sensors are capacitance based and TDR, which stands for “Time-Domain Reflectometry”. A major drawback of capacitance based sensors is that the EC of the soil throws off measurements. EC of soil is also referred to as the salinity of soil. The higher the salinity, the less accurate the WC measurements become.

TDR is a superior technology when it comes to measuring WC



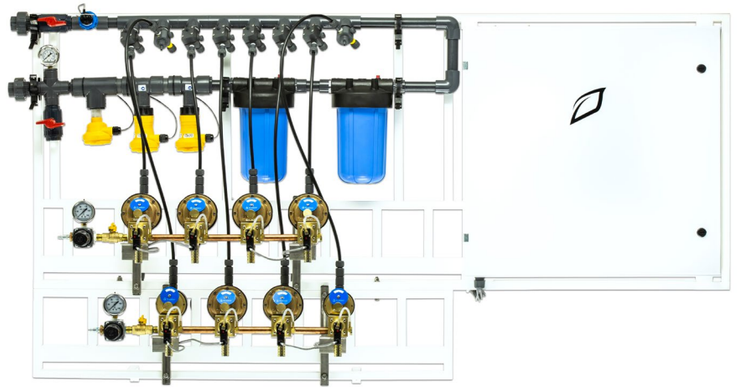
The graph above demonstrates the accuracy of TDR versus capacitance based sensors as salinity increases in the solution. In this study the sensors are submerged in water, thus WC should always be 100%. As the salinity of the solution increases, which results in an increase in EC, the accuracy of the Meter Group Teros 12 capacitance sensor declines precipitously. In contrast, the Growlink TDR sensor accurately reports WC despite the increase in salinity.

growlink

Fertigation Systems

Fertigation systems allow you to schedule the timing and volume of your feedings. When combined with soil probes that track substrate WC and EC, many fertigation systems also allow you to specify triggers that initiate irrigation events.

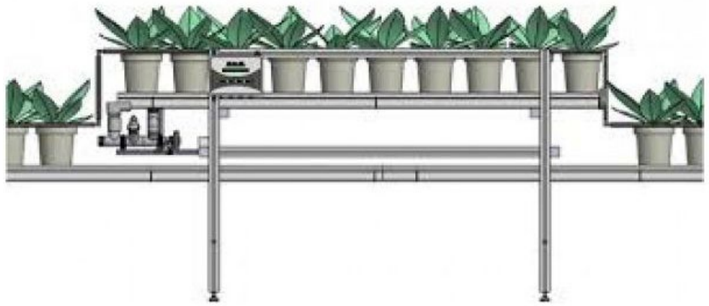
Fertigation systems eliminate the labor associated with tasks like hand-mixing and hand-watering and eliminates much of the human-error in those processes. Input costs are reduced by feeding the right amount of water and nutrients at the right time. By having consistent EC and pH both crop quality and yields can be greatly improved.



Source: Growlink

Drain Calculator

Drain collection and measurement is a method of determining runoff over a period of time. You can determine the volume of drain for a crop by placing one or more plants in a raised tray that allows for the collection and measurement of solution that drains through the substrate after the substrate has reached saturation. With an automatic system you will also be able to see if and when you achieve drain, in addition to measuring the total volume of drain. Knowing when you are achieving first drain, whether or not you achieve it at each irrigation, and comparing total drain per day to total amount of irrigation applied will help you



Source: Netafim

PART 04

CULTIVATION MANAGEMENT SOFTWARE

SOFTWARE BUILT FOR GROWERS

In commercial cultivation facilities, with numerous grow rooms and thousands of plants in various growth stages, tracking crop data can be a daunting task. Luckily, there's software to help simplify and automate these activities.

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Trym can help you successfully steer your crops by providing you with tools to:

- Plan crop schedules and track plant inventory
- Log climate and root zone sensor data
- Enable efficient crop registration

FLEXIBLE SENSOR INTEGRATIONS

growlink TrolMaster ARGUS CONTROLS aranet

Grow with Trym

Trym brings visibility into your entire operation so you can grow to your full potential. Schedule a demo today to learn how Trym can help you steer your crops and scale your business.

Get Started

PART 05

GLOSSARY

- **Crop Registration:** The collection of detailed data related to key performance indicators of a crop such as plant height, root development, stem diameter, leaf color, and node spacing, to enable the tracking of crop productivity and inform cultivation decisions.

- **Crop Steering:** A method of leveraging vegetative and generative growth cues in controlled environment agriculture, such as climate, irrigation, and photoperiod, in order to induce hormonal responses in the plants and achieve desired outcome.

- **Dry Back:** The difference between the water content of your substrate from the last irrigation event of the previous lights-on period to the first irrigation event of the subsequent lights-on period.

- **Electrical Conductivity (EC):** A measurement of how well water in the substrate accommodates transport of electric charge. Since fertilizer ions carry electrical charge and their presence increases conductivity of electricity through solution, EC is proportional to the total amount of fertilizer salts present in a solution.

- **Generative Growth:** Growth that is characterized by the plant's energy being directed toward the creation of flowers.

- **Growth Cue:** An action that is intended to trigger a hormonal response from a crop.

- **Plant Balance:** A term used for fruit-producing crops to describe the balance between leaves and fruit of a plant. Plants that are unbalanced are either overly 'vegetative' or overly 'generative'.

- **Runoff:** (AKA: Drain) The water that drains from the substrate once the substrate has reached its saturation point.

- **Substrate:** The medium that the root system of a plant grows in or on, such as rockwool, coco coir, or soil.

- **Transpiration:** A process in which water and essential nutrients move through a plant from cell to cell.

- **Vapor Pressure Deficit (VPD):** The difference (deficit) between the amount of moisture in the air and how much moisture the air can hold when it is saturated. Once air becomes saturated, water will condense out to form dew or films of water over leaves. Because of this. VPD is very important for cultivators. If a film of water forms on a plant leaf, it becomes far more susceptible to rot. On the other hand, as the VPD increases, the plant needs to draw more water from its roots.

- **Vegetative Growth:** When roots, stems, and foliage are the predominant focus of a plant's energy use and resulting growth.

- **Water Content (WC):** Water content is the volume of liquid water per volume of substrate.

Thanks for reading! If you have any questions or would like to learn more about Trym, message us at info@trym.io

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