PRECISION IRRIGATION

Quality plants need many things, particularly the right combination of ideal substrate physical and chemical properties, an optimal watering strategy, and an appropriate growing environment. Following these proven irrigation techniques will help you achieve a high-quality product while optimizing your use of water and nutrients. These parameters will help you determine the best irrigation and climate strategies to apply at ideal time throughout the plant's lifecycle.

Vegetative Stage

- Vegetative growth focuses on early root and shoot development along with maximization of leaf area index to absorb all available photons delivered by the sun and/or supplemental lighting. It is critical to maintain proper water content in the root zone during this phase without over or under-saturating the growing media
- Every irrigation event creates a vegetative response in the plant, so you should apply multiple small irrigations throughout the day without over-saturating the block. Initially after transplant, only 1-2 events per day may be needed to maintain optimal water contents. However, after plant roots begin colonizing the substrate, additional irrigation events should be added to ensure the blocks remain at a relatively high day-time water content with small overnight dry-backs and small inter-irrigation dry backs.
- Over-saturating the growing media will slow down plant growth and can cause issues with crop nutrition
- A lower EC (than used in flower) in the irrigation water and the substrate will allow for easier water uptake and help with vegetative steering.

Generative Stage

- Generative growth focuses on maximizing production of flower dry matter and secondary metabolites such as terpenes and cannabinoids.
- In this state, water content is generally maintained at lower levels than in the vegetative stage. Larger volume irrigations applied at a lower frequency will have a generative effect on a crop. However, the larger overall plant size and biomass typically achieved in the flowering phase often demands a high baseline number of irrigation events to maintain an adequate day-time water content. Generative cues include larger overnight dry-backs, larger inter-irrigation dry-backs, and larger shots at a lower frequency.
- A higher EC within the irrigation water and the substrate will control water uptake contributing to a more generative response from the plant

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The below chart outlines recommended irrigation start and stops times specific to the Vegetative and Generative growth stages. These should be adjusted to fit the specific environment and genetics being cultivated.

Irrigation Volumes

SHOT SIZE	% OF SUBSTRATE VOLUME
XSMALL	1-2%
STANDARD	3%
LARGE	4 - 6%

For drip irrigation, suggested flow rate is 0.3-0.5 gph

of Drip Stakes per Block

BLOCK WIDTH	# STAKES
4" width or smaller	1-2
6" width	2
>6" width	2 or more

Crop Steering

	IRRIGATION START AND STOP TIMES	
START	0 - 1 HR AFTER SUNRISE/LIGHTS-ON	VEGETATIVE
START	1 - 2 HR AFTER SUNRISE/LIGHTS-ON	NEUTRAL
START	2 - 4 HR AFTER SUNRISE/LIGHTS-ON	GENERATIVE
STOP	0 - 2 HR BEFORE SUNRISE/LIGHTS-OFF	VEGETATIVE
STOP	2 - 3 HR BEFORE SUNRISE/LIGHTS-OFF	NEUTRAL
STOP	3 - 4 HR BEFORE SUNRISE/LIGHTS-OFF	GENERATIVE

	VEGETATIVE	GENERATIVE
EC	LOWER	HIGHER
WATER CONTENT	HIGHER	LOWER
DRYBACKS	SMALLER	LARGER

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Irrigation Amount (shot size) During Each Watering Event

Each irrigation event's volume should generally equal 3% to 6% of the stone wool volume being utilized. For example, a GR10 (4"x4"x4") is a total volume of 1 liter. A 3% shot would be 30mL. To calculate shot size, simply convert the liter volume into milliliters and calculate the desired percent. When stacking blocks on slabs or other blocks, add the volumes together to determine the proper irrigation volume. There are some outlying scenarios in which shot sizes slightly smaller than 3% and slightly larger than 6% can be beneficial. In general, small shots will encourage less drain and increasing water contents, whereas larger shots are more likely to trigger runoff and stabilizing the water content.

Using a measuring cup, record how long the dripper(s) takes to achieve the 3% to 6% watering volume. That time is your PUMP ON time.

- The use of low-flow, pressure-compensating drip emitters with a flow rate of no more than 0.3-0.5 gph is imperative to ensure that water is delivered uniformly and retained throughout the substrate.
- Regular measuring of flow rates from multiple emitters will help ensure consistent water delivery across your farm.
- When using pressure-compensated drippers, you must ensure that your pumps and injectors meet the minimum and maximum flow rate and pressure requirements. Contact manufacturers before purchasing pumps.
- Filters, tubing, and dripper emitters should be cleaned and sanitized properly between crops to avoid occlusion, contamination, and build-up of biofilm and minerals.

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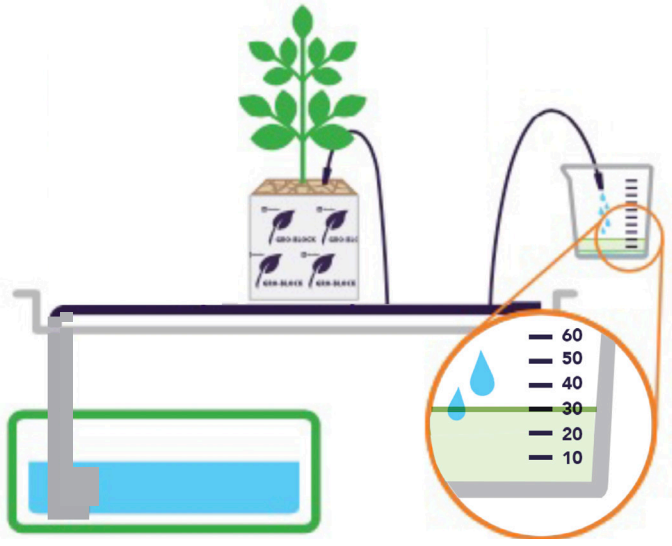
Substrate Volumes and Irrigation Shot Size

GRODAN PRODUCT	REAL VOLUME (L)	SHOT SIZE (mL)	SHOT SIZE (mL)
BLOCKS		**3%**	**6%**
GR 4 Small 3"	0.37	11	22
GR 5.6 Large 3"	0.56	17	34
GR 6.5 Small 4"	0.65	20	39
GR 7.5 Medium 4"	0.75	23	45
GR 10 Large 4"	1.00	30	60
GR 22.5 Jumbo	2.25	68	135
GR 32 Hugo	3.20	96	192
GR 40 Uni-Block	4.00	120	240
GR Big Mama	8.37	251	502
SLABS			
GR Unislab	4.68	140	281
GR 3" Tall Slab	10.13	304	608
GR 4" Tall Slab	13.50	405	810
GR 8" Wide Slab	13.16	395	790
GR 12" Wide Slab	20.25	608	1215



Blocks and Slabs

Product	Length (cm)	Width (cm)	Height (cm)	~ Dimensions (in)	~Volume (cm3)	~Volume (L)
GR 4 Small 3”	7.5	7.5	6.5	3*3*2.6	365.63	0.366
GR 5.6 Large 3”	7.5	7.5	10	3*3*4	562.50	0.563
GR 6.5 Small 4”	10	10	6.5	4*4*2.6	650.00	0.650
GR 7.5 Medium 4”	10	10	7.5	4*4*3	750.00	0.750
GR 10 Large 4”	10	10	10	4*4*4	1000.00	1.00
GR 22.5 Jumbo	15	15	10	6*6*4	2250.00	2.25
GR 32 Hugo	15	15	14.2	6*6*6	3195.00	3.195
GR 40 Uni-Block	20	20	10	8*8*4	4000.00	4.00
GR Big Mama	20.3	20.3	20.3	8*8*8	8365.43	8.365

Block volumes are approximate due to hole and drainage grooves

Product	Length (cm)	Width (cm)	Height (cm)	~ Dimensions (in)	Volume (cm3)	Volume (L)
GR Unislab	24	19.5	10	9.5*8*4	4680	4.68
GR 3” Tall Slab	90	15	7.5	35*6*3	0125	10.125
GR 4” Tall Slab	90	15	10	35*6*4	13500	13.5
GR 8” Wide Slab	90	19.5	7.5	35*8*3	13163	13.163
GR 12” Wide Slab	90	30	7.5	35*12*3	20250	20.25

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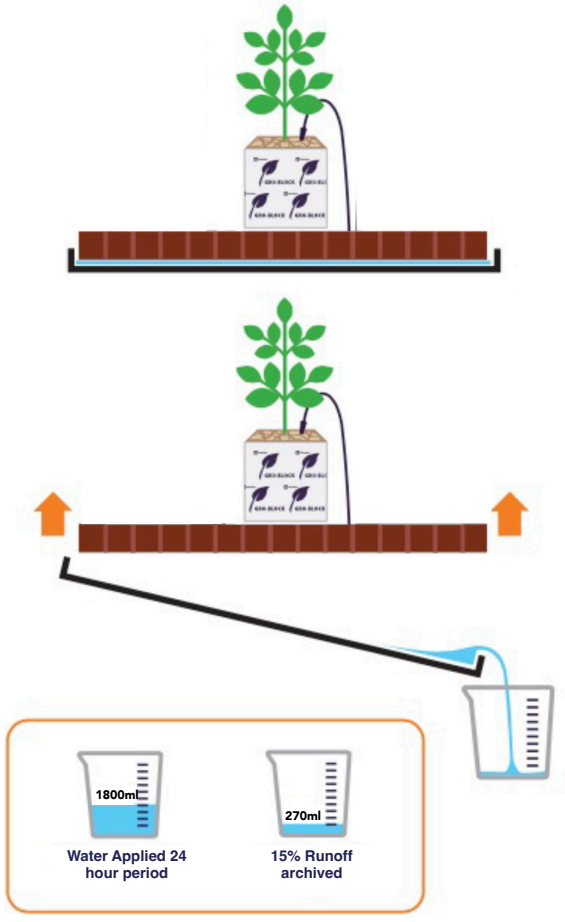
Water Frequency and Volume

Many factors drive the amount of water a plant will consume. These factors include, but are not limited to: genetics, plant size, planting density, root-system volume, leaf area index, light intensity and spectral composition, air movement, ambient temperature and humidity, leaf surface temperature, CO2 concentration, solute concentration, and substrate temperature.

Rest time between irrigation events should be no less than 20-30 minutes, and in the early stages of growth, the rest time between irrigation events could be as long as several hours. Pay close attention the dry-back rate between irrigation events, per hour, and overnight to see how it increases and decreases as climate and substrate conditions change over the course of the crop cycle.

Measuring the daily volume of runoff can help you determine if you are over or under-watering. The total runoff should be about a 5% to 25% fraction of the total water applied during the day. Smaller volumes of leachate are acceptable in the vegetative stage and any time you are trying to stabilize or increase the substrate EC. Larger volumes of leachate are often required during the generative phase to maintain fertilizer and pH balance, and will often reduce the substrate EC, bringing it closer in line with the drip EC.



15% Runoff archived

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Tracking Runoff

You can measure your leachate fraction by placing blocks or slabs on a slightly elevated and perforated surface, such as a grow-smart tray, within a vessel that can catch and hold the runoff. At the end of the irrigation cycles, measure the total runoff volume collected in the container and divide this volume by the total amount of water applied per plant that day.

You should have 5% to 25% runoff of total volume applied to the plant over the course of the day.

If you have a growing system that captures and stores the entirety of each day's leachate in a holding tank, you can take the daily volume captured and divide by the number of plants. This will be your per-plant runoff average.

Increase or decrease watering frequency and shot sizes (within the range of ~3-6%) as needed to manipulate your leachate fraction and steer the substrate EC up or down. This tactic can be utilized in combination with gradually titrating the drip EC up or down as needed.

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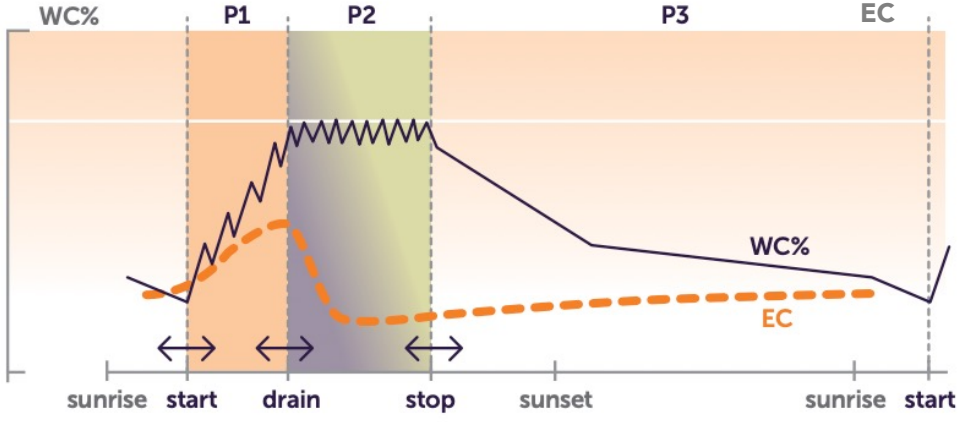
24-Hour Water Content & EC Cycle

- The chart below shows the "day dynamic" for irrigation. It shows how the Water Content (WC) and Electrical Conductivity (EC) behave in the root zone daily.
- Period 1 (P1) is the time from first irrigation until first drain. It occurs after lights have come on (or the sun has come up) and the plants have begun transpiring. Transpiration before irrigation is an important rule in this period. Several irrigations should be applied to build up the water content until the point of the first drain.
- P2 takes place when first drain occurs and concludes with the final irrigation event. This period is the drain and water content maintenance phase. During P2, several drain events may be achieved to refresh the nutrient balance and control the substrate EC.
- P3 is the dry-back period of the day. This period will begin after the final irrigation event of the day. The irrigation stop time in, in combination with the start time in the subsequent day's P1, is used to manage and control the total dry-back during the night-time period. Larger P3 dry-backs will offer plants a generative cue, while smaller P3 dry-backs will create more vegetative balance.



Golden rule: "transpiration before irrigation"