GRODAN GROW GUIDE CANNABIS EDITION

Guides And Tips for Growing in Stone Wool

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Grodan Story

Designed to grow, together

Stone wool, also known as wool or mineral wool, is a type of soilless, inert growing media ideally suited to indoor cultivation of all plants, from cannabis to vegetables and floriculture.

Grodan debuted stone wool in 1969, and in the decades since then, our company has led the way in advancing indoor gardening technology. We love sharing our knowledge of best practices for rapid root development and achieving consistent, efficient production and maximum yields through minimal resource inputs.

There's a reason stone wool is the preferred choice as a substrate, thanks to its compatibility with a range of plant production systems, irrigation regimens, lighting types, nutrient delivery systems, and other advanced precision growing techniques.

The standardized size and shape of each Grodan stone wool product make it easy for cultivators to build a graduated system that grows in volume from seedlings through maturity and harvest. And after the growing cycle is complete, stone wool is recyclable in more and more places around the world.

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GRODAN STONE WOOL CHARACTERISTICS

What Is Grodan Stone Wool Made Of?

The main component of this inert substrate is in its name—stone wool is made from sustainably sourced basalt and chalk rock. Here's a quick rundown of how the stone is transformed into an airy "wool" that is ideal for root development and is 1/10 of the weight of a bag of potting soil:

First, the raw stone material is superheated to almost 3,000 degrees Fahrenheit. The molten rock is injected with air and spun into a fibrous yet light consistency resembling spun sugar. The material is treated with a hydrophilic binder to facilitate liquid absorption, which ensures the even distribution of water and nutrients upon use.

The stone wool is then cut into a graduated series of sizes and shapes—from small-sized starter plugs to larger Gro-blocks and slabs - each product is designed for different stages of crop production. The finished products are wrapped in a special film that blocks UV light and limits the growth of algae on the substrate surface.

The result is a unique, uniform, and inert growing medium that is sterilized of pathogens, including mold and mildew, free of pests, and boasts plenty of pore space for roots to grow and access water, nutrients, and oxygen. Clean stone wool is designed to retain water and air while promoting healthy drainage fertilizer balance from top to bottom - unlike soil-based media that are prone to compaction and can become hydrophobic (water-repelling) if allowed to dry out.

GRODAN STONE WOOL CHARACTERISTICS

How Does Stone Wool Differ From Other Growing Media?

The main difference between stone wool, coco coir, peat, and soil-based media is that stone wool is a wholly inorganic mineral-based substrate, not carbon-containing organic matter. It's made of natural stone, not coconut husks, bog-sourced peat moss, or the composted wood byproducts found in most potting soils.

Because stone wool is heated to such extreme temperatures (about 3,000 degrees Fahrenheit) during the manufacturing process, it's a hygienic, clean growing media free of pathogens and pests. It's also fully compatible with hydroponic and automated growing systems and crop-steering techniques that rely on precise irrigation timing and water content control.

Stone wool is the best-growing medium for indoor cultivation environments where the grower controls every aspect of the plants' lighting, nutrition, and hydration.

Stone wool products are designed for precision growing and are fully compatible with the sensors and automation tools utilized for data-driven cultivation strategies, offering unparalleled opportunity for optimal root-zone management.

GROWING IN STONE WOOL BENEFITS

Hygienic and safe from pathogens

Stone wool is a clean, hygienic, and safe growing medium made from natural stone that has been heated to extreme temperatures. It is a mineral-based, inert substrate. It is much less likely to come contaminated with fungi, oomycetes, yeasts, bacteria, and insects, than other growing media. Stone wool enhances crop quality and reduces the need for pesticide use as well as the risk of heavy metal contamination.

In addition to the naturally hygienic qualities of stone wool, Grodan also wraps its products in a protective film that discourages algae growth and makes for easier handling by cultivation staff.

- Hygienic and safe, and less likely to be contaminated by pathogens and pests
- Reduces the need for pesticide use
- Lower risk of heavy metal contamination

Extremely efficient growing media

In addition to its hygienic and practical benefits, stone wool is also a very resource-efficient growing medium. It can retain moisture and nutrients very effectively, which means that plants can grow quickly and efficiently.

- Inert/Minimal CEC (cation exchange capacity) - will not add or hold back applied nutrients or water from the plant.
- The best choice for recirculating systems. Leachate is re-useable from the the initial saturation to harvest, reducing water & fertilizer inputs.
- More easily available water - plants do not have to exert as much energy to extract water from stone wool pores when the substrate is at a low water content.
- Excellent re-saturation capability.
- The most uniform growing substrate results in consistent plant growth.

Control over lighting, climate, nutrition, and irrigation

Stone wool is the best-growing medium for indoor cultivation environments where the grower controls every aspect of the plants' lighting, nutrition, and irrigation. Stone wool products are designed for precision growing and are fully compatible with the sensors and automation tools utilized for data-driven cultivation strategies, offering unparalleled opportunity for optimal root-zone management.

- Precise control of water content and electrical conductivity, so the grower can steer plant growth.
- Uniform and rapid water distribution throughout the media.
- Holds water and nutrients well

INTRODUCTION TO CROP STEERING

Indoor cannabis cultivation has several benefits, including the ability to control our climate, light intensity, and irrigation, which significantly regulates how our plants grow. Every action we take, from the adjustment of day/night temperature, humidity, light intensity, day length, irrigation volume, and frequency to the timing and way we defoliate our plants, steers the plant's physical and chemical growth response.

So, it's essential to understand how these factors affect a plant's development and how to use them to your advantage. By taking regular measurements of climate and rootzone conditions in combination with tracking plant growth, you can determine how to get the best performance out of your crop.

What is Crop Steering?

Crop steering is a method of managing plant growth by adjusting irrigation and climate to achieve a desired response from the plant. By adjusting environmental and root-zone conditions, growers can steer plant growth vegetatively or generatively. Vegetative and generative steering can be used at every growth stage to keep the plants in balance throughout their lifecycle.

Vegetative Growth is when the plant produces roots, leaves, and shoots for a strong structure.

Generative Growth is the development of fruits and flowers reproductive organs

INTRODUCTION TO CROP STEERING

Crop Steering Using Irrigation

Crop steering can be achieved in part through irrigation. The volume, frequency, and timing of irrigation events are applied to influence the plant's response and steer the growth. Adjusting the irrigation strategy specifically for the environment, genetics, and stage of development will optimize the plant's growth and maximize final product yield and quality.

ROOT ZONE	VEGETATIVE	GENERATIVE
WC	↑	↓
WC DECREASE NIGHT START - STOP TIME	→ ←	→ ←
IRRIGATION FREQUENCY	↑	↓
EC	↓	↑
TEMP SUBSTRATE	↑	↓

This chart shows examples of irrigation steering. These are specific to certain crops and varieties, so in some cases, something that creates a generative action in one type of plant might be a vegetative action in another. So, it's important to test them and measure how the plants react.

If you want your plants to grow more vegetatively, you can implement a vegetative irrigation strategy by:

- Maintaining a higher overall WC in the root zone
- Having smaller dry backs between daytime irrigation events and smaller dry backs from the last irrigation of the day until the first irrigation the following day.
- Using small shot sizes at a high(er) frequency of irrigation
- Lowering the EC at the dripper and in the root zone
- Maintaining higher root zone temperatures

These actions will help the plants grow and recover from transplant faster while maintaining vigor. If you want your plants to be more generative, you might:

- Decrease the overall WC in the root zone
- Increase the dry backs between each irrigation and overnight by delaying the first irrigation of the day and increasing the time between the final irrigation event and the dark period.
- Decrease irrigation frequency while increasing the volume of each shot
- Increase the dripper and rootzone EC
- Maintain lower substrate temps

To figure out how each cultivar would react, it's important to try out these strategies while performing regular crop registration of plant height, node spacing, root development, overall plant development, and health. This will help determine how each cultivar will respond to the irrigation steering.

INTRODUCTION TO CROP STEERING

Crop Steering Using Climate

Like irrigation, climate has a profound effect on how plants grow and can be used as a tool to steer growth. Climate steering techniques shown in the next chart should be tested to see how they affect each individual cultivar. For photoperiodic plants like cannabis, switching the day-night cycle to 12 hours on and 12 hours off is used for induce flower. Just like the change in photoperiod, there are many other climate parameters that can be manipulated to steer the plant's growth vegetatively or generatively.

Maintaining higher ambient temperatures is more vegetative, keeping the plant more active in developing roots, shoots, leaves, and stem, while overall lower temperatures slow growth rates and mimic the natural seasonal changes that the plant might experience towards the end of its lifecycle in many outdoor climates, thus steering it more generatively. That said, even subtle shifts in ambient temperatures can signal plants to shift their energetic expenditures from vegetative production to generative production. Changes in the difference between day and night temperatures can potentially control stretching, with large differences increasing inter-node spacing and small differences decreasing inter-node spacing and creating a more sturdy and compact plant structure.

The speed of the temperature change from day to night/night to day, increasing or decreasing relative humidity, the number of air exchanges in the room, and in greenhouse, the heating temperature used (pipe temperature) also helps to steer the plant. So, it's important to keep track of climate parameters and correlate them to crop development.

CLIMATE	VEGETATIVE	GENERATIVE
TEMPERATURE 24 HOURS	↑	↓
DIFFERENCE TDAY-TNIGHT	↔	⟷
SPEED TEMP CHANGE	↗ ↘	↗ ↘
VAPOR PRESSURE DEFICIT (kPa)	↓	↑
VENTILATION / AIR CHANGE	↓	↑
PIPE TEMPERATURE (IF USING)	↑	↓

This chart shows examples of climate steering. These are specific to certain crops and varieties, so in some cases, something that creates a generative action in one type of plant might be a vegetative action for another type. It is always important to test new climate strategies and measure how the plants' response.

INTRODUCTION TO CROP STEERING

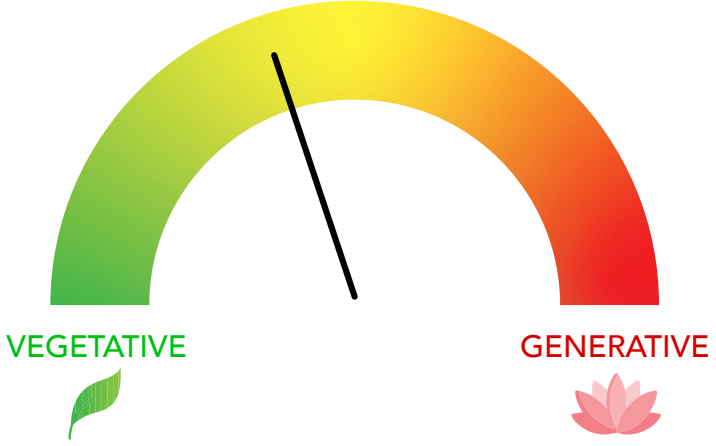
Knowing How and When to Steer Plant Growth

Most indoor gardeners know how much they grow per light and their general potency levels, but knowing how they achieved that result and how to repeat the result time and time again is key.

> "The more you know, the better you grow."

Having a thorough understanding of how your plants develop is a critical step to growing a consistent and quality crop time after time. Notes on how the plants develop and react to climate and irrigation conditions will be critical in helping determine which steering strategies should be deployed in each phase of growth. At every growth stage, you should take detailed notes on the root development speed and root-system architecture, plant posture, plant height, stem diameter, leaf/stem color, and node spacing.

You should also note the time it takes for flower sites to develop as well as how rapidly they fill out. Important rhizosphere conditions to track daily over the life-cycle of the crop include substrate water content, substrate electrical conductivity, substrate temperature, irrigation volume, drip electrical conductivity, drain volume, drain electrical conductivity, and drain pH. All these parameters will help you determine the optimum irrigation and climate strategies to apply to your plants at the right time throughout the crop's lifecycle.



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

PRECISION IRRIGATION

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

PRECISION IRRIGATION

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.

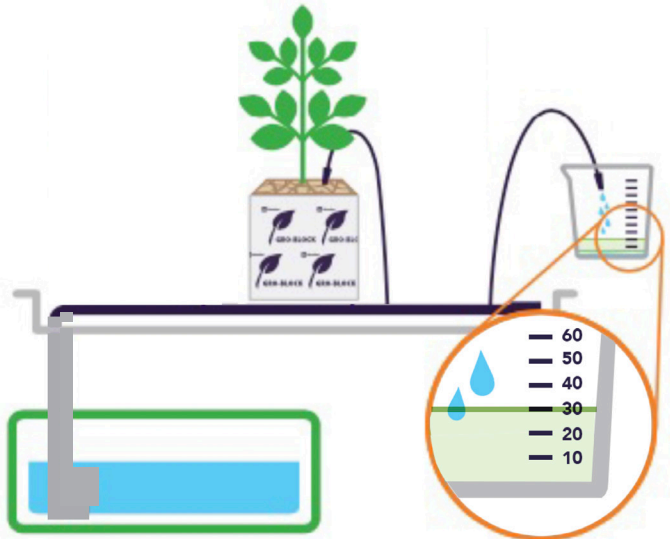
Using a measuring cup, record how long the dripper(s) takes to achieve the 3% to 6% watering volume. That time is your PUMP ON time.

- 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.

PRECISION IRRIGATION

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

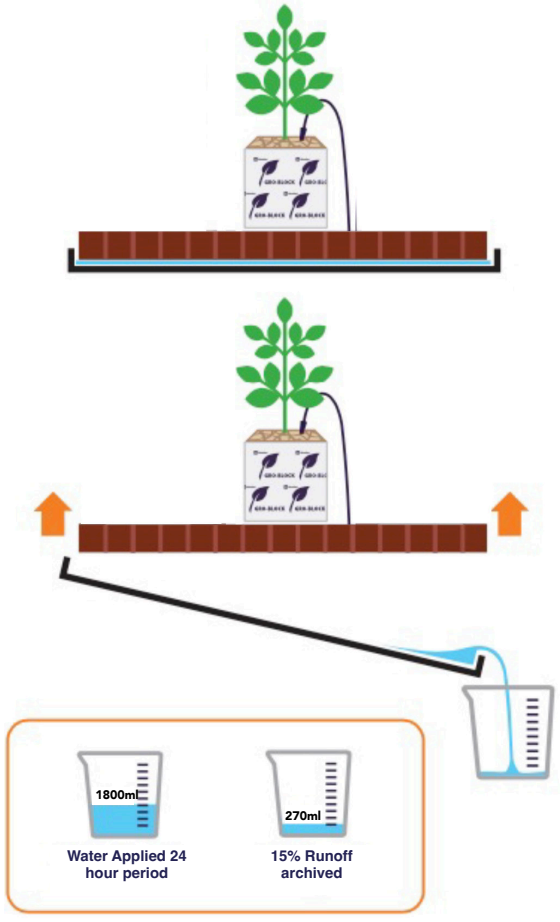
PRECISION IRRIGATION

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

PRECISION IRRIGATION

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.

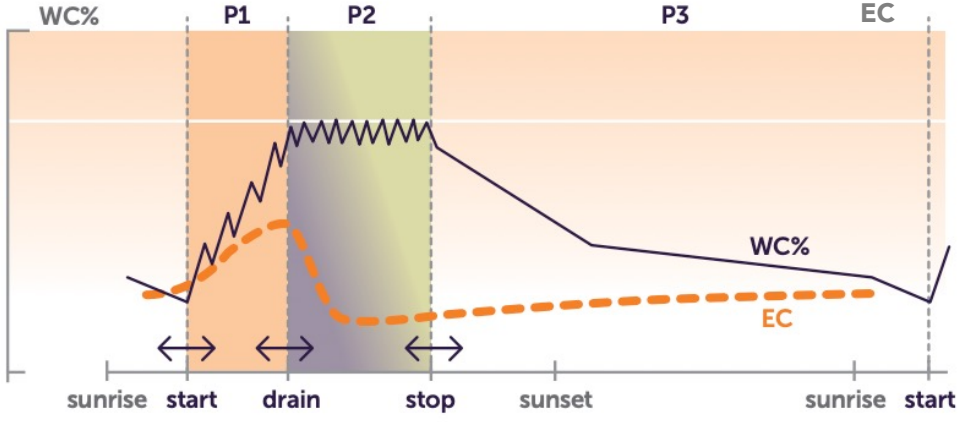
If you have a growing system that captures and stores the entirety of each day's leachate in a holding tank, you can take the daily volume captured and divide by the number of plants. This will be your per-plant runoff average.

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.

PRECISION IRRIGATION

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"

PROPAGATION OF CUTTINGS

Clonal propagation is, at present, an integral part of the cannabis growing process. Propagating uniform, healthy, and vigorous cuttings lays the foundation for consistent and quality harvests. Growers can ensure the production of quality propagules year-round by measuring and adjusting environmental parameters and root zone conditions.

Mother Care

The quality, strength, and establishment time of new cuttings are highly dependent upon the health of the source plant material. The cultivation of hardy, active, and vigorous mother plants plays an integral role in the successful establishment of clones. Proper plant nutrition, ideal climate, and a tailored irrigation strategy, are among the most important components of developing strong mother plants. The nutrient solution applied to mother plants should be maintained at a minimum of 1.5 mS/cm or higher (highly dependent on light intensity) and applied in frequent daily irrigations that achieve drainage fractions of 15% -25%, depending on the age and size of the mother plant.

Mother plants should be pruned and topped early and often to generate large quantities of upright and uniform cuttings. Mother plant canopies should be trained in a balanced manner to maintain an open canopy structure that will produce healthy new shoots without over-stressing the plant. Mother plants should be culled and re-started from fresh cuttings every 3-4 months to avoid proliferation of latent viroids. Retaining individual mother plants for extended periods of time will typically lead to a gradual decrease in cutting quality, vigor, and rooting time.

PROPAGATION OF CUTTINGS

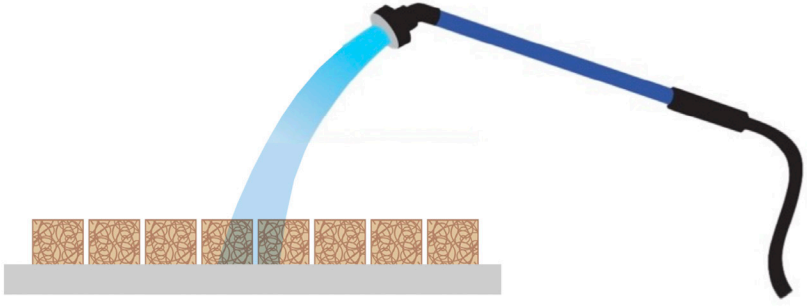
Saturating the Starter Plugs

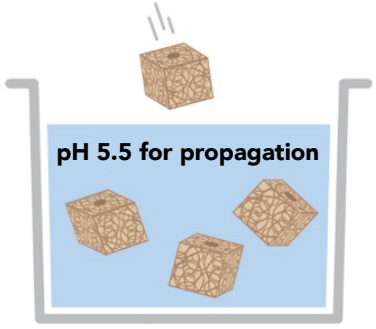
Correct saturation of the growing media sets the stage for proper root development. Because stone wool is an inert and clean substrate, lacking essential nutrients, growers must provide complete and balanced fertilizer to sustain the cuttings as their roots develop. Cuttings will need a near-immediate source of nutrients to maintain existing tissue and growing, so it is imperative that cultivators saturate the plugs with fertilizer initially. A steady nutrient supply becomes especially important once rooting has been initiated. Starter plugs and cubes should be saturated in a nutrient solution of 1.5 mS/cm or higher and 5.5 pH.

The saturation process can performed by soaking plugs and cubes in the solution for several minutes or via overhead saturation through a watering wand fitted with a coarse spray head. If saturating via a watering wand, it is important to apply the solution multiple times to ensure full saturation. Cubes and plugs may not reach full saturation if only one pass is made overhead.

Facilities with wettings lines or irrigation booms can automate the overhead saturation process, but must allow the substrate to pass under the nutrient solution multiple times to ensure full absorption.

After initial saturation, allow excess nutrient solution to drain away. Measure the weight of a few starter plugs or trays to ensure that they are uniform and fully saturated. Now you are ready to take cuttings.

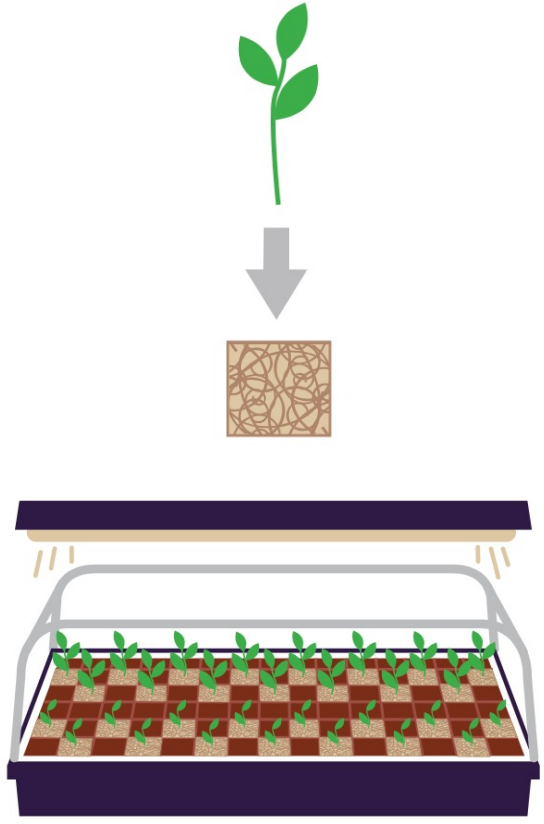




PROPAGATION OF CUTTINGS

Tips for Taking Cuttings

- Select sturdy, straight, and upright shoots, preferably from the top of the plant.
- Select shoots equal in length and diameter to ensure a uniform canopy.
- When applying a rooting solution, avoid excess powder or gel on the stem, as this can potentially cause disease and/or slow down root development.
- Stems should be placed around 1/2in (1cm) into the starter plug. This allows for root initiation in the plug from the top.
- Measure and note the starting weights of completed clone trays to help determine when to apply irrigation.
- Target a humid environment once clones are cut to prevent water loss to the environment through the leaves and maintain turgor in plant cells.
- Moisture loss can be controlled via a humidity dome, or by maintaining a consistent high relative humidity and low vapor pressure deficit throughout the propagation chamber.
- Humidity domes can be gradually vented and eventually removed once root-colonization is underway. This process of hardening off must be monitored closely and performed gradually.
- If maintaining cuttings in a propagation chamber, the relative humidity should be gradually reduced until it matches the relative humidity of the environment that plants will be transferred to in the vegetative stage.
- Acclimating plants to slightly lower humidities as they approach transplant will ensure a seamless transition from the clone stage to the vegetative phase.

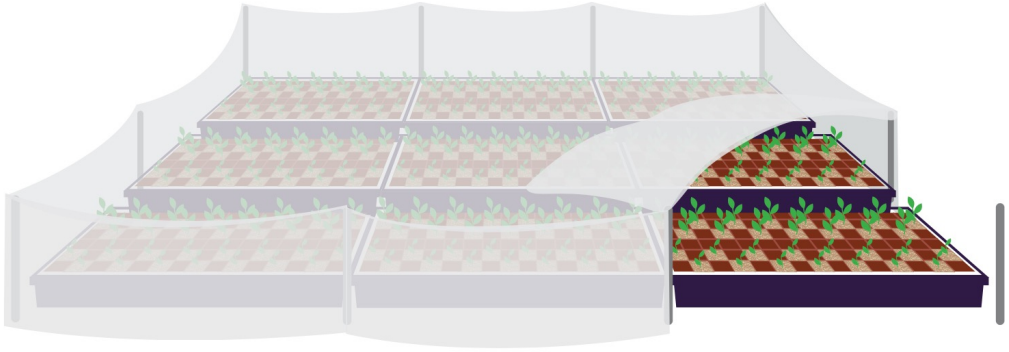


PROPAGATION OF CUTTINGS

Cutting Care

Once cuttings have been placed in starter cubes or plugs, they need to enter an environment that encourages root development. Humidity, temperature, light intensity, and air movement will affect how the cuttings develop, so monitoring and adjusting the climate daily is important. While small propagation domes are a popular choice, they can create a challenging environment for growing quality cuttings on a large scale. High humidity (90%+) and overly wet conditions in the canopy slow root initiation and increase disease, pest, and pathogen pressure.

If using humidity domes, it can be helpful to fill trays at 50% capacity to improve air flow and avoid fungi and bacteria development. For large-scale cutting production, an alternative is to use controlled-environment propagation chambers or large humidity tents to cover batches of cuttings. Chambers and humidity tents allow for better air movement, and the larger air volume creates a more stable climate.



PROPAGATION OF CUTTINGS

Cutting Care

In addition to environmental conditions, irrigation plays a significant role in root development. Overly wet conditions in the root zone can slow root initiation and facilitate the establishment of pathogens. The best way to determine when to irrigate is to:

1. Measure the weight of a tray of dry plugs filled at your desired density. This could be 50 plugs per tray, 39 per tray, 25 per tray etc. This depends on your style of tray and your number of cutting per tray. You will be taking the cumulative weight of the tray, the insert (if using), the dry plugs, but no dome. Notate this weight.

2. Next, fill a tray with your choice of fully saturated blocks or plugs at the same planting density/quantity per tray. Notate the total weight of the system with the plugs at full saturation.

3. Take the second weight (fully saturated plugs + tray + insert) and subtract from it the first weight (dry plugs + tray + insert). This number is your total water weight in the plugs per tray. Post this number in the propagation room.

4. Next prepare and place your cuttings

5. After you have filled the plugs with cuttings, take the final weight of the tray (tray, insert, saturated plugs, and clones) and notate it on the front of tray.

6. Weigh trays daily without their domes and apply irrigations to the cuttings once the total tray weight notated on the front in step 5 has decreased by 40-50% of the water weight calculated in step #3. This formula = (weight from step 5) - (40-50% of water weight from step 3).

7. By following these steps you can target an specific decrease in water content in the root zone and apply irrigation accordingly, no matter how many cuttings you choose to fill each tray with. This is especially important when growing multiple varieties, as they will consume water at different rates.

It is imperative that you do not weigh your trays with standing water in the base. This will skew the weight measurements and lead to incorrect irrigation.

Apply irrigations using a water wand, ebb/flow system, or by manually dipping the trays in a nutrient solution of 1.5 mS/cm or higher, 5.5pH about 1⁄2 to 3⁄4 inch (1 to 2cm) up the side of the starter plugs or cubes. If dipping whole trays into nutrient solution, dispose of the solutions between each tray to avoid cross-contamination. It is important to drain away excess solution because overly wet conditions at this stage will slow growth and increase the likelihood of disease, mold, algae, and pests.

PROPAGATION OF CUTTINGS

In conclusion, applying precision growing techniques can maximize propagule development speed and improve a cutting's final quality. Healthy mother plants that receive proper nutrition, and daily irrigations are the key to healthy cuttings Monitoring and adjusting climate conditions will improve root initiation and prevent the development of plant diseases.

Using a balanced fertilizer solution from the very beginning will ensure the cuttings have the optimal nutrition to develop without deficiencies. Measuring the weight of the starter cubes or plugs throughout the cutting stage will help determine the ideal moment to irrigate.

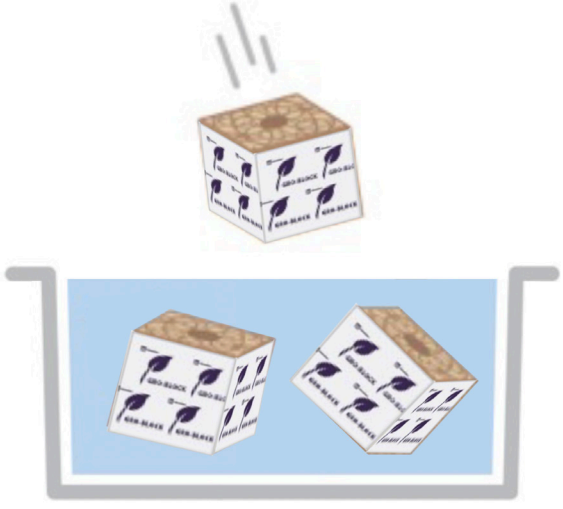
Propagation Table for Indoors: 18-22 hrs light per day

Days	1 - 4	4 - 7	7 - 10	10 - 14
Humidity (%)	80 - 90	75+	70+	70+
Temperature (°F)	75 - 80	75 - 80	75 - 80	75 - 80
Fertilizer (EC)	1.5-2.5 mS/cm	1.5-2.5 mS/cm	1.5-2.5 mS/cm	1.5 -2.5 mS/cm or more

Transplanting

Transplanting from a small block to a large block or slab is an important step in plant development, allowing for further root development and greater plant stability for large fruiting and flowering crops.

Extra care must be taken throughout this process to prevent plant shock, delayed growth, and poor root development. Transplanting from a smaller volume of growing media into a larger one provides better irrigation control and allows the plant to develop the root system required to support maximum flower and fruit development.



Preparation

The initial conditioning of blocks and slabs sets the stage for proper rooting-in. First, the EC of the conditioning nutrient solution should be close to what the plant has already been receiving. Using a similar EC will make it easier for the roots to grow into the new substrate. Ideally, the plant should already be irrigated with a nutrient solution of 1.5-3.0 mS/cm and a pH of 5.5-6.0 before transplanting.

Slabs can be conditioned using a drip irrigation system by filling the bags with the proper nutrient solution until they are full, ballooning, and taught at the seams. Once slabs are fully saturated, drainage slits should be cut at the lowest point of the slab, beneath the seam, closest to the drain. Placement of drain slits is important as it allows for optimal WC and EC management throughout the remainder of the crop cycle.

Large blocks may be conditioned using a watering wand, automated wetting line, or boom system by making several low-speed passes over the top of the blocks with a course spray until full saturation is achieved. Block weights and water contents must be checked to to ensure that full saturation has been consistency achieved.

Blocks can also be conditioned by fully immersing them in a reservoir containing the proper nutrient solution until they sink.

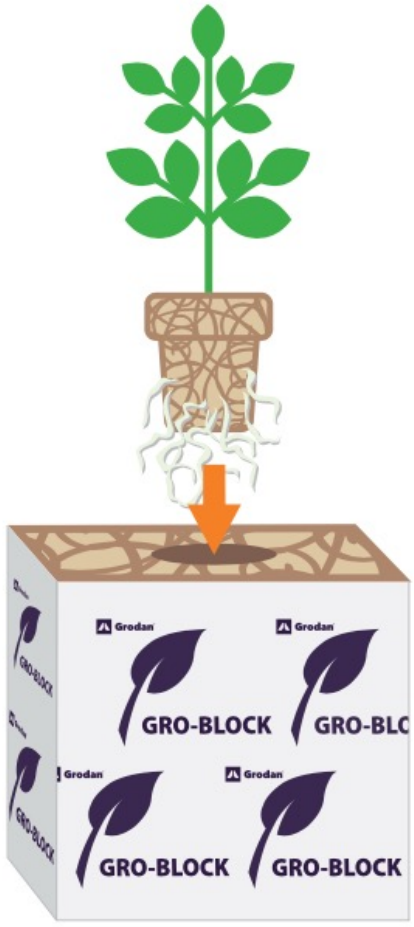
Blocks may also be conditioned using a flood table, as long as the solution can reach the top of the block and be held for a few minutes at that height.

PROPAGATION OF CUTTINGS

Transitioning to Transplant

Plants must be carefully transitioned to new environments to avoid transplant shock that will delay growth, reduce final product yield, and negatively impact quality. Environmental conditions such as temperature, humidity, CO2, light intensity should be maintained as close as possible to what the plant has already been acclimated to for the first 48-96 hours after transplant. After this acclimation period climate and lighting conditions can be intensified and manipulated as needed to target maximum growth and photosynthesis.

When transplanting, the water content (WC) of the transplanted block should around be 70% to 80% at field capacity. Once the transplant is placed on the slab or larger block, a single irrigation event equal to 3% of the total substrate volume should be delivered to even out the WC and EC at the point of interface and encourage water holding in the upper block. Irrigation events should be delivered via pressure-compensating drip stakes with a maximum flow rate of 0.3-0.5 gph.



VWC = ~ 70 - 80%

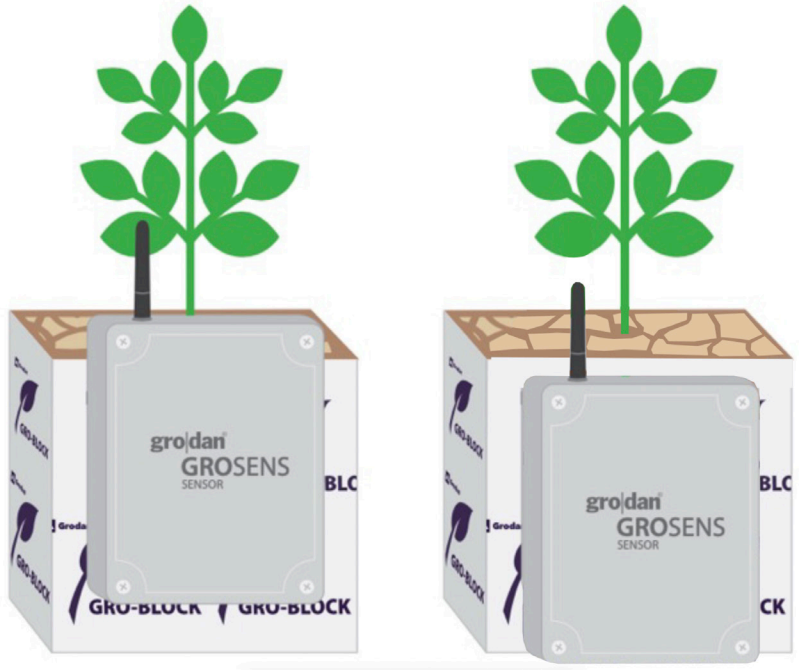
TRANSPLANTING TO BLOCKS

Irrigation Strategy

Irrigation strategy plays an important role in how a plant develops during the transplant phase. By utilizing the Grodan root-zone sensors to accurately measure substrate WC, EC, and temperature, you can determine the optimal irrigation strategy for your crop.

After the initial transplant, the Grodan root-zone sensors should be placed in the top block for the first 24-72 hours. Irrigation volumes of 1-3% should be applied approximately every 1 to 4 hours for the first 24-72 hours hours after transplant to maintain a WC between 60-70% in the top block. With small shots and a rest time between irrigation events, growers can maintain upper block water contents high enough to sustain existing roots until they transition to the lower block or slab, while simultaneously preventing the top block from becoming over-saturated.

24-72 hours after the initial transplant, any night-time irrigations should be eliminated, and the Grodan root-zone sensor should be moved to the bottom slab or block. Day-time water content should be monitored and maintained at 50-75%. Roughly 5-7 days after the initial transplant, the plant should be well rooted into the new substrate, and the desired crop steering irrigation strategy can be implemented for vegetative or generative growth.



Rooting-In Position **Steering Position**

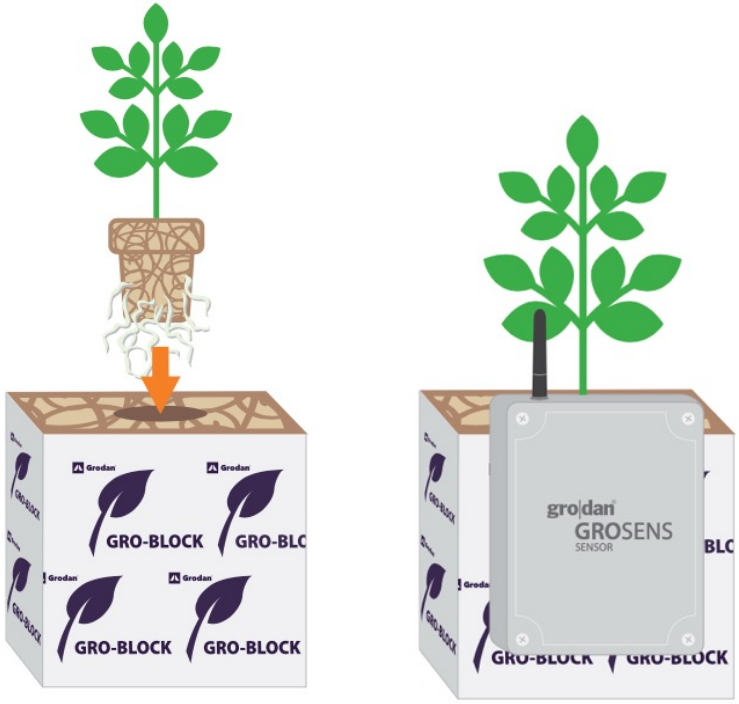
GROWING IN GRODAN PRODUCTS

Best Practices for Hugo Blocks

The Grodan® HugoTM (6" x 6" x 6") Gro-block is a popular choice for growing larger plants. The Hugo block allows a grower to transplant a cutting directly into a one-touch block configuration that will carry plant growth through harvest.

Created as a slab alternative for home growers, this block has become popular amongst commercial and hobby growers alike.

Employing the best practices outlined below will allow you to maximize the performance of your Hugo blocks quickly and efficiently with minimal input.



Start with a healthy, vigorous cutting that has a well-developed root system. Weak or stressed cuttings with under-developed root systems are not ideal candidates for transplant into Hugo blocks due to the large volume of media the roots must colonize.

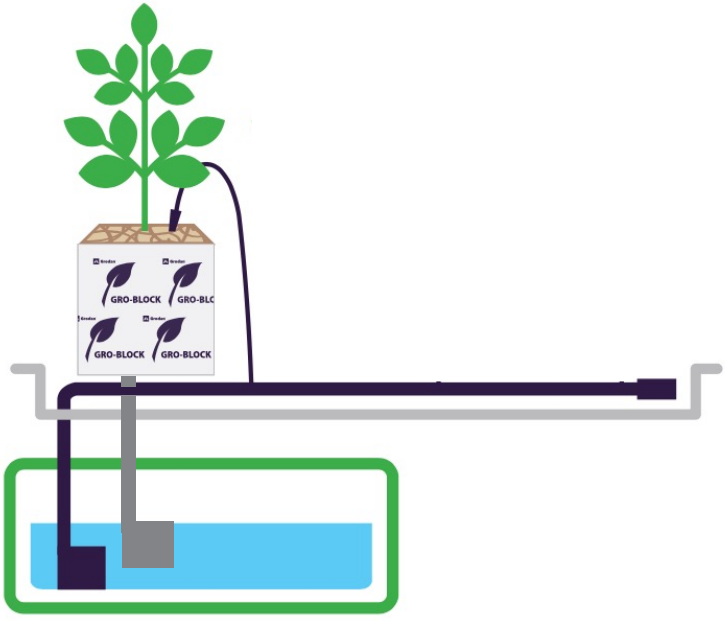
Select healthy and uniform cuttings with roots present throughout the starter plug. These cuttings should already be accustomed to daily irrigations with a well-balanced nutrient solution with a minimum EC of 1.5 mS.cm and a pH of 5.5 - 6.5. Deliver multiple small irrigation events daily until roots colonize the Hugo block.

GROWING IN GRODAN PRODUCTS

Because rock wool is completely inert, nutrients are needed from the onset to fuel encourage plant growth. Condition the Hugo with a similar strength nutrient solution you were applying to the cuttings prior to transplant. To perform the initial saturation submerge the blocks in the nutrient solution for a few minutes. The blocks should sink. Alternatively, you can perform an overhead saturation by making several applications with the nutrient solution via a watering wand fitted with a course spray head to wet the media (multiple times) until fully saturated. After initial saturation, allow the excess nutrient solution to drain away. Check the weights of the blocks to ensure they are uniformly saturated. A Hugo Gro-block should weigh a minimum of 2650 grams. If the blocks you sample do not weigh 2650 grams or more, you must continue to make overhead passes with the watering wand. Insert your rooted cutting into the Hugo block and apply an initial irrigation within the first 24 hours using the same nutrient solution used to condition the block.

After the initial transplant, measure the weight of the block to determine when to apply the next irrigation. Wait to irrigate until the block weighs 20%-30% less than its initial weight at first saturation.

If using Grodan root-zone sensors to measure volumetric water content, you should wait until WC is about 60%-65% before implementing the desired irrigation strategy. Work to apply 1 or more irrigations per day (1-3% shot sizes) for the first 1 to 2 weeks or until rooting is evident. This will steer the plant vegetatively and ensure the cutting's roots are incentivized to establish in the top few inches of the block.



Runoff volume ÷ Total Daily Gift/Plant = % Drain Fraction

GROWING IN GRODAN PRODUCTS

Once rooting-in is complete, growers should use their drip irrigation systems to apply watering events at roughly 3% to 6% of the total volume of the growing media. This is about 100 mL to 200 mL per irrigation event for a Hugo. If hand watering, you can apply larger volumes of 200 mL to 500 mL per irrigation event, but it is most optimal to reduce the flow rate of the wand to a low level.

Throughout the plant's life cycle, the irrigation strategy must be adjusted based on genetic variety, growth stage, environment, and root zone conditions. During early vegetative growth, growers should aim to apply smaller volumes of water (3%) at greater frequencies to encourage vigorous growth of leaves, stems, and structural tissue.

As the plant progresses towards flower and fruit production, growers should begin generative steering by applying larger volumes of water (6%) at lower frequencies. Balancing vegetative and generative growth in the Hugo blocks will allow you to maximize your plant's potential productivity and quality. For more detailed information on crop steering, refer to Grodan's brochure, Basics of Precision Growing.

Monitoring the block water content daily will help you determine when irrigations should be applied. During the vegetative phase you should aim to achieve a 5-15% runoff fraction of your total daily water gift. During the flowering phase you should aim to achieve a 15-25% runoff fraction of your total daily water gift. It is important not to over-saturate the block after the initial transplant.

Over-saturating the root zone will lead to algae establishment, nutrient imbalance, slow plant growth, and increased pest and disease pressure. Over application of water and nutrients also harms the environment and wastes valuable resources. Conversely, it is important not to allow the block to dry back below ~25-30% volumetric water content.

Drying back too aggressively will diminish root development, slow growth, and create inconsistencies between plants in different blocks. Dry backs that push the block below 25-30% VWC will also make it harder to re-saturate the media, creating dry spots in the blocks.

GROWING IN GRODAN PRODUCTS

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Taking regular measurements of block weights will help you determine when irrigations should be applied. Toward the third week after transplanting, you will want to achieve 10% to 20% runoff of the total daily water gift applied to each plant. It is important not to over-saturate the block after the initial transplant.

Over-saturating the root zone will lead to algae establishment, slow plant growth, and increased pest and disease pressure. Over application of water and nutrients also harms the environment and wastes valuable resources. Conversely, it is important not to allow the block to dry back below 50% of its weight at initial full saturation.

Drying back too aggressively will diminish root development, slow growth, and create inconsistencies between plants in different blocks. Dry backs beyond 50% of the initial saturation WC will also make it harder to re-saturate the media, creating dry spots in the blocks.

GROWING IN GRODAN PRODUCTS

Irrigating Large Blocks

Ideally, a pressure-compensated, low flow (0.3-0.5 gph max) drip irrigation system should be used to deliver precise amounts of nutrient solution to each plant.

For large blocks like the Grodan Hugo, 2 drip stakes per block should be used. Most drip stakes should be placed only about 1-1.5" inches into the top of the block on diagonals, about halfway between the plant stem and corner of the block. Inserting drip stakes too far into the blocks can often result in water only being delivered to the lower portion of the substrate. Always check with your drip stake manufacturer to determine what depth is ideal.

If hand watering without root-zone sensors during flower, the timing of the first irrigation is important to ensure the plant does not dry out during the middle of the day. Try to apply an irrigation roughly 2 hours after the lights come on to ensure the plants have adequate access to water when they are transpiring. If possible, apply a second irrigation around mid-day, and a third roughly 2 hours before lights-off. It is important to ensure that you achieve 10% to 25% runoff of your total daily water gift. This ensures proper re-saturation of the blocks and substantial nutrient refreshment.

The use of flood systems can be challenging when using such a tall block. This method of irrigating necessitates a deep table capable of flooding up to 1 inch from the top of the block to avoid late-stage salt build-up. If you are unable to flood the block that high, it is recommended to hand water the top of the block at least once a week with the same solution used to

GROWING IN GRODAN PRODUCTS

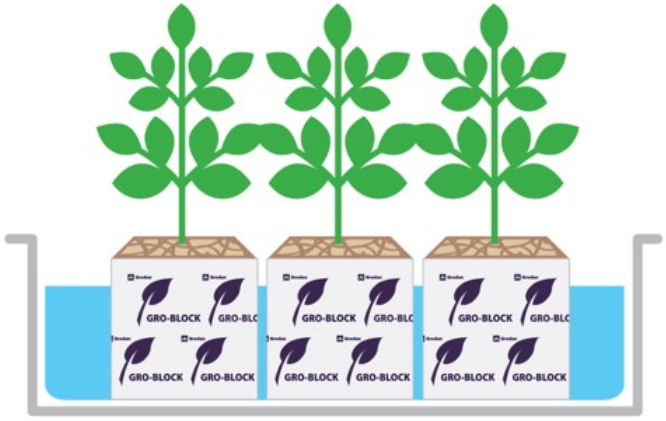
Irrigating Large Blocks

The Grodan Hugo Block is an excellent choice for growers looking for a one-touch product that allows them to grow from the vegetative stage through harvest without having to root into another block or slab.

Using a well-rooted cutting, the proper nutrient concentration, and a controlled irrigation strategy will ensure healthy plant growth. Through daily monitoring of block water content, you can determine the optimal times to irrigate the plants.

Grodan partnered with the Wageningen University and Research as well as top growers from all over North America to determine the optimal stone wool substrate and irrigation strategies for indoor and greenhouse specialty crops. This scientific rigor results in Grodan Gro-Block Improved with our Advanced Hydrophilic Binder and Wetting Agent.

These cutting-edge blocks have the optimal fiber structure and physical properties for plant uniformity, homogeneous Water Content (WC) throughout the height of the block, and thus, better nutrient distribution throughout the entirety of the substrate. More uniform water distribution along the vertical gradient forms the basis for a well-defined root system capable of to producing robust and vigorous crops. These benefits translate to higher yields, improved quality, less water and nutrient usage, and reduced crop sensitivity to diseases. The Gro-Block Improved line offers the greatest steering capabilities yet.



GRODAN AOK, MACRO PLUGS AND TRAYS

Grodan plugs are known for their uniformity and reliable consistency, providing predictable and homogeneous propagation and a high success rate. Every plug offers uniform density, firmness, and fiber structure. The shape and firmness of the plugs make processing, whether manual or automated, significantly easier. The plug consistency allows for a balanced distribution of water and nutrients, which benefits rooting and initial crop development.

Application

- Suitable for cloning and propagation from seed
- Available in different sizes, 36x36x40mm (1.5 inch plug) and 50x50x40mm (2 inch plug)
- Also available as plugs pre-loaded and separated into plastic trays

1. Uniform root emergence and plant quality

Grodan plugs have a highly uniform fiber structure and firmness, guaranteeing excellent distribution of water and nutrients and promoting fast, consistent germination and root development. With these high-quality plugs, differences within and between batches of plants are smaller than ever. More uniform seedlings result in accelerated plant development.

2. Improved air/water ratio

The unique fiber structure ensures an optimum air/water ratio and exceptional water and nutrient distribution. Thanks to the fast absorption of water, the plug's fibers become completely saturated when irrigated for the first time. The large pores allow for a permanent supply of fresh air and promote fast root development throughout the entire plug.

3. Good firmness and stability

Grodan plugs are firm, maintain their shape during handling, and constitute a stable basis during rooting and seedling initial development. They can be handled easily by hand during transplanting. This durability minimizes the risk of damage to the roots, enhancing uniformity and limiting losses.

4. Efficient use of water and nutrients

The plugs' steerability allows for greater water content control, and the uniform fiber structure ensures consistent distribution and fast absorption when irrigating. That means less watering for you, and more efficient use of the water and nutrients, resulting in a more sustainable propagation process and lower costs.

GRODAN AOK, MACRO PLUGS AND TRAYS

	Item	Description	Dimensions	Quantity	Options
	**AO Plugs**	• Square size plugs connected to each other at the top of the plug forming a sheet fitting a 10/20 tray • Plugs have a tapered bottom, for improved transplanting • Ideal plug for cannabis crops in hydroponic systems • Great to use for germinating seeds	• 1" AO Plugs (1"x1"x1.6") • 1.5" AO Plugs (1.4"x1.4"x1.6") • 2" AO Plugs (2"x2"x1.6")	• 6000 plugs/carton • 2940 plugs / carton • 1500 plugs/carton	Available in wrapped individual sheets or 30 sheets unwrapped in carton
	**Macro Plugs**	• Loose, round plugs that fit perfectly into the Grodan Gro-Block hole • Slit to insert clones • Ideal plug for cannabis clones • Same great benefits as the AOK plugs, only these plugs are loose and pre-filled into a tray	• Macroplug 1.5"round, 1.57"high	• 2000 plugs loose / carton • 1750 plugs / carton, 35 per box	
	**AO Pre-filled Tray**	• Same great benefits as the AO plugs, only these AOs are pre-cut and pre-filled into an insert tray	• 1.5" AO Plugs (1.4"x1.4"x1.9") - pre-cut/pre-fill insert of 50	• 30 inserts/ carton	
	**Gro-smart Plug Tray**	• Double-sided tray. Use the 78-cell side for 1.5" Aos and Macro plugs, use the mesh side for mini-blocks and gro-blocks. Place in 10"x20" tray	• Gro-Smart Tray has78 Cells for 1.5" AOs	• 5 trays / carton	
	**AO Plugs Loose**	• Our 1.5" AO Plugs, pre-cut and loose in carton	• 1.5" AO Plugs (1.4"x1.4"x1.6") - Pre-cut	• 2310 plugs, bulk in carton	
	**Cress Plate**	• The Grodan Cress Plate is our thinnest stone wool product available at just 0.3 inches. It's ideal for micropropagation and microgreens	• 495mmx240mmx-10mm; bare	• 95 plates / carton	

GRODAN GRO-BLOCK IMPROVED

Grodan partnered with the Wageningen University and Research Facility and top growers from all over North America to determine the optimal stone wool substrate and irrigation strategies for indoor and greenhouse specialty crops. This scientific rigor results in Grodan Gro-Blocks Improved with our Advanced Wetting Agent.

These leading-edge blocks have the optimal fiber structure and physical properties for crop uniformity, more even Water Content (WC) and Electrical Conductivity (EC) distribution throughout the entire block, and the greatest steering capabilities available. Water distribution is more uniform throughout the entire block, which is the basis for a well-defined root system with higher water and nutrient uptake capabilities to produce robust and vigorous crops. These benefits translate to higher yields, improved quality, less water, and nutrient usage, and reduced sensitivity of the crop to diseases.

GRODAN GRO-BLOCK IMPROVED

Key features

New and improved wetting agents and hydrophilic binder technology greatly enhances the water characteristics of Grodan Gro-Blocks Improved, giving even better water distribution over the height of the block. This results in greater plant development and steerability and more efficient use of water and nutrients. The optimized wool density allows for faster rooting-in and nutrient solution refreshment, all while the Gro-Block Improved maintains its structure, firmness, and rigidity throughout the growing process.

Key benefits

Excellent control

The higher field capacity upon initial saturation, and improved water distribution throughout the height of the block results in improved root growth, enhanced water holding capabilities, and more stable EC behavior in the root zone. This makes it easier than ever before to control your crop, with even fewer inputs, from propagation through to harvest.

Greater steering possibilities

The advanced technology used in Grodan Gro-Blocks Improved, combined with the uniformity of WC and EC throughout the entire block, provides better vegetative and generative steering. WC and EC can be adjusted more rapidly and efficiently with less leachate required to reduce and stabilize substrate EC. This offer the grower a nimble, flexible substrate that can be steered generatively and vegetatively with a high degree of efficiency.

Roots making better use of the entire substrate volume

Both the rooting-in and rooting-through growth phase has improved thanks to the Gro-Block Improved technology. Trials have repeatedly shown that the initial rooting-in phase in Grodan Gro-Block Improved occurs several days faster, speeding up the vegetative phase and time to harvest. The more effective rooting-through of the entire substrate volume leads to a visible increase of roots and, thus, better water and nutrient uptake. Naturally, this results in enhanced plant health and productivity from start to finish.

Stronger, more vigorous plant development

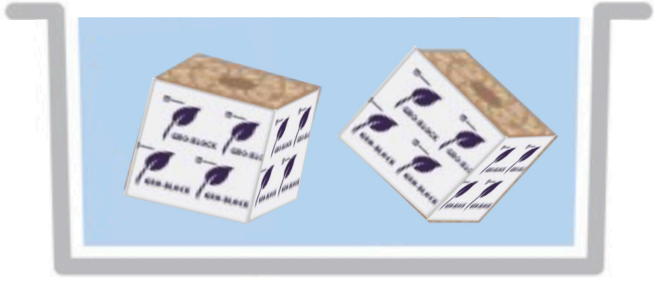
Due to the better-developed root system in Grodan Gro-Block Improved, the trial results showed increased plant growth, especially during the vegetative phase, in the form of larger plant size, greater stem thickness, and bigger leaves. Ultimately, this can lead to higher yield, while at the same time, the stronger, more vigorous plants show increased resistance to disease.

Guides and Tips For Growing In Stone Wool

Full and thorough initial saturation is recommended for optimal performance of the GRO-blocks and is essential for successful cultivation. It is the basis for root development and growth of your crop.

1. Wetting blocks by submersion

- Prepare a nutrient solution with a minimum EC of 1.5 mS/cm, pH adjusted to 5.5 - 6.5.
- Fill a reservoir with the nutrient solution to ensure the solution fully covers the blocks. Blocks should essential be "swimming" in solution.
- Place blocks into the reservoir and allow them to submerge in the solution. Approximate sinking times are listed in the chart.
- Keep the blocks submerged until the bubbling stops.
- Remove blocks from the solution and place them on the growing bench or gutter with the grooves pointing in the direction of the drain/slope. This enables excess nutrient solution to drain from the block on flat surface that do not have drainage grooves.



2. Checking the water absorption in the blocks

- It is important to ensure full saturation of Grodan products to prevent dry areas that might affect root development. To properly assess saturation, we advise checking the wet weight of the blocks.
- You must weigh several blocks in different parts of your bench and facility to ensure there are no outliers.
- Compare the wet weight after saturation to the chart below, noting that these are guidelines.
- Use the recommended target weight per product as indicated in the table.

Description	Dimensions (WxHxL) in cm	WC advice in grams (minimum)
Grodan GRO-BLOCK Improved Mini-Block 1.5"	4*4*4	57
Grodan GRO-BLOCK Improved Mini-Block 2"	5*5*5	110
Grodan GRO-BLOCK Improved GR4 Small 3"	7.5*7.5*6.5	275
Grodan GRO-BLOCK Improved GR5.6 Large 3"	7.5*7.5*10	500
Grodan GRO-BLOCK Improved GR6.5 Small 4"	10*10*6.5	550
Grodan GRO-BLOCK Improved GR7.5 Medium 4"	10*10*7.5	600
Grodan GRO-BLOCK Improved GR10 Large 4"	10*10*10	800
Grodan GRO-BLOCK Improved GR22.5 Jumbo	15*15*10	1800
Grodan GRO-BLOCK Improved GR32 Hugo	15*15*14.2	2650
Grodan GRO-BLOCK Improved GR40 Uni-Block	20*20*10	3200
Grodan GRO_BLOCK Improved Big Mama	20.3 x 20.3 x 20.3	6400

GRODAN IMPROVED GRO-SLAB AND UNI-SLAB

Grodan Improved Gro-Slabs and Uni-Slabs offer a wide control range to steer your crop using precision irrigation strategies. Featuring the Advanced Hydrophilic Binder and Wetting Agent, Gro-Slabs offer more uniform WC and EC distribution throughout each slab. Fast rooting and vigorous growth throughout the entire growing cycle, improves cannabis plant health, increases crop resilience, and delivers higher yields. The improved slab density and physical properties guarantee rapid re-saturation within a wide water content steering range.

Grodan Improved Gro-Slabs are the ideal solution for growers seeking a reliable substrate that facilitates easy irrigation and leaves nothing to chance throughout the cultivation cycle.

Product Features

- Single-plant and multi-plant slab options
- Vertical fiber orientation
- Inert hydrophilic binder fiber technology
- High re-saturation capacity, even after large dry-backs
- Uniform water distribution throughout the Grodan Improved Uni-Slabs

Application

Grodan Improved Gro-Slabs and Uni-Slabs are extremely versatile and lend themselves perfectly to the cultivation of cannabis. Blooming plants will show fast growth, uniform stem development, and inflorescence early setting.

GRODAN IMPROVED GRO-SLAB AND UNI-SLAB

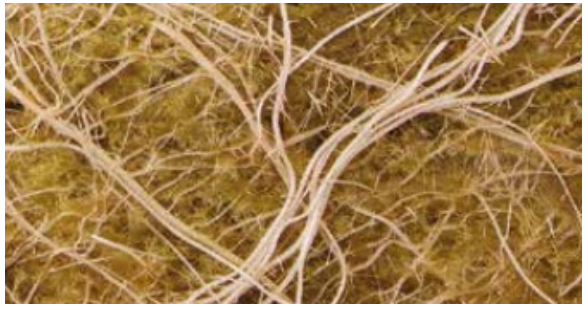
Key benefits

Retains sufficient water

The Advanced Hydrophilic Binder and Wetting Agent in Grodan Improved Gro-Slabs results in more uniform water distribution throughout the entire slab. As the slab tends to retains sufficient moisture, the risk of plants drying out is minimized. Gro-Slabs' improved capillary action also ensures moisture is retained more evenly throughout the slab.

Easy irrigation

The properties of Grodan Improved Gro-Slabs enable a multi-faceted irrigation strategy by allowing growers to vary the volumetric water content within a safe range of 45% and 75% (day level). If insufficient water has been supplied, the slab can be re-saturated quickly at any moment. And if too much water has been given, the slab's properties will ensure that excess water is drained away efficiently to prevent the WC from rising too high.

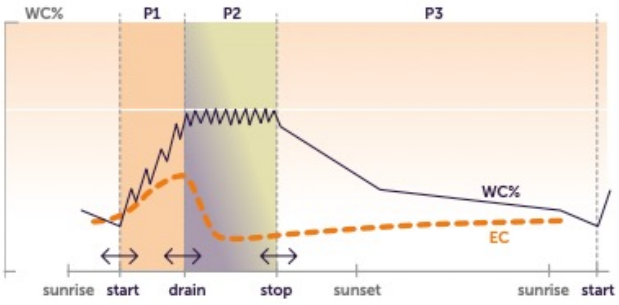


Fast, uniform crop development

The vertical, fiber structure of Grodan Improved Gro-Slabs enables roots to penetrate the slab easily, resulting in fast root development and lower energetic expenditure to initiate rooting. Homogenous development in the root zone guarantees vigorous and uniform crop growth resulting in stronger, healthier plants. In addition, the firmness of the slab structure guarantees physical plant stability right up until the end of the cultivation cycle, even with large and tall plants.

GRODAN IMPROVED GRO-SLAB AND UNI-SLAB

Key benefits



Excellent Steerability

The ability of Grodan Improved to distribute water and fertilizer evenly throughout the slab volume creates optimal steering capabilities. Growers have more control of the plant's balance throughout the crop cycle, facilitating crop steering with precise adjustments of the WC and EC in the root zone.

Sustainable water and nutrient use

Stone wool fibers do not bind nutrients and do not require flushing or buffering at the start of the cultivation cycle. An initial targeted application of recyclable water and nutrients enables sustainable water and fertilizer use. Together with other management strategies, including Grodan sensors and e-Gro software tools, Grodan Improved Gro-Slabs facilitate optimum crop steering for healthier plants and greater yields.

WETTING INSTRUCTIONS FOR GRODAN IMPROVED GRO-SLABS AND UNI-SLABS

Full initial saturation is required for the successful performance of the Grodan Improved Gro-Slabs and Uni-Slabs. It is the basis for optimal root development and growth of your crop.

Grodan Improved Gro-Slab, without pre-cut plant holes

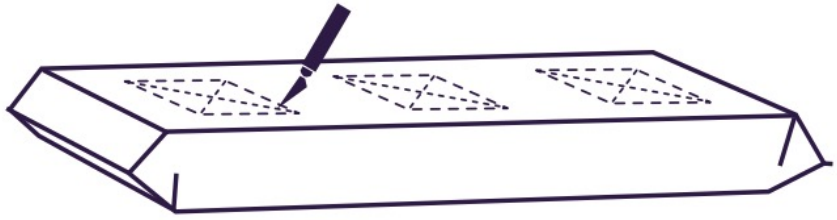
1. Using a sharp instrument, on the top side of the foil only, cut your "X"s the same size as the Grodan Improved Gro-Blocks that will be transplanted. Try not to cut the stone wool in this process. Alternatively, you can complete squares of the same dimensions as the Gro-Block that will transplanted. Most commonly, growers utilize 3-plants per slab, but 2 plans per slab can also be used.

2. Insert 1-2 drip stakes into each plant-hole. Do not push drip stakes all the way through the slab. Fill the Grodan Improved Gro-Slab with your desired nutrient solution adjusted to a pH of 5.5-6.5 by turning on the drip irrigation. Allow the drip stakes to fill the bags until they are completely full, ballooning, and taught at the seams. Alternatively, you can use a hose and watering wand to fill the slabs as well. If using a watering wand, ensure you have filled the bags with enough nutrient solution to make them taught at the seams, nearly overflowing. Once bags are completely full, let soak for a minimum of 30 minutes.

3. Cut a drainage slit across the lowest point of the slab, beneath the seam, closest to the drain. If using a flat table, cut one (1) slit in each of the four corners of the Gro-Slab. Make sure slits go fully to the base of the slab to allow excess water to drain correctly.

4. Place a well-rooted Grodan Improved Gro-Block onto the plant holes you cut so that the base of the block is in direct contact with the top of the slab. Press down very gently to ensure contact.

5. For best results, irrigate using 0.3-0.5 gph emitters with 1-2 drip stakes inserted into the top of each the block.



WETTING INSTRUCTIONS FOR GRODAN IMPROVED GRO-SLABS AND UNI-SLABS

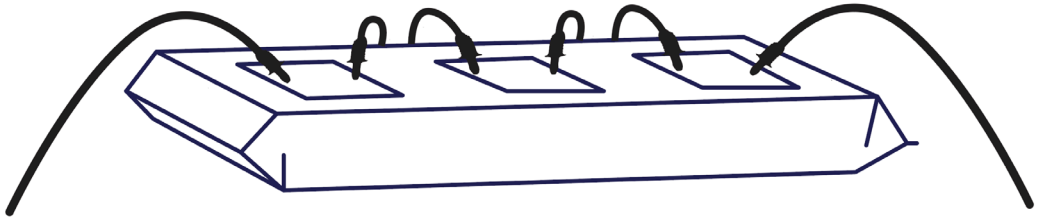
Grodan Improved Gro-Slab with pre-cut holes

1. Insert 1-2 drip stakes into each plant-hole. Do not push drip stakes all the way through the slab. Fill the Grodan Improved Gro-Slab with your desired nutrient solution adjusted to a pH of 5.5-6.5 by turning on the drip irrigation. Allow the drip stakes to fill the bags until they are completely full, ballooning, and taught at the seams. Alternatively, you can use a hose and watering wand to fill the slabs as well. If using a watering wand, ensure you have filled the bags with enough nutrient solution to make them taught at the seams, nearly overflowing. Once bags are completely full, let soak for a minimum of 30 minutes.

2. Cut a drainage slit across the lowest point of the slab, beneath the seam, closest to the drain. If using a flat table, cut one (1) slit in each of the four corners of the Gro-Slab. Make sure slits go fully to the base of the slab to allow excess water to drain correctly.

3. Place a well-rooted Grodan Improved Gro-Block onto the plant hole(s) you cut so that the base of the block is in direct contact with the top of the slab. Press down very gently to ensure contact.

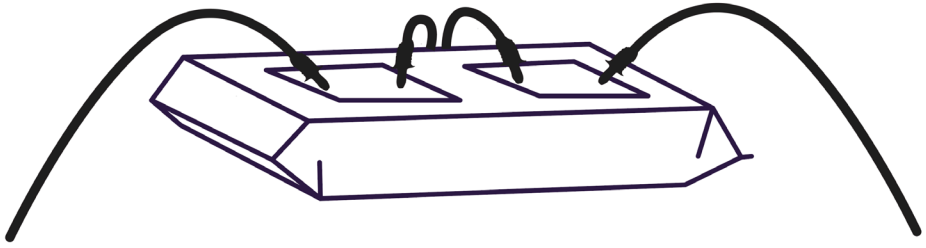
4. For best results, irrigate using 0.3-0.5 gph emitters with 1-2 drip stakes inserted into the top of each the block.



WETTING INSTRUCTIONS FOR GRODAN IMPROVED GRO-SLABS AND UNI-SLABS

Grodan Improved Uni-Slab

1. Using a sharp instrument, on the top side of the foil only, in the center of the Uni-Slab, cut an “X” the same size as the Grodan Improved Gro-Block that will be transplanted. Try not to cut the stone wool in this process. Alternatively, you can cut a full square of the same dimensions as the Gro-Block that will transplanted.
2. Insert 2 drip stakes into the plant hole you cut. Do not push drip stakes all the way through the slab. Fill the Grodan Improved Gro-Slab with your desired nutrient solution adjusted to a pH of 5.5-6.5 by turning on the drip irrigation. Allow the drip stakes to fill the bags until they are completely full, ballooning, and taught at the seams. Alternatively, you can use a hose and watering wand to fill the slabs as well. If using a watering wand, ensure you have filled the bags with enough nutrient solution to make them taught at the seams, nearly overflowing. Once bags are completely full, let soak for a minimum of 30 minutes.
3. Cut a drainage slit across the lowest point of the slab, beneath the seam, closest to the drain. You should be making your drainage slit along the shorter end of the slab. If using a flat table, cut one (1) slit in each of the four corners of the Uni-Slab. Make sure slits go fully to the base of the slab to allow excess water to drain correctly.
4. Place a well-rooted Grodan Improved Gro-Block onto the plant hole you cut so that the base of the block is in direct contact with the top of the slab. Press down very gently to ensure contact.
5. For best results, irrigate using 0.3-0.5 gph emitters with 2 drip stakes inserted into the top of each the block.



E-GRO

Replace your tedious spreadsheets with the power of e-Gro, the sensor and data-insights platform based on Grodan's 50+ years of precision growing experience. e-Gro helps you optimize your entire growing facility from propagation through processing.

e-Gro gives you the power to view substrate and climate sensor data from all grow rooms in your facility as well as key key performance indicators such as overnight dry-back, dry-back since last irritation, average ambient temperatures, and average relative humidity. You can track every batch from mother plant to harvest. You can even create custom alerts to notify you the moment a root-zone or climate parameter falls outside of your preferred range.

Powerful Algorithms Analyze All Data Sources

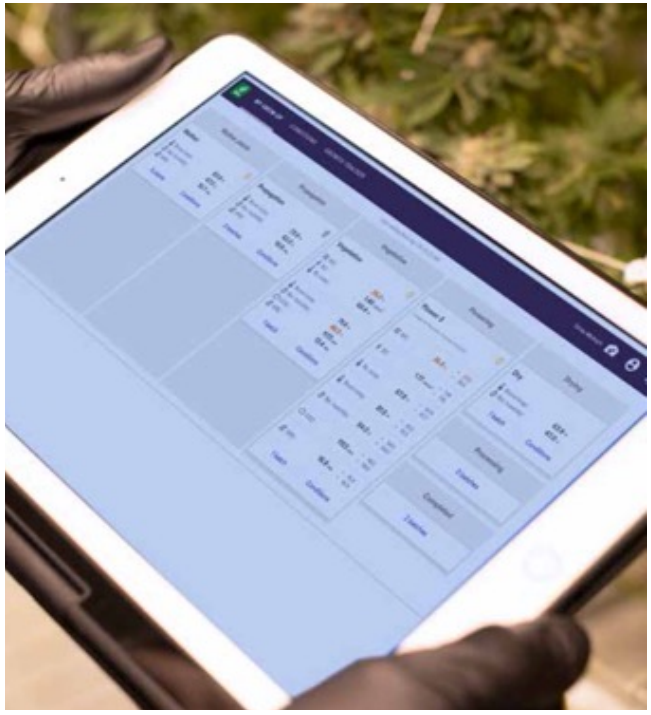
e-Gro collects data and uses powerful substrate algorithms based on Grodan's 50+ years of expertise in measuring root-zone WC, EC, and temperature, delivering a complete overview of the cultivation process. These tailored insights allow growers to view and compare batch performance, receive automatic calculations, set alerts, compare key growing info, tag colleagues, and share data by adding notes and pictures.

E-GRO

My Grow Op

My Grow Op module provides a complete high-level dashboard where you can check the status of your entire growing facility, from mother plants to processing, accessible 24/7.

In My Grow Op, you can view important overviews of your facility's climate and root-zone information per room.



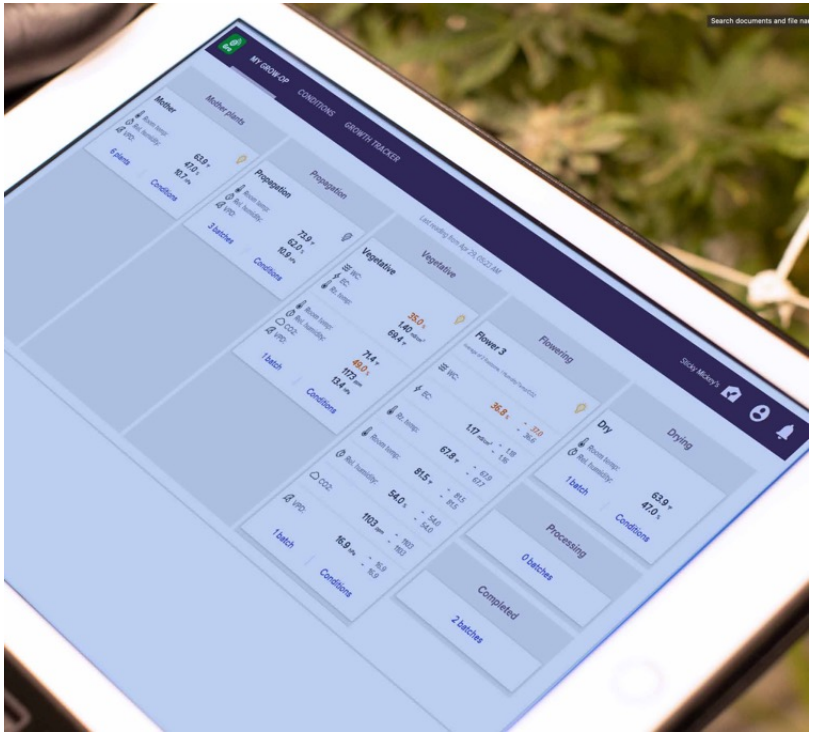
- WC
- EC
- Substrate Temperature
- Room Temperature
- Relative Humidity
- CO2
- VPD
- Number of Batches
- Lights on /off

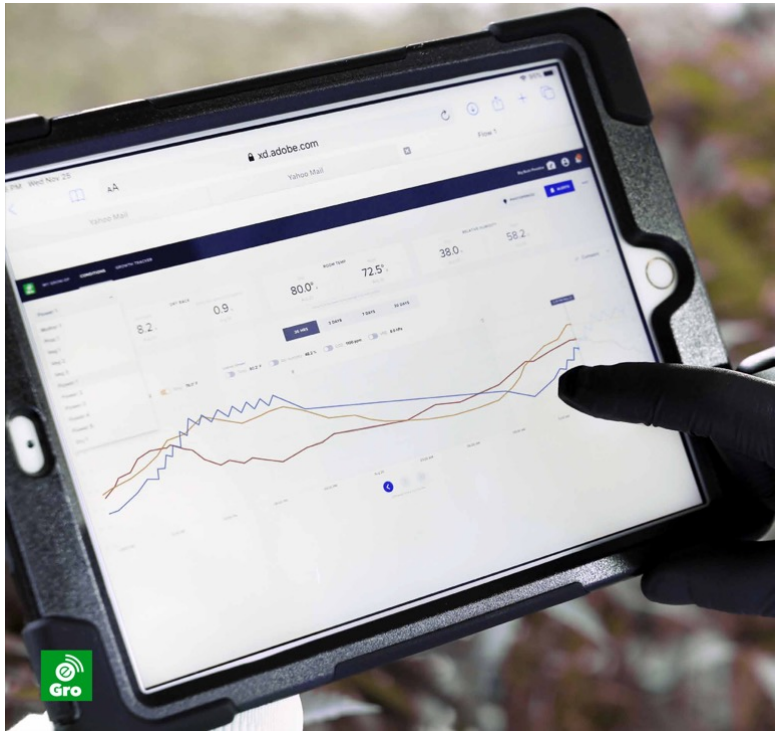
Instant alerts notify you of any parameters falling out of range, so you can better control your growing strategy.

E-GRO

Benefits of My Grow Op

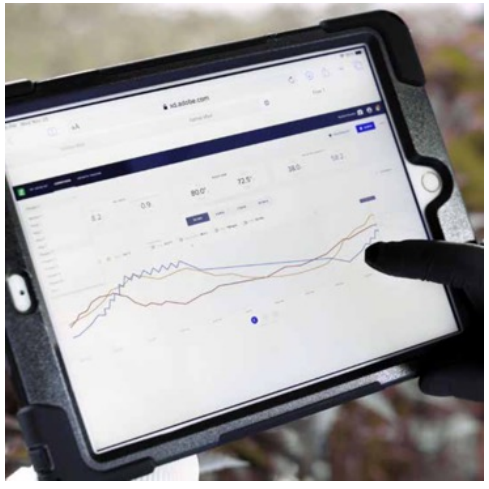
Integrating the feedback from both root-zone and climate sensors allows you to identify potential issues and better steer your crops based on the needs of each cultivar.





E-GRO

Conditions Module



The Conditions Module gives you the power to overlay and analyze root-zone and climate data to optimize your irrigation and crop steering strategies. Visualizing key climate parameters on the same graph as substrate data, allows growers to gain greater insights into how their climate strategies drive root-zone dynamics and vice versa.

This module helps you minimize inputs costs, while maximizing yield and crop performance.

Rootzone data

Get real-time data from Grodan root-zone sensors, including VWC (%), EC (mS/cm), and temperature (° C or F).

Climate data

Get real-time data from the Grodan climate sensor, including relative humidity, ambient temperature, room VPD, and CO2 concentration.

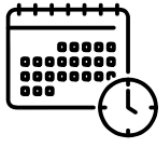
E-GRO

Conditions Module Personalized Viewing

e-Gro lets each user see the graphs and data that are the most important to them and in the format they prefer, so decisions can be made quickly and efficiently.

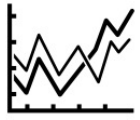
View Multiple Sensors at One Time

You choose the sensors and zones you want to see. Data Cards let you see up to 7 data sources to analyze together.



Time Slider

Easily see your crop's history in 36-hour, 3-day, 7-day, and 30-day intervals.



Compare Performance in Different Rooms

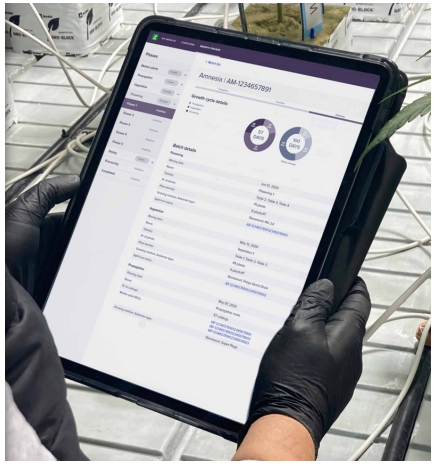
You have the flexibility to add a second graph and compare data from other rooms to better understand performance between the two grow rooms.

Benefits of Conditions Module

Optimize your irrigation and climate strategies based on real-time accurate data to save on inputs, maximize yield, and increase sustainability.

E-GRO

Growth Tracker



Process efficiency is increasingly important to realize optimal yields and quality of your crops. The Growth Tracker module allows you to easily input and track key parameters throughout the various stages of a batch's lifecycle, from mothers, to propagation, veg, flower, and harvest, culminating in cultivar-specific, crop-cycle insights. In Growth Tracker, you can view each batch's historical climate and rootzone information to optimize crop steering and genetics for future production runs.

Benefits of Growth Tracker

With the Growth Tracker module, you can optimize:

Cultivar-Specific Strategies

Gather and analyze all crucial strain-specific information throughout the entire growing cycle by batch.

Crop Steering

Compare the performance of individual batches to desired average performance to adjust and hone your irrigation and crop steering strategy.

Crop Data

Get a comprehensive view of your data and plants with the option to add pictures and notes.

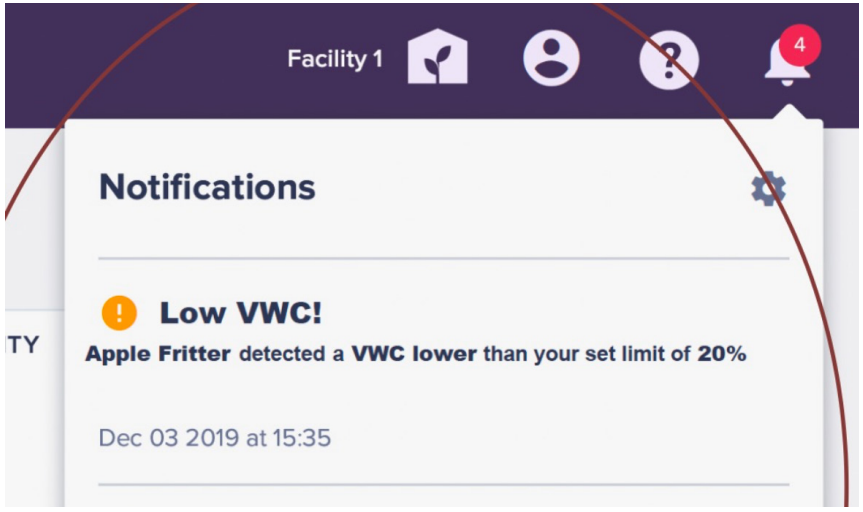
SOPs

Use captured data to improve SOPs and train all team members on the operational parameters.

E-GRO

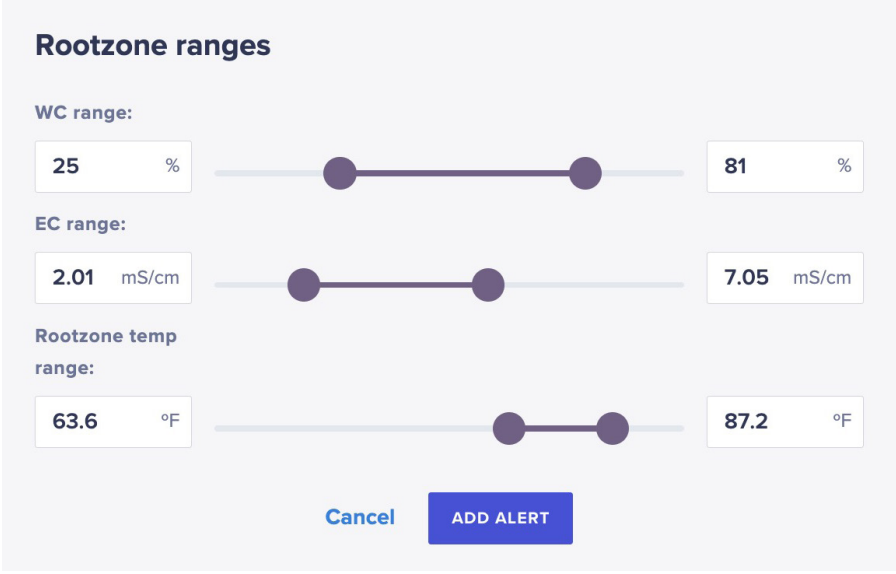
Alerts

Proactively address suboptimal growing conditions with immediate notifications in the app and via SMS when your crop's climate or rootzone settings go out of your customized range.



Set It

Set your alert choices for each stage of the crop's growth cycle. You can set the alert range for specific rooms or phases. You can even be notified if sensors have a low battery or weak signal.



Benefits of Conditions Module

Reduce the chance of errors or problems from issues such as irrigation line occlusion, failed solenoids, or closed vales with custom, timely alerts for water content and EC. Ability to customize the alert for each grow room, crop, variety, and growth stage.

E-GRO

Grodan Root-Zone Sensors

The Grodan root-zone sensor is one of the most widely used and trusted sensors in the cannabis industry for both indoor and greenhouse crops. Based on over 50 years of precision growing expertise, we have expanded the system to include Grodan root-zone and Grodan Climate sensors.

The Grodan sensor family integrates with the e-Gro software to provide precision data for analysis. If you want solid and actionable insights, the data source must be highly accurate and precise. All Grodan sensors are built to the highest standards and are rigorously tested at scientific institutes, including the world-renowned Wageningen University in The Netherlands.

Accuracy

All Grodan sensors have been tested and proven in comparative trials to provide precise measurements of all parameters. The more accurate the measurements, the more confidently you can adjust your growing conditions and deploy optimal crop steering strategies.

Custom Configurations

Grodan sensors are modular, so you can scale them to meet your operational needs.

E-GRO

GroSens Root Zone Sensor

Grodan root-zone sensors have a high degree of accuracy and give you 24/7 access to real-time measurements of volumetric water content (VWC), electrical conductivity (EC), and substrate temperature in the stone wool substrate.

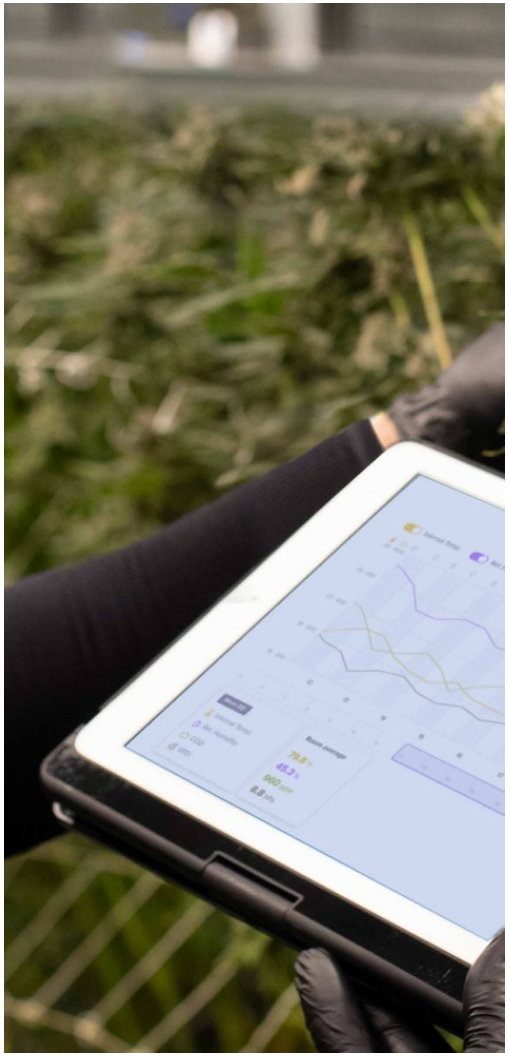
Data logging

Easy access to all historical measurements, up to 2,300 historical data points to be precise.

GroSens Climate Sensor

Climate is a critical aspect of crop optimization. Measure relative humidity, ambient temperature, vapor pressure deficit (VPD), and CO2 concentration with high accuracy over a wide range.

E-GRO - SUPPORT AND SERVICE



Grodan Crop Advisors

When you invest in your cultivation business with e-Gro, you get priority access to Grodan's expert Crop Advisors.

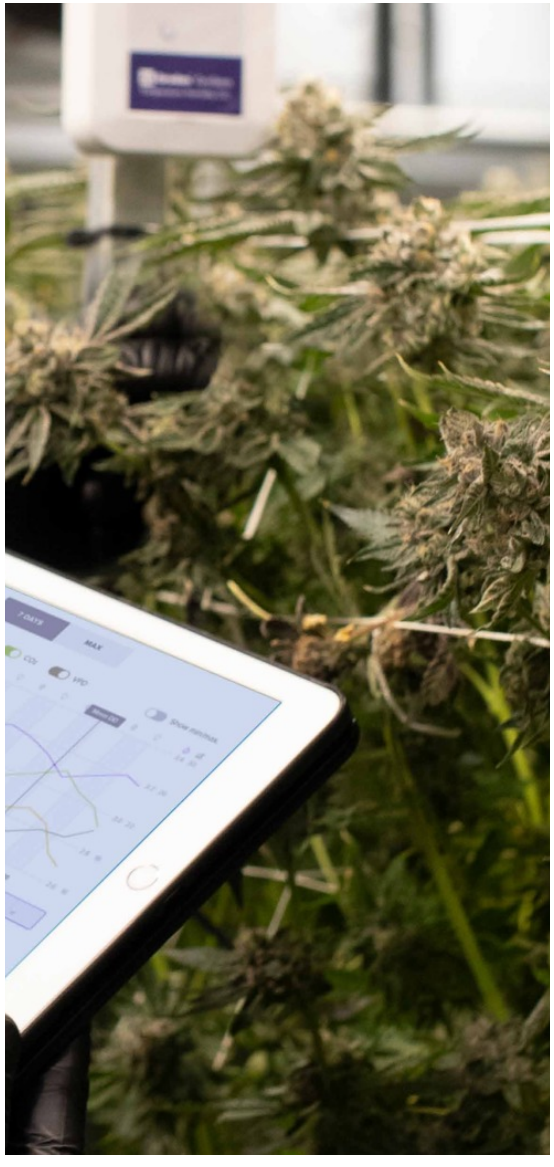
They help you get the maximum benefit from e-Gro's powerful platform and support you in interpreting your data, diagnosing problems, and optimizing your crop steering and irrigation strategies with our proven precision growing methods. You can leverage Grodan's 50+ years of crop steering expertise.

Dedicated e-Gro Support Team

They are like your own e-Gro concierge who will set you up on the platform, so there is no guesswork or fumbling around on your own; you are guided so you can quickly get value from your investment. You can email or phone the e-Gro support team for any questions or help with solving technical issues.

When you invest in e-Gro, your product doesn't end there. It grows. We have an entire e-Gro Development Team of industry-leading Data Scientists, Software Engineers, UX Designers, and Technical Experts who are committed to improving and expanding e-Gro's capabilities. So, your return on investment grows too.

E-GRO - CONTINUOUS DEVELOPMENT



Data Security

Your data security is of paramount importance. We use state-of-the-art encryption and security protocols that meet and exceed all North American, European, and local laws and regulations.

The GRODAN Group is the preferred supplier of innovative, sustainable stone wool substrate solutions for the licensed cannabis industry. Based on expert Precision Growing principles, these advanced substrate solutions help growers achieve greater yields and crop quality. In addition to its stone wool substrates, the GRODAN Group also provides tailor-made advice and tools to support Precision Growing and thus facilitate the sustainable production of crops.

RECYCLING YOUR STONE WOOL

Grodan stone wool is recyclable

Not only is Grodan stone wool recyclable, but our stone wool can also contain up to 75% recycled content. Stone wool's durability and resilience in the growing process also make the material an attractive product in the recycling market.

- Grodan stone wool can contain up to 75% recycled materials.
- The recycled content consists of cutting and trim and other factory wastes that are recycled back into the production stream, aka virgin material.

Rockwool's RockCycle Project takes back used stone wool to factories across the globe. Currently, RockCycle is targeted more toward the insulation business.

There should be no concerns about potential contamination from used materials. Uniform product quality is assured across each manufacturing facility – nothing can survive in the Rockwool furnace.

Stone wool is non-hazardous & non-toxic

As concluded through independent laboratories, stone wool is non-toxic, non-ignitable, non-reactive, and non-corrosive. The used Grodan material is typically classified as "Non-Hazardous - Solid Waste." – please confirm with your local regulator.

Grodan recycles its stone wool

Grodan collaborates with leading recycling institutions across the globe. Together, we have achieved a worldwide recycling rate of 65% in 2022. For reference, Germany (believed to be the most efficient recycling country in the world) recently recorded a recycling rate of 68% - if Grodan was a country, it would be one of the leading recyclers in the world.

Rockwool International is committed to sustainability, specifically circularity, and aims to offer recycling services in over 30 countries by 2030. Our manufacturing facilities in Denmark and Netherlands offer a take-back system – a fully circular manufacturing model.

RECYCLING YOUR STONE WOOL

Re-use/recycling opportunities for your used stone wool

Used Grodan stone wool has several re-use markets, also called "secondary applications." This includes feedstocks for brick manufacturers, compost, potting mix, industrial bedding, and engineered soils. These options vary in every region based on what processors exist. Stone wool consumers should follow all local solid waste guidelines in their districts and reach out to their municipal waste management authorities to determine suitable options for recycling.

Stone wool usage in compost

In North America, Grodan composts over 5,000 tons of stone wool per year through leading compost facilities. Used stone wool improves its aeration, porosity, and water retention. This can lead to better growth for potted plants and other plants that are grown in compost.

Here are some of the benefits of using used stone wool in compost:

- Better growth for plants: Used stone wool can improve the growth of plants by providing them with a more aerated and porous growing medium. This allows the roots of the plants to breathe more easily and access more water and nutrients.
- Increased aeration: Used stone wool can help to increase the aeration of compost, which can help to prevent the growth of anaerobic bacteria. Anaerobic bacteria can produce gases that can be harmful to plants.
- Higher total porosity: Used stone wool can help increase the total porosity of compost, which means more space for air and water to flow through. This can help to improve the drainage of the compost and to prevent it from becoming waterlogged.

RECYCLING YOUR STONE WOOL

Self Processing

How to Process Used Stone Wool for Potting Soil

- Each municipality has its own solid waste regulations; stone wool consumers seeking to process the material on-site should follow all local rules and regulations for handling and disposing of solid waste and alternative waste classifications.
- If stone wool consumers have confirmed that they are able to handle the material on-site, used stone wool makes a great amendment for potting soil.
- Consumers should de-sleeve the plastic wrapping. This can be done using a conventional box cutter. Self-processing can consist of the removal of the stalk, stem, and other green waste. Crumble the stone wool, and sift the media in with potting soils. Always use gloves, goggles, and appropriate safety apparel.

Separating out the plastic foil

Consumers should check with their recycler to see if they can accept the material with plastic.

- If the recycler cannot take the plastic foil, it can be easily torn and separated from the stone wool with a knife or box cutter during harvest.
- If I compost or backfill with stone wool, will its degradation into the soil increase my heavy metal content? Does the used stone wool release heavy metals? No, new and used stone wool has been thoroughly tested and shown no traceable leaching values. In Europe, Grodan stone wool qualified for the "EUROPEAN ECOLABEL," – which ensures safe ecological criteria for growing media, soil improvers, and mulch.
- 3rd Party testing results available upon request.

RECYCLING YOUR STONE WOOL

Recommend Grinder/shredder

- Stone wool can be processed using most conventional grinders.
- Most conventional greenhouses will require small-scale shredders with motor sizes ranging from 5-30 hp. This means they have less footprint, less operating costs, and are a fraction of the price of traditional shredders. Consumers should coordinate the specific size requirements and other needs with the manufacturers and distributors.
  - Two of the leading suppliers include JWC Environmental and High Yield Solutions Corp., Which includes the Muffin Monster Shredder Series from JWC and the Plant Muncher from HYSC.
  - Material processing footage and results are available upon request.

Grodan recycling services

- Grodan is constantly expanding its reach to give our consumers better access to recycling across North America and around the globe. Together we can make stone wool one of the most recycled materials in the world.
- Please visit www.grodan101.com/about/recycling-solutions

The State of Biodegradable Plastic Foil and Grodan's Commitment to Sustainability

- Biodegradable plastics are still developing for commercial scales. Presently, most products in the marketplace are not fit for typical greenhouse environments and are often not accepted at composting facilities across the country.
- Plastic foil plays a pivotal role in the growing process; Grodan's R&D team is actively exploring how to best utilize this valuable resource, deliver the highest quality products to the marketplace, limit the environmental impact from its plastic stream, and identify long-term viable and environmentally friendly alternatives to plastic foil.
- Many plastic products in the market are claiming to be biodegradable. All biodegradable plastics should conform to the technical standards and requirements set by the Biodegradable Products Institute and include a "BPI Certification." If there is no BPI labeling, this material will not be accepted at most organic processing facilities.

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