Grodan®

Part of ROCKWOOL Group

Grow Guide Cannabis Edition

Guides And Tips for Growing in Stone Wool

Volume 2

HIGH PERFORMANCE GROW SOLUTIONS

GRODAN

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.

Grodan® Grow Guide Contents

Access a digital copy of this guide in it's entirety or by individual chapter.

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.

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.

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.

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 to 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.

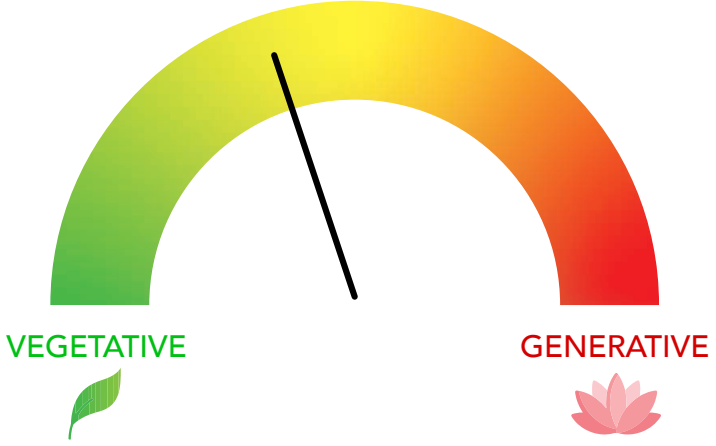
Knowing How and When to Steer Plant Growth

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 more 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.

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

Irrigation Amount (shot size) During Each Watering Event

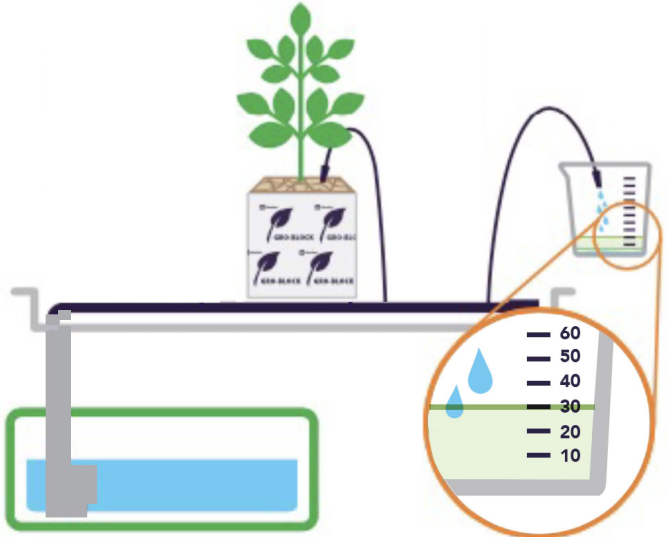
Each irrigation event's volume should generally equal 3% to 6% of the stone wool volume being utilized. For example, a GR10 (4"x4"x4") is a total volume of 1 liter. A 3% shot would be 30mL. To calculate shot size, simply convert the liter volume into milliliters and calculate the desired percent. When 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 increase water content, whereas larger shots are more likely to trigger runoff and stabilize 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.

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

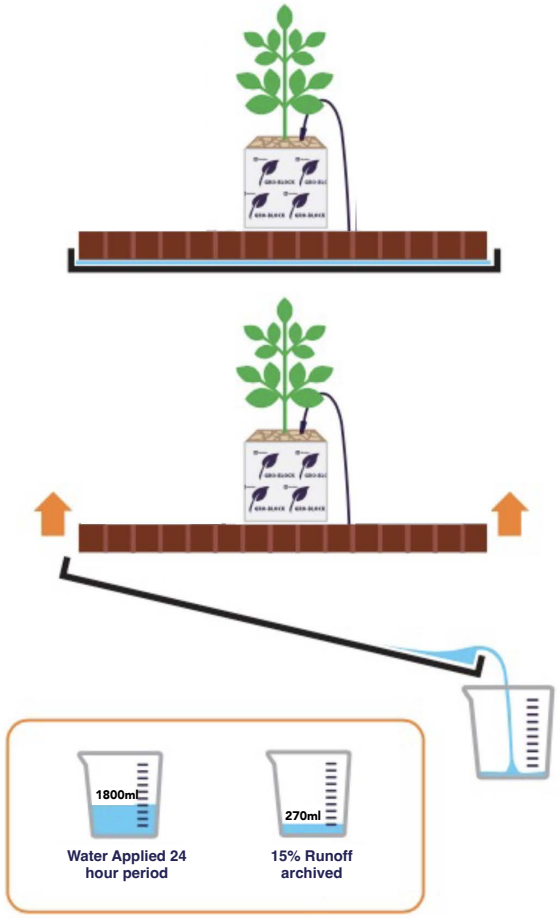
Product	Length (cm)	Width (cm)	Height (cm)	~ Dimensions (in)	Volume (cm3)	Volume (L)
GR Unislab	24	19.5	10	9.5*8*4	4680	4.68
GR 3” Tall Slab	90	15	7.5	35*6*3	0125	10.125
GR 4” Tall Slab	90	15	10	35*6*4	13500	13.5
GR 8” Wide Slab	90	19.5	7.5	35*8*3	13163	13.163
GR 12” Wide Slab	90	30	7.5	35*12*3	20250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

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

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 cycle, measure the total runoff volume collected in the container and divide this volume by the total amount of water applied per plant that day.

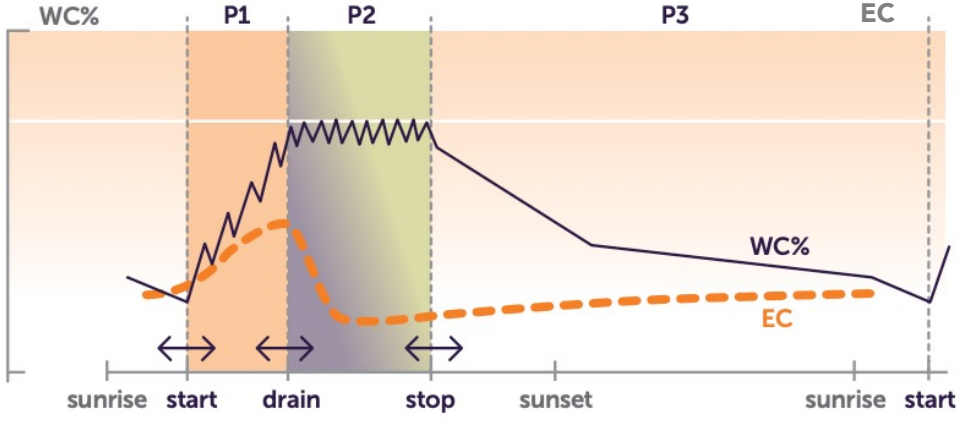
You should have 5% to 25% runoff of total volume applied to the plant over the course of the day.

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.

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 essential foundation for healthy cuttings

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.

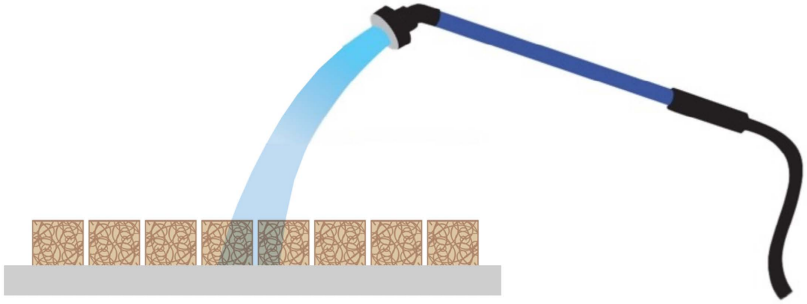
Saturating the Starter Plugs

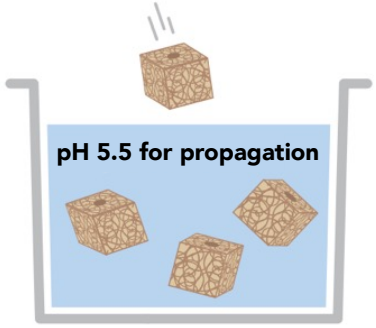
Correct saturation of the growing media sets the stage for proper root development. Because stone wool is an inert and clean substrate, lacking essential nutrients, growers must provide complete and balanced fertilizer to sustain the cuttings as their roots develop. Cuttings will need a near-immediate 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.

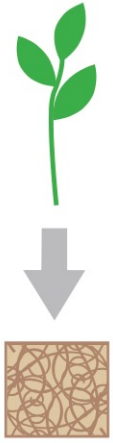
After initial saturation, allow excess nutrient solution to drain away. Measure the weight of a few starter plugs or trays to ensure that they are uniform and fully saturated. Now you are ready to take cuttings.

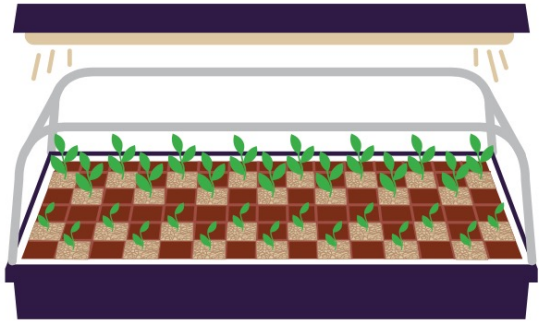




Tips for Taking Cuttings

- 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.

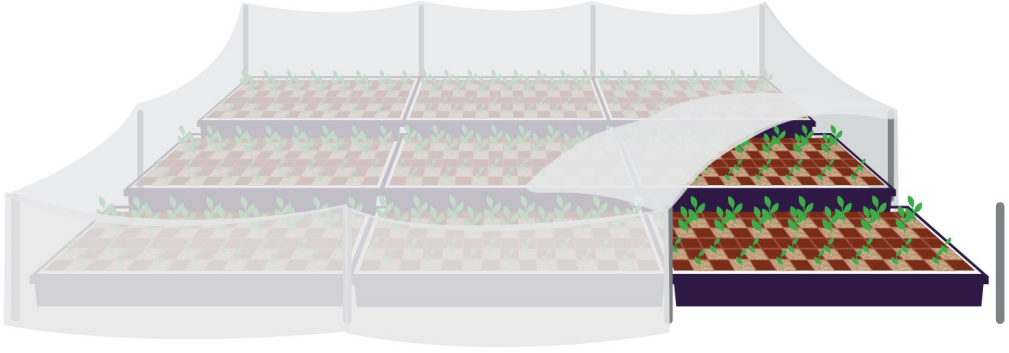




Cutting Care

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.



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.

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 time 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

PROPAGATION OF SEEDS

Introduction

Seed propagation is a critical component of the overall cultivation process for growers, breeders, nurseries, researchers, and a variety of other stakeholders throughout the industry. While clonal and in-vitro methods remain the primary mode of cannabis propagation in controlled environment agriculture settings, the seed industry has made considerable scientific advancements in recent years.

Science-driven breeding companies are ushering in a new era of Cannabis seed production from targeted breeding programs leveraging gene sequencing and editing technology, to the production and commercialization of stable F1 hybrid seed lines.

The highly competitive landscape of the North American Cannabis market drives growers and propagators to seek relevancy by searching for new and genetically diverse cultivars with desirable morphological characteristics, pest and disease resilience, and unique aesthetic and chemical characteristics.

As global seed quality and stability improves, sound propagation protocols for use with consistently engineered, clean growing media will ensure exemplary germination success rates for highly valuable cannabis seed. Currently, the relatively high cost of cannabis seed requires growers to adopt a meticulous, science-backed approach to propagation, mitigating the percentage of seedlings culled.

In this chapter, we will outline a comprehensive protocol for propagation of Cannabis seeds in Grodan stone wool, providing a step-by-step guide informed by institutional research trials and Grodan's 50+ years of experience pioneering best practices in the horticulture industry.

A Note on Seed Selection:

The foundation of successful propagation lies in selecting high-quality seeds. Cannabis seeds should be sourced from reputable breeders or suppliers, ensuring viability, stability, consistency, and vigor. For commercial cultivators, the hierarchy of breeding selection criteria must be well understood and aligned with the cultivator's production goals. For example, a breeding project focused on the efficiency of biomass active pharmaceutical ingredient (API) extraction may place dried flower aesthetic quality low on the selection hierarchy. While a breeding project focused exclusively on finding and selecting the most colorful varieties may fail to prioritize performance indicators such as vigorous plant structure, or resilience to abiotic stressors.

Ideally, seed producers take a balanced approach, prioritizing the following key plant characteristics:

- Yield capacity
- Aesthetic quality
- Chemical profile (secondary metabolites)
- Plant and inflorescence structure
- Resiliency against pests, diseases, and abiotic-stressors

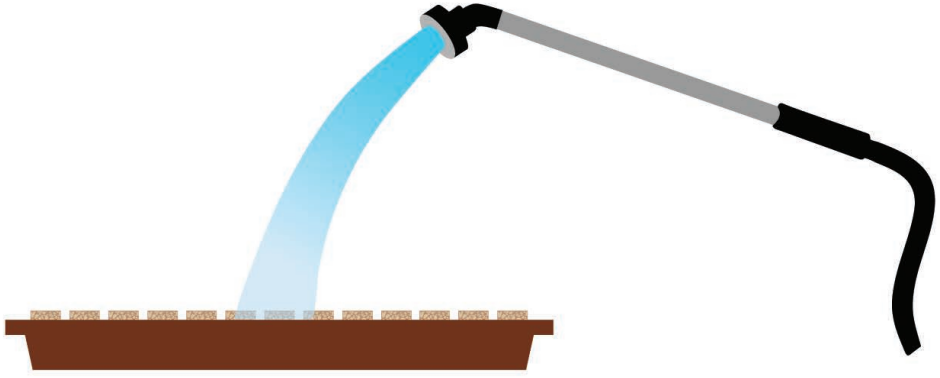
When selecting seeds, factors such as size, color, and hardness can be indicators of quality. Healthy seeds are typically dark-colored, firm, and free from damage or deformities.

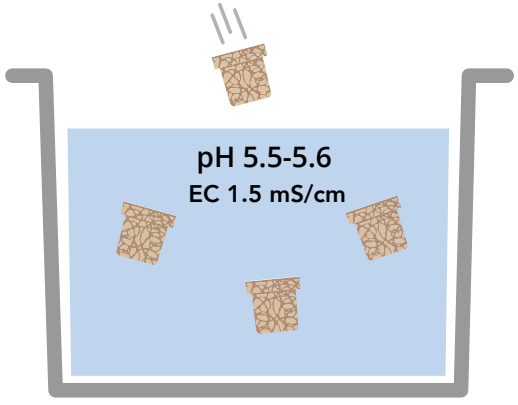
Preparing Propagation Media and Seeding

Grodan® A-OK Plugs are an ideal propagation media for growing cannabis seedlings. Consistently engineered through controlled manufacturing processes, they provide desirable structure, water behavior characteristics, and chemical properties for seedling growth. When using stone wool plugs, every stage of the propagation process can be carefully orchestrated to nurture robust seedlings primed for successful cultivation outcomes.

Process:

1. Soak individual A-OK plugs or complete A-OK sheets in a balanced fertilizer solution with an EC of 1.5 mS/cm, pH adjusted to 5.5-5.6, temperature of ~68° F. Plugs should remain in the solution until they sink and all bubbling stops.





Process Continued:

2. Place plugs in a standard propagation tray with an insert of your choice. Plugs can be planted in a Gro-Smart tray, in contiguous sheets with a basket insert in Grodan® SBS trays or in any other compatible cell-tray insert. Allow excess water to drain away naturally; there should be no standing water in the trays. Plug density per tray may vary depending on the insert utilized, but we recommend starting at a density of somewhere between 50 and 78 plugs per tray.

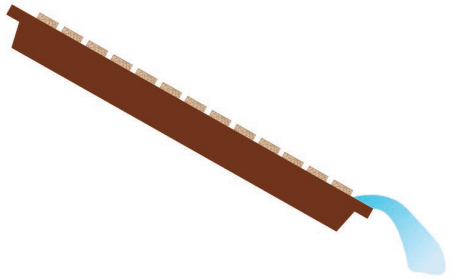
Note if starting a small quantity of seeds, lower densities can be utilized, but spacing plugs out (as described in step 12) may not be necessary after the first week of growth. Trays of seedlings with low densities may dry back quickly and will likely require more frequent irrigation.

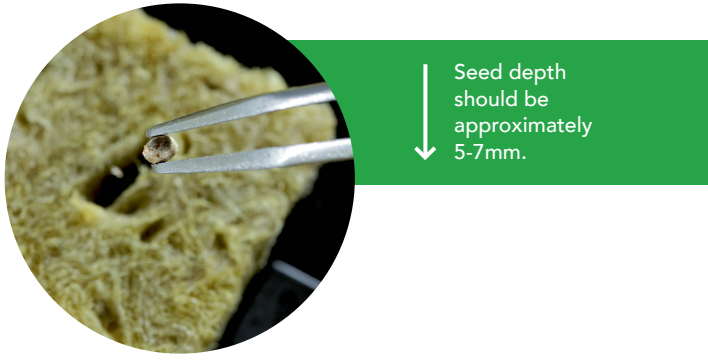
3. Spread seeds out on a clean surface and remove any deformed or broken seeds.

4. While the risk of disease, virus, and viroid transmission tends be lower via the seed propagation process than the clonal propagation process, seeds are capable of carrying plant pathogens if produced from infected parental stock. Consult your seed provider to discuss any recommended seed sterilization protocols prior to planting.

5. Use sterile forceps to place seed in the pre-drilled hole of the plug. Seed does not need to be inserted deeply into the plug. Seeding depth should be approximately 5-7mm. If the seeds you are using are quite large (>5mm), a sterile implement may be used to widen the pre-drilled hole.

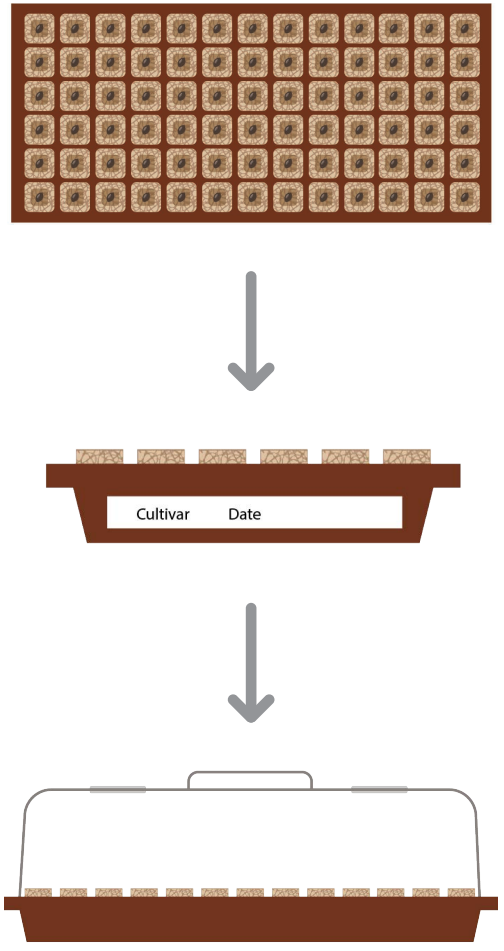
Note Grodan trials indicated sowing seeds at depths of <3mm and greater than >10mm reduced germination rate.





Process Continued:

6. Repeat this process until all seeds have been sown.
7. Label the front of the trays with the cultivar name, date of sowing, and any other relevant information. Leave space on your label for a tray weight. This will be added after the first irrigation.
8. At this point, newly sown seeds must be placed in a controlled environment such as a propagation chamber, greenhouse, or closely monitored humidity dome within a propagation room.



Pro-Tip

Quality Control Checkpoints

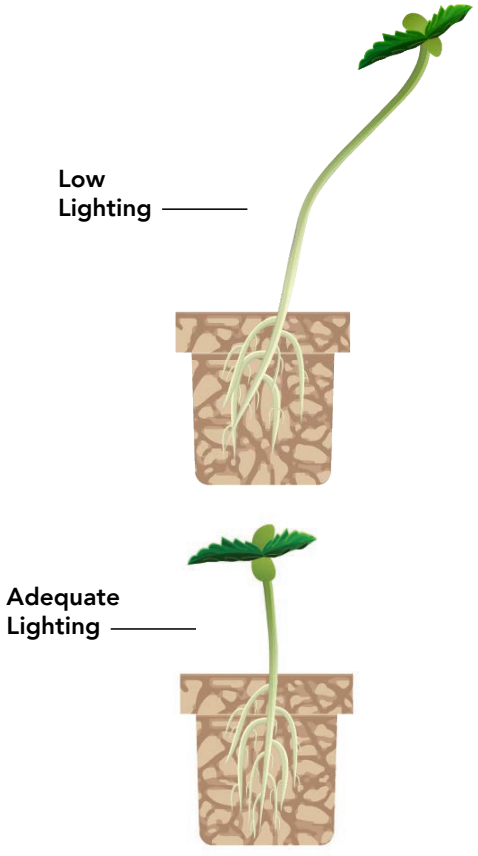
- ✓ Solution temperature verified
- ✓ pH meter calibrated
- ✓ EC meter calibrate
- ✓ No floating plugs
- ✓ No visible dry spots
- ✓ No standing water in tray

Setting the Climate for Week 1

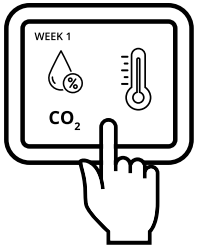
From the time of sowing, growers must maintain specific climate conditions, providing a conducive environment for germination and early growth. In the first week of germination and growth the seedling's environment must be warm and humid, however excessively high temperatures and/or relative humidities could cause fungal growth and general damping-off symptoms. If using humidity domes, it is highly recommended to place a temperature and relative humidity sensor inside the domes to monitor and control ongoing conditions.

Adequate light intensity is critical for successful seed germination and optimal early seedling structure. Cannabis seedlings require moderately high light intensity to remain compact and sturdy. Low light intensity impairs photosynthetic efficiency, limiting the seedling's ability to produce ample energy for metabolic processes. Insufficient light intensity, or placing seedlings too far from light fixtures, can result in etiolation, a phenomenon characterized by elongated, weak stems. In low PPFD (photosynthetic photon flux density) conditions, seedling stems will stretch rapidly, creating a flimsy and compromised plant structure that may bend or collapse.

If low light conditions are prolonged, leaf development and biomass accumulation is often delayed as resources are diverted toward stem elongation. Etiolated seedlings are more vulnerable to environmental stressors such as drought, high temperatures, and disease. Their weakened structure and reduced vigor make them less resilient in adverse conditions, increasing the risk of plant damage, reduced yield, and mortality. Checking light intensity carefully with a high quality PAR (photosynthetic active radiation) meter will help set the stage for strong vegetative plants.



Week 1 Climate Conditions

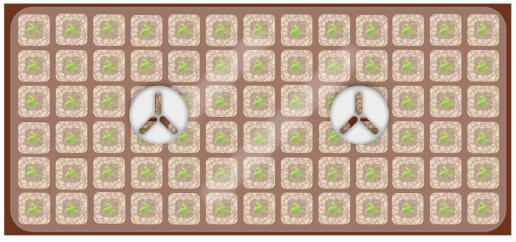


Temperature Day (°F)	Temperature Night (°F)	Relative Humidity	Photoperiod (hours on/off)	PPFD (umol/m2/s)	CO_2 (ppm)
78	76-78	88-90%	18-20 / 4-6	150-200	500-750

Week 1 Monitoring and Plant Management

9. After 72 hours, observe the seedling condition from overhead. Remove any plugs that contain seedlings with obvious fungal growth or deformities.
10. After 4-5 days, remove any plugs containing seeds that failed to germinate and/or emerge. Remove any plugs containing seedlings with bent or twisted stems.

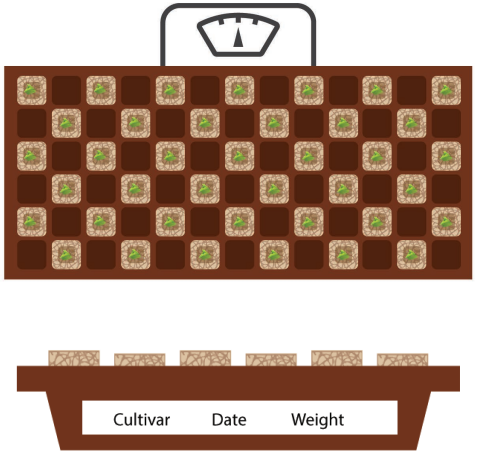
Note It is unlikely for high quality and healthy seedlings to emerge more than 5 days after planting.



11. If seed hulls remain adhered to any cotyledons and are inhibiting leaf unfurling you may gently spritz the cotyledon surface with clean water, avoiding wetting the top of the plug or base of the stem. After wetting, the seed hull can be easily removed with clean forceps. It may also fall off naturally, so removal is only recommended if seed hull is inhibiting the first set of true leaves.

Week 1 Monitoring and Plant Management

12. At the 6-7 day mark, if using a 50 or 78-count plug density, begin spreading out seedlings to a 50% density, or checkerboard pattern within propagation trays to allow for optimal spacing, air flow, and light interception. Trays should be at their final lower plant densities now and all stunted or damaged seedlings removed.
13. Typically, between day 6-8 the first irrigation can be applied. Irrigate the plugs lightly (~10-15mL/plug) using a balanced fertilizer with an EC of 1.5-2.0 mS/cm, pH adjusted to 5.5-5.6, temperature ~68° F. Be careful not to over-saturate the plugs, as this can lead to pathogen establishment around the base of the stem.



14. After applying the first irrigation at the final planting density, create a spreadsheet for recording the weights of individual propagation trays. Place individual trays (with insert, plugs, and seedlings, omitting domes) directly onto a scale and record the date and starting weight. We will use the weight decrease from this starting point to determine optimal irrigation times. You may also notate weights on the front of trays for easy referencing.

Pro-Tip

Use weight tracking to:

- Prevent over/under-watering
- Maintain consistent moisture
- Optimize irrigation scheduling

Weighing Protocol

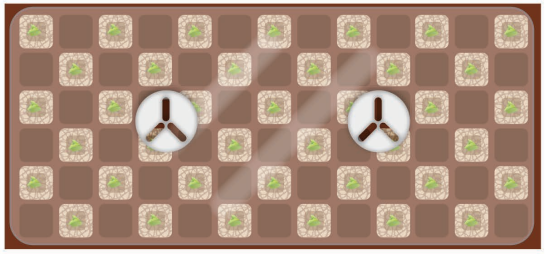
- ☐ Tray
- ☐ Insert
- ☐ Plugs
- ☐ Seedlings

*Do NOT include dome.

Data Recording Format:

Tray ID	Date	Start Weight	Target Range
A1	11/1	2680g	1876-2010g

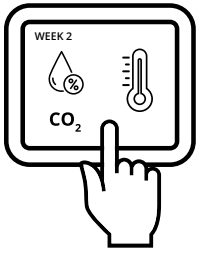
15. If utilizing humidity domes, at the 6-7 day mark the vents should be opened and seedlings should be carefully and gradually acclimated to the new climate set-points outlined below for week 2 of growth. This acclimation process may occur over 2-3 days.



Setting the Climate for Week 2

After 7 days of growth, seedlings will need to receive higher light intensity to maintain optimal structure and growth momentum. Seedlings should be gradually acclimated from a light intensity of 150-200 umol/m2/s to 400 umol/m2/s over the course of the second week of growth. From day 8 until day 12-14, PPFD should be increased by 15-20% per day until the target PPFD is achieved, maintaining the same photoperiod as week 1 of growth.

Week 2 Climate Conditions



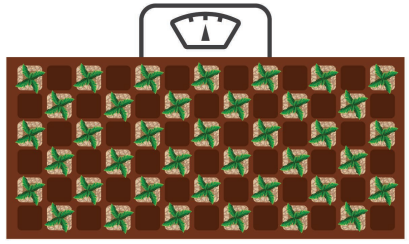
Temperature Day (°F)	Temperature Night (°F)	Relative Humidity	Photoperiod (hours on/off)	PPFD (umol/m2/s)	CO_2 (ppm)
80	73-75	75-80%	18-20 / 4-6	200-400	600-750

Week 2 Monitoring and Plant Management

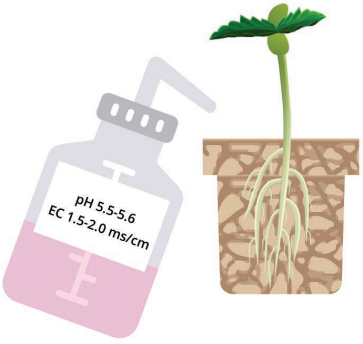
16. After the first irrigation is applied (between ~ day 6-8) and weights are recorded, trays should be weighed to monitor plug dry-back and determine irrigation timing. When tray weights have decreased by ~25-30% of their initial starting weight, it is time to apply a light irrigation with a targeted spray mechanism or laboratory squeeze bottle.

    Example: After first irrigation, weight of tray + plugs + insert + seedlings = 2680 grams
    25-30% decrease = 670-804 gram loss
    2680-670 grams = 2010 grams
    2680-804 grams = 1876 grams

    Apply irrigation once tray weight reaches 1876-2010 grams



17. Irrigate the plugs lightly (~10-15 mL/plug) using a balanced fertilizer with an EC of 1.5-2.0 mS/cm, pH adjusted to 5.5-5.6, temperature ~68° F. Be careful not to over-saturate the plugs, as this can lead to pathogen establishment around the base of the stem.
18. Check tray weights daily to monitor plug moisture levels. Apply irrigations whenever tray weights decrease by 25-30% from initial weight. Typically, under the outlined climate conditions, this results in an irrigation every other day or every 2 days. Irrigation frequency will likely need to be increased throughout the second week of growth.



19. Monitor seedling root development closely during the second week of growth. Seedlings will typically be ready for transplant to a small stone wool block within 12-16 days. A-OK plugs should be well colonized with short pin roots before seedlings are transplanted.

Note If seedlings develop elongated root systems it may be an indication of over-watering. Reducing irrigation volume and avoiding standing water in trays can discourage roots from elongating outside of the plug.

Conclusion

Whether sowing seed for large scale commercial production, breeding projects, or simply germinating new varieties to select mother stock, implementing a precision growing strategy will invariably yield the most healthy and sturdy seedlings. By selecting high quality seed stock and adhering meticulously to the climate and lighting parameters outlined above, growers can quickly and efficiently generate new healthy plants poised for robust vegetative growth.

Seedling Climate and Fertigation Summary Table

	Week 1	Week 2
Temp Day (°F)	78	80
Temp Night (°F)	76-78	75-78
Relative Humidity (%)	88-90	75-80
Photoperiod (hours on/ off)	18-20 / 4-6	18-20 / 4-6
PPFD (umol/m2/s)	150-200	200-400
CO2 (ppm)	500-750	600-750
Fertigate EC (mS/cm)	1.5	1.5-2.0
Fertigate pH	5.5-5.6	5.5-5.6
Fertigate Temp (°F)	68	68

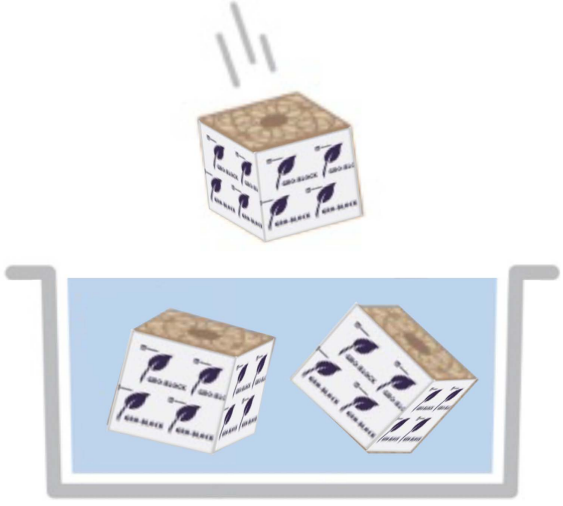
Plant Monitoring & Task Summary Table

Week 1 Monitoring and Tasks Summary						
Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
☐ Prepare media ☐ Sow seeds ☐ Apply week 1 climate		☐ Remove plugs with seeds showing deformities or fungal growth	☐ Remove seedlings that failed to germinate or emerge ☐ Remove any remaining seed hulls from cotelydons	☐ Remove seedlings that failed to germinate or emerge ☐ Remove any remaining seed hulls from cotelydons	☐ Remove seedlings that failed to germinate or emerge ☐ Remove any remaining seed hulls from cotelydons ☐ If using domes begin opening vents ☐ Gradually acclimate to week 2 climate	☐ Spread out seedlings to 50% density ☐ Apply first irrigation and notate weight of trays afterwards ☐ If using domes begin opening vents ☐ Gradually acclimate to week 2 climate
Week 2 Monitoring and Tasks Summary						
Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14
☐ Weigh trays to determine irrigation timing ☐ Increase PPFD 15-20% until 400 umol/m2/s	☐ Weigh trays to determine irrigation timing ☐ Increase PPFD 15-20% until 400 umol/m2/s	☐ Weigh trays to determine irrigation timing ☐ Increase PPFD 15-20% until 400 umol/m2/s	☐ Weigh trays to determine irrigation timing ☐ Increase PPFD 15-20% until 400 umol/m2/s	☐ Weigh trays to determine irrigation timing ☐ Increase PPFD 15-20% until 400 umol/m2/s ☐ Monitor root development to determine transplant timing	☐ Weigh trays to determine irrigation timing ☐ Increase PPFD 15-20% until 400 umol/m2/s ☐ Monitor root development to determine transplant timing	☐ Weigh trays to determine irrigation timing ☐ Increase PPFD 15-20% until 400 umol/m2/s ☐ Monitor root development to determine transplant timing

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 coarse spray until full saturation is achieved. Block weights and water contents must be checked to to ensure that full saturation has been consistently achieved.

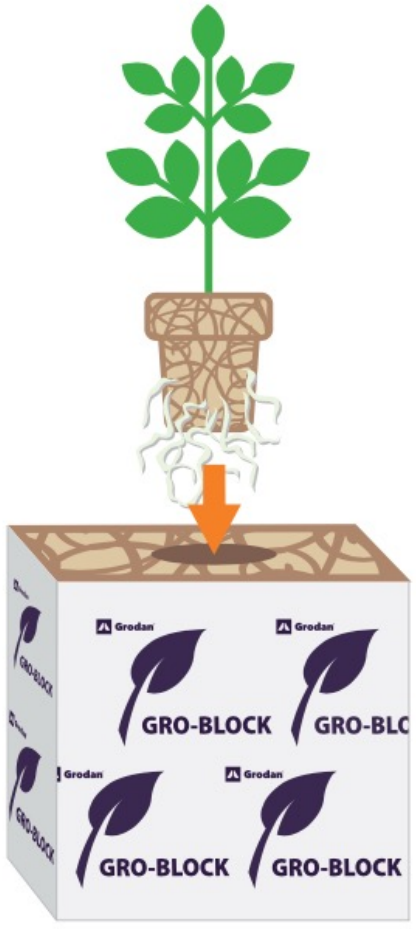
Blocks can also be conditioned by fully immersing them in a reservoir containing the proper nutrient solution until they sink.

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.

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 and 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 emitters with a maximum flow rate of 0.3-0.5 gph.



VWC = ~ 70 - 80%

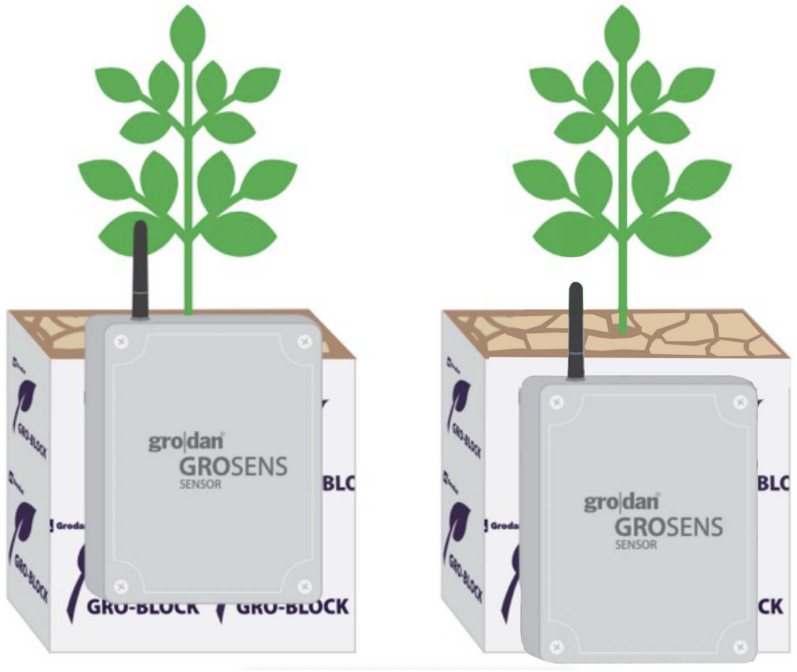
Transplanting to Blocks

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**

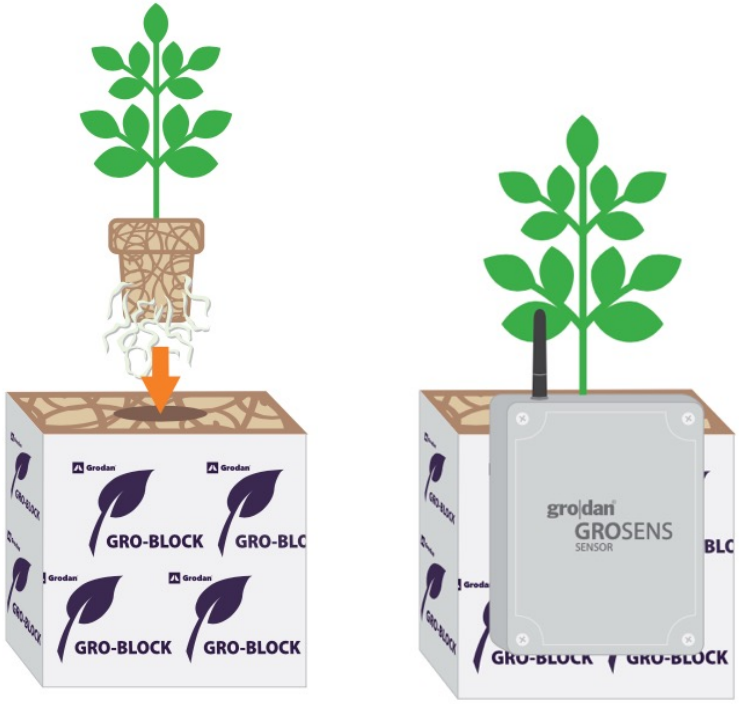
GROWING IN GRODAN PRODUCTS

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.



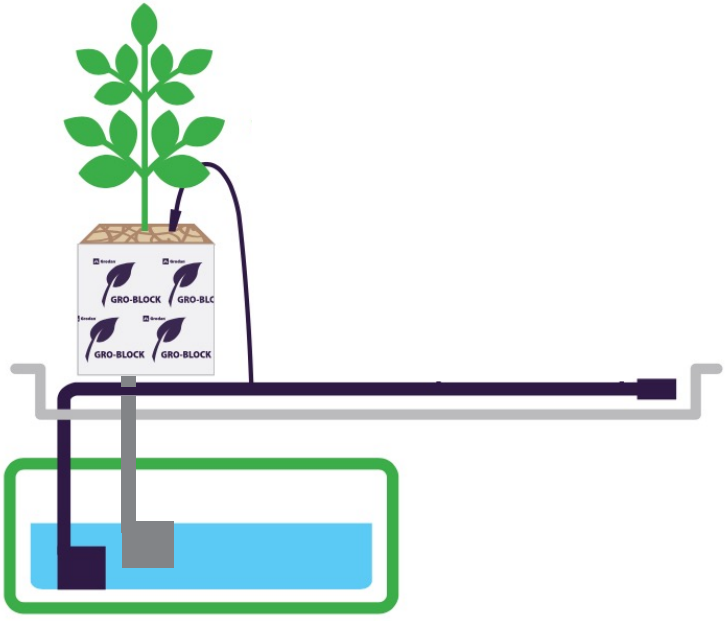
Start with a healthy, vigorous cutting that has a well-developed root system. Weak or stressed cuttings with under-developed root systems are not ideal candidates for transplant into Hugo blocks due to the large volume of media the roots must colonize.

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.

Because rock wool is completely inert, nutrients are needed from the onset to fuel 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 coarse 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

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 chapter 3: Introduction to Crop Steering.

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.

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.

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.

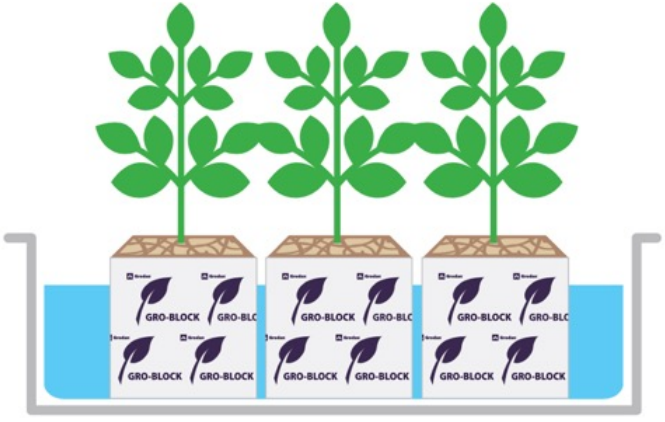
If hand watering without root-zone sensors during flower, the timing of the first irrigation is important to ensure the plant does not dry out during the middle of the day. Try to apply an irrigation roughly 2 hours after the lights come on to ensure the plants have adequate access to water when they 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 ebb and flow 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 flood the block.**

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.

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 A-OK, 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.

	Item	Description	Dimensions	Quantity	Options
	**A-OK 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" A-OK Plugs (1"x1"x1.6") • 1.5" A-OK Plugs (1.4"x1.4"x1.6") • 2" A-OK 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, No-slit option avail as special order • Ideal plug for cannabis clones	• Macroplug 1.5"round, 1.57"high	• 2000 plugs loose/carton • 1750 plug/carton	Available with and without slit
	**A-OK Pre-filled Tray**	• Same great benefits as the A-OK plugs, only these A-OKs are pre-cut and pre-filled into an insert tray	• 1.5" A-OK Plugs (1.4"x1.4"x1.9") - pre-cut/pre-fill insert of 50	• 30 inserts/carton • 1500 plugs/carton	
	**Gro-smart Plug Tray**	• Double-sided tray. Use the 78-cell side for 1.5" A-OK and Macro plugs, use the mesh side for mini-blocks and gro-blocks. Place in 10"x20" tray	• Gro-Smart Tray has 78 Cells for 1.5" A-OKs	• 5 tray /carton	
	**A-OK Plugs Loose**	• 1.5" A-OK Plugs, pre-cut and loose in carton	• 1.5" A-OK 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 • 19.4" x 9.4"	• 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.

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 offers 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

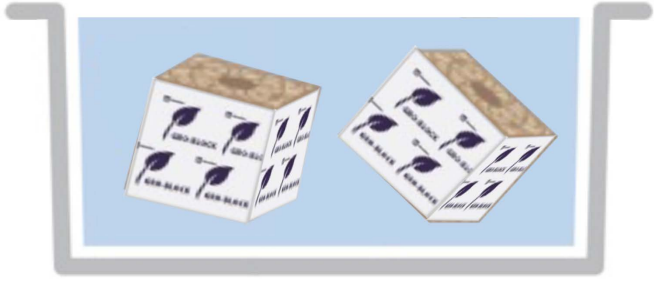
Due to the better-developed root system in Grodan Gro-Block Improved, the trial results showed increased plant growth, especially during the vegetative phase, in the form of larger plant size, greater stem thickness, and bigger leaves. Ultimately, this can lead to higher yield, while at the same time,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

GRO-BLOCK IMPROVED WETTING INSTRUCTIONS

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 essentially be "swimming" in solution.
- Place blocks into the reservoir and allow them to submerge in the solution.
- 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-SLABS AND UNI-SLAB

Grodan Improved Gro-Slabs and Uni-Slab 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.

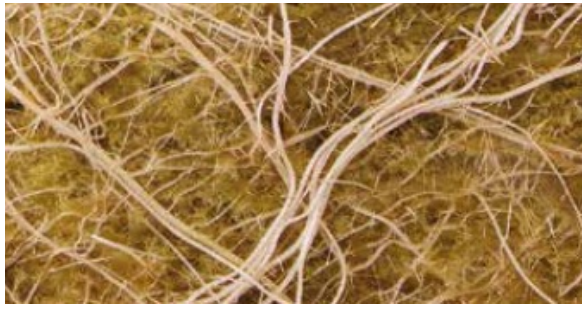
Key benefits

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 retain 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

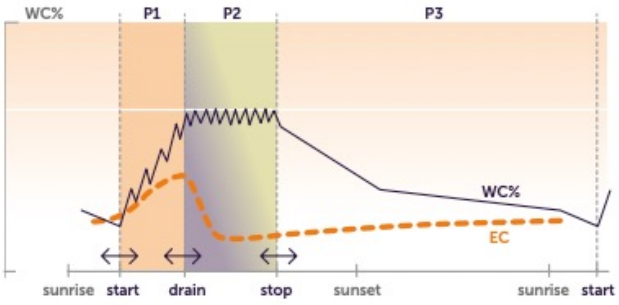
The properties of Grodan Improved Gro-Slabs enable a multi-faceted irrigation strategy by allowing growers to vary the volumetric water content within a safe range of 45% and 75% (day level). If insufficient water has been supplied, the slab can be re-saturated quickly at any moment. And if too much 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.

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.

GRO-SLABS AND UNI-SLABS WETTING INSTRUCTIONS

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

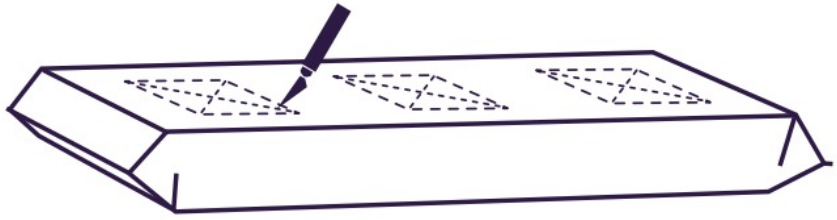
1. Using a sharp instrument, on the top side of the foil only, cut your "X"s the same size as the Grodan Improved Gro-Blocks that will be transplanted. Try not to cut the stone wool in this process. Alternatively, you can complete squares of the same dimensions as the Gro-Block that will transplanted.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



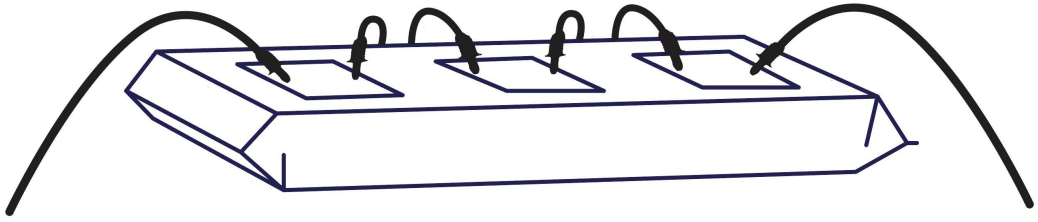
Grodan Improved Gro-Slab with pre-cut holes

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.

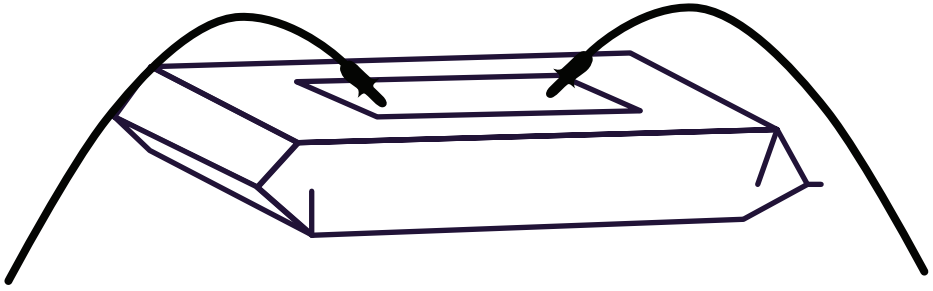
3. Place a well-rooted Grodan Improved Gro-Block onto the plant hole(s) you cut so that the base of the block is in direct contact with the top of the slab. Press down very gently to ensure contact.

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.



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.



GRODAN® GROSENS SUITE

We get it. You are looking for a smart way to improve your growing cycle. To produce high quality crops with even more precision. To get access to insights that support data driven growing. To get a second opinion and technical support when you need it.

Grodan GroSens Suite provides rootzone information that puts you in the driver's seat. A ready to use solution that offers immediate insights, anytime, anywhere. The high quality sensors with the reliable platform enable you to monitor and steer your crops.

View sensor data from all rooms in your facility and monitor key measurements such as EC, WC, room temperatures, relative humidity and more. Grodan GroSens Suite is a growing solution that puts you in control of your strategy, all year round.

Top features and benefits of GroSens Suite

- Grodan® GroSens Suite provides a complete solution for starting, improving, and optimizing your rootzone.
- It is a seamless integration of sensors, software, and support.
- Giving you easy access to rootzone insights and 24/7 online support.
- Designed with our advanced stone wool products and expert growing advice.
- Grodan® GroSens Suite unlocks the power of precision growing.

Introducing the e-Gro Base Software

Features

Seamless cross-platform experience – With our Progressive Web Application, you experience a seamless and responsive cross-platform interface, benefit from fast loading speeds, and enjoy enhanced user engagement.

30 - 100 day view – In the Conditions module, you can use the 30 Day view port to access the historical data you need for deriving valuable insights. Additionally, you have the option to download and analyze data in Excel, allowing you to access information for up to 100 days.

Fall-back Connection – In the event of internet interruption, our backup LTE solution ensures you retain access to valuable data via the e-Gro native mobile app, preventing any potential data loss. Moreover, LTE guarantees the continuous data stream to the e-Gro cloud.

Improved database structure – With the new database, accessing the data is faster and more reliable. You can be assured that we have a reliable back-end supporting your valuable data.

Sensor management – You can assign and name sensors according to your needs using a single platform, providing convenient management and viewing of sensor data.

User access and management – Effortlessly manage and accommodate up to 99 user accounts with the added assurance of enhanced security through role-based permissions. This ensures that your users receive precisely the access they need.

Facility & sensor management – You have the flexibility to set up your facilities and sections to match your growing operations.

Frequent platform releases a year – You can be assured that the platform is continuously maintained and updated to the latest security and technology standards

Your data is safe – Your data in e-Gro is protected by state-of-the-art encryption and security protocols. Everything on e-Gro is processed in accordance with all local laws and regulations.

Service and support

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.

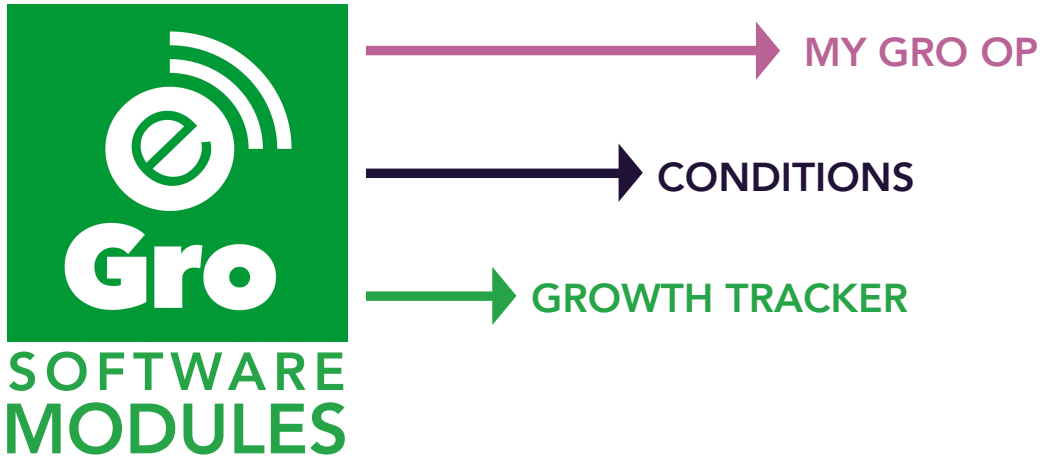
Dedicated e-Gro support team

They are like your own personal e-Gro concierge who will personally set you up on the platform, so you can quickly get value from your investment in data. A dedicated Zendesk helpline is available for quick response.

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.

e-Gro PLUS modules



My grow op module

My Grow Op module provides a complete high-level dashboard where you can check the status of your entire growing facility from mother plants through to processing that you can access 24/7. In My Grow Op, you can view important details about your facility's climate and rootzone information per room:

- WC
- EC
- Relative Humidity
- Temperature
- Room Temperature
- CO2
- VPD
- Number of Batches
- Lights On/Off

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

Conditions module

The Conditions Module gives you the power to analyze the rootzone and climate together so you can optimize your irrigation and crop steering strategies. It helps you to maximize input cost savings, yield, and crop performance.

Rootzone data – get real-time data from the GroSens Rootzone Sensor including WC, EC, temperature

Climate data – get real-time data from the GroSens Climate Sensor including humidity, temperature, VPD, and CO_2

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

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 full history in 30-day intervals

Growth tracker module

The Growth Tracker module allows you to easily input and track key parameters throughout the various stages of a batch's life cycle from propagation, veg, harvest, and mothers culminating in cultivar specific insights. In Growth Tracker, you can view historical climate and rootzone information on each batch to further optimize crop steering and genetics.

Strain-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 really dial in 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

Standard operating procedures (SOPs)
Use captured data to improve SOPs and train all team members on the operational parameters

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.

Meet the redesigned GrosSens device

The new GroSens suite provides more accuracy, highly reliable and precise rootzone temperatures, WC and ED measurements. This results in better growing insights.

Features

Improved design and performance

Plug & play setup

LoRa technology

Benefits

The new sensors have an improved, compact and waterproof product design, with an integrated antenna. Thanks to the distinctive blue color, spotting it in the facility is easier.

The ease of use and seamless connectivity of the new device make it incredibly user friendly. You can connect it to a network without requiring any additional configuration or installation. This not only saves setup time for you but also reduces the likelihood of errors.

LoRa has become the de facto wireless platform for IoT, connecting sensors to the cloud and enabling real-time communication of data. Our new devices can transmit data over longer distances, providing an extended communication range for enhanced connectivity.

GroSens CLIMATE SENSOR

We offer two climate sensor models. The both measure relative humidity, internal temperature, and VPD*. The second model also includes CO_2 measurement. *VPD is based on a calculation from the relative humidity and internal temperature.

Features

- Real-time data
- Accurate & reliable rootzone data
- More accurate measurements

Benefits

Enhance the performance and efficincy of your IoT application with real-time data acquisition provided. This enables seamless data analysis and visualization for improved functionality.

With our data models designed around your substrates, and combined with the patented 6 pin layout, GroSens offers you accurate and consistent rootzone insights, measuring Water Content (WC), Electircal Conductivity (EC), and rootzone temperature.

You can use the sensor to measure Water Content in the range between 0-100%, Electircal Conductivity in the range between 0-20 mS/cm, and Temperature in the range between 0-50 degrees Celsius or 32-122 degrees Fahrenheit.

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.

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.

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.

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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