Steering crops in high-tech controlled environment agriculture: how stone wool supports unparalleled control over plant development

Steerable

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Steerability is the keyword when it comes to precision growing. But what does steerability mean, exactly? How can growers leverage stone wool growing media and real-time data to gain unparalleled control over plant development? And what are the benefits in terms of yield, quality, resource efficiency and sustainability? In this first whitepaper in our series, Grodan's Jos Beerens (Senior Crop Technical Specialist) and Marielle Taft (Head of Crop Advice North America) take you on a deep dive into the world of stone wool steerability.

As part of Grodan's commitment to advancing knowledge and pushing the boundaries of controlled environment agriculture (CEA) practices, the company has been involved in countless scientific research initiatives and practical trials over the years – ranging from more established greenhouse crops such as tomatoes, peppers and cucumbers (aubergines & flowers), to emerging opportunities in crops such as cannabis, strawberries and leafy greens. These activities have continuously produced new insights into how specific crops and varieties can be manipulated to achieve unparalleled yield, quality and resource utilisation.

Stone wool gives growers fast, efficient, responsive, predictable and repeatable control

"Here at Grodan, we conduct extensive research to understand the root zone and environmental cues that influence plant growth behaviour and energy allocation. Uncovering the science behind how each stimulus impacts crop development allows us to help growers deploy the right techniques and strategies to steer their crops for maximum production and quality," says Marielle Taft.

What is root zone steerability?

'Steerability' means the grower's ability to intentionally influence the plant's vegetative and generative energy balance through measurable changes in the greenhouse climate conditions and/or in the root zone. By sending targeted signals in specific crop phases, growers can optimise plant development and therefore maximise crop quality and yield in each cycle.

"Stone wool gives growers fast, efficient, responsive, predictable and repeatable control – that's the essence of a truly steerable substrate," states Taft. Understanding the root zone is key to steerability. Discover how the root zone microbiome contributes to plant health, resilience and nutrient uptake.

Precision growing by design

All of Grodan's stone wool growing media products are engineered and manufactured to have the ideal physical structure and chemistry to optimally support each crop's specific preferences. "We've done a huge amount of R&D and testing, both internally at Grodan and externally with commercial growers, to develop the ideal characteristics for each crop type," says Jos Beerens.

"These characteristics include the structure, orientation and density of the fibres, and also the dimensions – especially the height. As a result, the substrate itself can be a very important steering factor," he continues. "And because stone wool growing media are homogeneous and uniform, growers can measure and steer more precisely on water content percentage (WC%) and electrical conductivity (EC), and know that the same change will produce the same results across the whole of their crop, every time."

Even a small adjustment to the irrigation strategy can produce a rapid and effective change in the stone wool slab or block. This responsiveness enables growers to quickly alter the vegetative or generative balance to encourage the desired type of development in plant architecture, such as a higher leaf area index (LAI), faster flowering or earlier fruit-setting.

How do the physical and functional properties of stone wool support steerability?

Effective steerability starts with a well-rooted substrate.
"A plant with an extensive, evenly spread root system has a bigger capacity to take up the irrigation water and nutrients, enhancing the steerability based on WC% and EC. That's why it's important to encourage the roots to colonise the entire substrate in the rooting-through phase, using all the available space in the slab, rather than shooting straight down to the bottom," explains Beerens.

All of Grodan's stone wool growing media solutions have therefore been precisely engineered to meet the needs of a particular crop type – not only in terms of dimensions, but also fibre thickness, orientation and density.
"For example, our tomato substrates have a horizontal fibre structure with a denser top layer to slow down growth after the rooting-in phase and get the crop off to a more generative start, stimulating the development of high-quality first clusters," he says.

"In contrast, our solutions for cucumbers and peppers are lower-density substrates with a more vertical fibre structure to encourage faster and more homogeneous rooting-in. We're also continuously fine-tuning our other products to offer the best properties for crops like lettuce, strawberries and leafy greens," continues Beerens.

Grodan's stone wool solutions also rely on advanced hydrophilic chemistries, enabling improved irrigation efficiency and fertiliser balance.
"This ensures that our substrates can absorb and retain water exceptionally well – such as during the P1 re-saturation phase after overnight decrease in WC% – and can also titrate the EC level quickly with an efficient drain phase," adds Taft.
"Moreover, due to the advanced chemistry of our binder technology and wetting agent, in combination with the carefully designed physical fibre properties of our stone wool, there is more homogeneous distribution of water and fertiliser from the top to the bottom layers compared to other growing media (such as organic).

Furthermore, when you really get the physical and functional properties of a substrate right, you have reduced chance of channelling or 'false drain', which is quite common in some organic growing media. When this happens, the water essentially funnels out of the substrate without having any significant impact on the EC or pH balance, and sometimes even fails to re-wet entirely."

Stone wool substrates do not degrade over time.

"Whereas organic media continue to decompose and change throughout the crop cycle, stone wool remains stable until the end. This supports steerability, because the grower knows that any changes in the root zone data indicate what is actually going on with the plant itself, without interference from the substrate's decomposition process," says Taft.

Importantly, stone wool substrates have a limited cation exchange capacity. As a result, they do not interfere with the chemical composition or ion availability in the fertiliser.

Even though the nutrient recipe is carefully balanced to steer the plant toward health, resilience and productivity, some organic growing media naturally adsorb some of the ions to the particle surfaces. In contrast, the fidelity of the fertigate composition is unmatched when deployed in stone wool. What you deliver through the irrigation system is exactly what the plant receives via the pore water," she states. "Because stone wool is a blank, steerable canvas, you know that the plant receives 100% of what you give it." ■

Steerability is only as good as the substrate it runs on. How your growing medium is engineered determines how accurately you can read your crop, how quickly it responds to your inputs, and how much of your steering strategy actually reaches the plant.
Explore the **benefits of Grodan growing media**.

Minimising fluctuations for a more resilient crop

The experts are keen to point out the difference between 'responsive' and 'reactive'. "Imagine driving along a five-lane highway. A responsive substrate like stone wool enables you to move between wet and dry conditions by changing lanes smoothly, one lane at a time, whereas in a reactive substrate such as organic media, a dry substrate like perlite or small substrate volumes, the change is more extreme," says Beerens.

"When you're aiming to build a resilient crop – which is essential to minimise susceptibility to pests and diseases and therefore maximise the likelihood of high yield and high quality – it's important to avoid creating volatile conditions, because those fluctuations require the plant to waste valuable energy on adaptive responses. This is especially relevant in view of ever-tighter limitations on the use of pesticides, for example. The responsiveness of stone wool enables growers to provide their crops with more stability, minimising unnecessary stress," adds Taft.

"Additionally, if you want to augment any part of your fertiliser recipe, for example by limiting nitrate, the nutrient solution present in the substrate can be quickly displaced and refreshed in stone wool," she says.

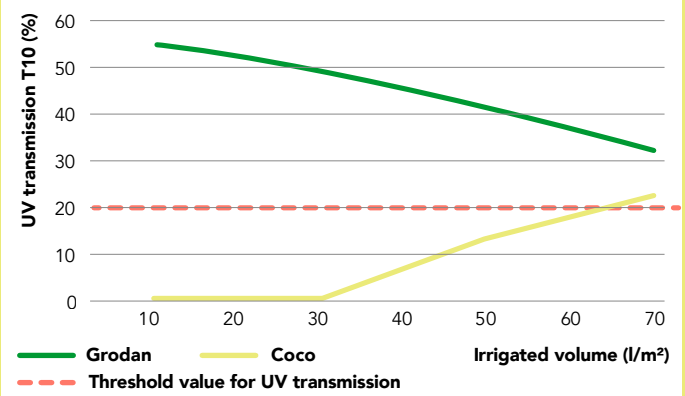
"Similarly, that 'flushability' is beneficial when growers are using plant protection products. Whereas organic media can retain residues for days or even weeks, flushing a stone wool substrate eliminates any residues almost immediately," continues Beerens.

Managing nutrients more efficiently

Stone wool makes nutrient management more efficient in multiple ways. First, due to the functional properties of stone wool as explained above, growers are sure that 100% of the balanced nutrient solution is going to the plant, rather than being partially adsorbed to the particle surfaces of organic growing media. Second, it enables growers to take a data-driven approach in which they can maintain nutritional balance while limiting drain, reducing the discharge of effluent irrigation water and fertiliser into municipal and regional waste streams. And third, as an extension of this, stone wool makes it easier to reclaim and recirculate the nutrients contained in the drain water.

"It's clean and balanced from the very first flush. This is because stone wool does not contain organic matter, excess cations or biological contaminants. Moreover, it doesn't have the same high turbidity and low T10 found in peat and coir mixes that make the drain water less suitable for UV disinfection," explains Taft (see Figure 1).

Figure 1. UV transmission values*



How stone wool steers growers toward sustainability goals

Thanks to its steerability, stone wool equals greater sustainability for several reasons:

- Treatment and re-circulation of drain water from Day 1 ➔ reduced consumption of water and nutrients, and less wastewater released into the environment
- Healthier and more resilient plants ➔ less need for crop protection agents.
- More efficient nutrient extraction from the substrate ➔ reduced waste of scarce resources such as phosphorous.

* UV transmission values for coco peat and Grodan growing media measured at the start of pepper cultivation. Transmission improves after 30 l irrigation with T10 threshold value being reached at 60l. Source: Grodan commissioned trail at Botany, Horst-Meterik, 2011

"Stone wool not only creates savings for growers in terms of fertiliser costs, but also in terms of maintenance of the drippers, lines, filtration and disinfection systems, since the substrates do not shed particulate or organic matter that can cause blockages and occlusions," she states.

Gaining accurate and dependable insights

Accurate and reliable root zone data forms the basis for precision growing. "You can only steer effectively when you know exactly what is going on in the substrate at all times. That information tells you whether the crop has the desired vegetative versus generative balance, and informs your decision-making about corrective action if necessary," states Beerens.

"It's considerably easier to measure these parameters reliably in a substrate that has uniform physical properties, like stone wool, versus organic growing media with a lot of heterogeneity in terms of particle size and porosity," he says.

While there are various ways of obtaining such data, Grodan's GroSens Suite provides extra insights that add significant value for growers. "Our sensors measure not only the WC% but also the EC in the slab and in two horizontal layers. This gives growers a much more representative indication of the average root zone conditions in real time. They are also supported by ideal general reference values which growers can use during the development of the crop," explains Beerens.

"Within Grodan, we have conducted extensive R&D to develop state-of-the-art proprietary measurement models that are differentiated by substrate type. They have been fine-tuned for the physical properties of each of our growing media solutions, in combination with the specific crop type," states Taft. "Therefore, growers using the GroSens Suite in combination with Grodan substrates know that they can really trust and rely on the data they see."

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Learn more

Read the second whitepaper to learn actionable strategies for measuring and steering WC%, EC and nutrient supply to achieve predictable, high-quality results in your greenhouse:

Click to read second whitepaper

Designed to grow

Grodan is the global leader in supplying soilless rootzone management solutions for Controlled Environment Agriculture. These solutions are applied to the cultivation of vegetables, medicinal crops and flowers such as tomatoes, cucumbers, sweet peppers, eggplants, roses and gerberas.

At Grodan, we aim to help feed and treat the world's growing population by innovating solutions from our stone wool growing media to enable 'more-with-less' growing. Through the method known as out-of-soil, our stone wool substrates, sensor systems, software and expertise support the reliable, informed growing of healthy, fresh, high quality produce. Our material is 100% recyclable, and supports growing methods that use up to 50% less water, 20% less chemical plant protection products and 75% less land. Sustainability plays a prominent role within Grodan, from manufacturing stone wool substrates to recycling solutions and services.

Grodan has more than 50 years of cultivation experience. We pioneered the development of hydroponic growing methods in the 1960s, and today, our soilless rootzone management solutions are used in large-scale commercial greenhouses and indoor facilities in over 70 countries across the globe. The head office is located in Roermond, the Netherlands.

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