



Understanding Substrate Design

Key features of stonewool substrates and why they are important when implementing an irrigation strategy for optimum plant performance.

In the second of six articles for Practical Hydroponics & Greenhouses, Grodan® Crop Consultant ANDREW LEE provides an insight into the key features of stonewool substrates and describes how by understanding the basic principles behind them growers can gain maximum benefit from an applied irrigation strategy.

Root zone management

In the first article (July/August 2009) of the series we looked into the process of water movement and transport within the plant and how the root zone and climate interact in driving this process. We also touched upon the effects of water uptake on sunny and dark days and how the root zone environment needs to be 'steered' correctly in order to maximise the grower's revenue (i.e. production and fruit quality).

Correct root zone management can also assist growers in reducing input costs. One example is the increasing gas price in Europe (Figure 1), which is forcing growers to look critically at energy inputs and ways to manage these without detriment to yield and quality. The same situation currently exists in Australia. As a result of this focus the average energy inputs in Northern

European greenhouses have fallen from 60m³ in 2005 to 40-45m³ (natural gas) in 2009. This has been achieved with the implementation of lower maximum pipe temperatures in winter, using less or no minimum pipe for humidity control and increased use of movable energy screens and fixed anti-condensate films to insulate the greenhouses better against cold outside temperatures. Growers and consultants have set themselves ambitious targets to reduce energy input towards 30-35m³ in the near future.

These actions which ultimately limit the energy bill, which can still be in the region €10 m² (A\$16), create a greenhouse climate which reacts differently. This has, as described in the first article, implications for the root zone management strategy.

In order to get the optimum crop performance with minimal energy input the grower needs to make adjustments to the

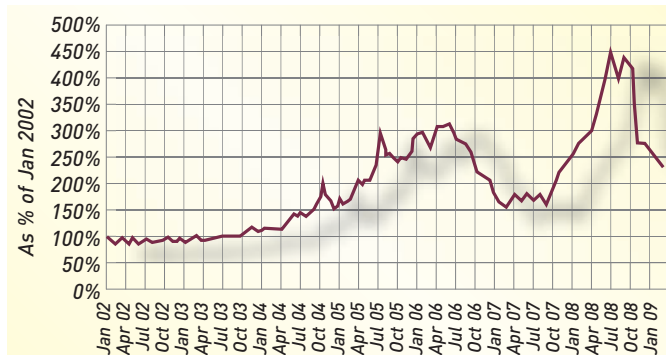
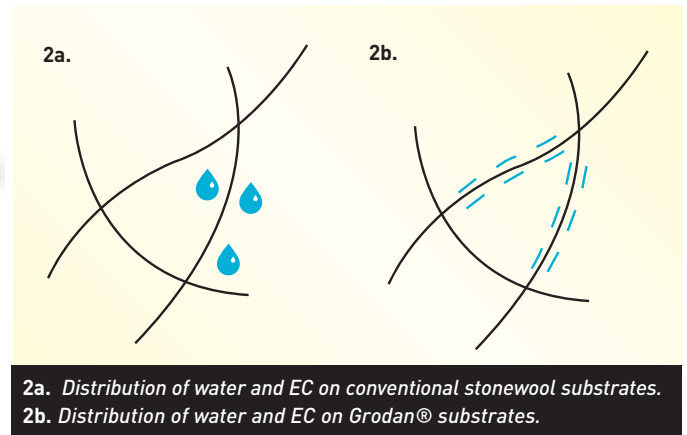


Figure 1. Gas price index 2002-2009.



2a. Distribution of water and EC on conventional stonewool substrates.
2b. Distribution of water and EC on Grodan® substrates.

irrigation strategy. To do this correctly he or she must understand the key design features of the substrate and what functionalities these deliver in practice. It's not simply a case of a 'wet bag' or 'dry bag' at the cutting edge of greenhouse innovation. Understanding the design features of a substrate enables the grower to develop specific irrigation strategies using the greenhouse computer to manage water content (WC) and EC to pre-determined targets, set according to their wishes. The added benefit is that the substrate supplier is also able to deliver the most appropriate and targeted user advice in support of the product.

Next Generation Technology

Grodan® has, over 40 years, built up a reputation as a reliable partner, knowledge platform and innovator in the greenhouse hydroponics industry. A number of aspects related to substrate functionality in use are taken into account when designing Grodan® slabs. Subtle design changes in fibre orientation, thickness and density result in substrates that perform differently in practice. The introduction of advanced hydrophilic fibres in the Next Generation Substrates of Grodan® substrates have further enhanced the performance of stonewool slabs as WC and EC are now distributed more uniformly over the surface of the stonewool fibres, rather like a thin film (Figure 2b).

Key substrate functionalities which impact on how a substrate performs in daily life are 'uniformity', because without uniformity you cannot grow to a pre-defined strategy, you will always be making compromises for slabs that are too wet or too dry or for a slab EC that is too high or too low.

The 'Control Range WC' is important because greenhouse crops require generative or vegetative steering, depending on their balance without detriment to plant growth, root function, yield and quality. Consequently the substrate needs certain minimum and maximum operating levels which can be tailored to the specific needs of the customer. The ability to restore desired day level WC quickly and easily depends on the 're-saturation' properties of the substrate and, in combination with the 'irrigation efficiency' of the substrate, determines how the applied drip solution is utilised, for optimum EC control. For example, what proportion of applied irrigation is used to dilute the slab solution, what proportion replaces the old solution, and what proportion runs directly to drain?

Key functionalities in practice

In practice, growers require uniformity across length and height of the substrate. This provides confidence, for example, that the substrate will not become too dry in the top layer and allows specific strategies to be implemented when steering the crop to maximise revenue but also limit costs (i.e. fertiliser inputs). This key design feature is principally derived through the quality of the manufacturing process and the defined production tolerances. However, subtle design features can dramatically change WC and EC distribution in the slab.

Figures 3a, 3b, 3c and 3d illustrates the WC and EC distribution for a tomato crop in two types of stonewool slab each given the same irrigation strategy. The pattern of WC and EC distribution across the length and height of the slabs is clearly different, the denser top layer clearly having a higher WC (Figure 3a) and lower EC (Figure 3c) compared to a standard slab (Figure 3b and Figure 3d). Growers must therefore be aware of how evenly WC and EC is distributed in their chosen substrate to get the best out of it in terms of the applied irrigation strategy.

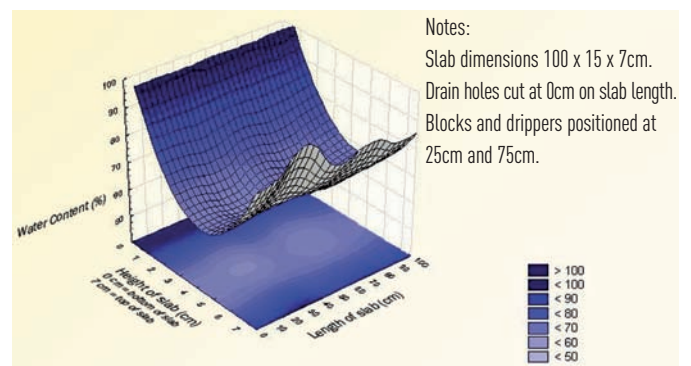


Figure 3a.
Typical WC distribution in dual density horizontal fibre slab.

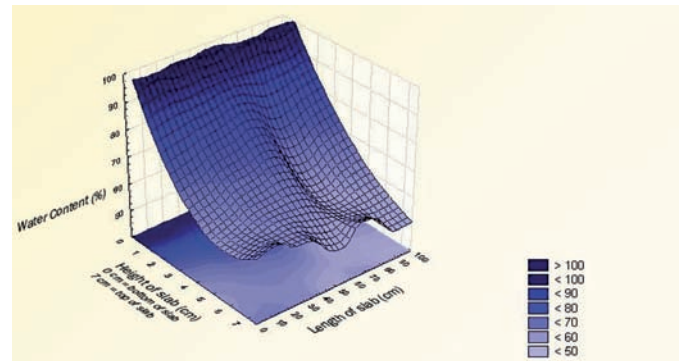


Figure 3b.
Typical WC distribution in a standard stonewool slab.

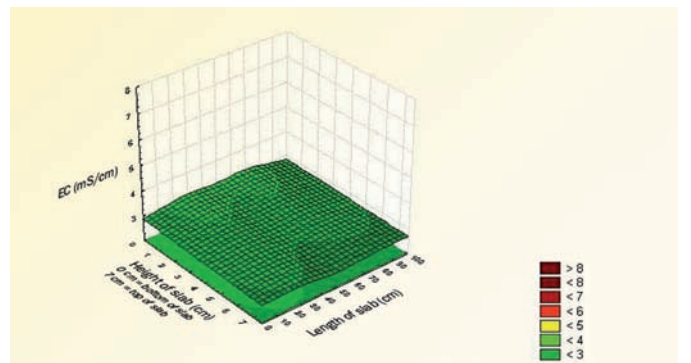


Figure 3c.
Typical EC distribution in a dual density horizontal fibre slab.

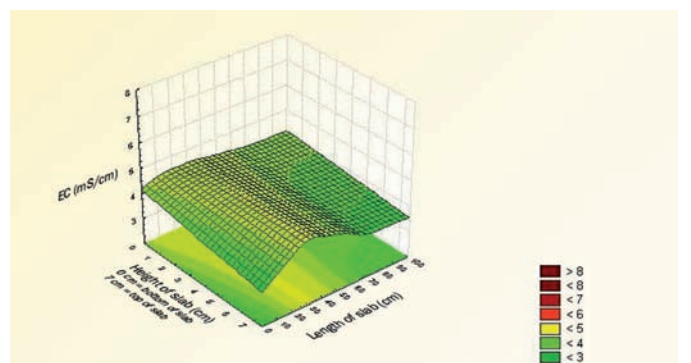


Figure 3d.
Typical EC distribution in a standard stonewool slab.

Water content

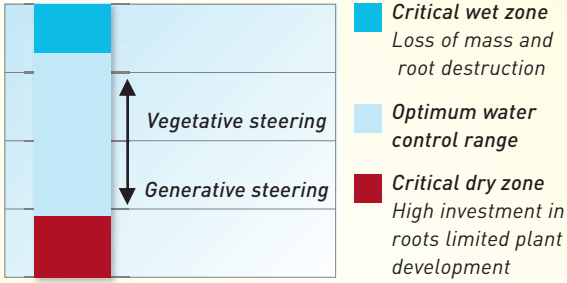


Figure 4. Schematic representation of Control Range WC for greenhouse substrates.

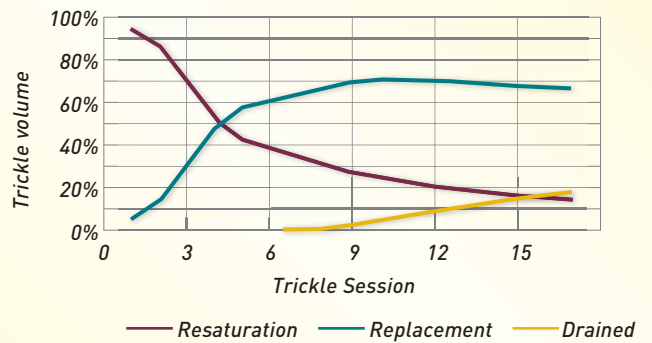


Figure 5d.

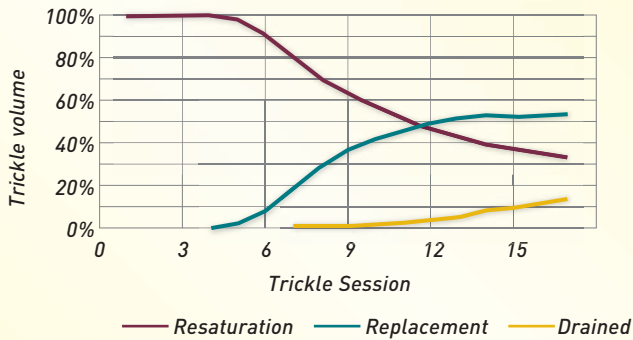


Figure 5a.

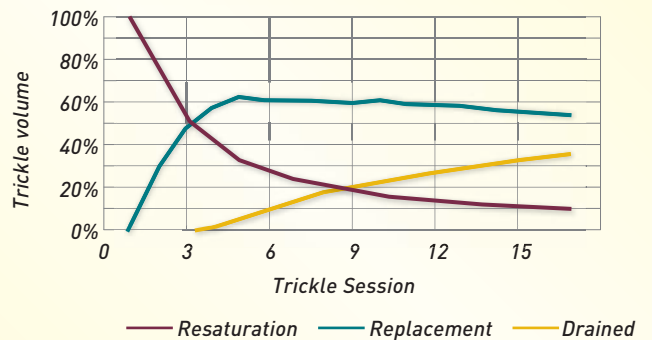


Figure 5e.

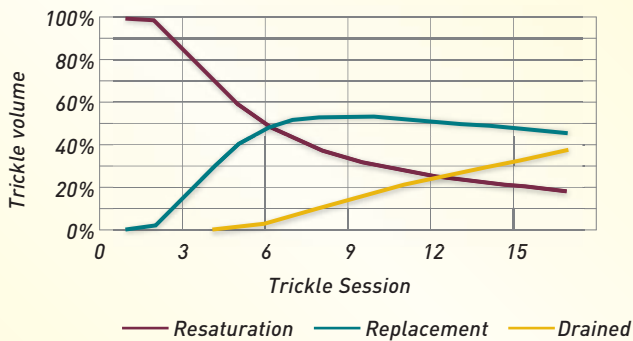


Figure 5b.

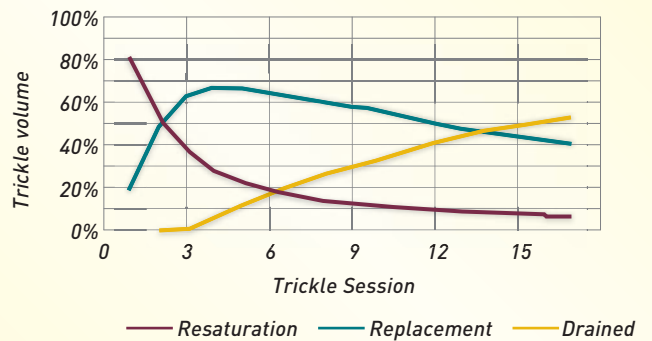


Figure 5f.

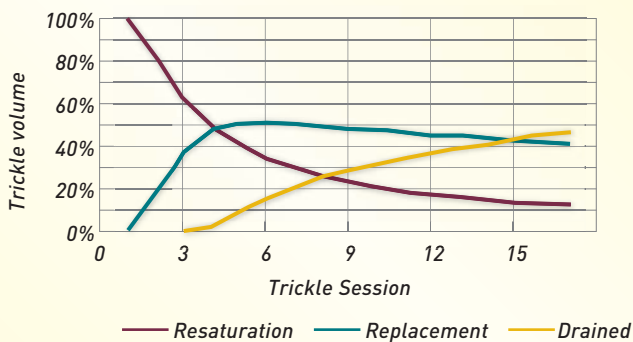


Figure 5c.

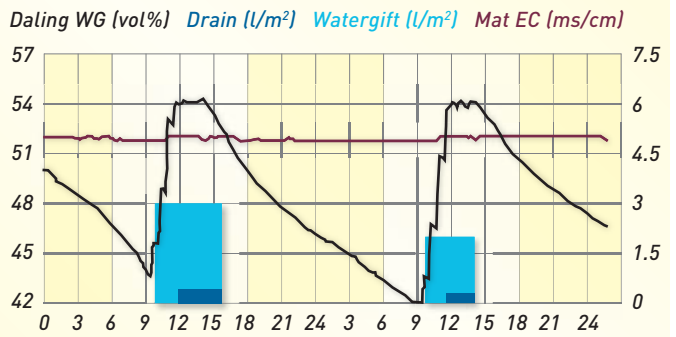


Figure 6. The WC and EC development with applied irrigation and drain volume over 2 days.

Control range WC for substrates is represented schematically in *Figure 4*. Plant performance is optimised if the day level WC can be maintained within certain operating limits. Within these limits growers make optimum use of inputs (i.e. energy). The lower limit maximises generative steering and the upper limit maximises vegetative steering. The degree of steering offered is dependant on substrate design. Operation of day level WC outside these limits has a negative impact on plant performance. For example, we know that if day level WC is stabilised in the critical dry zone (*Figure 4*), proportionally more investment by the plant is put into root development at the expense of controlled plant development. If day level WC is stabilised in the critical wet zone the result again is a loss of plant development and destruction of root quality. The energy input to the crop is not optimised in both scenarios. It is therefore important to know what the operating limits for control range WC are from your substrate supplier.

The re-saturation and irrigation efficiency of the substrate is clearly linked to the volumes of applied irrigation as shown in *Figure 5a*, *Figure 5b*, *Figure 5c*, *Figure 5d*, *Figure 5e*, and *Figure 5f*. Substrates react differently according to their design characteristics. It can be seen that the horizontal dual density substrate creates less drain than a standard slab and that larger irrigation volumes replace a greater proportion of the substrate solution.

In practice, if you know the irrigation efficiency of the substrate you are using and how it reacts to different volumes of applied irrigation you can implement an irrigation strategy that will achieve a specific slab WC and EC. Just as importantly, if corrective actions are required to level EC or adjust WC you will know what changes are required. This is an

important functionality that has a large impact on start and stop times, hence energy saving measures.

This is demonstrated in practice in *Figure 6*. The start time of irrigation is 3.5 hours after sunrise allowing slab WC to fall 12% overnight, facilitating energy saving measures by limiting greenhouse humidity rise in the morning and providing a strong generative crop reaction. The substrate design enables large irrigation volumes to be applied, indicated by the steep rise in WC. The irrigation efficiency allows EC to be stabilised at 5.0mS and day level WC at 54%, again a generative action and with minimal drain volume (dark blue bar), saving fertiliser.


Future articles from Grodan®


In conclusion, the design features of the substrate impact on its ultimate performance and management in the greenhouse. Understanding these features facilitates specific user advice to be generated by the manufacturer which in turn allows the grower to get the optimum performance out of a crop.

In the next issue of *Practical Hydroponics & Greenhouses* I will define the targets and goals for steering the balance in the crop from planting through to final production.


About the author

Andrew Lee works for Grodan B.V. as Business Support Manager for North America and Export Markets. He is a PhD graduate from the University of London, England, and has been working for Grodan® over the past 9 years providing consultancy and technical support for its customer base worldwide. ☞






‘The control range is truly gigantic’



Next Generation Substrate



Grodan products are EU Ecolabel certified | NL / 029 / 1

The benefits

- **Maximum control range**
- **Efficient EC replacement**
- **Full root development**

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