Recycling Drain Water

Improving the Efficiency of Water and Fertiliser Use

A steerable substrate with a focused irrigation strategy combined with recycling the drain water can significantly help reduce input costs as well as enable compliance to environmental emission laws without affecting yield and quality.

In the last of the current series of articles for *Practical Hydroponics & Greenhouses*, Grodan® crop consultant ANDREW LEE outlines the true cost of water and fertiliser and how recycling of drain water from the start of cultivation can result in significant cost savings for growers as well as helping them comply with stricter environmental legislation.

By ANDREW LEE

Introduction

Inclement weather conditions impact massively on water uptake by the crop and therefore directly impact on the amount of irrigation water that is required (*PH&G*, Jul/Aug 2009). To allow the grower to exert total control of the root zone environment Grodan® substrates are now engineered so that WC Water Content) and EC (Electroconductivity) can be steered accurately, whilst at the same time using water and fertiliser efficiently. In this way day level EC and WC can be managed according to the prevailing weather conditions, plant balance and energy input into the greenhouse (*PH&G*, Nov/Dec 2009). However, as with all things horticultural, there is no 'magic button' that you can press to ensure success, you need an overall plan, which meets both marketing (size and quality) and production (kg/m^2) goals (*PH&G*, Jan/Feb 2010). The plan should be robust enough to enable the crop to cope with extreme temperatures and facilitate strong and regular growth even in the darkest periods of the year. With the support of the climate computer and measuring tools such as the WCM (Water Content Meter), continuous informed decisions can be made in respect to the (irrigation) strategy to steer the crop on a daily basis (*PH&G*, Mar/Apr 2010). The benefits that this knowledge can provide and how it can be used to improve the financial returns to the company by optimising fruit quality were subsequently addressed in the last article (*PH&G*, May/Jun 2010).

In this, the final article of the current series, I will outline how growers can become more efficient at using water and fertiliser by recycling the drain water, demonstrating what is possible with *current technology.* I will also provide some useful tips on how mundane operations such as cutting and positioning of the drain hole can impact significantly on substrate functionality and water use efficiency.

How much water and fertiliser do you use and what does it cost?

Most growers when asked can tell you exactly how much they spent during the last cultivation cycle on labour and energy, but very few can actually tell you directly how much irrigation they applied per hectare and what it cost. The cost can be significant.

The average water use for a tomato grower using Grodan stone wool substrate in Europe is approximately 1.25m^3/m^2 per year (2.85mL per joule) with 25% drain (0.312m^3). The cost of fertiliser is close to €0.5/m^3/EC unit. With an average EC of 3.0mS the total cost to the grower in this example would be €1.88/m^2 or €18,800/ha.

3.0mS x €0.5/m^3/EC unit x 1.25m^3

Recycling drain water

In the above example recycling the water would reduce the fertiliser bill to approximately 1 Euro/m^2. This excludes disinfection cost, which for a Priva UV Vialux system is approximately €0.15/m^3. Recycling the drain water in a 'closed system' should therefore be a 'no brainer', simply based on the costs savings that can be made year on year. In addition, recycling also presents a *positive company image* and will most likely play a significant role in any company's external sustainability message towards its customer.

Sustainable cultivation

Water, of sufficient quality, is already a scarce resource even in areas of Northern Europe where the annual rainfall is abundant. However, greenhouse growers can be proud of the fact that they already use water more efficiently compared to open field production. Greenhouse operations recycling their drain water in The Netherlands consume approximately 15 litres of water per kilogram of fruit produced. This compares to 60 litres of water per kilogram of fruit in an open field situation in southern Spain.

The scarcity of water is of course more acute in most areas of Australia. It is therefore important that you use water as efficiently as possible. This can only be achieved with good irrigation management practices, drain water collection and recycling systems. Do not underestimate the importance of the substrate. This should be of uniform quality allowing you to steer WC and EC accurately. Key functionalities are the ability to steer water content on a low day level (40-45%[1]) in winter and a higher level (75-80%[1]) in summer, whilst at the same time being able to change or refresh EC quickly in periods of changeable weather. In this respect the climate computer should allow you to implement flexible irrigation settings (*PH&G*, Mar/Apr 2010) in combination with providing good graphics *(Figure 1)* as this will enable you to make informed decisions regarding any necessary adjustments to the settings on the computer.

[1] Range indicated is for Next Generation Grotop Master

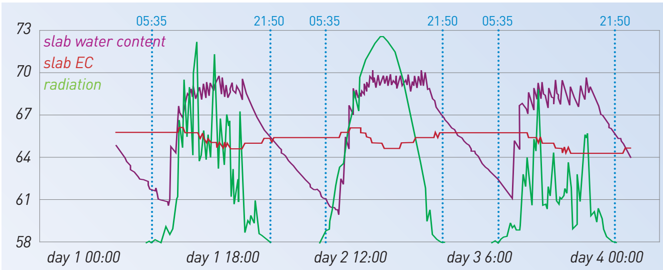

Figure 1: *Advised standard graphic to illustrate the development of WC and EC in the substrate in respect to incumbent weather conditions.*

Environmental legislation

Worldwide, growers are also coming under increasing legislative pressure related to the emission of water and nutrients from the greenhouse, particularly in the countries making up the European

Union and more recently Ontario, Canada. Within Europe the Dutch Government has gone one step further, due largely to the concentration of horticultural holdings, and announced the *Kaderrichtlijn Water*, *2010* (Water Directive, 2010). In essence, this directive has the goal of realising zero emission of fertilisers from the greenhouse by 2027. The goal is extremely ambitious and will not be achieved unless technological advances in nano-filtration, in-line ion measurement, and precision dosing technologies can be commercialised. However, there are many things that can be implemented today based on current technology to help reduce environmental emission, even if legislation is not yet forcing the issue, notably:

- Adequate rain water storage (i.e. a pure source of water with no Na^+ contamination) in Northern Europe based on an annual rainfall of 800mm ($80m^3$/ha) dictates $500m^3$/ha.
- Adequate drain water storage (in Europe, specification dictates $40m^3$/ha).
- Accurate application of water and fertiliser.
- Accuracy within the distribution system (i.e. uniformity dosing equipment and drippers).
- Re-using first flush. (First flush describes water emitted from the substrates following the action of cutting the drain holes.)
- Minimal drain per cent during the cultivation with more accurate steering of WC and EC in the root zone combined with regular monitoring and adjustment of nutrient levels.

Table 1 illustrates the levels of emission reduction that can be achieved with drain water recycling and implementation of a structured irrigation strategy to minimise the drain volume.

Table 1:
Theoretical emission on N (Kg/ha) from commercial greenhouses.

Strategy	Nitrogen emission (Kg/ha)
1. 100% run-to-waste 'open system' realising 30% drain	945 Kg/ha
2. 85% re-use and realising 30% drain	142 Kg/ha
3. 85% re-use and realising 15% drain	71 Kg/ha

Data assumes a water application of 1250 l/m² with an average N application during the cultivation 18mmol/L.

In Holland, a survey of 46 tomato growers by Guus Meis (LTO Glaskracht) found that the average N emission was 115kg/ha, which is very close to the figure 85% re-use and 25% drain. There are a number of reasons why with current technology drain still required *(Table 2)*.

Table 2: ***Reasons to run-to-waste during the production cycle.***

Reason	Possible causes
Uniformity of greenhouse design	Hot spots and cold spots resulting in differences in water uptake by the crop – (i.e. heating in winter/pad and fan in summer).
Unbalanced nutrient solution	Start of the crop (i.e. flushing coco slabs). Infrequent slab/drain analysis. Adjustment of drip solution.
High sodium content in drain water	Quality of primary water supply. Quality (purity) of fertiliser.
Equipment limitations and/or failure	No reverse osmosis unit. Insufficient drain water storage capacity. Failure of disinfection equipment (i.e. T10 values of drain solution).
Subjective grower opinions/observations	'Fear factor' of re-using first flush. Growth performance

Precision growing

Grodan is a pioneer in precision growing, providing root zone solutions for its customer base worldwide. In this respect Grodan has committed its *Application and Development* program to generate knowledge that will assist growers apply water and fertiliser more efficiently, reducing costs and minimising emission. This is the number one precondition for environmentally friendly horticulture today and in the future. One way to reduce emission within the confines of current technology is to optimise what you apply from day one.

Initial saturation of the substrate

At the start of the cultivation cycle Grodan stone wool is saturated with a complete nutrient solution. The drain holes are then cut and excess nutrient solution drains from the slab. A standard slab configuration (133 x 15 x 7.5 cm) will require

15 litres of nutrient solution for complete saturation, with approximately 6000 slabs per ha. This equates to 90m^3/ha water and fertiliser. For maximum steering in the WC control range for your chosen slab type, Grodan advise one drain hole per 133 cm slab length (see side panel tips for drain hole cutting). This should be cut at the lowest point in the slab *(Photo 1a and Photo 1b)* and be ideally positioned at least 20cm from the nearest dripper. This will allow maximum irrigation efficiency (i.e. it will generate minimal drain volumes whilst providing excellent EC refreshment in the slab *(Figure 2)*.

Photo 1a (left): *Drain hole positioning Example a.*
Photo 1b (right): *Drain hole positioning Example b.*

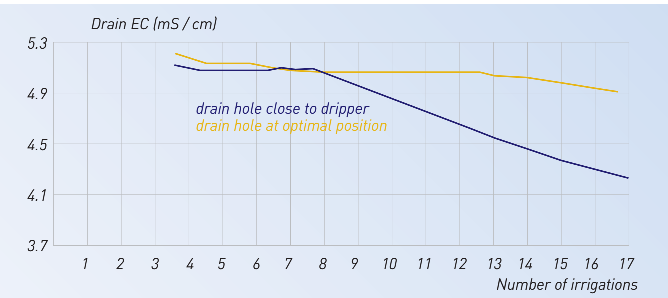

Figure 2: *Effect of drain hole location to the proximity of the dripper on EC in the drain solution. A higher drain EC = higher irrigation efficiency as more substrate solution is replaced.*

Tips for drain hole cutting and positioning

1. One drain point is required per 133 cm slab. For slabs longer than 133cm in length one or two drain holes can be cut, based on the preference of the grower. Please note more drain holes will make it harder to re-saturate the water content in the slab in spring. Also, more drain will be required to level the EC in the slabs.
2. The closest distance between first dripper and drain hole defines the water behaviour in the slab. The greater the distance, the more refreshment and re-saturation can take place in the slab. In the Next Generation assortment the advice is at least 20cm.
3. The cut should be made at the lowest point at the end of the slab in the direction of the slope. In case of an uneven profile, extra drainage holes will be required once the slabs have settled at the lowest point. Never make the drainage holes directly below a propagation block or irrigation pin.

Managing emission at the start of the crop

When the drain holes are cut approximately 2 litres of drain solution will be realised (12m^3/ha). Grodan stone wool is chemically inert. As such, what you apply in the drip is what you receive back in the drain *(Figure 3a)*. If this solution is allowed to run-to-waste it can result in significant emission, particularly N to the environment *(Table 3)*. In some circumstances, one reason for not re-capturing 100% of this solution is that the drain volumes created can cause the hanging gutters to overflow. If this is the case, to manage the flow the drain holes can be configured in two stages *(Figure 4)*.

Table 3: *N emission (kg/ha) from first flush using standard feed recipes for tomato, pepper and cucumber.*

N emission (kg/ha)	Tomato	Pepper	Cucumber
N emission Grodan based on first flush 12 m^3*	3.95	2.86	3.53
N emission Coco based on first flush 24 m^3	7.90	5.72	7.00

** Only if first flush is allowed to run-to-waste.*

However, it is perfectly safe to reuse the first flush from Grodan slabs, provided that the drain basin is free of chemicals used during the clean-up of the old crop, a strategy that would result in zero emission *(Table 4)*. Conversely, our research indicates for a like-for-like substrate volume, coco realises twice the initial drain volume (i.e. 24m^3/ha) and, therefore, twice the N emission based on the application of the same nutrient solution *(Table 3)*. However, as coco is not chemically inert the drain solution is not balanced *(Figure 3b)* and would require blending (EC 1.0mS) prior to reuse. However, due to the tannin content in the drain solution, this is not possible *(Photo 2b)* as the T10 values are not at acceptable levels until at least 60 l/m^2 (600m^3/ha) water has been applied *(Figure 5)*, equivalent to the volume that would be required in the first 8-10 weeks of a winter crop grown on Grodan.

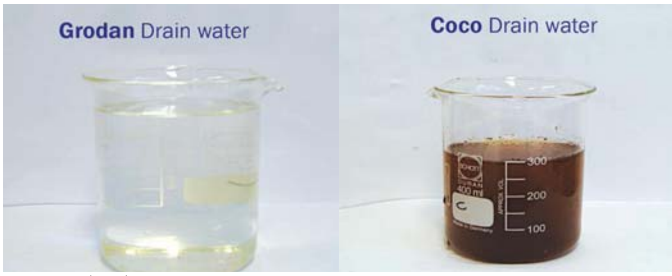

Photo 2a (left): *Colour of first flush from Grodan is clear, permitting immediate and effective use of UV sterilisation systems and, therefore, reuse of first flush.* **Photo 2b (right):** *Colour of first flush from standard coco is brown due to tannins. Use of UV sterilisation is not advised due to inadequate T10 values.*

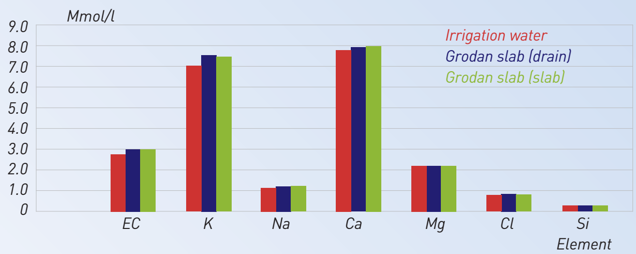

Figure 3a: *Analysis of drip, slab and drain solutions during initial saturation of Grodan slabs.*

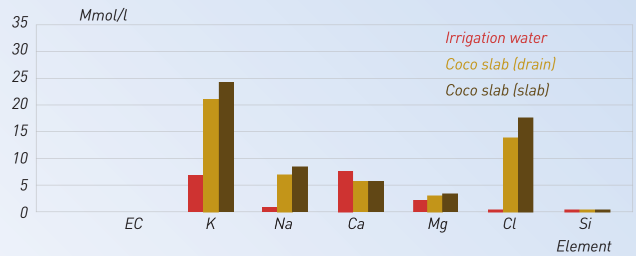

Figure 3b: *Analysis of drip, slab and drain solutions during initial saturation of coco slabs.*

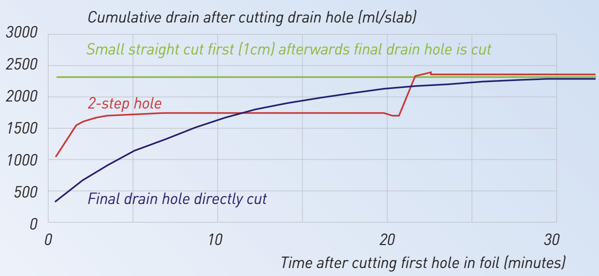

Figure 4: *Managing the flow of drain solution by two-stage cutting of the drain holes.*

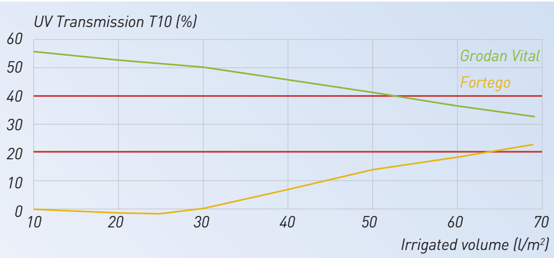

Figure 5: *Amount of flushing on coco required to achieve acceptable T10 values for effective drain water disinfection with a UV system.*

The potential difference in N emission during the first flush and flushing period of coco is huge *(Table 4)*.

Table 4:
Potential emission (N kg/ha) from Grodan and Coco slabs for a tomato based on volume of 1st drain and volumes required to reach acceptable T10 values for recycling the drain water.

	1st drain	Flushing	Total
Grodan	0 kg/ha	0 kg/ha	0 kg/ha
Coco	7.00 kg/ha	59.20 kg/ha	67.10 kg/ha

Managing water and nutrient supply during cultivation
Emission reduction during the main cultivation period is achieved by recycling and working with minimal drain volumes *(Table 1)*. Taking the example for a tomato crop further it is also possible to reduce the N-NO3 levels in the initial feed solution to 8-10 mmol/L for more 'generative' start to the crop, and then add 1 mmol/L per cluster until standard feed levels (16-18 mmol/L) are reached (*Source:* Groen Agro Control, The Netherlands). However, it is only possible to impact the desired crop response if you structure the irrigation strategy to target zero or very low drain volumes in the initial weeks of crop development. This is due to the uptake concentration of $N\text{-}NO_3$ by the crop. That is, the more irrigation you apply (i.e. to flush the substrate), the more the crop lives from the drip solution and the effect of low $N\text{-}NO_3$ feed minimised *(Figure 6)*.

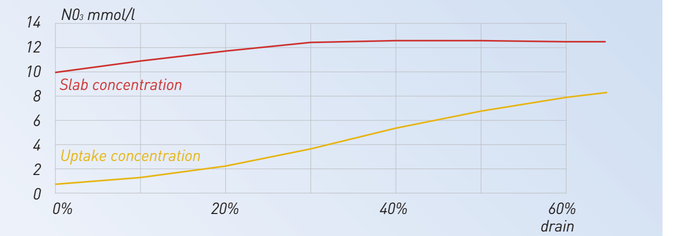

Figure 6: *Slab and uptake concentration of N-NO3 at different drain volumes. (Source: Groen Agro Control, The Netherlands)*

For winter planted crops the strategy would see the substrate EC increase and the WC fall *(Figure 7)*. When the crop requires approximately 2 litres irrigation per day the EC can be stabilised at a lower level as first drain volumes are realised.

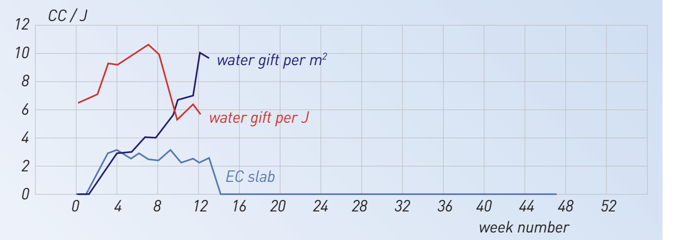

Figure 7: *Development of EC and water gift at the start of a winter planted tomato crop in northern Europe.*

For additional detail on how to structure an irrigation strategy to provide the level of control illustrated in *Figure 1* refer to the article *Water and EC management* (*PH&G*, Mar/Apr, 2010), remembering the key triggers in the decision making process, notably:

- Transpiration then irrigation.
- Drain by 400 J/cm² or 600 W/m².
- First drain in line with EC refreshment.
- EC refreshed and stable in line with global radiation during peak solar hours.
- Stop irrigation in relation to plant activity for a stable decrease in WC. It is also worthy to note that on the dark days in winter to maximum rest time will drive the total volume of water you give (assuming start and stop are correct). The values provided in *Table 5* are a useful indicator related to radiation (W/m²).

Table 5: *Guides for maximum rest time settings in line with light intensity (W/m²).*

Number irrigations per hour	Radiation (W/m²)
0-1	200
1-2	400
2-4	600
4-6	800

During the main cultivation period when the crop is growing quickly it is also important to take regular analysis (7-10 days) of the slab and/or drain solution because the balance of nutrient elements will change quickly. Regular adjustment will allow you to target fertiliser input more accurately and potentially recycle the solution for longer. In this respect remember that your drain may only be 25%, but that the drain solution may account for 33% of the nutrients you apply, due to the EC pre-setting on the computer *(Table 6)*.

Table 6: *Proportion of drip and drain solution used to irrigate the crop.*

	EC	%
Drip EC	3.0 mS	
Drain EC	4.0 mS	
Drain %		25%
EC pre-setting	1.0 mS	
Proportion of new feed solution		33%

Managing emission at the end of the crop

Continuing with the example of the tomato crop planted in winter, the goal is to have the drain basins empty by the end of the cultivation, in effect using all the fertiliser you paid for. Implement the strategy about 4 weeks from the end of the crop *(Figure 8)*. Start by increasing the EC pre-setting to 1.5-2.0mS so that you use proportionally more of the drain solution to provide the new feed, and work on lowering the drain volumes by decreasing the slab WC. This will result in less solution coming back to the drain basin and they will gradually empty. The reaction in the substrate will be lower WC and higher EC *(Figure 9a and Figure 9b)*. Fruit quality should not be affected as all of the remaining clusters will be in the ripening phase of their development.

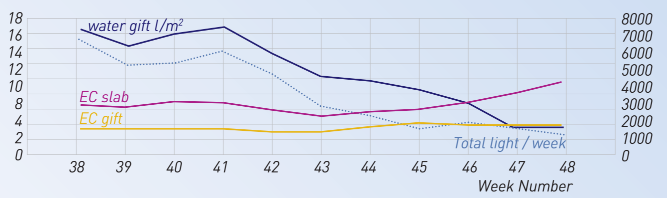

Figure 8: *Managing drain towards the end of the crop. In this example the heads were removed in week 38. WC decreased and slab EC increased approximately 4 weeks from the end of the crop.*

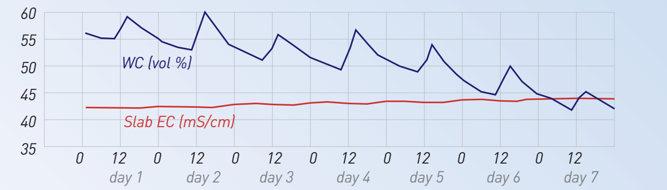

Figure 9a: *Slab WC and EC are significantly reduced in the week prior to removal of the crop.*

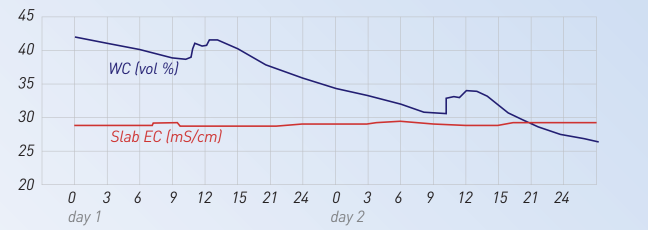

Figure 9b:
Slab WC is reduced to minimal levels before the end of the crop. This practice not only minimises fertiliser use but also enables easier handling during turnaround as the slabs are lighter.

Summary

This article has highlighted the cost to the business of water and fertiliser and how these inputs can be minimised via drain water recycling. Sustainable growing means minimising water and fertiliser input whilst maximising output and quality. To move towards totally closed systems will require technological innovations, which are currently not commercially viable. However, recycling from day one, working with a structured irrigation strategy, and frequent nutrient analysis during the cultivation cycle to reduce the volume of drain required, will all help minimise the environmental impact in the short term.

This was the last, albeit delayed article in the current series. I hope you found the content of each article interesting and the discussions they generated informative. All at Grodan wish you every success in the coming cultivation.

About the author

Andrew Lee works for Grodan BV 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 10 years providing consultancy and technical support for its customer base worldwide.