A New Hydroponic Substrate
GREENHOUSE CUCUMBER CULTIVATION ON GROWSTONES GROW BAGS

A comparison between cultivation on Growstone and Rockwool

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SUMMARY
Fruit production and quality were compared for cucumbers (*cv. Shakira)* hydroponically grown in Growstones and Rockwool substrates at the University of Wageningen Applied Plant Research Lab[1], The Netherlands, in 2006. The trial clearly demonstrated that cultivation of cucumbers in Growstones offered several management advantages over Rockwool, while offering equal or slightly higher cumulative yields. Owing to its drier nature, production in Growstones resulted in an earlier first harvest as well as significantly lower susceptibility to *Pythium*.

INTRODUCTION
Awareness of the environmental impacts of the hydroponic industry have already affected government policies and changed grower's practices in The Netherlands. Looking to reduce the negative effects of a too-wet media for cucumber crops which prefer a drier root zone, growers in The Netherlands have already transitioned from Rockwool to perlite. Yet there is also increasing interest in finding more environmentally sustainable alternatives to strip-mined substrates such as Rockwool and perlite. These actions are in line with mandatory government policies to promote growers' adoption of practices which increase production efficiency regarding energy and fertilizer inputs, while minimizing the environmental impact of the hydroponic industry.

Growstones substrates, made from recycled glass bottles, are 35% drier than Rockwool and serve the drier root zone requirements of crops such as cucumbers, while also fulfilling the required move to environmentally sustainable practices.

EXPERIMENT
The trial was conducted in a Venlo-type greenhouse at the Applied Plant Research Lab associated with the University of Wageningen, The Netherlands. The crop season was from September to December, 2006. Plant density was 1.8 plants per m^2. Day/night temperature regime was 22/20 ºC (71.6/68 ^{o}F). Photoperiod was extended to 16 h per day with assimilation lights. For both substrates the irrigation volume per day was the same: 110 ml per irrigation cycle. Drainage water from each substrate was kept separate for evaluation of transparency and pH stability. In both cases, drainage water was recirculated. A standard cucumber nutrient solution was delivered to both substrates and corrected on drain sampling.

RESULTS

Yields
First harvest was 2 days earlier in Growstones than Rockwool. Initial yields were 230 g per m^2 in Growstones and 140 g per m^2 in Rockwool. This difference was natural and resulted from the drier nature of the Growstones substrate, as well from a significantly higher resistance to soil fungi such as *Pythium*. Later this yield difference was reduced, and final cumulative yield (Figure 1) and number of fruits (Figure 2) was only slightly higher in Growstones substrates.

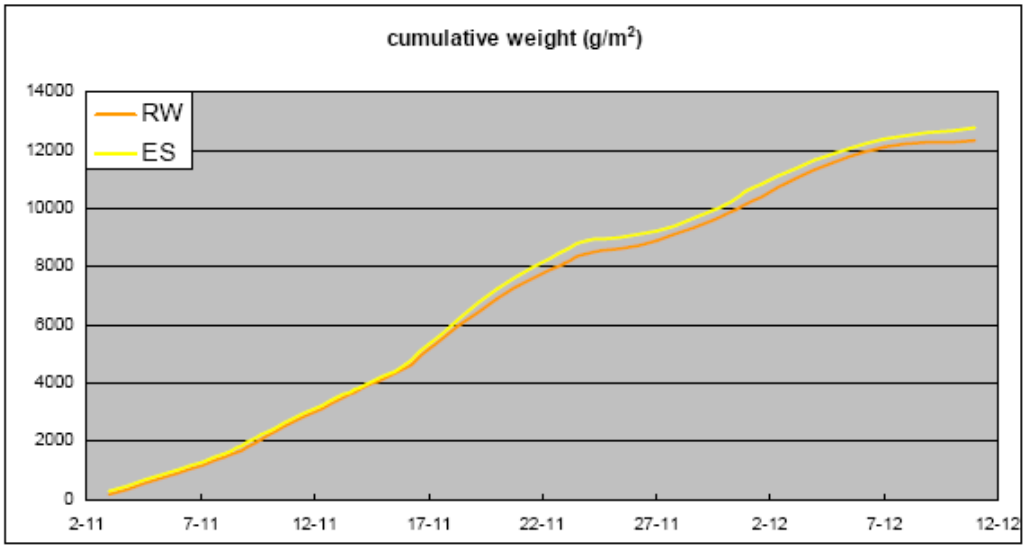

Figure 1. Cumulative fruit yields of cucumber (g/m^2) growing in Growstones (ES) and Rockwool (RW) between first harvest and the end of trial December 2007.

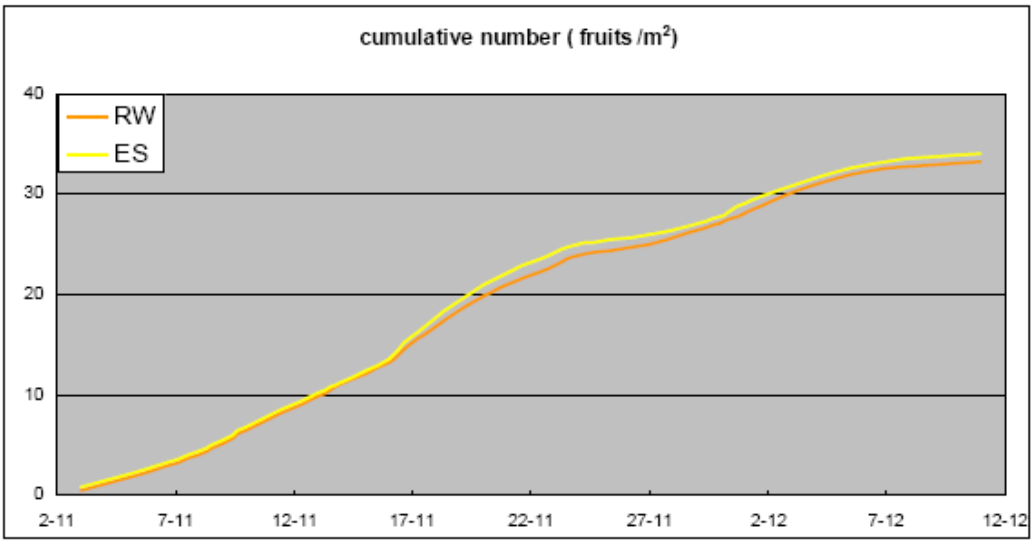

Figure 2. Cumulative number of cucumber fruits (fruits/m^2) cultivated in Growstones (ES) and Rockwool (RW) between first harvest and the end of trial December 2007.

The slightly lower production in Rockwool (Figure 1 and 2) was partially caused by a more severe incidence of *Pythium* in Rockwool plants which resulted in loss of plants (Table 1) and thus reduction in yields, until replacement plants started producing fruits. Previcure was used to prevent further loss of plants.

Number of plants	
Rockwool	Growstones
15	1

Table 1. Number of cucumber plants lost due to *Pythium* in each substrate.

Pythium incidence is typically higher in wet substrates, especially when associated with weaker plants due to lower light levels characteristic of this fall-winter crop season. This trial

clearly showed the root zone moisture content is particularly important while growing cucumbers under low light levels.

Fruit quality
A waxy layer was observed in the skin of fruits grown in Growstones. These fruits resembled soil grown fruits, considered an undesirable characteristic for the Dutch market. The thicker waxy layer was caused by an increased level of Silicon (Si) found in the recirculating water rinsed off the Growstones material. In the lab, the Si concentration in Growstones material was
0.4 mmol per liter, while in the recirculating system Si levels varied between 0.25 and 1.20 mmol per liter, showing that an accumulation of Si resulted from recirculating drain water. However, the waxy layer in fruit skin was reduced after a system flush with a diluted solution of 1 mmol per liter of nitric acid, which was drained to waste. After the flush, Si content in the recirculating system was reduced to 0.68 mmol per liter.

A high Silicon content in Growstones might be a positive characteristic for other crops such as tomatoes and flowers. In fact, past studies at UC Davies and at USDA have shown beneficial effects from adding potassium silicate to the fertilization regime since it increases plants' resistance to fungal diseases such as *Pythium* and pests such as leaf miners.

Transplant and pH issues
Rinsing of Growstones grow bags prior to transplant is recomended in order to reduce substrate pH. In most greenhouses, the pre-rinse requirement does not represent a problem as growers have acid dosing as an active possibility in their nutrient system hardware. After the initial rinse, the pH of the drainage water was maintained at stable levels in both substrates by using the normal pH-regulated nutrient solution.

Drainage holes were cut about 5 mm from the bottom of the bags to allow complete drainage. This helped reducing free standing water at the bottom of the bag.

Irrigation frequency and drainage
Irrigation frequency was adjusted according to integrated solar radiation in order to allow for 30% drainage. Both substrates were irrigated with the same total volume per day. This was accomplished by adjusting the radiation threshold for irrigation to 70 J per cm^2 and 110 ml for Rockwool, and to 35 J per cm^2 and 55 ml for Growstones. Therefore, Growstones plants were irrigated at double the frequency but half the duration of Rockwool plants.

Furthermore, the irrigation of Growstones substrates was extended into the night. This adjustment was thought important given the lower water retention capacity of Growstones, but resulted in 50% drainage. The higher percent drainage compared to Rockwool suggests that irrigation duration and/or night irrigation could have been reduced in order to keep drainage at 30%, which was thought to be adequate for both substrates.

Drainage of Growstones was improved when drainage holes were cut 5 mm from the bottom of the grow bags. For both substrates, one dripper per plant was used, and a third dripper was thought necessary in between plants. Most Dutch growers use the third dripper regardless of substrate when growing tomatoes.

Other observations
Sterilization of recirculating water. The transparency of the drainage water from both substrates was excellent. This is of practical significance because it means the solution can be easily sterilized with commonly used UV-light systems.

Steam sterilization and re-usage of Growstones substrates. Growstones grow bags were steam sterilized without negatively impacting material structure, strongly suggesting that the material can be reused without losing physical strength.

Algae. Growstones drainage tanks showed more algae compared to Rockwool. The higher amounts of algae were the result of an initially higher percent drainage due to higher irrigation frequency in Eathstone bags which kept the drainage system permanently wet. The algae originated from the drain water collection rim of the hanging gutters. This issue was minimized by reducing the drainage to 30%.

Downward curled leaves. The incidence of downward curled leaves, a common occurrence in cucumbers under assimilation light, was significantly higher in Rockwool with 52 curled leaves, compared to Growstones with only 17.

CONCLUSIONS

This trial clearly proves that Growstones is an effective sustainable alternative to Rockwool regarding yield and resistance to fungal diseases frequently associated with crop seasons characterized with low light levels. Furthermore, results show that due to its drier nature, Growstones substrates enhance generative plant growth compared to Rockwool substrates. This characteristic is of great value particularly in climates that by nature tend to promote plant vegetative growth, such as regions with low light levels and high humidity.

An advantage over Rockwool is the higher number of macro pores present in Growstones. Over-irrigation of Growstones should be impossible if the grow bags remain properly drained. Dutch cucumber growers that visited the trial preferred the Growstones material over Rockwool due to its drier nature, ability to be steam sterilized, and its ease of use in various container systems.

An added benefit of using Growstones substrate is that it is made with 98% recycled glass bottles that would otherwise be accumulating in landfills. Also, by recycling the glass, the need for strip mining is reduced. Therefore, the use of Growstones substrates reduces waste and strip mining, a two-fold positive impact in our environment, while maintaining cucumber fruit production and quality for the fresh market.

Aknowlegments:
[1] The study was conducted at the Wageningen UR Greenhouse Horticulture, Applied Plant Research Lab, The Netherlands under the guidance of Chris Blok, MSc. Project Manager Rooting Media and Plant Nutrition