Sustainable Agriculture, Sustainable Horticulture and Urban Agriculture

What do we mean by 'Sustainability'?

Sustainability is a buzzword all over the world. As with most buzzwords, often its true meaning gets lost in translation or bias political interpretation. So what does sustainability really mean? In pure and simple terms, it means "the use of products and practices that allows for the environment to maintain itself for years to come".

Any business can only be considered truly sustainable when its operations and practices are driven by three basic principles: environmental consciousness, social responsibility, and economical profitability. This is no different for sustainable agriculture or horticulture. There are many factors to consider in a greenhouse operation. The choice of growing media is among the most important ones, only second to water and energy consumption.

What makes Growstones a sustainable media?

Sustainability in commercial hydroponics greenhouse requires re-evaluating the choices of media used. This is no longer just a price point issue. Consistency of source material and pre and post usage environmental impact needs to be taken in consideration. Growstones growing media is part of the solution because not only allows for similar yields as mineral wool, but also because it helps preventing further degradation of natural resources and accumulation of post consumer glass.

Growstones is made from recycled glass bottles received from either the landfill or another source collecting and processing glass bottles. The manufacturing process of Growstones, involves first the crushing of the glass bottles into small glass pieces, which are then ground into a fine flour-like powder. This powder, composed by approximately 98% of vitreous soda lime glass (inert glass) is mixed with 2% of calcium carbonate, a natural foaming agent, and heated and expanded in a kiln. After a cooling process, the final product is a rigid, porous glass foam material which is then crushed and screened into different particle sizes (aggregates) suitable for hydroponic vegetable production in a wide variety of climates.

There are several sustainable advantages associated with Growstones:

- Growstones uses a waste product (glass bottles), which prevents its accumulation in landfills and gives it a second profitable life (environmental consciousness).
- Growstones is an environmental conscious product not only because it is manufactured from recycled glass, therefore conserving resources and reducing waste in landfills. Moving its manufacturing facility next to the city of Albuquerque landfill, Growstones will soon use the gas released from the landfill to satisfy all manufacturing power requirements. This will bring Growstones to a zero carbon foot-print manufacture status. Driven by the demand for more glass created by Growstone manufacturing plant in Albuquerque, the city now plans to implement curbside recycling instead of volunteer recycling currently in place (environmental consciousness and social responsibility).
- The manufacturing process of Growstones allows engineering the media for different growing conditions. Growstones can be designed for specific physical characteristics such as pore size (large or small pores) and pore structure (open or closed pores) by manipulating the fraction of foaming agent added to the glass powder and the temperature curves associated with the baking process. The size of aggregate can also be controlled during the crushing and screening process. This way Growstones can satisfy different growing requirements (more water retention, faster drainage) suitable for a wide range of climate conditions, growing preferences, and marketing applications (economical profitability and social responsibility).

How do Growstones compare with other growing media?

Growstones is characterized by some of the most desirable physical characteristics of an ‘ideal’ growing media. Table 1 below summarizes some of the most important characteristics of Growstones and compares them with other commonly used hydroponic growing media.

Table 1. Comparison of physical characteristics between different media at saturation.

Growing media	Uniformity	Bulk density (g m^{-3})	Total porosity (%)	Air filled porosity (v/v, %)	WHC (v/v, %)	Steer ability
Growstones [1]	high	0.18	87	53	35	high
Perlite[1]	NA	0.14	62	32	31	NA
Rockwool[2]	low		95	15	80	low

[1] Source: Department of Horticulture, University of Arkansas, Fayetteville, AK (2008).

[2] Source: Grodan.

NA – Information not available.

What are the advantages of Growstones?

The advantages of Growstones are directly related with its unique physical characteristics and plant responses.

Physical characteristics

- Drier nature - due to Growstones drier nature (compared to mineral wool or coco coir) it is easy and quick to control root zone moisture content, EC and pH under different climate conditions and for different plant requirements. Growstones are highly steerable.
- Steer ability - Growstones highly steerable root zone guarantees that plants respond faster to deliberate changes in irrigation management and environmental conditions, compared with wetter media like as mineral wool or coco coir, for equivalent total irrigation volume per day.
- Yields - There are no differences in yield from plants growing in Growstones or in mineral wool. This was proven through continuous research trials in the southwest of the US (tomato, 2006-2008) and in The Netherlands, WUR (cucumbers, 2006 and tomato, 2007). In both substrates tomato yields reached 40 kg per m^2 in a 5-month production period in Arizona. This is especially significant when considering that no CO_2 enrichment was used. To find out more click here **[Results from Research trials.doc]**
- Water-Air ratio - Growstones are engineered for a specific ratio between water holding capacity (WHC) and air filled porosity (AFP) at saturation (table 1). The large percentage of inner pores inside each individual aggregate assures good

WHC (35%, v/v% at saturation). The large spaces between each aggregate, promotes drainage and high AFP (53%, v/v% at saturation).

This results in a balanced growing media in which water holding capacity and air filled porosity are not mutually exclusive (Figure 1).

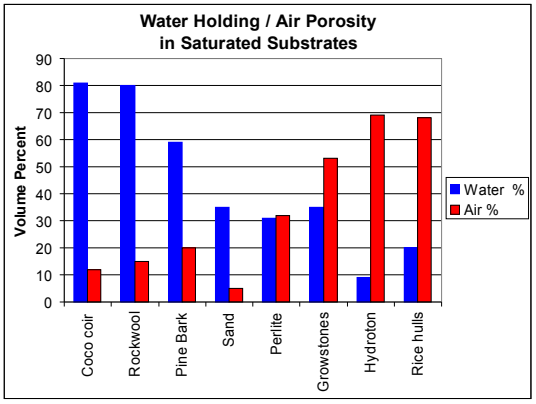

Figure 1. Comparison of water holding capacity (WHC, v/v,%) and air filled porosity (AFP, v/v,%) between different hydroponic growing media. Data collected during tests at the University of Arkansas. Rockwool data was obtained from Grodan.

The comparison chart above shows the clear distinction between media that are strong in water retention (left) and those strong in aeration (right).

Growstones and perlite have a great balance between the two. In Growstones in particular, high aeration (53% at saturation) is not accomplished at the expense of lower water holding capacity (35% at saturation). The combination of high aeration and good WHC guarantees enough moisture and gas exchanges.

The WHC and aeration balance make it very easy to: (a) control moisture at the root zone any given time root zone can be as dry or as moist as the grower needs it to be; and (b) steer plant growth - increased irrigation frequency leads to higher moisture content and more vegetative plants; reduced irrigation frequency leads to drier media and plants promoting more reproductive plant growth - set flowers and develop fruits faster.

Other hydroponic substrates also allow for this, like new types of rockwool slabs. What is especial about Growstones, is the faster response of plants to the steering actions (irrigation and/or environmental).

- Bulk density and porosity - Growstones are characterized by low bulk density and high porosity. Bulk density is a measure of the mass of media plus voids per unit volume [g cm^{-3}]. For most substrates, bulk density has a distinct and negative relationship with total porosity: the lower the bulk density the higher the total

porosity. Highly porous media enhances gas exchanges (O_2 and CO_2) between the root zone and the environment. Therefore, in growing media with low bulk density there is considerably more oxygen available in the root zone, and considerably less CO_2 from root metabolism. High oxygen content has a positive effect on the growth rate of roots.

However, it is important to distinguish between total porosity and available air filled porosity (available air spaces after irrigation). High total porosity is only relevant for root formation and growth if the available air filled porosity is not significantly reduced after irrigation. For greenhouse production, the best substrates have a total porosity of 50-60%, which contain at least 20-25% air filled porosity after irrigation. Growstones achieve 53% air filled porosity right after irrigation.

- Capillary rise - In Growstones water rises by capillary action up to 15 cm above a water table. Capillary rise is driven by pore size and pore structure. In Growstones aggregates, mean pore diameter is 98.7 µm and 79.4% of the total porosity are open cells which allow for uniform water diffusion in the root profile.
- Engineered pore size and structure - Because Growstones are an engineered substrate, pore size and pore structure can be designed to satisfy grower and crop requirements for more water retention (small pore size) or more and faster drainage (larger pore size).
- Physical integrity - Growstones maintain its physical integrity over time and do not brake or compact with usage. Each Growstones aggregate is hard and irregular shaped preventing substrate to compact around the roots throughout long crop seasons even for crops with strong root systems. For this reason it can be reused several times after adequate sterilization between crops.
- Different particle sizes - Growstones can be screened to particle sizes between 2 – 6 mm (small particle size) for higher water retention and capillary action; or from 12 – 25 mm (large particle size) for higher porosity and enhanced drainage.
- Safe - Growstones are inert, free of weeds, nutrients and harmful substances.

Final thoughts

Despite huge efforts to recycle glass, there is a lot of waste glass cullet impacting our environment. Currently, in most states, active landfills have stockpiled mountains

(hundred thousands of cubic yards) of waste glass that conscious individuals made an effort to separate and recycle using appropriate recycling bins. Due to lack of information regarding sound business alternatives for recycling glass, in most states, the landfill remains the final repository of the ‘recycled’ glass.

The re-use of post consumer use glass bottles to grow fresh, high quality greenhouse vegetables, is a new and sound alternative to strip-mined hydroponic media and can only lead to a win-win situation for growers, consumers and the environment - a truly eco-effective and sustainable practice in horticulture.