## Characteristics of Soilless Substrates

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### Outline

- **Container Media**
  - Advantages
  - Properties
- **pH, EC and Alkalinity**
  - Irrigation water Quality
  - Alkalinity
Container Media

Advantages of Using Growth Media Instead of Soil

• No need for arable land
• Light weight
• Total control over root environment
• Precise irrigation scheduling
• Improved crop uniformity
• Limits root disease
• Lower environmental impact
What Constitutes a Good Growing Media?

Physical and Chemical properties

a) Nutrient retention
   • low soluble salts content, but need to have an adequate cation exchange capacity. pH should be between 5.0 and 6.5

b) Gas exchange/aeration and porosity
   • High total porosity (60-85%), sum of all the space in the macro-pores and micro-pores
   • Aeration (10-20%), large particles - more aeration and less water holding capacity

c) Water retention and drainage
   • Porous and well drained, but must retain enough moisture between irrigations (50-65%) to satisfy plant water requirements

d) Biologically and chemically stable
   • Organic substrates need to be well composted - no nitrogen negative period at the onset of production
   • Inorganic substrates that are inert and well composted organic substrates work best.

What Constitutes a Good Growing Media?....continue

e) Standardized and uniform batches
   • Allow grower to use standardized production practices, such as fertilization and irrigation, with every crop.

f) Free from harmful soil pathogens
   • Inorganic substrates like rockwool and perlite are sterilized by virtue of the production process

Shape and volume of the container, affects water-holding capacity

Cost and availability

Irrigation equipment and strategy, adapt according to physical properties of substrate

Environmental impact
Popular Container Media/Substrates

<table>
<thead>
<tr>
<th>Natural</th>
<th>Synthetic</th>
<th>Organic Media</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>Foam mats (Polyurethane)</td>
<td>Sawdust</td>
</tr>
<tr>
<td>Gravel</td>
<td>Polystyrene Foam</td>
<td>Pine Bark</td>
</tr>
<tr>
<td>Rockwool</td>
<td>“Oasis” (Plastic Foam)</td>
<td>Wood chips</td>
</tr>
<tr>
<td>Glasswool</td>
<td>Hydrogel</td>
<td>Sphagnum Peat moss</td>
</tr>
<tr>
<td>Perlite</td>
<td>Biostrate Felt® (Biobased Product)</td>
<td>Coir (Coconut Peat/Fiber)</td>
</tr>
<tr>
<td>Vermiculite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pumice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expanded Clay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zeolite</td>
<td></td>
<td></td>
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<tr>
<td>Volcanic Tuff</td>
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</tbody>
</table>

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pH of Different Media | Cation Exchange Capacity

Table 11.9 Cation exchange capacities (CEC) of some substrates and substrate constituents expressed as C\(^1\) mmol kg\(^{-1}\) dry matter

<table>
<thead>
<tr>
<th>Materials</th>
<th>Average</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood fibre</td>
<td>4.8</td>
<td>3.8-5.4</td>
</tr>
<tr>
<td>Expanded clay granules</td>
<td>8.1</td>
<td>7.7-8.6</td>
</tr>
<tr>
<td>Coir chips</td>
<td>5.7</td>
<td>5.4-6.1</td>
</tr>
<tr>
<td>Coir dust</td>
<td>6.2</td>
<td>6.0-6.7</td>
</tr>
<tr>
<td>Perlite</td>
<td>6.3</td>
<td>5.2-7.7</td>
</tr>
<tr>
<td>PU-foam</td>
<td>6.6</td>
<td>4.7-8.9</td>
</tr>
<tr>
<td>Pumice</td>
<td>6.3</td>
<td>4.7-7.6</td>
</tr>
<tr>
<td>Rock wood</td>
<td>6.2</td>
<td>5.2-7.8</td>
</tr>
<tr>
<td>Peat</td>
<td>3.9</td>
<td>3.4-4.4</td>
</tr>
</tbody>
</table>

Table 11.9 The pH of different substrates and substrate constituents as given by Kipp et al. (2006).

1See text; 2Within pH 4.0–7.0.
Rockwool

- 60% diabase (form of basalt rock, dolerite), 20% limestone, and 20% coke
- Melted at 2912°F, spun at high speed into thin fibers
- Heated with phenolic resin and wetting agent to bind them together and lower the natural hydrophobicity of the material. Pressed into slabs

Characteristics:
- Low bulk density and high porosity
- High water-holding capacity (80%) and good aeration
- Chemically inert with pH 7.0 to 8
- No CEC or buffering capacity
- Dissolve at low pH, below 5.0
- Reusable. Can last for up to 2 seasons

Coconut Coir

- Coconut fiber/dust is an agricultural waste product derived from husk of coconut fruit
- Alternative to peat moss
- Composted for 4 months

Characteristics:
- Can have high amounts of salts
- Good aeration and water-holding
- Water and air content varies according to texture components
  - More fiber – High air and lower water content; Fiber, TPS 98% and AFP around 70%
  - More peat – a lot of water and little air; Coir dust, TPS 86-94% and AFP 9-14%. Relatively high EAW at around 35%

Photo: [http://blog.hooksandlattice.com/2013/03/12/what-is-coconut-coir/](http://blog.hooksandlattice.com/2013/03/12/what-is-coconut-coir/)
Coconut Coir

- Coir is hydrophilic, disburse evenly over surface of fibers
- Higher pH than peat moss, pH is 5.6 to 6.6
- Not inert and can store lots of nutrients, high CEC
- Require more Ca, S, Cu and Fe than peat moss. Greater N-immobilization than peat moss
- May contain excessive levels of K, Na and Cl. Soak and rinse well before use
- More lignin and less cellulose than peat, more resistant to microbial breakdown
- May shrink less than peat
- Easier to re-wet than peat
- Can be inoculated with beneficial microbes
- Use for up to 2 - 3 years

Photo: www.greenpeatcoco.com
**Perlite**

- Naturally occurring, nonrenewable, inorganic, siliceous volcanic rock
- Grinded and popped at ±1800°F. Expands to between 4 and 20 times larger
- Characteristics:
  - Lightweight, sterile, white, porous aggregate
  - Finished product is a "closed cell" that does not absorb water. Water will adhere to surface
  - Usually included in mixture to improve drainage or increase aeration
  - Neutral pH of between 6.5 and 7.5
  - Low CEC
  - Chemically inert

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**Vermiculite**

- It’s a mica-like, silicate mineral
- Contains mineral water between ore plates
- When heated at 1832°F, ore plates move apart into an open, accordion-like structure

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Vermiculite

- Characteristics:
  - Very light, high water retention and good aeration
  - Low bulk density
  - pH value is 7 to 7.5, and low EC
  - Low pH can release Al into the solution
  - Has a permanent negative electrical charge, and therefore CEC is high
  - High nutrient content (K, Ca and Mg)
  - Used as component of mixes and in propagation, to increase water-holding capacity

Photo: https://www.linkedin.com/pulse/facts-vermiculite-gil-strachan

Sphagnum Peat Moss

- Partial decomposition of sphagnum, other mosses and sedges
- Available in different colors, indicate degree of decomposition
- Light-colored peat, larger particles and limited decomposition. Provides excellent aeration and decomposes more rapidly than black peat
- Black peat is highly decomposed, physical properties vary greatly

Photo: https://commons.wikimedia.org/wiki/File:Sphagnum_flexuosum.jpg
Sphagnum Peat Moss

- Characteristics:
  - Light weight
  - High water-holding capacity
  - Good air capacity
  - Naturally acid with pH value between 3.0 to 4.0
  - Low nutrient content, but high CEC
  - Stable structure
  - Naturally hydrophobic when dry; wetting agent must be used
  - Slumping and shrinkage can be a potential constraint

Source: GAPs for greenhouse vegetables crops: Principles for Mediterranean climate areas. FAO, 2013
## EC, pH and Alkalinity

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### Greenhouse Irrigation Water Quality Guidelines

<table>
<thead>
<tr>
<th></th>
<th>Upper Limit</th>
<th>Optimum Range</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.0</td>
<td>5.5 – 6.5</td>
<td></td>
</tr>
<tr>
<td>EC</td>
<td>1.25 mS cm⁻¹</td>
<td>Near zero</td>
<td>0.75 mS cm⁻¹ for plugs and seedlings. High EC can be the result of accumulation of a specific salt which can reduce crop growth</td>
</tr>
<tr>
<td>Total Alkalinity (as CaCO₃), acid-neutralizing or buffering capacity</td>
<td>150 mg L⁻¹</td>
<td>0 – 100 mg L⁻¹</td>
<td>Measures the combined amount of carbonate, bicarbonate and hydroxyl ions. 30 – 60 mg L⁻¹ are considered optimum for plants pH 5.2, 40 ppm alkalinity; pH 5.8, 80 ppm alkalinity; pH 6.2, 120 ppm alkalinity</td>
</tr>
<tr>
<td>Hardness (amount of dissolved Ca²⁺ and Mg²⁺)</td>
<td>150 mg L⁻¹</td>
<td>50 – 100 mg L⁻¹</td>
<td>Indication of the amount of calcium and magnesium in the water. Calcium and magnesium ratio should be 3 – 5 mg L⁻¹ calcium to 1 mg L⁻¹ magnesium. If there is more calcium than this ratio, it can block the ability of the plant to take up magnesium, causing a magnesium deficiency. Conversely, if the ratio is less than 3:5 Ca:1 Mg, the high magnesium proportion can block the uptake of calcium, causing a calcium deficiency. Equipment clogging and foliar staining problems above 150 ppm</td>
</tr>
<tr>
<td>Bicarbonate Equivalent (HCO₃⁻)</td>
<td>122 mg L⁻¹</td>
<td>30 – 50 mg L⁻¹</td>
<td>Help to stabilize pH. Increased pH and can lead to Ca and Mg carbonate precipitation</td>
</tr>
</tbody>
</table>

1 mg L⁻¹ = ppm
Factors Affecting Root Media pH

- **Acidic Media**
  - pH less than 7...Sphagnum peat moss, coir

- **Neutral Media**
  - pH around 7...Perlite

- **Alkaline Media**
  - pH greater than 7...Vermiculite, rockwool

- **Alkalinity of the water** (carbonates/bicarbonates). High alkalinity will increase container media pH over time

- Ammonium or urea based fertilizers will acidify the root media

- Fertilizers that are nitrate based tend to increase root media pH over time

- Media pH can be altered prior to planting with Limestone (CaCO\(_3\)) or Dolomite (50% CaCO\(_3\) and 40% MgCO\(_3\))

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**Figure 1.** Effect of irrigation water alkalinity on substrate pH over time. Each irrigation included water soluble fertilizer (97% nitrate N at 200ppm). Source: Adapted from research by Bill Argo and John Blumhouse at Michigan State University (unpublished work).
Information Resources

University resources – Extension publications
Professional magazines
- Practical Hydroponics and Greenhouses, www.hydroponics.com.au
- Greenhouse Canada, www.greenhousecanada.com
Books
- Greenhouse Technology and management, Nicolas Castilla
- Greenhouse Operation and Management, Paul V. Nelson
- Soilless Culture, Michael Raviv & J. Heinrich Leith
- Growing Media for Ornamental Plants and Turf, Kevin Handreck & Niel Black
- Plant Nutrition of Greenhouse Crops, Cees Sonneveld & Wim Voogt
- Hydroponic Food Production, Howard M. Resh

Trade shows and conferences
- Indiana Small Farm Conference, March 2-4, 2017 – Danville IN
- Indoor Ag Con, May 3-4, 2017 – Las Vegas NV
- Cultivate’17, July 15-18, 2017 – Columbus OH

Manufacturers and distributors (list is not complete but it’s a good start):

THANK YOU

Questions?

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