Water Media Fertility

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The Root Zone Triangle

Irrigation

Media

Fertilizer

First Leg: Media

- Peat
- Vermiculite
- Perlite
- Pine Bark
- Sand

Functions of Media

- Provide plant support
- Serve as a reservoir for mineral nutrients

Grower Control

- Only providing plant support is a given function of the substrate
- All other functions under grower control
Physical Media Components

- Organics: peat moss, bark, whole trees, coconut coir, composts and other organics

Pine Bark

- Byproduct of lumber/pulp industry
  - Slowed due to lack of construction
  - Price can fluctuate
  - Must be aged properly
  - Doesn't hold much water but does have good CEC

Cation Exchange Capacity

- Also called CEC
- Nutrient holding capacity
- High CEC components
  - Peat, bark, and vermiculite
- Low CEC components
  - Perlite, Styrofoam, and sand

Sphagnum Peat Moss

- Low pH
  - 3.0-4.0
  - Lime may be needed
- Very low mineral content
- Great moisture retention
- Hydrophobic, so may need wetting agents

Whole Tree Substrates

- Research
  - Virginia Tech
  - NC State
  - Auburn
  - Corporate R&D
- Loblolly Pine (South)
- Eastern White Pine (North)

Whole Tree Substrates

- Whole trees are chipped, then ground in a hammer mill
  - (with or without bark, limbs, needles)
- Or clean chip residual – byproduct of tree harvesting process
  - 40% pine wood
  - 50% bark
  - 10% needles
Coir
- Byproduct of coconut processing
- Pros – easy to wet, relatively high pH, good moisture holding capacity and aeration
- Cons - concerns about high salt/chloride levels, small particles break down rapidly
- LOTS of other uses, prices inching up

Physical Media Components
- Organics:
- Inorganics:
  - field soil
  - vermiculite
  - polystyrene foam
  - crop by-products
  - sand
  - perlite
  - rock wool

Inorganics / Aggregates
- ↑ air space and drainage
- ↓ decrease bulk density
  - Vermiculite
    - Moderate pH (depends on source)
    - Good CEC
    - Bit of K, Mg, Ca
  - Perlite
    - Virtually inert
    - Fluoride?

Physical Media Components
- Texture – size and distribution of particles in mix
  - Affects water retention and porosity
  - Finer texture has smaller particles, smaller pores and therefore greater water retention
  - Need balance for adequate porosity

Physical Components
- Structure – particle combinations into larger aggregates to create air spaces (pores)
Physical Components

- Easily destroyed by rough handling during media preparation or use
  - Do not pack pots
  - Do not stack pots

Composition of Media Mix

- Affects amount of air, water and nutrients that can be held in the pot
- Affects the chemistry of the media
  - CEC
  - pH
  - Electrical Conductivity (EC)
  - Water Quality
- Determines irrigation and fertilization practices

Substrate Porosity

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Percent Porosity of Substrate</th>
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<tbody>
<tr>
<td>1 Peat: 1 Rockwool</td>
<td>92%</td>
</tr>
<tr>
<td>1 Peat: 1 Vermiculite</td>
<td>87%</td>
</tr>
<tr>
<td>3 Bark: 1 Peat: 1 Sand</td>
<td>70%</td>
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<tr>
<td>Mineral soil</td>
<td>60%</td>
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</table>

Structure and Pore Space

- Pine Bark
- Germination Mix

Generalized Soil Moisture Conditions

- Saturated
- Field capacity
- Typical
- Wilting point
- Capillary water
- Gravity water
- Adsorted water
- Mineral particle
- Air
- Dry
Balance of Air and Water

- Good media
- Compacted

Good media
Compacted

Drainage

- Gradient of moisture content in pot
  - Least at top
  - Most at bottom
  - Bottom often saturated

Container Size

Peat : Vermiculite Media

<table>
<thead>
<tr>
<th>Container Size</th>
<th>6-inch</th>
<th>4-inch</th>
<th>48</th>
<th>288</th>
<th>648</th>
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<tbody>
<tr>
<td>Air</td>
<td>20</td>
<td>13</td>
<td>8</td>
<td>3</td>
<td>0.5</td>
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<tr>
<td>Water</td>
<td>67</td>
<td>74</td>
<td>79</td>
<td>84</td>
<td>86.5</td>
</tr>
<tr>
<td>Solid</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
</tr>
</tbody>
</table>

Handling of Media Mixes

- Rough handling or packing breaks down media structure
  - Reduces pore size
  - Reduces water penetration and availability
  - Increases water retention
  - Reduces aeration

Filling Flats or Pots

- Avoid compaction
- Use moist media
- Overfill containers
- Brush off excess
- Dibble
- Water in
Proper Air : Water Ratio

- Grower must:
  - Select appropriate components
  - Mix properly
  - Handle with care
  - Finally, manage that mix for optimum growth!

Commercial Soil-less Media

- Uniform
- Consistent
- Free of contamination
- Flexibility to choose
  - Crop
  - Goal
  - Stage of growth

Commercial Soil-less Media

- Custom blends available
- Evaluate economics
  - Even large operations may be better off buying in the mix

Commercial Formulations

- Too numerous to list
- Use a reputable company
  - Quality assurance program
  - Technical assistance
  - Testing lab
- Availability and shipping costs?

Mixing Your Own Media?

- Management and economics
- Mixing costs: equipment, raw materials, costs of skilled labor, consequences of error, quality control testing
- Consistency can be problematic
- Less than 100,000 sq.ft.?
  - May be cheaper to buy

Summary: Root Zone Management

- Create optimum root environment by:
  - Buying or blending appropriate mix
  - Properly filling pots/flats
  - Properly watering in

All under grower control!!
Second Leg: Fertilizer

Fertilizer Nutrients

- Macronutrients
  - Nitrogen
  - Phosphorus
  - Potassium
  - Calcium
  - Magnesium
  - Sulfur

- Micronutrients
  - Iron
  - Manganese
  - Boron
  - Copper
  - Chlorine
  - Zinc
  - Cobalt

Fertilization Methods

- Pre-plant incorporation
  - Mixed into media prior to planting
  - Starter fertilization "starter charge"
  - Short duration, about two weeks usually
  - Often included in pre-mixed meds

- Controlled release fertilizers
  - Can be top-dressed or incorporated
  - Incorporation provides better distribution
  - Wide variety of release rates and analyses

  Pros
  - Reduced labor costs
  - Less loss to leaching
  - Post harvest fertility
  - Plant available?

  Cons
  - Loss of fertility control
  - Temp / Irrigation

Fertilization Methods

- Constant Liquid Fertilization (CLF)
  - Application of water-soluble fertilizers through irrigation water
    - Requires an accurate injection system
    - Ability to match fertilization with crop needs quickly
    - Wide variety of fertilizers available

Reading a Fertilizer Label

- Formulation
- Analysis
- Potential acidity or basicity
- Recommended rates
- Mixing instructions
Fertilizer Analysis

- Percentages of N-P-K

Guaranteed Analysis

- Nitrogen form
- Mg and micronutrients

N Effects on Fertility Program

- Nitrogen form
- High NH$_4^+$ ratio = decreases pH
- High NO$_3^-$ ratio = increases pH
- Watch for pH “creep”
  - 15-16-17 or 20-10-20: acidifying (slowly)
  - Remedy: calcium nitrate or a complete fertilizer with high nitrate-N to ammonium-N ratio

Potential Acidity or Basicity?

- Nitrogen form drives this
- 20-10-20 Peat Lite is acidic
  - 406 pounds calcium carbonate per ton
  - So one ton of this fertilizer can neutralize 406 pounds of calcium carbonate (lime)
- Important to note “acidic or basic”
  - Basic fertilizers tend to have high nitrate or calcium and magnesium percentages

N Effects on Fertility Program

- N form affects frequency of application
  - Urea/ammonia are “storage” forms
    - Slower breakdown, less leaching
    - Media type (bacterial process)
  - Low temperatures require more nitrate
    - Slow conversion of ammonia to nitrate
N Effects on Plant Growth

- Nitrogen form affects plant growth
  - Ammonia = lush
  - Nitrate = compact
- Plant tolerances for ammonia differ (<40%)

Common Fertilizers

- Peters 20-20-20 General Purpose
  - Very acidic formula
  - 70% N is in ammoniacal form
  - Contains micronutrients
- Peters 20-10-20 Peat-Lite
  - Acidic formula
  - 39% N is in ammoniacal form
  - Contains greater amounts of micronutrients

Additional Info on Label

Peters Professional 20-10-20 Peat-Lite Special
Water Soluble Fertilizer
(Suggestions for Commercial Growers)

Selecting Fertilizer Formulations and Analysis Considerations:

- Crop and growing stage
  - Nitrate vs. ammonia
  - Micronutrient availability
- Water quality (alkalinity)
- Media pH management
- Weather conditions / time of year?

Other Considerations:

- Correct P Applications
  - 5 to 10 ppm P usually
- All essential elements supplied?
  - Calcium and Magnesium
  - Ca : Mg : K ratio 1:2:4
  - Micronutrients supplied?

Fertilizer Injectors or Proportioners

Inject specific amount of concentrated fertilizer per increment of irrigation water that passes through the injector to give final fertilizer solution
Fertilizer Injector Ratio

- Volumetric ratio of stock solution to dilute solution
  - Ex. a 1:100 injector delivers 100 gal of dilute fertilizer solution for each gal of concentrated stock solution
- Available 1:5 to 1:500
  - Most common 1:16 and 1:100
- Determines the concentration of the fertilizer stock solution

Mixing Instructions on the Label

<table>
<thead>
<tr>
<th>Ounces of Peters Professional 20-10-20 Per Gallon of Concentration</th>
<th>ppm</th>
<th>Injector Ratios</th>
<th>E.C.</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>1:15</td>
<td>1:100</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>0.50</td>
<td>3.38</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>1.00</td>
<td>6.75</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>1.50</td>
<td>10.13</td>
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<tr>
<td></td>
<td>200</td>
<td>2.00</td>
<td>13.50</td>
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<tr>
<td></td>
<td>250</td>
<td>2.50</td>
<td>16.88</td>
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<td>23.63</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>4.00</td>
<td>27.00</td>
</tr>
</tbody>
</table>

Mixing Fertilizer Stock Solutions

- Accurately weigh and measure fertilizer and water
- Add fertilizer to partially filled stock tank
- Add (warm) water to desired volume

Mixing Instructions on the Bag

- What if you are not using injector?
  - Divide 1 oz. by 15 to reduce from 1 gal stock to a ready to use at 100 ppm N

The Third Leg: Water

- Water sources
- pH
- Alkalinity
- EC (electrical conductivity)
- Specific ions

Components of Water Quality
Water in Virginia:

V & R – highest volume of water often high in calcium and bicarbonates.

Water in Virginia:

Blue Ridge – Less available but usually very pure.

Water in Virginia:

Piedmont – More variability, wells tend to fluctuate seasonally, may be contamination.

Irrigation Water pH

- pH is a measure of the acidity or basicity of the water.
- Measurement of the concentration of the hydrogen ions in the solution.
  - Scale 1 to 14 with 7 as neutral.

pH:

Irrigation Water pH

- pH is a measure of the acidity or basicity of the water.
- Measurement of the concentration of the hydrogen ions in the solution.
  - Scale 1 to 14 with 7 as neutral.
  - Preferred range 5.4 to 6.8.
Irrigation Water pH
- Does not control potting medium pH
- However, high pH $>$7.2 indicates a need for testing to be sure
- Can also cause salts to precipitate out in holding tanks
- Reduction in pesticide efficacy (Florel, Captan, and others)

Water Alkalinity: Definitions
- Measure of water’s capacity to neutralize acids
- Establishes the buffering capacity of the water
- Measured by ppm of bicarbonate ions (Ca, Na, Mg bicarbonate salts) + carbonate ions (Ca carbonate salts)

Irrigation Water Alkalinity
- Prefer 60 to 100 ppm bicarbonates for greenhouse and nursery crops
- High alkalinity is like adding lime with each irrigation
  - Raises media pH
  - Countered by acidic fertilizers (to some degree)

Irrigation Water Alkalinity
- Low alkalinity – limited ability to buffer effects of fertilizers
  - Acidic fertilizers rapidly reduce media pH
  - Basic fertilizers rapidly raise media pH

Irrigation Water Hardness
- Concentration of calcium and magnesium dissolved in water
- Hard water often has high alkalinity
- Ca:Mg ratio between 3:1 to 5:1

Irrigation Water Salinity
- Total dissolved salts (ions)
- Measured by electrical conductivity (EC)
- Determined by total dissolved salts (TDS)
- Measures salinity (sum of all the ionized dissolved salts)
Irrigation Water Salinity

- Water high in salinity can cause salt accumulation in pots
- Prevents water uptake
- Can be leached
- Not for use in sub-irrigation systems
- Clogs emitters on drip/mist systems

Irrigation Water EC

- Upper limits
  - Greenhouse crops – 2.0 mS/cm
  - Nursery crops – 2.0 mS/cm
- Preferred ranges
  - Greenhouse crops – < 0.75 mS/cm
  - Nursery crops – < 1.25 mS/cm

How Can You Manage High Water Alkalinity?

- Start with a complete irrigation water test
- Use a qualified lab
  - Commercial labs
  - Fertilizer and media companies
- Not a drinking water test
- Labs include interpretation

Local Testing:

- A & L Labs Richmond
  - Water, Greenhouse Media, and Tissue
    - 7621 Whitepine Road
    - Richmond, Virginia 23237
    - Phone: (804) 743-9401
    - Fax: (804) 271-6446
- Virginia Tech
  - Soil Testing
  - 540-231-6893

How Can You Manage High Water Alkalinity?

- Dilute with a more pure water source
- Use a growing medium with less limestone (lower pH)
- Use acidifying fertilizers

If these do not overcome the alkalinity issues then….
How Can You Manage High Water Alkalinity?

- Counter high alkalinity by acid injection
- Three main types (always use caution!)
  - Sulfuric Acid
  - Nitric Acid
  - Phosphoric Acid
- Use acid approved injection system
- Be aware of added nutrients

How Can You Manage High Water Alkalinity?

- Get a complete irrigation water analysis
- Contact your Extension Office or suppliers
- Use AlkCalc online Alkalinity Calculator
  [http://extension.unh.edu/agric/AGGHFL/Alkcalc.cfm](http://extension.unh.edu/agric/AGGHFL/Alkcalc.cfm)
  part of the GroCalc family of on-line calculators
- Water Quality Publication:
  [http://www.aces.edu/pubs/docs/A/ANR-1158/](http://www.aces.edu/pubs/docs/A/ANR-1158/)

AlkCalc on-line Alkalinity Calculator

![AlkCalc on-line Alkalinity Calculator](http://extension.unh.edu/agric/AGGHFL/Alkcalc.cfm)

Lab Analysis also gives ions:

![Lab Analysis](SpectrumAnalyticalInc.png)

Specific Ion Limitations: Greenhouse and Nursery

- Na – 70 ppm
- Cl – 70 ppm
- B – 0.5 ppm
- F – 1.0 ppm
- Mg – Ca: ratio 5 Ca to 1 Mg (ppm)
Tie it all Together:
- Media, Fertilizer, and Irrigation
- Combine in the pot to make the substrate solution
- Lots of things going on!

Media Interactions with Substrate Solution Chemistry
- Components of media
  - Peat, pine bark tend to acidify solution
- Media additives
  - Initial lime added to media to adjust starting pH to 5.5 to 6.5
  - Prefer pH 5.4 to 6.3 for substrate solution

Media Interactions with Substrate Solution Chemistry
- Fertilizer
  - Acidic or basic?
  - Nitrogen source?
- Irrigation water
  - Alkalinity, hardness, salinity

All Combine to modify pH
Media pH is critical to nutrient availability

Preferred pH Ranges for Crops

Summary
- Media: Texture, structure, porosity
- Fertilizer: Formulation, N-source, application method
- Irrigation: Alkalinity, pH, water analysis

All combine in the pot to affect pH and EC of substrate solution which in turn affects plant growth and development
Resources

- Media components
  - NCSU Substrates/Fertility (Bailey, Fonteno & Nelson)

- Greenhouse Operator’s Training Manual
  - Plant Nutrition, Fertilization, and Monitoring
  - Irrigation Water Quality for Greenhouse Production
  - Selecting Growing Media

For more information

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