Totally Potted
Making the most of your media

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Outline

- Properties of media
  - Physical
  - Chemical
  - Biological
- pH/EC testing
- Media components
- Compost considerations

What does soil do for plants?

Supplies

- Water
- Nutrients
- Air (oxygen)

Anchors the plant in the pot

May help/hinder the plant in fighting off root diseases

container media versus field soils

Property	Container	Field
Water	**Saturation→Wilt in 1-3 days** **Irrigate daily!**	**Field Capacity → Wilt in 1-3 weeks** **Irrigate weekly**

container media versus field soils

Property	Container	Field
Temper-ature	50 – 100+ °F in 1 day (120 °F will kill roots)	Fairly constant over the season

container media versus field soils

Property	Container	Field
pH	1 pH unit change in weeks	1 pH unit change takes several months (ex. liming)

Physical Properties of Potting Media

- **Bulk Density**: dry weight of substrate / volume
  ↑bulk density → heavier container

- **Moisture holding capacity** = the amount of water held (% by volume at container capacity)
- **Porosity** (aeration) = the volume of air space (% by volume at container capacity

Selecting the right substrate is a balance between:

Moisture holding ↔ Air porosity

- **Rule of Thumb:,** choose a mix where:
- Total porosity is greater than 50%
- Moisture holding capacity is greater than 40%
- Air porosity is greater than 10%

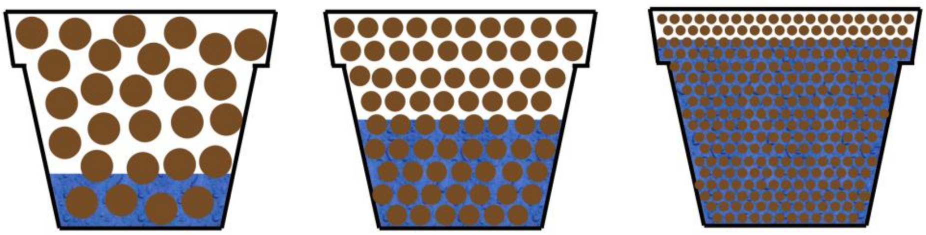
Aeration and Water Holding affected by particle size and container height

- larger particle size:
  - increased aeration
  - decreased water holding

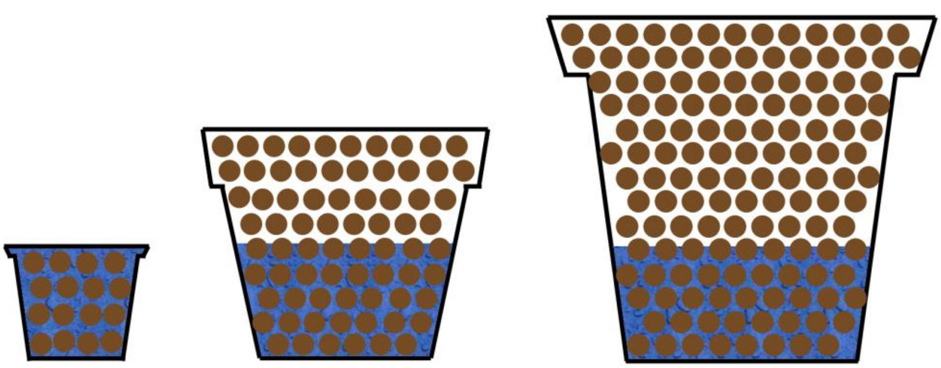
- smaller particle size:
  - poor aeration
  - increased water holding

The particle size of most soils is too fine for use in containers

Particle size effects water holding capacity/aeration and height of the water table



Water table height is only affected by particle size, not by container height



Importance of Aeration (Air Filled Pore Space) and Plant Growth

- Oxygen is needed for normal root growth and respiration
- If normal root growth cannot occur the plant will have problems taking up water and nutrients

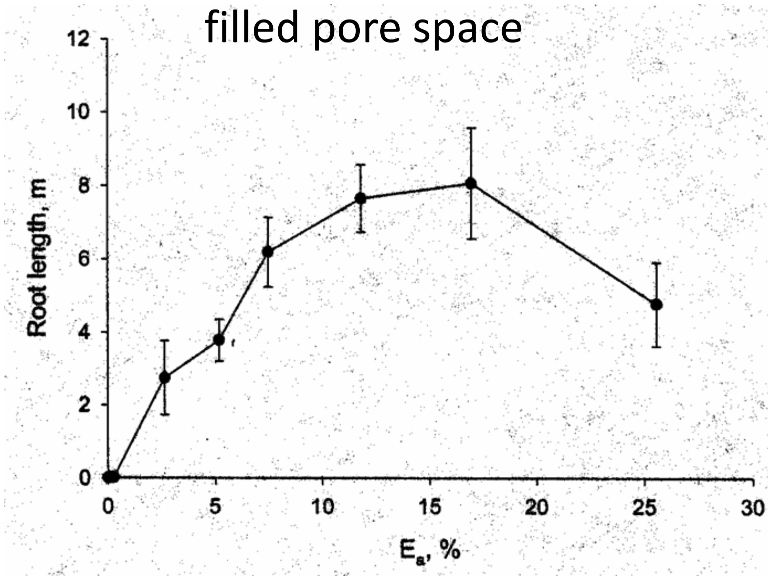
Symptoms of Low Aeration

- Mild-moderate stress
  - less vigorous growth
  - smaller leaves
  - dark green or chlorotic leaves
- Severe stress
  - poor root growth/shallow growth (root growth only toward top of container)
  - leaf drop
  - wilting in the early afternoon (can also be caused by high salinity/disease)

Soil Chemical Responses

- SO_4^{2-} → H_2S which is toxic to plants (this smells like rotten eggs)
- NO_3^- → NO_2^- (toxic)
- Mn^{4+} → Mn^{2+} (toxic)
- Fe^{3+} → Fe^{2+} (non toxic)

Fresh weight of chrysanthemums and air filled pore space

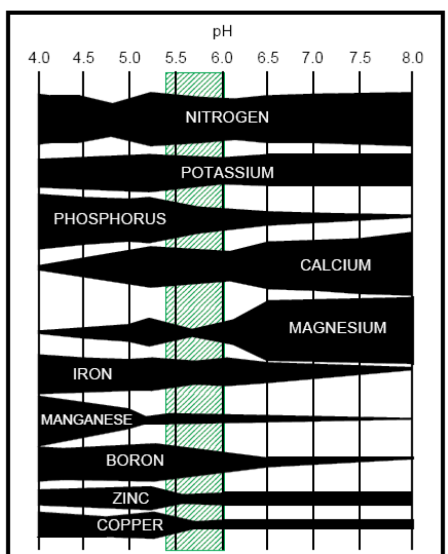


Example physical properties

mix or amendment	Total porosity (%)	Water holding capacity (%)	Air-filled porosity (%)
sphagnum peat	94	84	10
peat + perlite (1:1)	93	54	39
peat + vermiculite (1:1)	94	81	13
sand + redwood sawdust + peat (1:1:1)	73	57	16
coir	95	79	16

Chemical properties of Potting Media

- pH: effects plant nutrient availability →
  - optimal: 5.5 – 6.5
- Soluble salts
  - measured by electrical conductivity
  - optimal: 0.5-2 mS/cm
  - CRF: 0.2-0.5
- Cation exchange capacity (CEC)
  - ability of substrate to hold positively charged fertilizer salts
  - more is better



pH and CEC of potting mix components

Amendment	pH	Cation Exchange Capacity (meq/100 cm^3)
Sphagnum peat moss	3.5-4.2	15
Redwood bark	3.2	6
Ponderosa pine bark	3.6	8
Hypnum peat moss	5.1	32
White fir bark	4.4	16
Fir sawdust	4.0	3
Redwood sawdust	3.8	5
Pine sawdust	4.5	4
Coconut Coir	7.0	20-80

pH and CEC of potting mix components

Amendment	pH	Cation Exchange Capacity (meq/100 cm^3)
Calcined clay	negligible	3-12
Perlite	negligible	0.15
Rockwool	negligible	negligible
Sand	negligible	negligible
Vermiculite	variable	2-3

Iron deficiency is common at high pH

Rhododendron

Symptoms:
yellowing between the veins on upper leaves

Sweetgum

Correcting Iron Deficiency

Quick solution:

- Foliar application of iron chelate
  - The only way to correct severely affected tissue

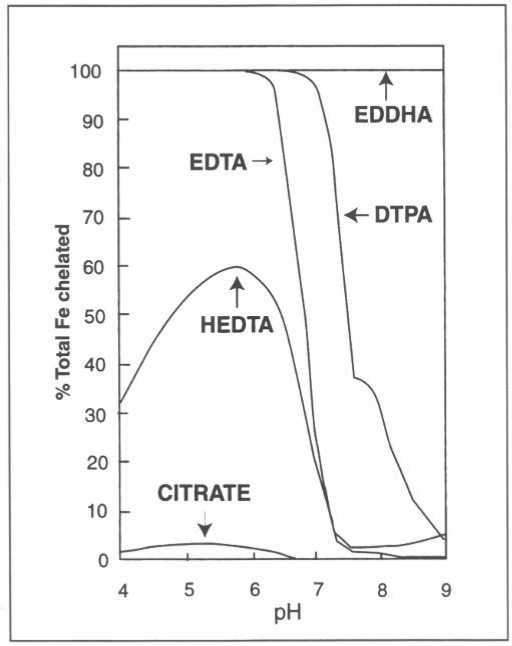
Short-term:

- Drenches with iron chelate

Long-term:

- Lower substrate pH
- Check fertilizer bag for presence of iron chelates

Solubility of Various Iron Forms



Source: Reed, 1996

Commercial Products

Iron Form	% Iron	Product
Iron EDTA	13%	Sequestrene Fe Dissolzine EFe13
Iron DTPA	10-11%	Sequestrene 330 Sprint 330 Dissolzine DFe11
Iron EDDHA	6%	Sequesterene 138 Sprint 138 Dissolzine QFe6

- Apply drenches at 5 oz/100 gal
- Foliar sprays at 60 ppm Fe (6-8 oz/100 gal)

Phytotoxicity and Foliar Iron Sprays

Where do salts come from?

- Water source
  - salt deposits, limestone, sea-water incursion, road salt

    Target: 0.2-0.75 dS/m

    Acceptable: 0-1.5 dS/m

Salts in container media

Substrate	EC (dS/m)
Compost (Dairy)	7-20
Peat	1.1
Sand	0.2
Field Soils	0.3-1.0
Vermiculite	0.1

Salts in fertilizer

- Liquid fertilizer…

Concentration (ppm)			Injector Ratios*					Electrical Conductivity (E.C.)**
N	Ca	Mg	1:15	1:100	1:128	1:200	1:300	mmhos/cm
25	8.3	3.3	0.34	2.25	2.88	4.50	6.75	0.17
50	16.7	6.7	0.68	4.50	5.76	9.00	13.50	0.33
75	25	10.0	1.00	6.75	8.64	13.50	20.25	0.50
100	33.3	13.3	1.35	9.00	11.52	18.00	27.00	0.66
150	50	20.0	2.03	13.50	17.28	27.00	40.50	0.99
200	66.7	26.7	2.70	18.00	23.04	36.00	***	1.32
300	100	40.0	4.05	27.00	34.56	***	***	1.98
400	133.3	53.4	5.40	36.00	46.08	***	***	2.64

- Controlled Release Fertilizers have much lower EC readings

Using Soluble Salts to Diagnose Nutrient Disorders

- **Excess salts mean**
  - fertilizer levels exceed plant requirements
  - insufficient leaching during irrigation
  - irrigation water contains a high amount of dissolved elements
- **Low salt levels**
  - insufficient fertilizer levels
  - excess leaching during irrigation

Symptoms Excess Soluble Salts

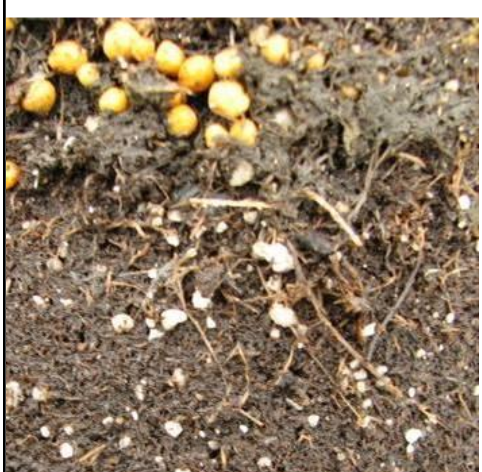
- Osmotic stress
  - Wilting

Symptoms of Excess Soluble Salts

- marginal chlorosis → necrosis of older leaves


Symptoms of Excess Soluble Salts

- Death of root tips
- Increased *Pythium* root rot susceptibility




Symptoms low soluble salts

- Fertility is too low
  - plant growth stunted

Pour Thru method pH/EC monitoring

- Nondestructive
- Use on each important crop
- Sample periodically (ideally every 1-2 weeks)
- Take 5-10 samples per crop each time and average this

Source: North Carolina State University, http://www.pourthruinfo.com

Pour Thru Methods

1) Irrigate your crop one hour before testing

- Containers should be fully saturated
- If fertilization is periodic (ex: weekly), test on the same day of the fertilizing cycle

Pour Thru Methods

2) After container has drained for one hour, place saucer under container

Pour Thru Methods

3) Pour enough distilled water on the surface of the container media to get 50 mL (1.5 ounces) of leachate

How much water to add?

Container Size	Water to Add	
	mL	fluid ounces
4-6 inch	75	2.5
1 quart	75	2.5
1 gallon	150	5.0
3 gallon	360	12.0

Pour Thru Methods

4) Collect Leachate for pH and EC testing

Pour Thru Methods

5) Calibrate pH and EC meters before testing (needs to be done every day you use the meters)

Pour Thru Methods

6) Measure pH and EC of samples

Media sampling for 1:2 dilution method or sending to lab for analysis

- take slices/cores of media from the area where roots are actively growing
- take samples from 10 representative plants
- pool the samples together
- most labs require 1-2 cups of material
- taking sample from the upper third of the container will overestimate fertility

1:2 dilution method pH/EC monitoring

- air dried media sample
- combine 1 part media and add 2 parts DI water (by volume)
- mix thoroughly
- allow it to stand for 30 minutes
- pour some of sample into a cup

EC guidelines by extraction method

Table 3. EC interpretation values (mS/cm) for various extraction methods[1].

1 : 5	1 : 2	SME	PourThru[2]	Indication
0 to 0.11	0 to 0.25	0 to 0.75	0 to 1.0	**Very Low.** Nutrient levels may not be sufficient to sustain rapid growth.
0.12 to 0.35	0.26 to 0.75	0.76 to 2.0	1.0 to 2.6	**Low.** Suitable for seedlings, bedding plants and salt sensitive plants.
0.36 to 0.65	0.76 to 1.25	2.0 to 3.5	2.6 to 4.6	**Normal.** Standard root zone range for most established plants. Upper range for salt sensitive plants.
0.66 to 0.89	1.26 to 1.75	3.5 to 5.0	4.6 to 6.5	**High.** Reduced vigor and growth may result, particularly during hot weather.
0.9 to 1.10	1.76 to 2.25	5.0 to 6.0	6.6 to 7.8	**Very High.** May result in salt injury due to reduced water uptake. Reduced growth rates likely. Symptoms include marginal leaf burn and wilting.
>1.1	>2.25	>6.0	>7.8	**Extreme.** Most crops will suffer salt injury at these levels. Immediate leaching required.

[1]Adapted from: On-site testing of growing media and irrigation water. 1996. British Columbia Ministry of Agriculture.
[2]Due to the variability of the PourThru technique results, growers should always compare their results to the SME method to establish acceptable ranges.

Saturated Media Extract

- the most universal method for laboratory testing of container media (not practical for "in-house" measurements)
- DI water is slowly added and stirred to the media sample (≈1 cup media) until a "glistening paste" is formed
- The mixture is allowed to stand for 30-90 minutes
- The filtrate is extracted under suction
- Filtrate analyzed for pH/nutrients of interest etc.

EC: conversions and confusions

Table 1. Units for expressing electrical conductivity (EC).

Method	Abbreviation	Units	Example
millisiemens	mS/cm	EC x 10^{-3}/cm	2.25 mS/cm
millimhos	mmhos/cm	EC x 10^{-3}/cm	2.25 mmhos/cm
A new term for millimhos is millisiemens, which is the metric (SI) unit of expressing electrical conductance. There is no change in value, just terminology.			
decisiemens	dS/m	EC x 10^{-1}/m	2.25 dS/m
Decisiemens per meter is the common term used in scientific literature of expressing electrical conductance. The term deci- means one-tenth and the term milli- means one-thousandth, so a deci- is 100 times greater than a milli-. While expressing dS/m, the denominator is given in terms per meter (m) and for mS/cm the denominator is given in terms per centimeter (cm). One meter contains 100 cm, therefore when comparing values in dS/m and mS/cm, the zeros cancel out mathematically and the decimal point appears at the same place for both units (i.e. 2.25 dS/m = 2.25 mS/cm).			
	mho x 10^{-5} /cm	EC x 10^{-5}/cm	225 mho x 10^{-5}/cm
Some labs prefer to express EC as a whole number (i.e. 225), therefore the decimal point is shifted two places to the right. (The NSUC Plant Disease and Insect Clinic reports in these units.)			
micromhos	µmhos/cm	EC x 10^{-6}/cm	2250 µmhos x 10^{-6}/cm
The term micro- means one-millionth and is 1000 times smaller than a milli-.			

Biological Properties

- Organically based substrates (peat, compost, bark, soil) may contain several living organisms
- Fungi, microbes, water-molds
  - many of these will be neutral (do not harm plant/roots)
  - some are beneficial, such as mycorhizae that retain nutrients
  - some are harmful: root-rots
- Insects - especially fungus gnats
- Weed seeds

Examples of biologicals added to substrates

- Pro-Mix products contain Mycorise® Pro – mycorrhizae help retain nutrients, and help roots scavenge water/nutrients
- Some Pro-Mix products contain Subtilex® biofungicide. This is a bacteria (Bacillus subtilis) that helps prevent root pathogens, such as damping, off from gaining-hold
- RootShield® WP – the substrate can be drenched with this, contains a fungus, Trichoderma, which helps protect roots from pathogens
  - Also RootShield granules (last 12 weeks)

Thoughts on Media Components

Organic media components

- Sphagnum peat moss
- Coconut coir
- Pine and hardwood bark
- Rice hulls
- Leaf and yard waste composts
- Animal waste composts

Sphagnum peat

- high moisture holding
- low pH (limestone needed to raise)
- High CEC
- Renewable?

Not all peat is created equal…

- Virgin peat (top layers), longer fibers less decomposed
  - Has better drainage (aeration)
  - Can be used in lower perlite and perlite free mixes
- Lower layers, peat is finer/more decomposed
  - Propagation mixes, consumer mixes, mushroom compost
  - Higher cation exchange capacity
  - Mixes hold more water, less aerated
  - Need more perlite to get enough aeration

Coconut coir

- Shredded coconut husk

- high moisture holding
- moderate pH (5.5-7.0)
- little nutrients
- High salts (leach before use?
- Renewable!

Coir breaks down over time

Pine and hardwood bark

- partially decomposed/composted is best
  - When used fresh can decompose rapidly
  - Microorganisms compete with plants for soluble nitrogen (this is called "nitrogen draft" – a rapid depletion of media nitrogen)
  - Composting takes time and space so some growers do not do this, need to add nitrogen
- maintains porosity for a long period of time
- cheap – often used in the nursery industry because of the large containers used
- overtime media pH may decrease

Nitrogen Draft

Large N draft	Intermediate N draft	Low N draft
Hardwoods	Pine sawdust	Peat
Ponderosa pine bark	Douglas fir bark	Redwood bark
Jeffrey pine bark	Red fir bark	Sugar pine bark
		Incense cedar bark

If using fresh wood products, to account for N draft

- Add 4 pounds nitrogen per cu. yard for large N draft
- 2 pounds nitrogen for intermediate draft materials

- Historically pine bark 3/8-1/2 inch size has been preferred
- Whole tree (WT) is a new development
  - Composed of the entire aboveground parts of a pine tree including wood, bark, needles, and branches
  - Chipped and then ground with a hammer mill and screened to the desired size
  - Aging for 90 days has improved plant performance

Pine bark with rice hulls

Rice Hulls

- Current product primarily used is parboiled rice hulls (PBH) which removes rice grain and kills weed seeds, previously:
  - Aged hulls
  - Composted hulls
- Provides root-zone aeration, used as a substitute for perlite or other coarse components
- Often used 20-25% by volume
- At this incorporation rate does not affect nutrient tie up

COMPOSTS
Leaf and yard waste composts
Animal waste composts

- Decomposed, aged organic matter
- Be sure to consider:
  - Maturity
  - Particle size – if too fine – substrate will be water logged
  - Salts (can be high in manure-based composts – may need to limit to 5-10% by volume)
  - pH (often about 7.0 for finished compost)
  - Consistent/uniform source of material?
  - Quality control and testing?

Benefits of using compost

Microbes/Biologicals are one of composts benefits
- Microbes are also sensitive to high salts (from compost or fertilizer)

Compost increases the Cation Exchange Capacity (CEC)
- typically 100-300 meq/100 g
- Sandy loams, typically are 0-8 meq/100 g

Porosity
- Increases porosity in soil
- BUT, by itself, holds too much water in a container

Peat vs. Compost
- peat: nonrenewable/finite, “dead”
- compost: sustainable, “alive”

Problems with “immature”/”unfinished” compost

- physical and chemical properties vary based on source and how mature
- high salts (ex: manure-based)

Unfinished/Immature compost:
- volatile organic compounds
- odor
- reheating can occur (if compost is dry and rewetted)
- may contain pathogens, weed seeds
- Media in container can rapidly settle

Other things to consider when using compost

- Tests for Maturity:
  - Quick
    - Check for odors – Ammonia, Sulfur
    - large non-composted particles
    - Temperature – young compost will still be hot!
  - Bag test:
    - Moist sample in ziploc bag overnight – Does bag inflate? Off odors?

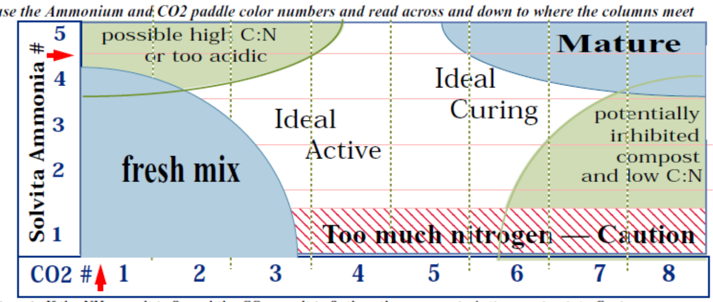
Commercial tests

Solvita®: test kit for ammonia and CO_2– the principle emissions in immature composts

- About $15 / test

Table 2 STATUS OF COMPOSTING PROCESS

use the Ammonium and CO2 paddle color numbers and read across and down to where the columns meet



Example: If the NH_3 result is 2, and the CO_2 result is 6, then the process is Active moving into Curing

Commercial testing labs

Cornell Nutrient Analysis Lab
- $45: % organic matter, salts, N, C, C:N
- $75: above + full nutrients

University of Maine, Soil testing lab
- $45: bulk density, salts, TS, TVS, C:N, most nutrients
- $10: compost stability

Rutgers
- $45: salts, nitrate-N, maturity index
- $125: above + OM, C-N, moisture, coarse/inert fragments

Characteristics of High Quality Compost *

pH	6.5 to 7.5
Soluble salts	≤5 mhos/cm
N, P and K	Ideally ≥ 1% (dry weight)
Bulk density	800-1000 lb/yd3
Moisture content	40 to 50 percent
Organic matter content	50 to 60 percent
Particle size	Can pass through 1/2-inch screen
Trace elements/heavy metals	Meet U.S. EPA part 503 regulations
Growth screening	Must pass seed germination and plant growth assays
Stability	Stable to highly stable

*Taken from: Stoffella and Kahn. 2001. Compost Utilization in Horticultural Cropping Systems. Lewis Publishers. (As reported by Taylor 2010)

Inert media components

Sand

- High bulk density
- Negligible pH, EC, and CEC
- Coarse size is best

Size Classes Sand

Class	Particle Size (diameter)
Very fine sand (VFS)	0.05 – 0.1 mm
Fine sand (FS)	0.1 to 0.25 mm
Medium sand (MS)	0.25 to 0.5 mm
Coarse sand (CS)	0.5 to 1 mm
Very coarse sand (VCS)	1 – 2 mm

Particle size and height of water table in container

Pore radius (cm)	Equivalent particle diameter (cm)	Height of water table (cm)
0.1	0.2 (very coarse sand)	1.47
0.01	0.02 (fine sand)	14.7
0.001	0.002 (very fine sand)	147

Perlite

- Volcanic rock crushed and heated to 1800 F
- High aeration (depends on particle size)
- Negligible pH/CEC
- Lightweight – low bulk density

vermiculite

- Mica crushed and heated to 1400 F
- High water holding (depends on particle size)
- pH 6.0-8.9
- High CEC
- Lightweight – low bulk density

Blending components for nursery container media

- Combine various components so that media has the correct balance of physical, chemical, (and biological) properties

Example

- 80% pine bark, 10% peat and 10% sand.
  - Shredded bark has good air porosity
  - Peat increases the water-holding capacity and nutrient holding CEC
  - Sand increases the weight reducing container tip-over

What about starter nutrient charge, nitrogen draft, and pH?

Recipe for "new" UC Mix

• 0.42 cubic yards	Fir bark
• 0.33 cubic yards	Peat
• 0.25 cubic yards	Sand
• 1 pound	Potassium-nitrate (13-0-46)
• 2 pounds	Single superphosphate (0-20-0)
• 5 pounds	Pulverized dolomitic limestone
• 1 pound	Ferrous-sulfate

QUESTIONS?

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