Greenhouse Soil Management

Bruce Hoskins
Maine Soil Testing Service
University of Maine
hoskins@maine.edu

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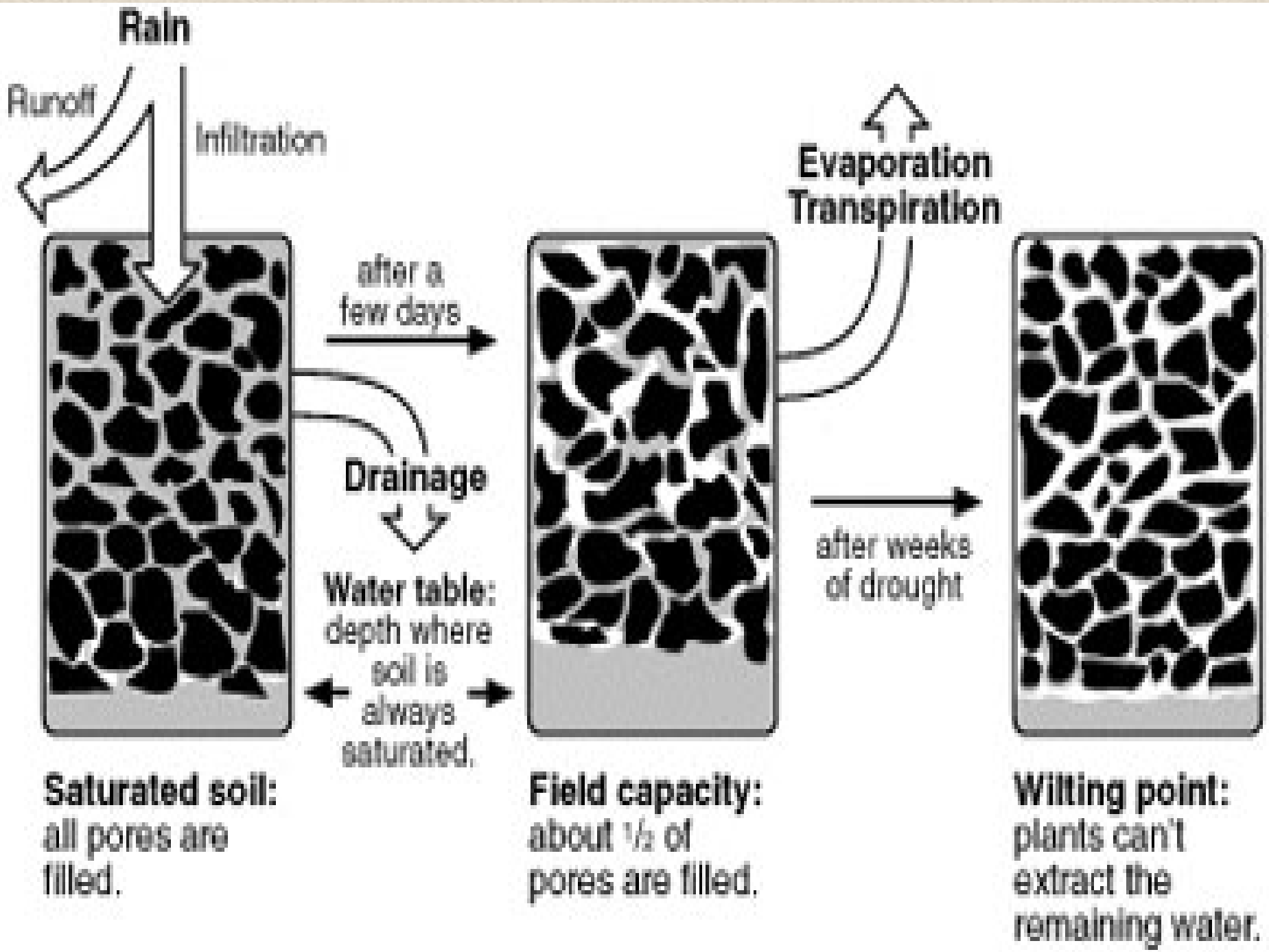
Soilless Mix Components

- Porosity of the mix is most critical

  Need both large and small pore spaces
  - ✓Large pore spaces for drainage & aeration
  - ✓Smaller pore spaces to hold sufficient water
- Commercial Soilless Mix typical ranges
  - ✓80 – 90 % total pore space by volume

    (field/garden soil normally 50 – 70 %)
- At Field Capacity
  - ✓~60 % water filled pore space
  - ✓Ideally 20 - 50 % air space


Rain
Runoff
Infiltration
Evaporation
Transpiration
after a few days
Drainage
Water table: depth where soil is always saturated.
after weeks of drought
Saturated soil: all pores are filled.
Field capacity: about ½ of pores are filled.
Wilting point: plants can't extract the remaining water.

Common Materials

- ✓ Sphagnum peat (large and small pores)
- ✓ Coir fiber (large and small pores)
- ✓ Vermiculite-coarse # 2 (asbestos?)
- ✓ Perlite
- ✓ Composted bark (may need extra nitrogen)
- ✓ Coarse Sand
- ✓ Pumice

Less Common Materials

(used in home made mixes)

- Limit to 25 – 30 % by volume

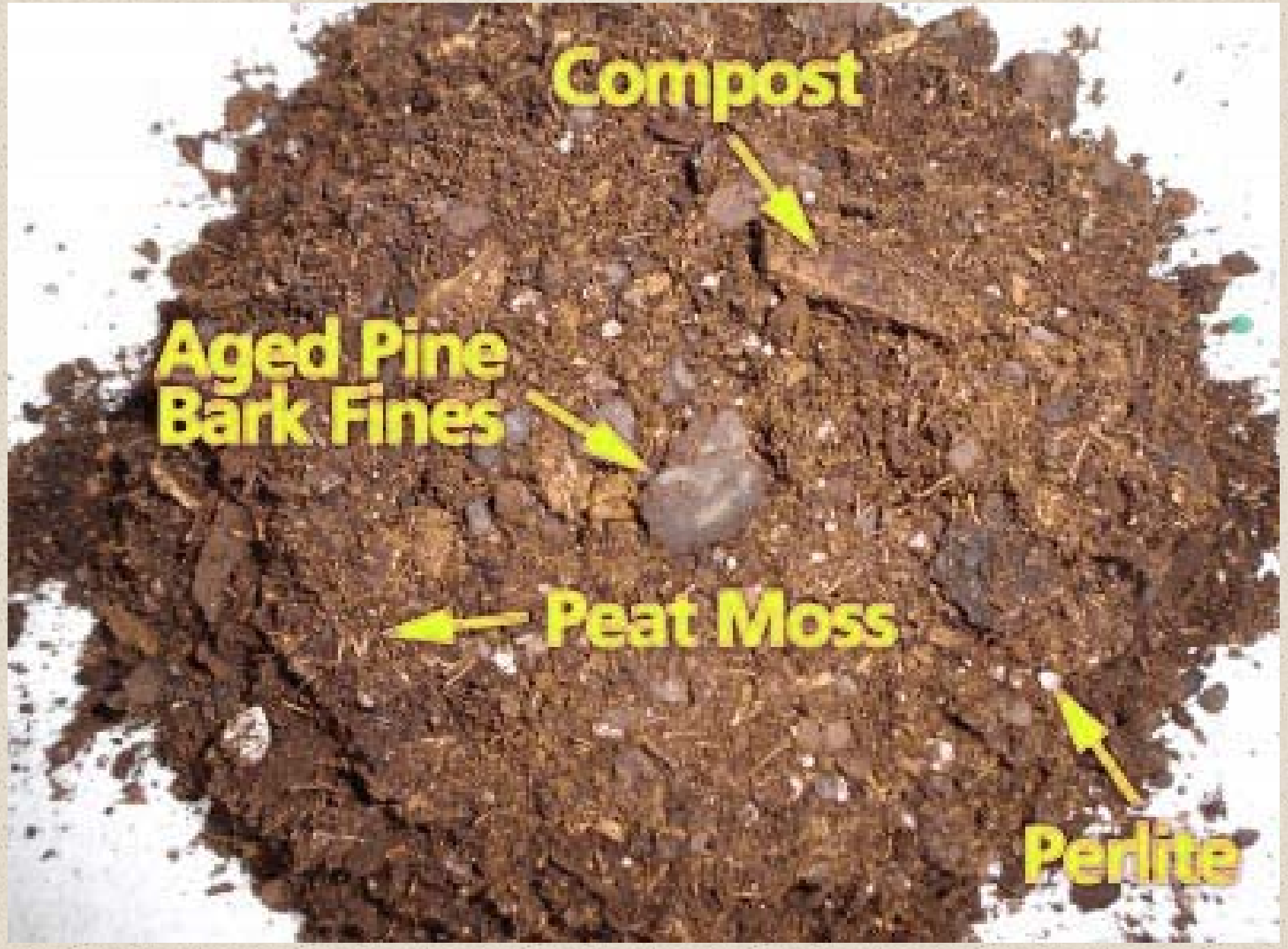
- ✓ Compost
- ✓ Field or Garden Soil (heat sterilized)
- ✓ Fine vermiculite (# 3)
- ✓ Worm castings
- ✓ Black peat (humified)

Water Holding Capacities

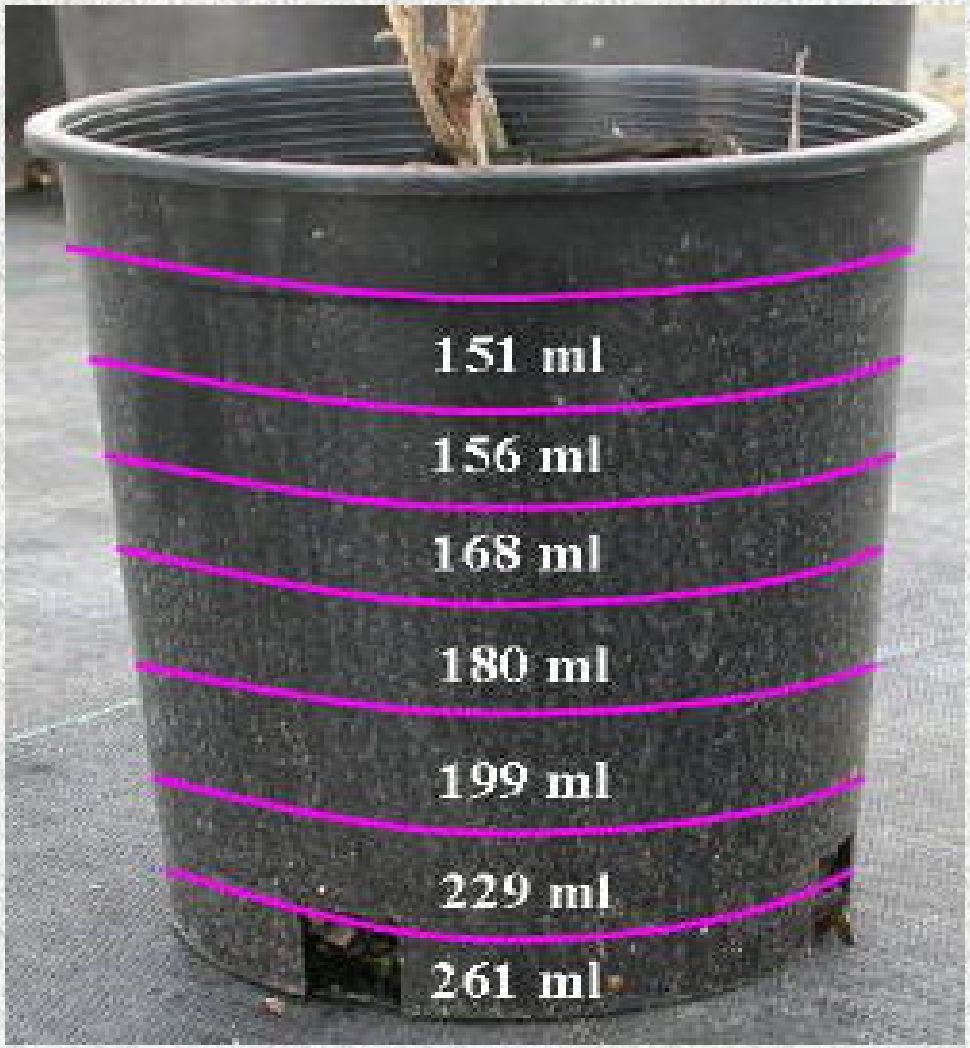
(relative to dry weight)

- Peat – 3 to 5 times
- Coir – 4 to 6 times
- Vermiculite – 1.5 to 2 times
- Perlite – 1 times
- Composted Bark – 1.5 times
- Finished Compost – *highly variable*

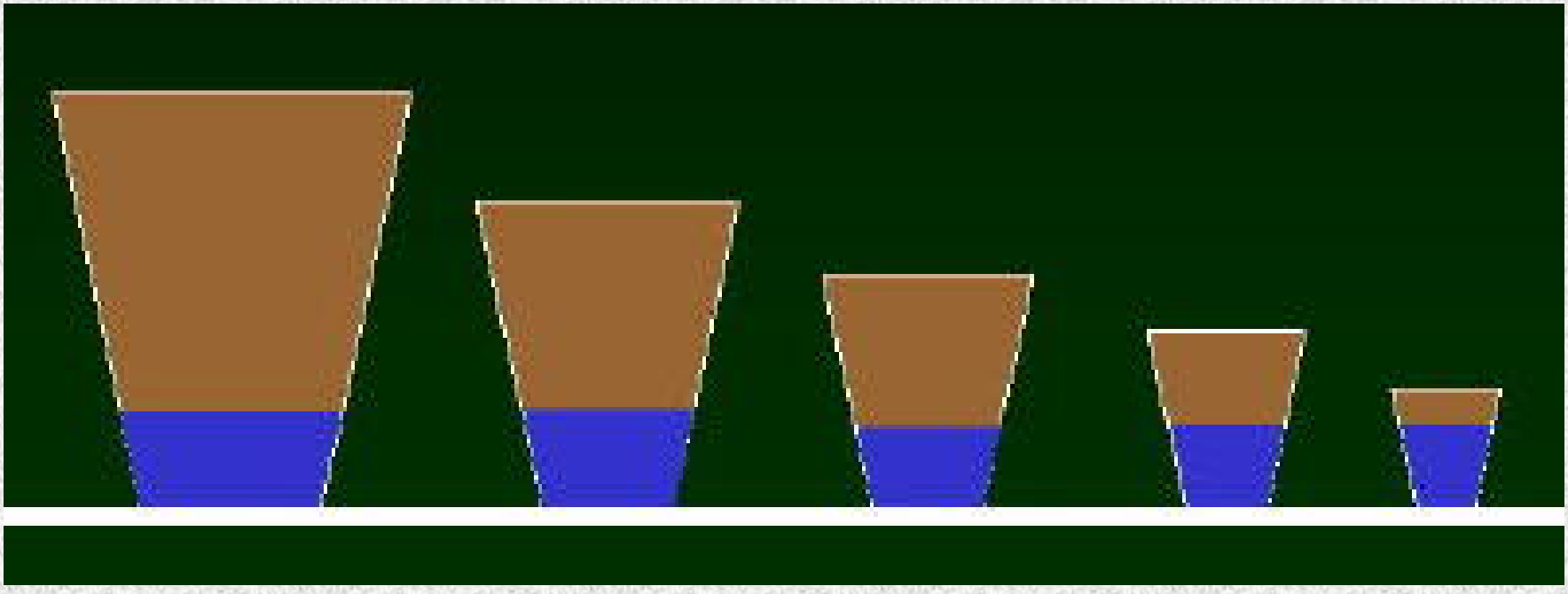
✓ **Ideal Complete mix – 2 to 3 times dry weight**


Compost
Aged Pine
Bark Fines
Peat Moss
Perlite

Container Water Content is NOT Uniform



Drainage is Most Critical in Seeding Flats or Plugs



Proper Mix Handling

- Avoid Compaction !

  Maintain large pore spaces

  - ✓Don’t compress mix in pots or cells
  - ✓Don’t stack flats or packs
  - ✓<u>Lightly</u> moisten mix before filling cell packs

Nutrients/Other Additives

- Lime – typically 5 - 10 lb/cu yd
  - ✓Less if you included compost
  - ✓More if you include > 50 % peat
- Mixed in dry -> must be wet up to react
- Different optimum pH range in soilless mixes
- Different ideal pH ranges for different plants

Soilless Mix Optimum pH Range

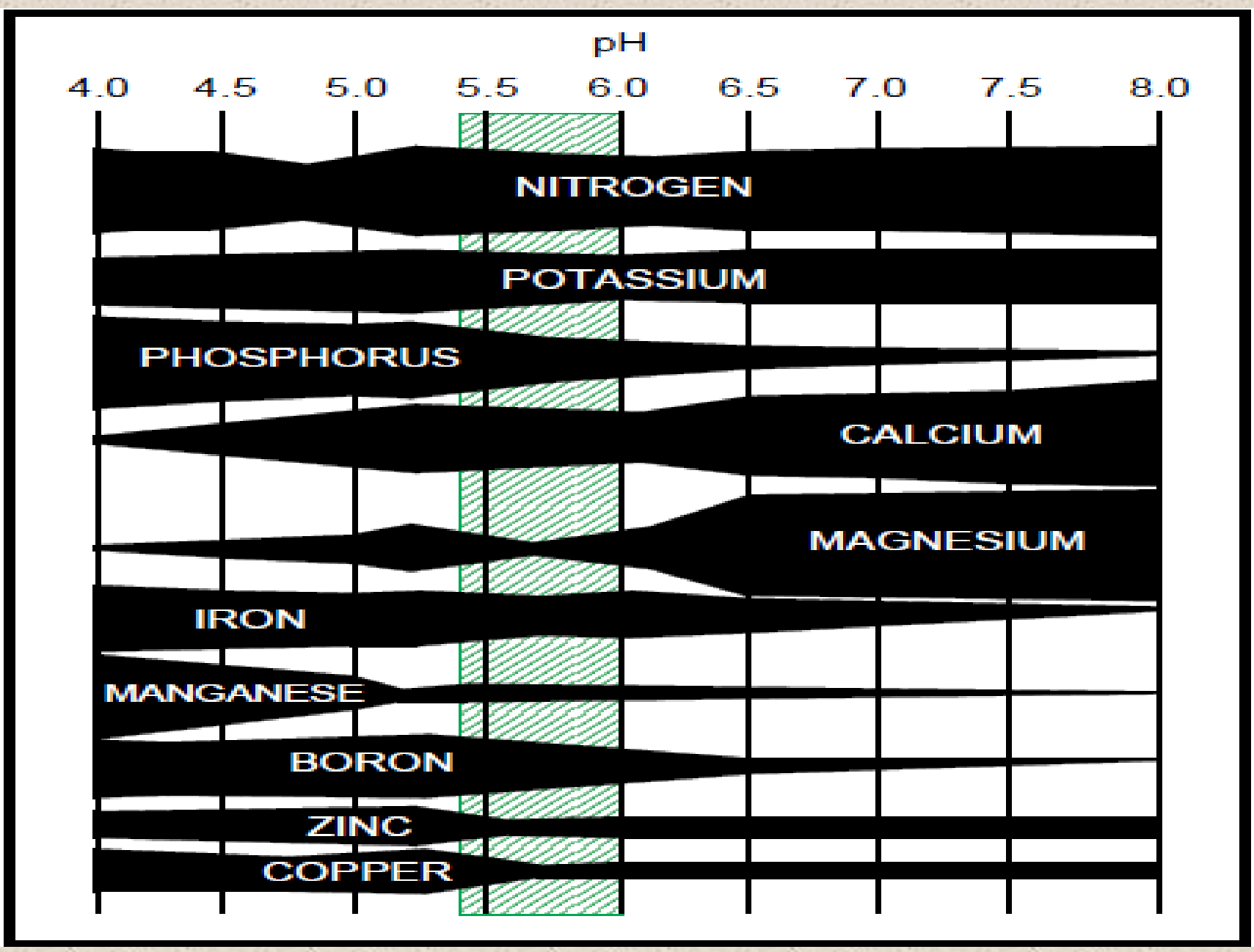
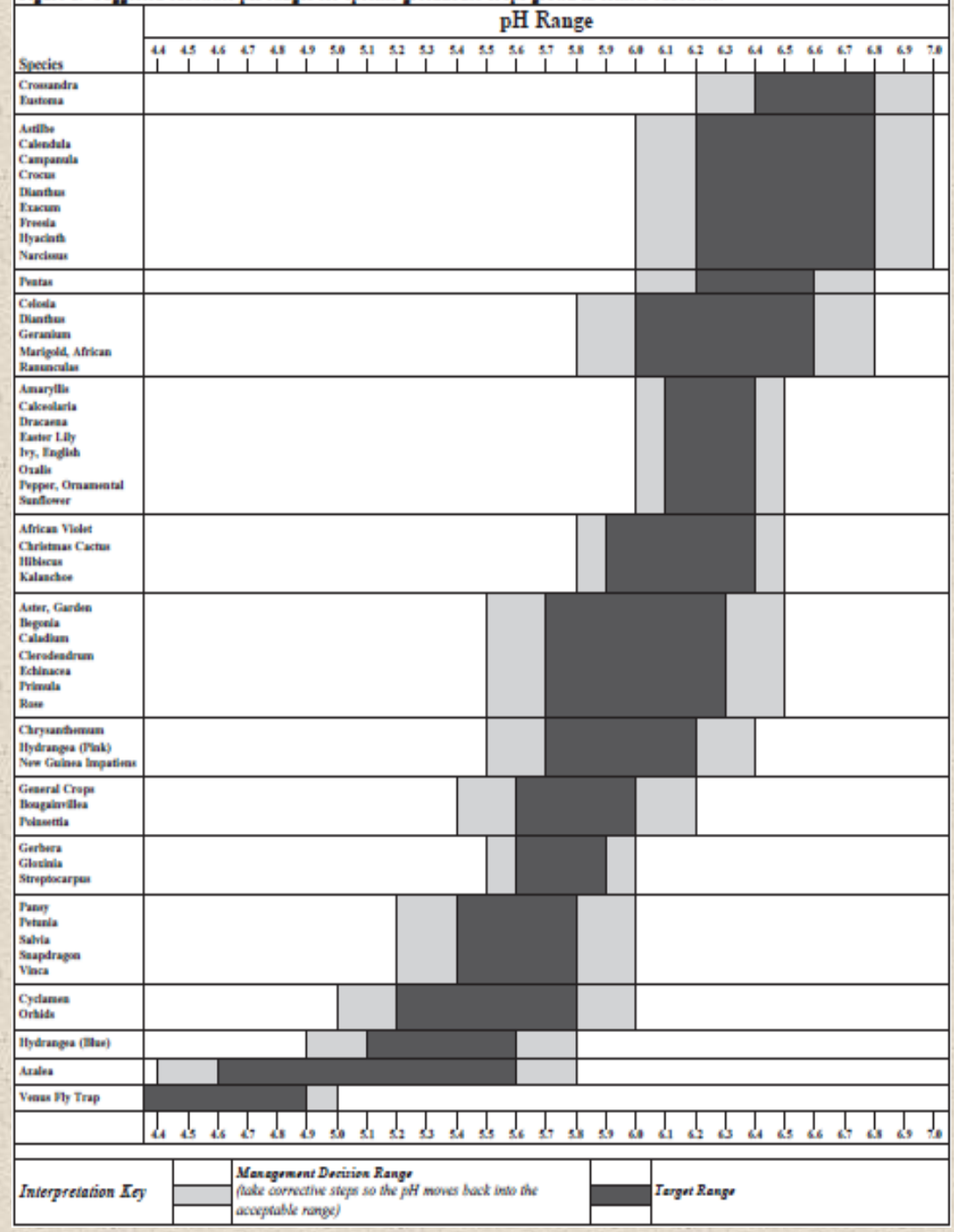


Figure 2. Suggested substrate pH ranges for specific greenhouse crops grown in soilless substrate.



Nutrients/Other Additives

- Starter Fertilizer
  - ✓ Complete N-P-K fertilizer
  - ✓ Water soluble fertilizers in conventional mixes
  - ✓ Non-chemical fertilizers in organic mixes
    - Plant & animal meals, natural minerals
    - Must be wet up/incubated to release nutrients

Mycorrhizal Innoculants

Additional Microbial Innoculants

- Beneficial (antagonistic) bacteria or fungi
  - ✓Compete with & Suppress Pathogens
  - ✓Trichoderma (fungus)
  - ✓Bacillus subtilis
  - ✓Bacillus Pumilis

Many Commercial Mixes to Choose From

- ✓Pro Mix
- ✓Sungro Horticulture
  - ✓Metro mix
  - ✓Fafard

- ✓Vermont Compost
- ✓Living acres
- ✓Coast of Maine
- ✓GreenTree

Common Issues & Problems

Container Media

Common Problems

- Poor drainage
  - Excess “small pore” material
  - Compacted mix
  - Compost one common culprit in org. mixes
- Poor aeration (roots require oxygen!)

  Poor root function -> limits nutrient uptake
- Incomplete N mineralization
  - ✓ Ammonium (NH_4^+)buildup -> high pH (>7)
  - ✓ Free ammonia (NH_3) gas -> Phytotoxic

Compost Blend Comparison

courtesy Mark Hutchinson

30% compost

Private Blend

50% compost

20% compost

100% compost

Common Problems

- Salt buildup
  - Normal fertilizing greater than uptake
  - ✓water stress/wilting of seedlings
  - ✓root damage and/or death
  - ✓Marginal and tip burn on leaves
- Watering technique very important
  - ✓"Water Through" regularly
  - ✓Flush excess salts through mix (some nutrient loss unavoidable)

Common Problems

- Media pH “Creep”
  - ✓Common with high alkalinity (hard) water
  - ✓Dissolved “lime“ gradually raises mix pH
- Test your irrigation water source!
  - ✓Alkalinity much more important than pH

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2/28/2018

Example Irrigation Water Report

received: 2/16/2018

Moderate to High Alkalinity

Sample type - water
Analysis - irrigation quality
Sample ID - Well

Job # 219B

Parameter		Level Found	Suggested Maximums for Greenhouse Use: Ohio State	Suggested Maximums for Greenhouse Use: NC State
pH		7.9	————	5.4 - 6.8
conductivity	(mmhos/cm)	0.50	< 1.0	< 2.0
alkalinity	(meq/liter)	3.8	< 2	< 2
NO3-N	(mg/liter)	0.26	< 5	< 10
Ca	(mg/liter)	14.3	< 120	< 120
K	(mg/liter)	110	< 10	< 10
Mg	(mg/liter)	8.6	< 24	< 24
Na	(mg/liter)	1.3	< 50	< 69
P	(mg/liter)	< 0.05	< 5	< 1
Al	(mg/liter)	0.09	< 5	< 5
B	(mg/liter)	< 0.01	< 0.8	< 0.5
Cu	(mg/liter)	0.06	< 0.2	< 0.2
Fe	(mg/liter)	< 0.01	< 5	< 4
Mn	(mg/liter)	< 0.01	< 2	< 1
S	(mg/liter)	4.4	< 80	< 30
Zn	(mg/liter)	< 0.01	< 5	< 0.3

Bruce Hoskins
Assistant Scientist
Analytical Lab

Irrigation Water Quality Effects on Media pH Management

- Media pH determines the availability of added nutrients
  - Low pH increases the availability of Cu, Fe, Mn, & Zn
  - High pH interferes with their availability
- Fe-inefficient plants need lower pH for adequate uptake
  - Petunia, pansy, snapdragon, calibrachoa, vinca
  - pH 5.4 to 5.8 optimum
- Fe-efficient plants need higher pH to avoid Fe/Mn toxicity
  - Geranium, marigold, New Guinea impatiens
  - pH 6.0 to 6.6 optimum

Water/Mix pH Adjustment Options

- Before planting

1) Surface water is superior to well water
   - ✓ Ponds, Streams, Shallow (dug) wells
   - ✓ Usually very low alkalinity

2) Match fertilizer acidity to water alkalinity level

Table 1. Some commercially available fertilizers, their percentage of total nitrogen as nitrate or ammonium plus urea, and potential acidity or basicity [a].

Fertilizer	NO_3	NH_4 [b]	Potential acidity [c] or basicity [d]
Ammonium sulfate	0	100	2200 a
Urea	0	100	1680 a
21-7-7 acid	0	100	1539 a
21-7-7 acid	0	100	1518 a
Diammonium phosphate	0	100	1400 a
Ammonium nitrate	51	49	1220 a
Monoammonium phosphate	0	100	1120 a
18-9-18	47.7	53.3	708 a
20-20-20	27.5	72.5	532 a
21-5-20	62.3	37.7	407 a
20-10-20	59.5	40.5	404 a
20-10-20	60	40	401 a
21-5-20	60	40	390 a
17-5-17	70.6	29.4	106 a
20-0-20	54	46	0
15-0-20	76.7	23.3	38 b
15-5-15	80	20	69 b
15-5-15	78.7	21.3	131 b
15-0-14	82.7	17.3	165 b
15-0-15	86.7	13.3	221 b
15-0-15	80.8	18.8	319 b
Calcium nitrate	100	0	400 b
Potassium nitrate	100	0	520 b
Sodium nitrate	100	0	580 b

[a] Table adapted and revised from Paul Nelson: Greenhouse Operation and Management. p. 315. 6th ed. Prentice Hall. New Jersey.

[b] The percentage of total N in the ammonium plus urea forms; remaining N is nitrate

[c] Potential acidity is defined as the pounds of calcium carbonate limestone required to neutralize the acidity of 1 ton of fertilizer

[d] Potential basicity: applying 1 ton of this fertilizer has the pH neutralizing effect of this many pounds of calcium carbonate limestone

Water/Mix pH Adjustment Options

- For established plantings

3) To raise pH

- ✓ Drench w/ potassium bicarbonate (2lb/100 gal)
- ✓ Drench w/ flowable lime (4 qt/100 gal)

Reference: Managing the pH of Container Media (Cornell publication)

4) Inject acid to neutralize alkalinity/lower pH

- ✓ Sulfuric, nitric, phosphoric, or citric acid

Reference: Alkalinity Control for Irrigation Water Used in Greenhouses (NC State Pub)

Common Problems

- Hydrophobic mixes
  - Won’t wet up readily when very dry
  - ✓Insufficient or no wetting agent in mix
- Mix shrinkage when dry
  - Most common with peat-based mixes
  - ✓Blend in some coir – less prone to shrinkage
  - ✓Briefly soak entire flat or container in water

Evaluating mixes

- Container media test differs from field soil
  - ❖High water retention, <u>limited</u> nutrient retention
  - ✓Fertility monitored by testing <u>soil water</u>
- Lab analysis – Saturated Media Extract
  - ✓pH, EC, water-soluble nutrient content
  - ✓Appropriate for chemical or organic production
- On Farm Monitoring
  - ✓pH, EC using portable meters (Pens)

Saturated Media Extraction

- Add water in a closed vessel just to saturation pt.
- Automatically accounts for moisture retention
- Constant relationship to field capacity (roughly 2X)

250 mL
KIMAX
KIMBLE USA

MAINE SOIL TESTING SERVICE
Greenhouse Media Analysis For:

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COMMERCIAL ORGANIC MIX

Dairy Manure Compost Base

Analysis date: 03/02/2018 Job # 252

Sample Name: Pre-plant

Crop Grown: Transplants

Comments: Routine test

Analytical Results

Determination	Optimum Level	Level Found
pH	5.8 - 6.4	5.8
Soluble Salts	0.75 - 3.50 mmhos/cm	3.12 mmhos/cm
Nitrate-N	40 - 200 ppm	8.4 ppm
(as % soluble salts)	(8 - 10 %)	(0.4 %)
Ammonium-N	2 - 20 ppm	50.0 ppm
Calcium	60 - 400 ppm	237 ppm
(as % soluble salts)	(14 - 16 %)	(11.9 %)
Potassium	40 - 300 ppm	355 ppm
(as % soluble salts)	(11 - 13 %)	(17.8 %)
Magnesium	30 - 200 ppm	50 ppm
(as % soluble salts)	(4 - 6 %)	(2.5 %)
Phosphorus	5 - 30 ppm	31.9 ppm
Aluminum	< 5 ppm	0.2 ppm
Boron	0.05 - 0.50 ppm	0.18 ppm
Copper	0.01 - 0.5 ppm	0.021 ppm
Iron	0.3 - 3.0 ppm	0.05 ppm
Manganese	0.1 - 3.0 ppm	1.19 ppm
Molybdenum	0.01 - 0.1 ppm	< 0.005 ppm
Sodium	< 25 ppm	145 ppm
Sulfur	75 - 125 ppm	408 ppm
Zinc	0.3 - 3.0 ppm	0.04 ppm

Note: Results are expressed as concentration in saturated media water extract.

In-house Monitoring

- Routine monitoring of pH and EC
  - ✓ pH/EC pens widely available

Pour-thru Method

- run 1 hour after normal watering
- Place clean saucer under pot
- Pour in 50 – 100 cc water (2-4 oz)

- Collect displaced leachate
- Test for pH & EC

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.

Summary and BMP's

1) Proper porosity important w/ all mixes

- ✓ Adequate "large pore" material for proper drainage
- ✓ Be careful not to compact your mix

2) Proper air/water balance for proper growth

- ✓ Always use containers w/bottom drainage
- ✓ Allow mix to dry nearly to wilting point
- ✓ Don't water on cloudy days, if possible

Summary and BMP's

3) Test your irrigation water source

- ✓ Balance water alkalinity with fertilizer acidity
- ✓ Inject acid for v. high alkalinity (>4 meq or 200 ppm)

4) Supplement fertility as necessary

- ✓ Monitor general fertility level by pour-thru/EC
- ✓ Lab analysis for complete nutrient profile
- ✓ Water through to leach excess salts

Suggested Links

Greenhouse Media Management

- NCSU Horticultural Substrates Lab
  - ✓ projects.ncsu.edu/project/hortsublab/
- UMass Greenhouse/Floriculture Program
  - ✓ ag.umass.edu/greenhouse-floriculture

  "Effects of growing media on water and nutrient mgt"
- Cornell Greenhouse Horticulture
  - ✓ greenhouse.cornell.edu/crops/factsheets/pHarticl.pdf

  "Managing the pH of Container Media"
- NCAT/ATTRA
  - ✓ attra.ncat.org/

  "Potting Mixes for Certified Organic Production"