Water Quality, Growing Media, and Fertilizer – Navigating the Greenhouse Bermuda Triangle

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The Dynamic Relationship between Growing media, Water Quality and Fertility Sources

- Irrigation Water Quality – Soluble Salts, pH, and alkalinity.
- Growing Media – Physical and chemical properties
- Fertility sources – Nitrogen sources and impact on growing media pH.

Water Quality - Soluble Salts

- **Measured by Electrical Conductivity (EC)**

- **Seedlings less than 0.75 dS/m**
- **General crops less than 1.50 dS/m**

- **Relationship between EC and TDS**

  EC (dS/m) X 640 = TDS (mg/L)

Water pH is known to impact:

- Availability of nutrients in the growing media
- Solubility of fertilizers in solutions
- Stability and efficiency of pesticides and growth regulators

Alkalinity

The primary impact of water on growing media pH stems from irrigation water alkalinity level.

Alkalinity is a measure of the facility of water to raise pH.

Reported as milliequivalents/liter (me/l) or ppm of equivalent calcium carbonate.

1 me/l = 50 ppm

Alkalinity

- **Water alkalinity causes substrate pH to rise gradually over time.**
  - **Length of crop period**
  - **Plant-to-substrate ratio**
  - **Upper substrate pH level tolerated by the crop**

Water quality guidelines and PGC water test results

The following lists the desirable qualities of irrigation water, as well as the results of a recent Plant Growth Center (PGC) irrigation water test. (mMhos/cm = milliMho per centimeter; meq/L = milliequivalents per liter)

Characteristic	Acceptable limit without treatment required	PGC test results
Electrical conductivity (mMhos/cm)	0.75 for propagation 2.0 for general production	0.20
pH	5.4 to 6.8	8.3
Alkalinity (meq/L)	1.5*	1.9

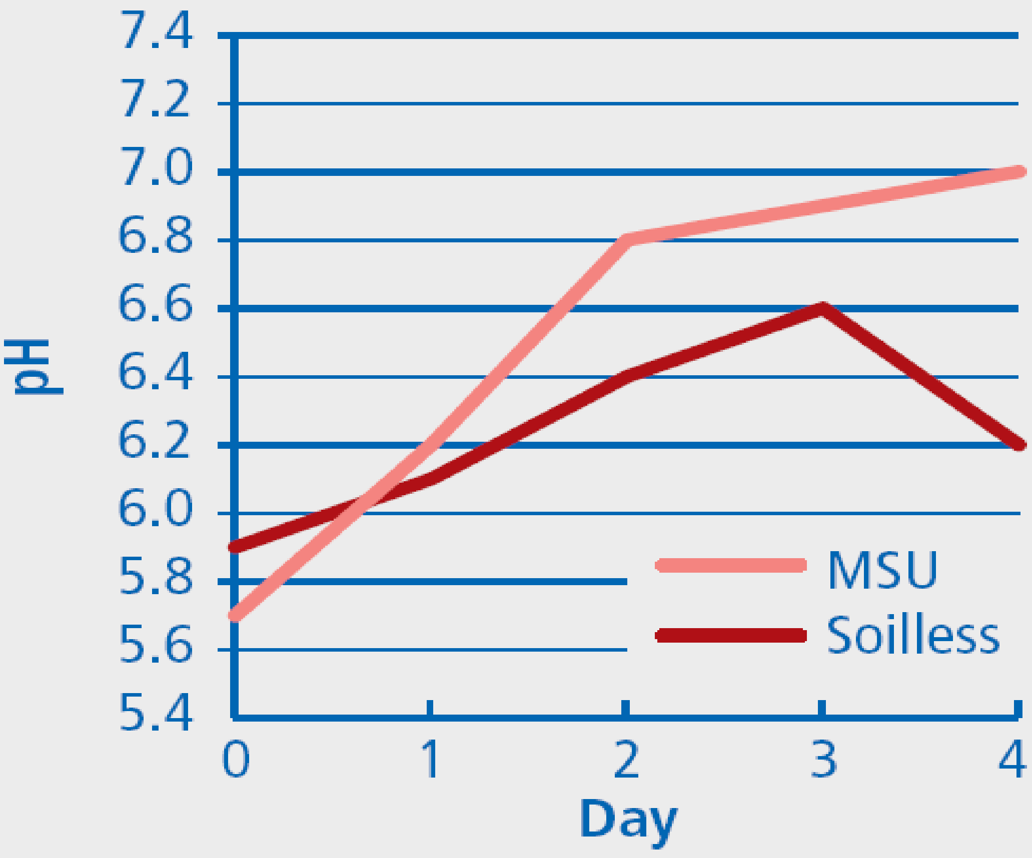
*Alkalinity levels from 3 to 8 meq/L may require acid injection to counteract the impact on growing media pH.

Alkalinity Treatments

Water Alkalinity	Treatment
< 1.5 me (75 ppm)	No treatment
< 3.0 me (150 ppm)	Acid forming fertilizer and/or less lime in media
<8.0 me (400 ppm)	Acid injection
>8.0 me (400 ppm)	Reverse osmosis

Media pH in two mixes

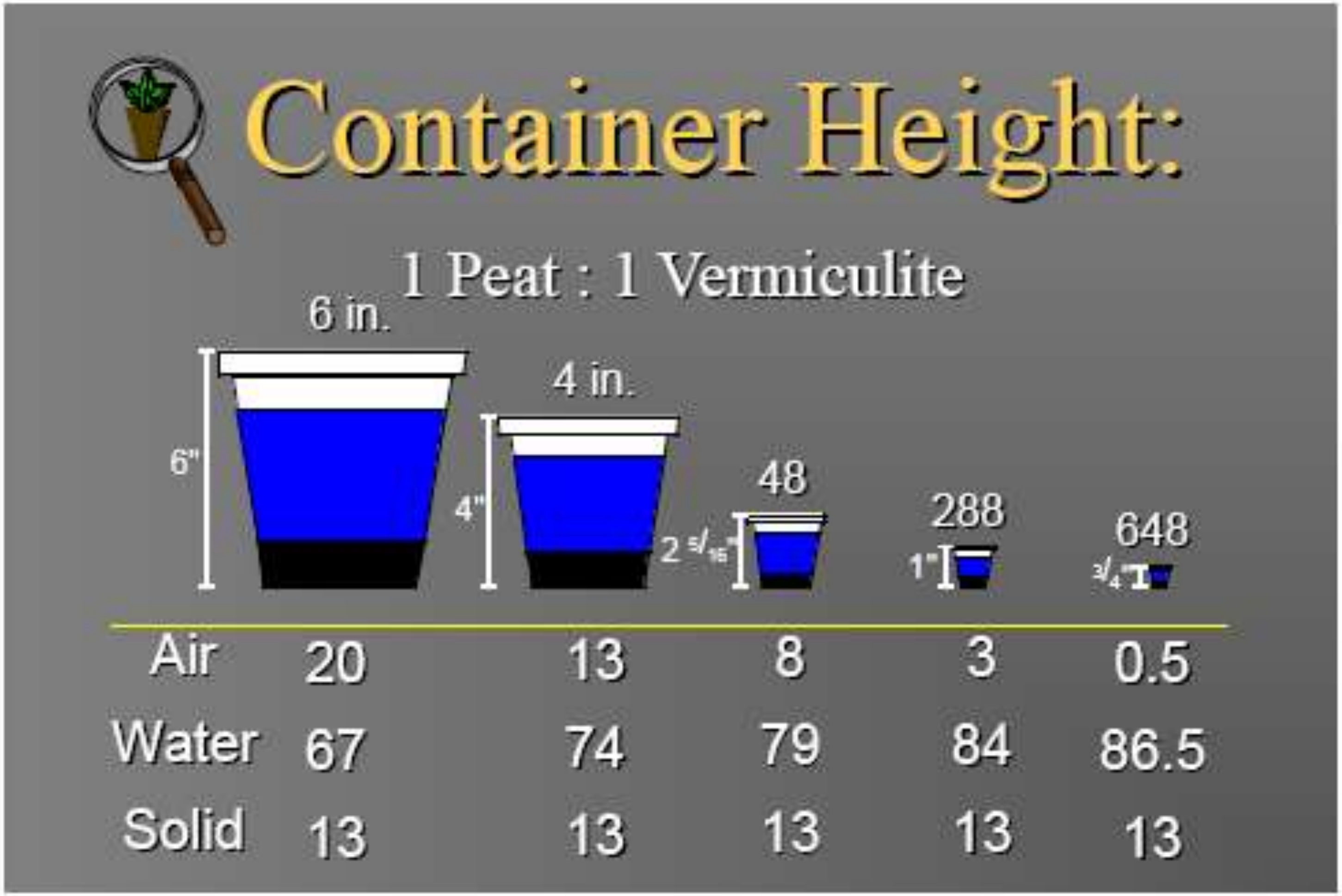
Media pH of commercially prepared soilless mix and Montana State University (MSU) prepared mix with daily application of irrigation water



Functions of Growing Media

- Hold water
- Hold nutrients
- Permit gas exchange to and from roots
- Provide support

Air : water ratio dependent on container height

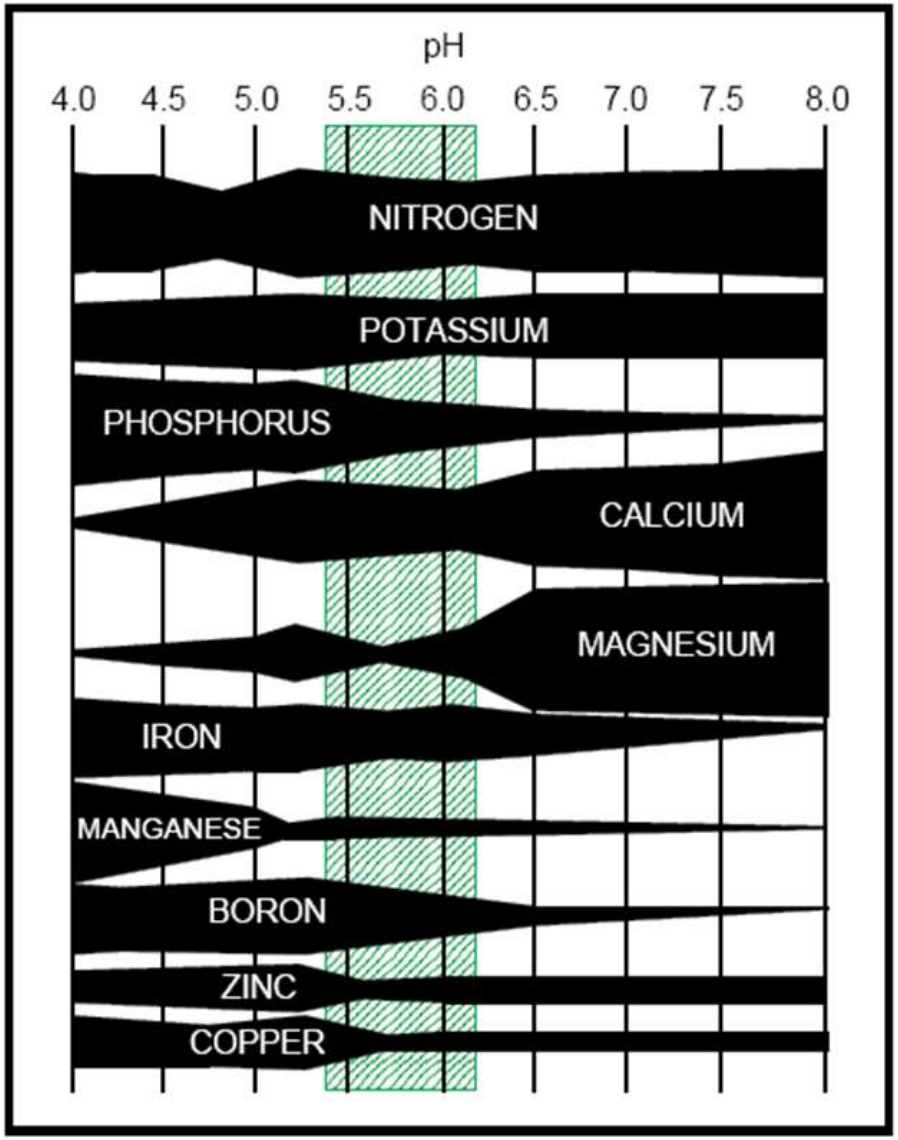


% of container volume at container capacity

Source: NCSU Greenhouse Substrates and Fertilization

Chemical Properties of Growing Media

- pH
  - controls the availability of all essential plant nutrients
  - pH range 5.4-6.0 for soil less media
  - pH range 6.2-6.8 for soil-based media (20% mineral soil by volume)



Potting Mix Components

Components that hold nutrients and water:

Peat Moss

Top Soil

Composted Bark

Coir (Coco Fiber)

Vermicompost

Potting Mix Components

Components that add porosity:

Perlite

Sand

Vermiculite

MSU Soil Mix vs. Sunshine Mix #1

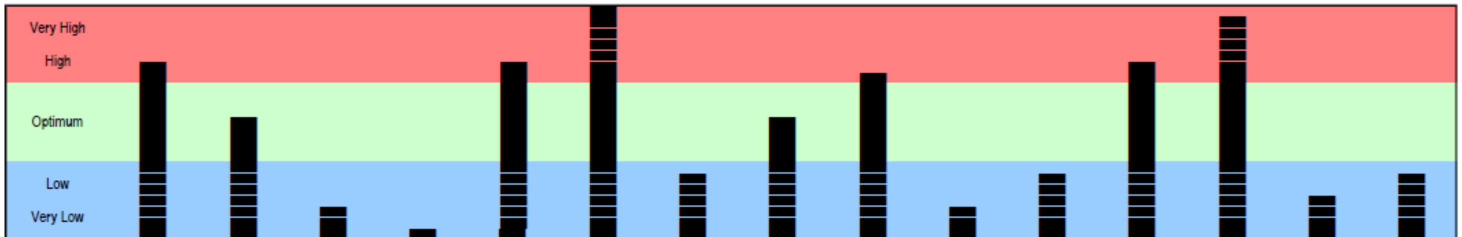
- MSU Soil Mix
  - 1 part Peat Moss:1 part Sand:1 part Topsoil. Aqua-Gro 2000G wetting agent.

- Sunshine Mix #1
  - 3 parts Peat Moss: 1 part Perlite. Wetting agent, dolomitic limestone, Si and starter fertilizer charge

MSU Mix and Sunshine #1Mix Test Results

Container Media Analysis: Modified (DTPA) Saturated Media Extract

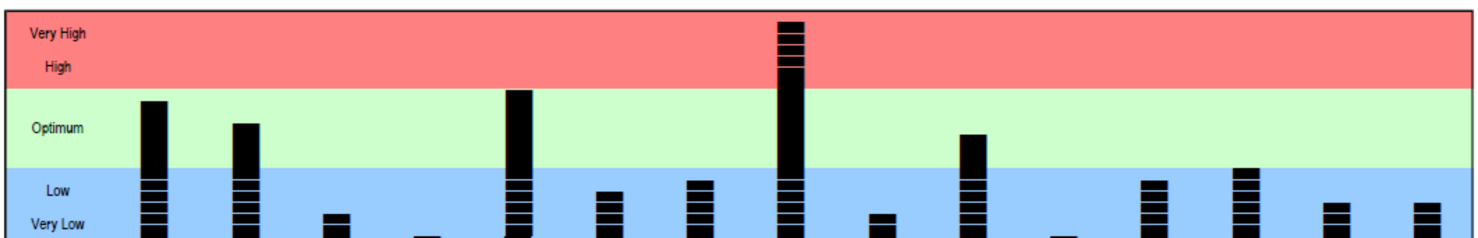
DATE OF REPORT: 09/08/15 LAB NO: 57898 SAMPLE ID: MSU CROP: PAGE: 1



Analyte	pH	ECe dS/m	NO_3-N ppm	NH_4-N ppm	PO_4-P ppm	Potassium ppm	Magnesium ppm	Calcium ppm	Sodium ppm	SO_4-S ppm	Zinc ppm	Manganese ppm	Iron ppm	Copper ppm	Boron ppm
Results	7.0	1.5	38	2	33	583	57	152	91	16	8	32	86	1	0.4
Optimum Range	5.5 6.8	1.0 2.0	70 200	50 100	15 25	100 150	70 150	100 200	50 80	70 200	10 30	10 30	25 50	2 10	0.5 1.0

Container Media Analysis: Modified (DTPA) Saturated Media Extract

DATE OF REPORT: 08/28/15 LAB NO: 56960 SAMPLE ID: SS#1 CROP: PAGE: 1



Analyte	pH	ECe dS/m	NO_3-N ppm	NH_4-N ppm	PO_4-P ppm	Potassium ppm	Magnesium ppm	Calcium ppm	Sodium ppm	SO_4-S ppm	Zinc ppm	Manganese ppm	Iron ppm	Copper ppm	Boron ppm
Results	6.5	1.5	30	3	25	69	48	366	15	124	1	8	23	1	0.1
Optimum Range	5.5 6.8	1.0 2.0	70 200	50 100	15 25	100 150	70 150	100 200	50 80	70 200	10 30	10 30	25 50	2 10	0.5 1.0

Selection of Fertilizer

- Proportion of potash (1N:1K_2O)
- Proportion of phosphate (1N: ½P_2O_5)
- Form of nitrogen
  - Ammonium (NH_4^+)
  - Urea
  - Nitrate (NO_3^-)

Nitrate nitrogen will tend to have a basic reaction, raising media pH. Ammonium sources of nitrogen will have an acid reaction, lowering media pH.

N Fertilizer - pH Relationship

Fertilizer	% NH_4^+	Potential Acidity
20-20-20	69	474 lbs.
20-10-20	38	393 lbs.
15-16-17	30	165 lbs.
		Potential Basicity
15.5-0-0	6	400 lbs.
13-0-44	0	460 lbs.

Paul V. Nelson’s Greenhouse Operation and Management

Potential Acidity: 400 lbs. Calcium Carbonate Equivalent per ton

SUNSHINE

TECHNIGRO®

20-10-20 NO BORON

For Continuous Liquid Feed Programs - For Professional Use Only

GUARANTEED ANALYSIS - USA

Total Nitrogen (N).	**20%**
8.0 % Ammoniacal Nitrogen	
12.0% Nitrate Nitrogen	
Available Phosphate (P_2O_5).	**10%**
Soluble Potash (K_2O).	**20%**
Magnesium (Mg).	**0.40%**
0.40% Water Soluble Magnesium (Mg)	
Sulfur (S)	**0.50%**
0.50% Combined Sulfur	
Copper (Cu).	**0.05%**
0.05% Chelated Copper (Cu)	
Iron (Fe).	**0.10%**
0.10% Chelated Iron (Fe)	
Manganese (Mn).	**0.05%**
0.05% Chelated Manganese (Mn)	
Molybdenum (Mo).	**0.01%**
Zinc (Zn).	**0.05%**
0.05% Chelated Zinc (Zn)	

DERIVED FROM: Ammonium Phosphate, Potassium Nitrate, Ammonium Nitrate, Magnesium Sulfate, Iron EDTA, Copper EDTA, Zinc EDTA, Manganese EDTA, Boric Acid, Sodium Molybdate.

POTENTIAL ACIDITY: 400 lb Calcium Carbonate Equivalent per ton.

NET WEIGHT: 25 lb / 11.3 kg

WARNING: This fertilizer contains Molybdenum. Its use on forage crops may result in crops containing levels of molybdenum which are toxic to ruminants.

Information regarding the contents and levels of metals in this product is available on the Internet at: http://www.aapfco.org/metals.htm

DIRECTIONS FOR USING 20-10-20 NO BORON

Mixing Concentrated Fertilizer Solutions: The table below lists how much Technigro fertilizer by weight to blend into a given volume of water to make a concentrated fertilizer solution. Recommended fertilizer concentrations are for a continuous feed program. However, the Technigro formula (NPK) and concentration (ppm) most suitable for individual use should be determined by soil and water analysis as well as plant response. Various target concentration and common injector ratios are included. Technigro dissolves faster in hot water. When mixing a concentrated solution with cold water, stir well and allow ample time for fertilizer to dissolve before using.

20-10-20 NO BORON fertilizer required in concentrate solution

Injector Ratio	50 ppm Nitrogen	100 ppm Nitrogen	200 ppm Nitrogen
No Dilution	0.03 oz/gal (0.25 g/l)	0.07 oz/gal (0.5 g/l)	0.13 oz/gal (1 g/l)
1:15 (Hozon)	0.5 oz/gal (3.8 g/l)	1 oz/gal (7.5 g/l)	2 oz/gal (15 g/l)
1:50	1.7 oz/gal (12.5 g/l)	3.4 oz/gal (25 g/l)	6.7 oz/gal (50 g/l)
1:100	3.4 oz/gal (25 g/l)	6.7 oz/gal (50 g/l)	13.4 oz/gal (100 g/l)
1:128	4.3 oz/gal (32 g/l)	8.5 oz/gal (64 g/l)	17 oz/gal (128 g/l)
1:200	6.7 oz/gal (50 g/l)	13.4 oz/gal (100 g/l)	26.7 oz/gal (200 g/l)

A soluble salts or conductivity meter can be used to estimate the concentration of fertilizer solutions. The correct conductivity (EC) in mmhos/ cm is listed below for various ppm Nitrogen concentrations. When measuring the conductivity of fertilizer solutions, be sure to subtract the conductivity of the water from the measured value of the fertilizer solution.

50 ppm Nitrogen	100 ppm Nitrogen	150 ppm Nitrogen	200 ppm Nitrogen	300 ppm Nitrogen
0.33	0.65	0.98	1.30	1.95

Miracle-Gro – Acid or Base Forming?

Miracle-Gro® Water Soluble All Purpose Plant Food 24-8-16

GUARANTEED ANALYSIS **F 1198**

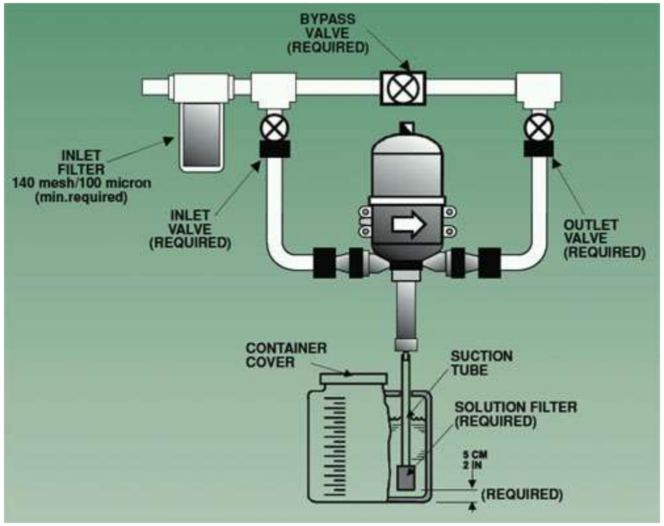
Total Nitrogen (N) 24%
3.5% Ammoniacal Nitrogen
20.5% Urea Nitrogen
Available Phosphate (P_2O_5) 8%
Soluble Potash (K_2O) 16%
Boron (B) 0.02%
Copper (Cu) 0.07%
0.07% Water Soluble Copper (Cu)
Iron (Fe) 0.15%
0.15% Chelated Iron (Fe)
Manganese (Mn) 0.05%
0.05% Chelated Manganese (Mn)
Molybdenum (Mo) 0.0005%
Zinc (Zn) 0.06%
0.06% Water Soluble Zinc (Zn)

Derived from Ammonium Sulfate, Potassium Phosphate, Potassium Chloride, Urea, Urea Phosphate, Boric Acid, Copper Sulfate, Iron EDTA, Manganese EDTA, Sodium Molybdate, and Zinc Sulfate.

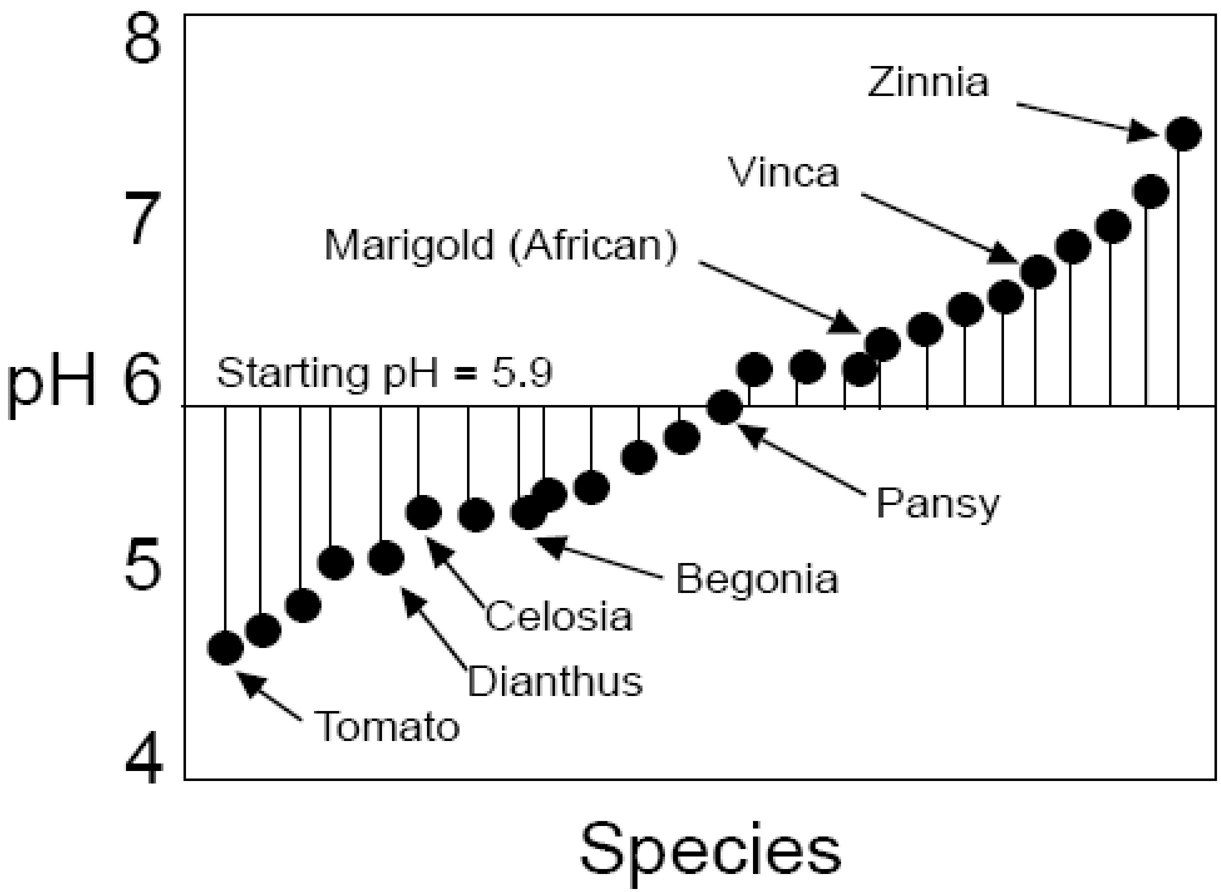
Information regarding the contents and levels of metals in this product is available on the Internet at http://www.regulatory-info-sc.com

Fertilizer Injection

Fertilizer Injectors



Species Effect on pH



Source: NCSU – Greenhouse Substrates and Fertilization

The “Big Four” Nutritional Problems

- Too High pH
  - Caused by highly alkaline water, excess lime, calcium nitrate fertilizers.
  - P, Fe, Mn, Zn, Cu, and B tied up.
- Too Low pH
  - Caused by acid forming fertilizers (NH_4^+)
  - Ca, Mg, S, Mo tied up. Excessively soluble Fe, Mn, and Al react with P to render it insoluble.

The “Big Four” continued

- Excess Soluble Salts
  - Caused by a combination of high salinity water and excess fertilization
- Low Soluble Salts
  - Caused by excessive leaching, infrequent fertilization and/or malfunctioning fertilizer injector

What happens when you confuse 17-17-17 Lawn and Garden fertilizer with 17-17-17 “time release” fertilizer.

The Pour Through Test

Figure 2a. Irrigate containers thoroughly.

Figure 2b. Saucer for pots.

Figure 2c. Saucers for cell packs.

Figure 2d. Applying water for extraction.

Figure 2e. Collected leachate for testing.

Figure 2f. Collect 50 ml (1.5 ounces) for testing.

Figure 2g. Calibration standards for testing.

Table 1. Amount of water to apply to various containers to obtain 50 ml (1.5 ounces) of extract*.

Container Size	Water to add**	
	milliliters	*ounces*
4 inch 5 inch 6 inch	75	2.5
6.5 inch azalea	100	3.5
1 quart	75	2.5
4 quart	150	5.0
12 quart	350	12.0
Flats 606 (36 plants) 1203 (36 plants) 1204 (48 plants)	50	2.0

**Containers should be brought to container capacity 30 to 60 minutes before applying these amounts.*
***These amounts are estimates. Actual amounts will vary depending on crop, substrate type, and environmental conditions.*

Figure 2h. Testing leachate samples.

NCSU Floriculture Website:
www.ces.ncsu.edu/floriculture/

EC interpretation values for Pour Through

Pour Through (mS/cm)	Indication
0 to 1.0	Very Low
1.0 to 2.6	Low
2.6 to 4.6	Normal
6.6 to 7.8	Very High
> 7.8	Extreme
Adapted from BC Ministry of Agriculture	

All this and more may be found on the PGC website:

ag.montana.edu/plantgrowth