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For more information on Small Farms, visit our website at: http://smallfarms.ifas.ufl.edu/ or contact your local County Extension Agent.

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Plant Nutrition – Hydroponic crops

• Essential plant nutrients
• Uptake
• Transport
• Functions of nutrients
• Managing nutrients
How many?

• Are beginners?
• Have been growing for a few years?
• Are fairly experienced?
Small Farms & Alternative Enterprises

Planning & Management
Getting Started, Agriculture Loans and Grants, Community Supported Agriculture, Enterprise Budgets, Farm Safety, Farmers’ Markets, Marketing, Postharvest Handling, Regulations, Success Stories, Ag Measures and Conversions

Food Safety

Livestock & Forages
Livestock, Forages

Crops
Agronomy, Flowers & Foliage, Fruits & Nuts, Herbs, Hydroponics, Aquaculture

About this Website
Explore topics related to the production, marketing and economics of specific small farm enterprises. More...

Events Calendar
- Rabbits & Blueberry Pruning Workshop July 31, 2014
- 2014 Florida Small Farms and Alternative Enterprises Conference August 1-2, 2014
- Many More...
Florida Hydroponic Resources

- Florida Small Farms/Alternative Enterprises Web Site -
  http://smallfarms.ifas.ufl.edu

- Virtual Field Day - 20 Hydroponic Modules
  http://vfd.ifas.ufl.edu
Plant nutrition
Plants are like factories

- Supplies are delivered – sunlight, water, carbon dioxide, nutrients
- Need the right conditions in the factory for the workers
- Need the blueprints – DNA
- Need the supervisors – various signaling compounds
Factories

- Basic components are put together – amino acids, sugars, carbohydrates, nucleic acids
- Workers at the assembly lines – enzymes
- Bigger components are constructed – Cells, DNA
- Tissues and organs are formed
Factories

• Constant supply chain, manufacturing, transporting, refurbishing, breaking down, and re-manufacturing

• *Plant nutrients* are some of the critical supplies needed in the process – growers can help here
Things good growers know

- What nutrients are needed by plants
- What functions do they have in the plant
- A little plant nutrition (physiology)
- How to supply the nutrients
- Symptoms when they are missing
- How to diagnose problems
- How to correct problems
- How to formulate nutrient solutions
Essential Plant Nutrients

- C, H, O, P, K, N, S, Ca, Fe, Mg, B, Mn, Cu, Zn, Mo, Cl

- C. Hopkins CaFe, mighty good, owned by my cousins Moe and Clyde

- Last one, Cl, added in 1954
- Nickel, Ni, recently added as essential
- Beneficial elements: Co, Na, Si, V
Essential Plant Nutrients

- C, H, O, P, K, N, S, Ca, Fe, Mg, B, Mn, Cu, Zn, Mo, Cl, Ni

- Macro and micro nutrients
- Sources: air, water, soil, fertilizers
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Average Concentrations of Mineral Nutrients in Plant Shoot Dry Matter that are Sufficient for Adequate Growth

Micronutrients and macronutrients
Practical “take-home”

- Macro and micro are not descriptive of relative importance of a nutrient to the plant’s growth and reproduction.
- Your handout has descriptions of all the nutrients.
Nutrient Uptake

• How do plants take up nutrients from the environment?
• Why is this knowledge important for growers?
Nutrient Uptake in the Root

• Passive, nonmetabolic
  – mass flow, diffusion, or exchange
  – Free space, outside the membrane
  – Apoplast

• Active, metabolic (requires energy)
  – Absorption across a membrane
  – Involves ion carriers in the membrane
  – Symplast
Nutrient Uptake Pathways

- Epidermis
- Endodermis
- Phloem
- Xylem
- Casparian Strip
- Symplastic Pathway
- Apoplastic Pathway
- Cortical Cells
- Root Hairs
Nutrient uptake pathways

- Plasmodesmata
- Cell wall
- Casparian strip
- Black arrows depict movement of ions
- Apoplast
- Symplast
Nutrient uptake

- Requires healthy roots – we don’t often observe roots
- Uptake and transport requires energy from respiration
- Impacted by temperature, oxygen, light intensity
- Influenced by how well we provide growing conditions in the greenhouse
- Fertilizer program and other plant management programs are linked-can’t always make a plant better by throwing fertilizer at it
Nitrogen (N)

- Absorbed actively as nitrate (NO$_3^-$) or ammonium (NH$_3^+$)
- High levels of ammonium can be toxic
- Nitrate is reduced and incorporated into amino acids
- For most species the greatest growth is with a supply of both forms of N
Amino acids

Nonpolar:
- Glycine (Gly)
- Alanine (Ala)
- Valine (Val)
- Leucine (Leu)
- Isoleucine (Ile)
- Methionine (Met)
- Tryptophan (Trp)
- Phenylalanine (Phe)
- Proline (Pro)

Polar:
- Serine (Ser)
- Threonine (Thr)
- Cysteine (Cys)
- Tyrosine (Tyr)
- Asparagine (Asn)
- Glutamine (Gln)

Electrically Charged:
- Aspartic Acid (Asp)
- Glutamic Acid (Glu)
- Lysine (Lys)
- Arginine (Arg)
- Histidine (His)
N is in chlorophyll molecule - the green pigment of photosynthesis
Greek: Chloros (green) and phyllon (leaf)
What else is in the chlorophyll molecule?
Magnesium is in the chlorophyll molecule?
HEME
(Oxygen carrying portion of Hemoglobin)

CHLOROPHYLL

[Chemical structures of Heme and Chlorophyll]
N deficiency

• Yellowing of older leaves
• N is mobile in the plant, can be moved from the older tissues to satisfy development
• Typically 1.5 to 4% by dry weight
• More commonly we see excessive N than inadequate N
Practical take-home

- Nitrogen ions make up a large portion of the ions in the plant
- The “gas pedal”
- Not enough – low yields and small fruit size
- Too much – excessive growth, increases in certain diseases, fruit shape can be affected
# Phosphorus (P)

- Taken up actively mostly as $\text{H}_2\text{PO}_4$
- Incorporated into nucleic acids, phospholipids, energy transfer compounds (ATP)
- Mobile nutrient, symptoms show first on older leaves
- 0.15 to 2.0%
The Nucleotides of DNA

Adenine  Guanosine  Thymine  Cytosine

Purines  Pyrimidines
Phosphorus deficiency
Calcium

- Passive absorption, mostly at the root tip area
- Casparian strip
- Cell walls, holding cells and tissues together
- Well water is high in Ca
- Fertilizer – calcium nitrate
Calcium localization, red dots

- Cell wall
- Plasma membrane
- Mitochondrion
- Middle lamella
- Cytoplasm
- Vacuole
Calcium

- 0.3 to 5.0% in plant tissue
- Not very mobile
- Where would you expect Ca deficiency symptoms first? (newest leaves or oldest?)
- Developing fruits of older fruits?
Calcium deficiency

Why does Ca deficiency mostly affect these young fruits?
Iron

- Absorbed actively
- Heme proteins such as cytochrome, involved in photosynthesis
- 50 to 150 ppm Fe
- Deficiency - what color would we see?
- Nonmobile – where do we first see the symptoms?
Toxicities

- Usually associated with the micronutrients
- Needed in small amounts
- Easy to over-apply
Nutrient toxicities

Cu toxicity

K deficiency
Satisfying the plant’s nutrient needs

- Irrigation water
- Media
- Fertilizer
Water testing - pH

• pH – most situations the pH will be high
• Presence of bicarbonates
• Problems with high pH and bicarbonate
  — Reduces growth
  — Precipitates of Ca and Mg – clog emitters
• Treat with acids – pH of 5.5 – 6.0
• Knowing about the water chemistry can help manage the fertilizer program
Water testing - EC

- Electrical conductivity
- How concentrated are the salts in the solution?
- An indirect, quick method for telling the relative nutrient concentration
- Does not say anything about any single nutrient or nutrients
- Expressed as dS/m or mmhos/cm
Water EC guidelines

• Good to excellent < 0.75 dS/m
• Permissible 0.76 to 2.00
• Problematic >2.00
E.C. and TDS?

• Need to be careful here
Water testing - EC

- High EC reduces growth, but can increase fruit TSS
- Crops vary in tolerance of high EC
- Problems using EC in organic fertilizer mixtures and under varying T
- Usefulness of EC measurements?
  - Evaluating leachate program
  - Evaluating the suitability of a water source
  - Still need nutrient analyses
Formulating the fertilizer solution

• Pre-mixed materials – weigh, mix with water, and apply – great for beginners and small growers
• Using a recipe and formulating yourself – Good for established growers
• Your handout
Nutrient solution formulation

• Handout – Nutrient Solution Formulation ....
• Elemental and oxide expressions
• Fertilizer trade $N - P_2O_5 - K_2O$
• Formulations use N-P-K

• Calculations and math??
• Florida Greenhouse Vegetable Production Handbook
  – http://edis.ifas.ufl.edu/cv265
P content in $P_2O_5$

- **Atomic Weights:**
  - Nitrogen (N) 14
  - Oxygen (O) 16
  - Phosphorus (P) 31
  - Potassium (K) 39

- **What is the P content in $P_2O_5$?**
  
  \[
  2 \times 31 = 62 \quad \text{(2 P atoms)} \\
  5 \times 16 = 80 \quad \text{(5 O atoms)} \\
  \text{Total} = 142
  \]

  \[
  \% \text{ P in } P_2O_5 = \frac{62}{142} \times 100 = 43.7 \% \quad \text{(Factor=0.44)}
  \]

  - So, for example, 8% $P_2O_5$ in a fertilizer is really 3.49% P!

  \[
  8 \% \text{ P2O5} \times \frac{62 \text{ lb P}}{142 \text{ lb } P_2O_5} = 3.49\% \text{ P}
  \]
Pre-mix formulation

- Amount of fertilizer in ppm to make 1 volume of stock solution =
  \[ \text{Desired conc. in ppm} \times \text{dilution factor} \times \% \text{ of element in fertilizer} \times \text{"C"} \]
- Dilution factor is the larger number e.g. 200:1
- “C” is conversion constant depending on the units you want to measure
Conversion constants

- $C = 75$ for ounces per gallon of stock
- $C = 1200$ for lb per gallon
- $C = 10$ for grams per liter
Example

• We have a 1:98 injector and a 20-10-20 fertilizer. We want a delivered 150 ppm solution of N at each irrigation. How many ounces of fertilizer will we need to weigh out to fill a 20-gallon stock tank?
Example

• List out the information we need:
  – Desired concentration in ppm is 150
  – Injector ratio is 98:1; dilution factor is 98
  – Fertilizer analysis is 20-10-20 (20% N)
  – Conversion constant; we want to measure out in oz/gal, so we will use C=75.
Example

Desired conc. in ppm X dilution factor
% of element in fertilizer X “C”

150 ppm N X 98
20% N X 75

14,700
1,500

9.8 oz of 20-10-20 per gal
Or: 196 oz for 20 gals
Plant tissue testing

- Using the plant to provide information about its nutritional status
- Leaves are typically the tissue of choice
- Petioles
- Petiole sap
Growth (% of maximum)

Concentration of Nutrient in Tissue (dry basis)

- Critical Concentration
- Critical Nutrient Range (no symptoms)
- 10% Reduction in Growth
- Luxury Consumption
- Toxicity
- Visual Symptoms

Redrawn from Havlin et al., 1999
Plant part

- Mobile nutrients - most recently matured leaf
- Immobile nutrients - use upper leaves
- Example of each?
- Simple leaf, compound leaf
- Petiole
- petioliule
http://www.ncagr.gov/agronomi/Tissue/tom03.htm
Plant tissue testing

- Important to understand normal trends over the season
- What are the normal concentration ranges with time?
- Where are your plants within that sufficiency range?
- Record-keeping
Things good growers know

- What nutrients are needed by plants
- What functions do they have in the plant
- A little plant nutrition (physiology)
- How to supply the nutrients
- Symptoms when they are missing
- How to diagnose problems
- How to correct problems
- How to formulate nutrient solutions