Expanding on Nutrient Management for Greenhouse Crops

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Outline

- Brief Overview of Essential Nutrients
- Calcium
- Iron
- Forms of Nitrogen
- Organic Fertilizers

Element	Symbol	PPM	Percent	Relative number of atoms
Nitrogen	N	15,000	1.5	1,000,000
Potassium	K	10,000	1.0	250,000
Calcium	Ca	5,000	0.5	125,000
Magnesium	Mg	2,000	0.2	80,000
Phosphorus	P	2,000	0.2	60,000
Sulfur	S	1,000	0.1	30,000
Chlorine	Cl	100	--	3,000
Iron	Fe	100	--	2,000
Boron	B	20	--	2,000
Manganese	Mn	50	--	1,000
Zinc	Zn	20	--	300
Copper	Cu	6	--	100
Molybdenum	Mo	0.1	--	1
Nickel	Ni	0.1	--	1

Deficiency/Toxicity

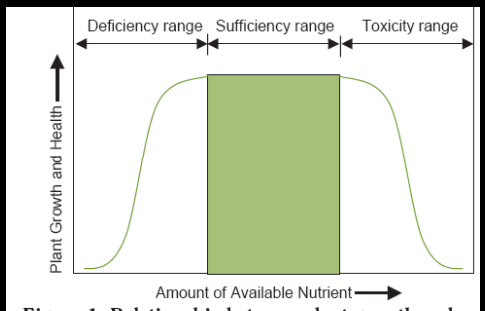
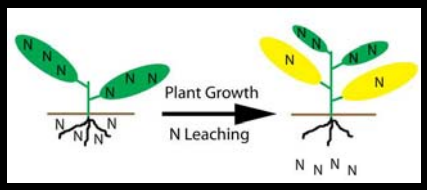


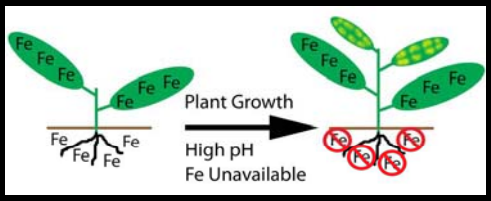
Figure 1. Relationship between plant growth and health and amount of nutrient available (Brady and Weil, 1999).

Visual Diagnosis and Mobile Nutrients



- N, P, K, Mg, Ni
- Deficiency symptoms occur on older leaves first

Visual Diagnosis and Immobile Nutrients

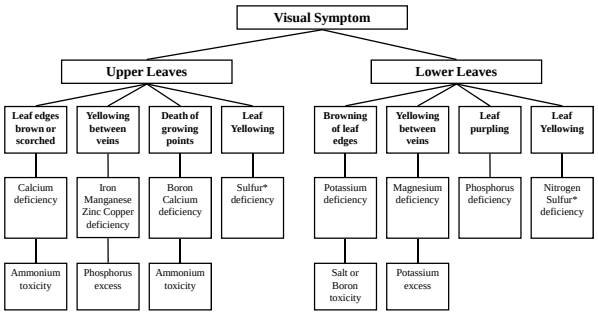


- B, Ca, Cu, Fe, Mn, Mo, Zn
- Deficiency symptoms appear first on new (upper leaves)
- Toxicity symptoms appear on old leaves first

A mobile nutrient, like Nitrogen, will show deficiency symptoms where?

A) In the roots
B) In old leaves
C) In young leaves
D) Flowers

Visual Diagnosis of Nutrient Disorders



*S deficiency appears as yellowing of both upper and lower leaves

Have you seen a plant that looks like this?

A) Yes
B) No
C) I don't look at tomatoes

Calcium

- Essential Roles in Plants
  - A component in cell walls
    - Associated with pectins in the middle lamella
    - Acts as a cement to bind cell walls together
  - Cell signaling, activation of enzymes

Calcium – more information

- An immobile nutrient
- Uptake by roots is passive – through the transpiration stream
  - Low light, High humidity, dry soil → calcium deficiency
- Uptake occurs at the tips of young roots
  - Root damage (salts, dry, diseases), Inactive roots → calcium deficiency

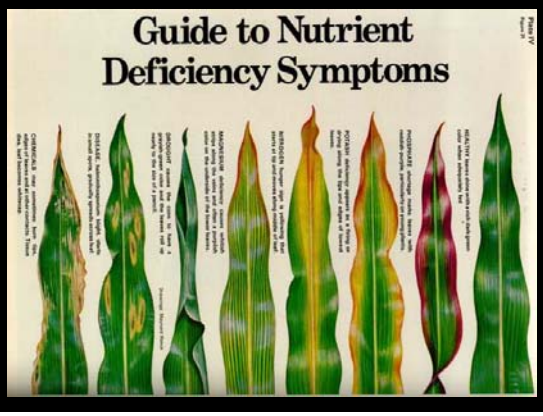
Symptoms of Calcium Deficiency

- Occur at the top of the plant (new growth)
- Poor expansion of new leaves
  - Leaf distortion, strap-like growth, crinkling
- Variable Leaf Chlorosis (yellowing)
- Necrosis (browning) on edges of new leaves
- Eventual death of the whole shoot
- Flowers can abort
- Fruit distortion (Blossom End Rot)

Tomato Calcium Deficiency

Corn Ca deficiency

Guide to Nutrient Deficiency Symptoms



Ornamentals Ca deficiency

Causes of Calcium Deficiency

- Lack of Ca in tapwater
- Lack of lime (CaCO3) added to the substrate
- Not using a fertilizer that contains Ca
  - (These do not have Ca: 21-5-20, 20-10-20, 20-20-20)
- Excessive leaching
- Fertilizer Injector malfunction
- Fertilizer mixing rate error

Causes of Calcium Deficiency

- Diseased root system
- Cool temperatures, high humidity, low light
- Overwatered soils
- Too much Mg, K, NH4 (ammonium), or Na

Correcting Calcium Deficiency

- Change environmental conditions to improve transpiration
- Growing practices to promote a healthy root system
- Check fertilizer calculations, injector
- Switch to a calcium containing fertilizer (15-5-15 Cal Mag)
- Add 100 ppm $CaNO_3$ to the current fertilizer program (7 ounces per 100 gallons water)

Correcting Calcium Deficiency

- Add additional lime to the substrate
  - Ex: an additional10 pounds per cubic yard
    - (Will lead to a higher pH)
- Do a soil test to ensure that Mg, K, NH_4, or Na are not over-supplied
- Foliar sprays with $CaNO_3$ (calcium nitrate) or $CaCl_2$ (Calcium chloride)
  - Use 4 Tablespoons per gallon (2-3 x per week)
  - Or use 4 pounds per 100 gallons

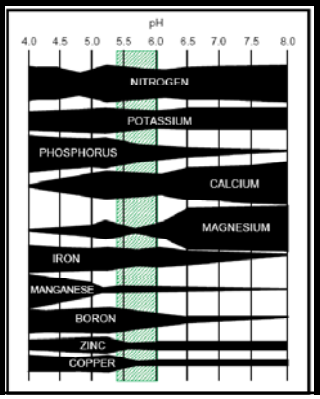
Iron deficiency is caused by?

A) pH too high
B) pH too low
C) Lack of Iron in fertilizer
D) Not enough liver and organ meats in the diet

Iron

- Essential Roles in Plants
  - Oxidation-reduction states, electron transfer reactions
  - Energy production (NADP)
  - Nitrate and sulfate reduction
  - Indirect role in chlorophyll production

Iron availability depends on pH



Iron – more information

- A relatively immobile nutrient (can move up to 1.5 cm)
- Some plants are better at taking up Iron than others (Iron Efficient plants)
  - Can release protons to acidify the root-zone
  - Can release natural chelating agents

Symptoms of Iron Deficiency

- Leaves develop interveinal chlorosis
- Young leaves can develop uniform chlorosis
- If symptoms advance – the entire leaf can lose chlorophyll pigment and become light yellow/white
- Finally leaves can become necrotic

Causes of Iron Deficiency

- pH of substrate is too high > 6.4 (most crops)
- Lack of Fe in fertilizer
- Lack of a chelated iron in the fertilizer (if pH is high)
- Root rot, saturated substrate, cool growing temperatures
- Too much P, Cu, Mn, Zn in the substrate

Correcting Iron Deficiency

Quick solution:

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

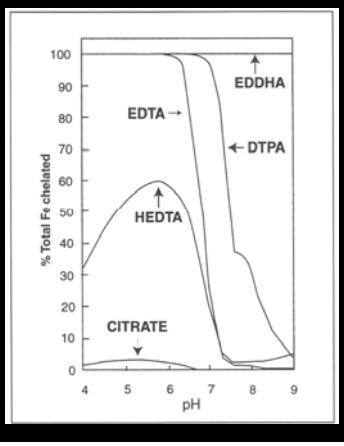
Short-term:

- 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

What is Optimal pH?

Iron-inefficient group (Petunia group)

- require a lower pH (5.4-6.0)
- Iron deficiency at high pH
  - Bacopa
  - Calibrachoa
  - Diascia
  - Nemesia
  - Pansy
  - Petunia
  - Snapdragon
  - Vinca

What is Optimal pH?

General group

- require a moderate pH (5.8-6.4)
  - Most plants
  - Chrysanthemum
  - Coleus
  - Ivy geranium
  - Poinsettia

What is Optimal pH?

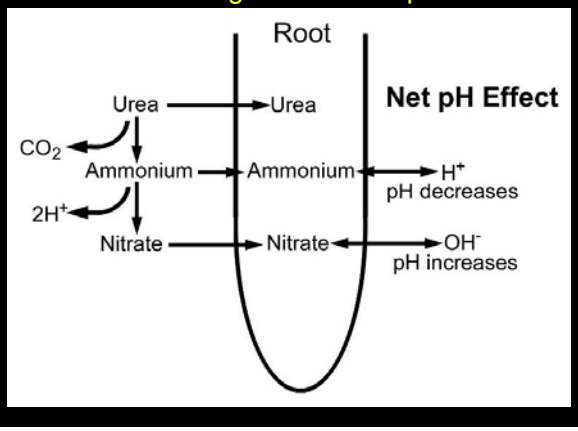
Iron-efficient group (Geranium group)

- Require a higher pH 6.0-6.6
- Iron/Manganese toxicity at low pH (bronze speckle)
  - Marigold
  - Seed/Zonal Geraniums
  - New Guinea Impatiens
  - Lisianthus

What is your favorite muffin?

A) Blueberry
B) Bran
C) Oatmeal
D) Lemon Poppyseed
E) Apple

Nitrogen Form and pH



Nitrogen and pH

- ammonium or urea based fertilized tend to acidify the root media
- nitrate based fertilized tend to increase the root media pH

Alkalinity Concentration (in ppm $CaCO_3$)	CCE (in lbs./ton)	% Acidic Nitrogen	Examples
250 – 300	>500 acidic	>50%	20-20-20 21-7-7
150 – 250	200 acidic – 450 acidic	40%	20-10-20 21-5-20
60 – 150	150 acidic – 150 basicc	20% - 30%	17-5-17 20-0-20
30 – 60	> 200 basic	<10%	13-2-13 14-0-14

[1]% acidic nitrogen is calculated as the sum of ammoniacal and urea nitrogen divided by the total nitrogen contained in the formula

Sources of Nitrogen Fertilizer

Urea (acidic)

Ammonium (acidic – decreases pH)

- Ammonium-nitrate
- Ammonium-sulfate
- Diammonium-phosphate
- Monoammonium-phosphate

Nitrate (increases pH)

- Ammonium-nitrate
- Calcium-nitrate
- Magnesium-nitrate
- Sodium-nitrate

Fertilizer Acidity/Basicity

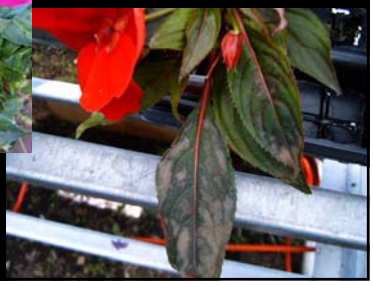
Fertilizer	Acidity	Basicity
15-5-15 Cal Mag		141
15-0-15 Dark Weather		296
20-10-20 General Purpose	392	
20-20-20 General Purpose	558	
12-7-7 Acid Special	1700	

Nitrate-based fertilizers can be used to:

A) Decrease pH
B) Increase pH
C) Maintain a neutral pH
D) Add extra Iron

Ammonium Toxicity

Symptoms:
Chlorosis/necrosis of leaf margins and between veins



Thick/leathery leaves
Death of root tips

Photos: Cari Peters

Sensitive Crops

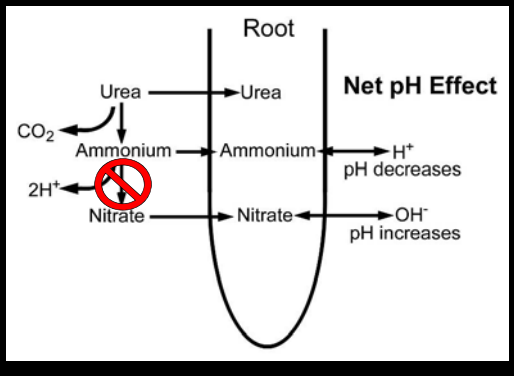
- Coleus
- Cosmos
- Geranium (*Pelargonium*)
- Salvia
- Zinnia
- Tomato
- Eggplant
- Pepper

Photo: Margery Daughtrey

Causes of Ammonium Toxicity

- High amount in fertilizer
- Use of manure/compost
- Cool/wet soils inhibits conversion of Ammonium → Nitrate
- Low pH (<5.5) inhibits conversion
- Ammonium does not readily leach

Ammonium accumulates when nitrification is inhibited



Solving Ammonium Toxicity

- Maintain Root temps ≥ 60 F
- Use ≤ 40% of Nitrogen ammonium
- Discontinue current fertilizer → switch to nitrate until conditions improve

- Ammonium does not readily leach, but…
  - Top dress gypsum - 1 tablespoon per 6" pot
  - water in with clear water
  - drench with 50 ppm calcium nitrate after 2 hrs

What is your favorite organic fertilizer?

A) Cow manure
B) Fish emulsion
C) Bat Guano
D) Bone meal
E) Worm compost

What is an organic fertilizer?

A fertilizer that is derived from animal or vegetable matter, or from naturally occurring minerals

Examples:

- *manure*
- *blood meal*
- *worm castings*
- *seaweed*
- *hydrolyzed fish*
- *rock phosphate*
- *limestone*

Comparison of 5 different fertilizer products

Conventional	Water Soluble	Peat-Lite Special ®	20-10-20
	Controlled Release	Osmocote Plus ®	15-9-12
Certified Organic	Hydrolyzed Fish +	Drammatic One ®	4-4-1
	Oilseed extract + $NaNO_3$	Daniels Pinnacle ®	3-1-1
Sustainable	Oilseed extract + inorganics	Daniels Professional ®	10-4-3

Comparison of 5 different fertilizer products

		Cost	Cost per lb Nitrogen
Conventional	Peat-Lite Special ®	$30 / 25# bag	$6.10
	Osmocote Plus ® 3-4 mo	$85 / 50# bag	$11.40
Certified Organic	Drammatic One ®	$114 / 5 gal	$68.00
	Daniels Pinnacle ®	$51 / 4.7 gal	$43.00
Sustainable	Daniels Professional ®	$34 / 5 gal	$8.10

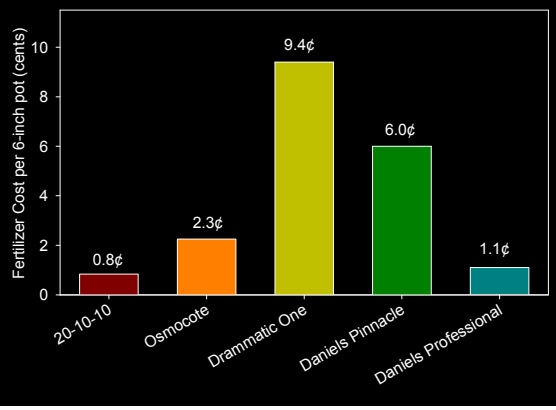
Estimated cost to produce a 6-inch crop?

Scenario Assumptions

- 6 week production period
- 1.1 gallons of water used per pot

- Crop of 'medium feeders' (ex: Petunia)
- Liquid products applied at 150 ppm Nitrogen
- Controlled release fertilizer added at medium rate (3.6 pounds per cubic yard)

¢ents to fertilize a 6-inch pot



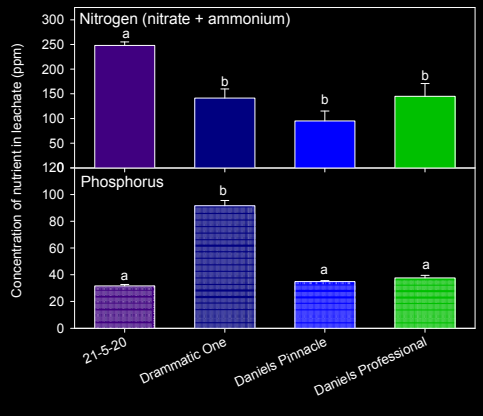
Organic/Sustainable Fertilizer Trial

Plant Material
- French Marigold, Impatiens, Pepper, Petunia, Tomato, Torenia

Fertilizers, applied at 150 ppm N
- 21-5-20 liquid feed
- Drammatic One ®
- Daniels Pinnacle ®
- Daniels Professional ®

Plugs/Liners transplanted in 4½-pots
Grown for 5 weeks

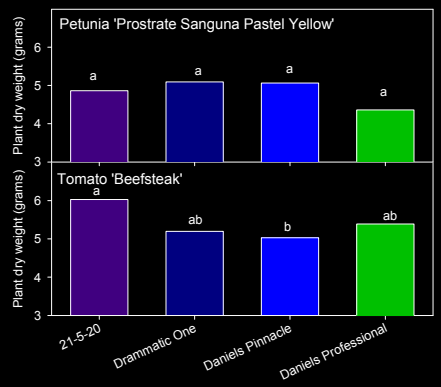
Was nutrient leaching reduced?



What did the plants look like?

21-5-20 Drammatic One Daniels Pinnacle Daniels Professional

Plant dry weight



Who's scared of blue punch?

A) Yes
B) No
C) Anything with sugar is okay with me

Nutrient Management Case Studies

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Outline

- Vocabulary
- Causes of disorders
- Steps to follow for diagnosing a disorder
- Diagnosis fun

This is an example of?

A) Iron Deficiency
B) Calcium Deficiency
C) Leaf distortion from thrips
D) Ammonium toxicity

Vocabulary

- Chlorosis: leaf yellowing
- Necrosis: tan/brown/blackened cells (tissue death)
- Marginal: edge of a leaf
- Interveinal: between the veins
- Leaf distortion: incomplete or abnormal expansion during leaf unfurling

Vocabulary

- Concentric rings: similar to tree rings, growth of a ring outside an old ring
- Mottled: scattered spots of different colors
- Epinasty: leaves stem curl downward even though fully turgid
- Leaf curling – upward or downward?
- Water soaked spots: cells appear damaged/soft and full of water

How would you describe this symptom?

A) Mottling of leaf
B) Whole leaf chlorosis
C) Interveinal chlorosis
D) Concentric rings

Causes of disorders

Environmental causes
- – Too much/little light
- – High/low temperature
- – Too much/little water
- – High humidity lack of air flow
- – Poor substrate aeration

Causes of disorders

Fertility Problems
- Deficiencies
- Toxicities
- pH
- High soluble salts

Photo courtesy of Peter Davies, Cornell University

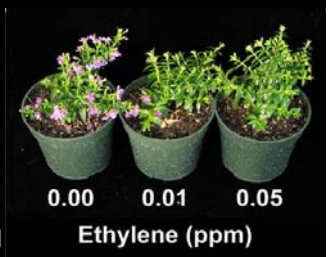
Causes of disorders

Pests and Diseases
- Viruses
- Insects
- Bacteria
- Mites
- Fungus
- Water molds
- Nematodes
- Etc.

Causes of disorders

Air pollutants
- Ozone
- Ethylene
- Ammonia

Symptoms of Ethylene:
- Top growth deformed
- Epinasty (leaves bending downward)
- Flower bud abortion
- Leaf chlorosis



Causes of disorders

Phytotoxicity from chemical applications

Often uniform symptoms develop a few days after application

- Pesticides
- Foliar Iron Chelate
- Growth Regulators

Cycocel damage on Begonia

Causes of disorders

Herbicide Injury
- Volatilization
- Drift onto crop
- Persistence in soil
- Pots or potting mix in contact with herbicide

Drift of 2,4-D

Problem Solving Steps

1) Describe the problem
   - Which species/cultivars are affected
   - Use your new vocabulary terms (chlorosis, distortion etc.)
   - Which part of the plant is affected (roots, old leaves, new leaves). LOOK AT ROOTS!
   - Examine upper and lower leaf surface

After Gibson et al., Nutrient deficiencies in bedding plants

Problem Solving Steps

2) Look for Patterns
   - How many plants are affected
   - Are all plants affected in the same way
   - Is damage occurring in a particular spot in the greenhouse (near cooling pads, by heating vents)
   - Is damage occurring across the whole greenhouses?
   - Did symptoms develop overnight; or over time?
   - Did the crop have a new batch of potting mix; new fertilizer?

After Gibson et al., Nutrient deficiencies in bedding plants

Problem Solving Steps

3) Compile Crop History
   - Fertilizer regime
   - Watering schedule
   - Any obvious insect or diseases?
   - Pesticides? Which ones, when applied?
   - Surfactants
   - Herbicides
   - Chemicals applied to neighboring crops

After Gibson et al., Nutrient deficiencies in bedding plants

Problem Solving Steps

3) Compile Crop History
   - Environmental conditions in the greenhouse
   - Extreme weather patterns
   - Air pollutants, such as ozone
   - Are heaters malfunctioning

After Gibson et al., Nutrient deficiencies in bedding plants

Problem Solving Steps

4) Collect Data

Take samples for in-house or lab testing
   - Substrate pH/EC
   - Water analysis
   - Substrate nutrient analysis
   - Tissue analysis
   - Lab disease/virus testing

After Gibson et al., Nutrient deficiencies in bedding plants

Problem Solving Steps

5) Determine the cause and take action
   - Form a best guess as to the cause of the problem
   - Don't be afraid to use Cornell Resources (Entomologist, Pathologist, Nutrition)
   - Sometimes a lab test is required to verify

Take action to correct the problem

Was the problem solved?

What will you do next time to prevent the problem?

After Gibson et al., Nutrient deficiencies in bedding plants

Save your information!

- Put together a file with
  - Problem description
  - Crop history
  - Photos
  - Tests results
  - Corrective actions and if they worked

  This will help in case the problem occurs again

What question would you like answered?

A) What is the substrate pH?
B) Was there iron chelate in the fertilizer?
C) Any creepy/crawlies under magnification?
D) Is this a heavy calcium crop?
E) How much ammonium was in the fertilizer?

What question would you like answered part 2?

A) What is the substrate pH?
B) Was there iron chelate in the fertilizer?
C) Any creepy/crawlies under magnification?
D) Is this a heavy calcium crop?
E) How much ammonium was in the fertilizer?

What is the problem?

A) Thrips damage
B) Ammonium toxicity
C) Virus
D) Calcium deficiency
E) High salts

Thrips damage

Petunia problem

What question would you like me to answer?

A) What is the substrate pH?

B) What is the EC of fertilizer water?

C) What is the type of Nitrogen in the fertilizer?

D) Is there calcium in the fertilizer?

E) Are plants affected in the whole greenhouse?

What question would you like me to answer Part B?

A) What is the substrate pH?

B) What is the EC of fertilizer water?

C) What is the type of Nitrogen in the fertilizer?

D) Is there calcium in the fertilizer?

E) Are plants affected in the whole greenhouse?

Petunia problem

What is the problem?

A) Fertilizer injector not working

B) Iron deficiency

C) Potassium (K) deficiency

D) Nitrogen (N) deficiency

E) Root diseases

K and N deficiency caused by injector not working

More petunia problems…

What question would you like me to answer?

A) Fertilizer Regime
B) Water Regime
C) Salt levels in irrigation water
D) What does the root system look like?

What is the problem?

A) High salts
B) Calcium deficiency
C) Lack of water
D) Too much water
E) Lack of Iron

Lack of Water!!!

What question would you like me to answer?

A) What is the substrate pH?
B) What is the EC of fertilizer water?
C) Are there any creepy/ crawlies under the microscope
D) Is there Iron Chelate in the fertilizer?
E) What is the EC level?

What question would you like me to answer Part B?

A) What is the substrate pH?
B) What is the EC of fertilizer water?
C) Are there any creepy/ crawlies under the microscope
D) Is there Iron Chelate in the fertilizer?
E) What is the EC level?

What is the problem?

A) Overwatering
B) Insect – Spider Mites
C) Lack of Calcium
D) High salts
E) Virus

Two spotted Spider mites

Cineraria and Primula Problems

Which question would you like me to answer?

A) What type of nitrogen is being used?

B) Is there calcium in the fertilizer?

C) Substrate pH?

D) Root system – okay or unhealthy?

E) What is the greenhouse temperature?

Which question would you like me to answer Part B?

A) What type of nitrogen is being used?

B) Is there calcium in the fertilizer?

C) Substrate pH?

D) Root system – okay or unhealthy?

E) What is the greenhouse temperature?

Questions?

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