Fertilizer and substrate management for container crops

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Outline

- Supplying and managing nutrients in container substrates
- Controlling pH and correcting pH problems
- Updates on new substrates and management practices

How much of the crop is made of nutrients?

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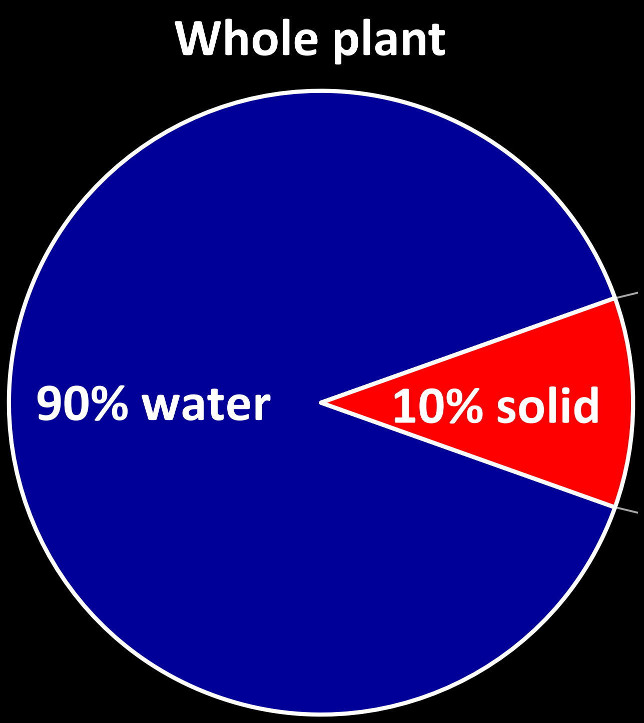
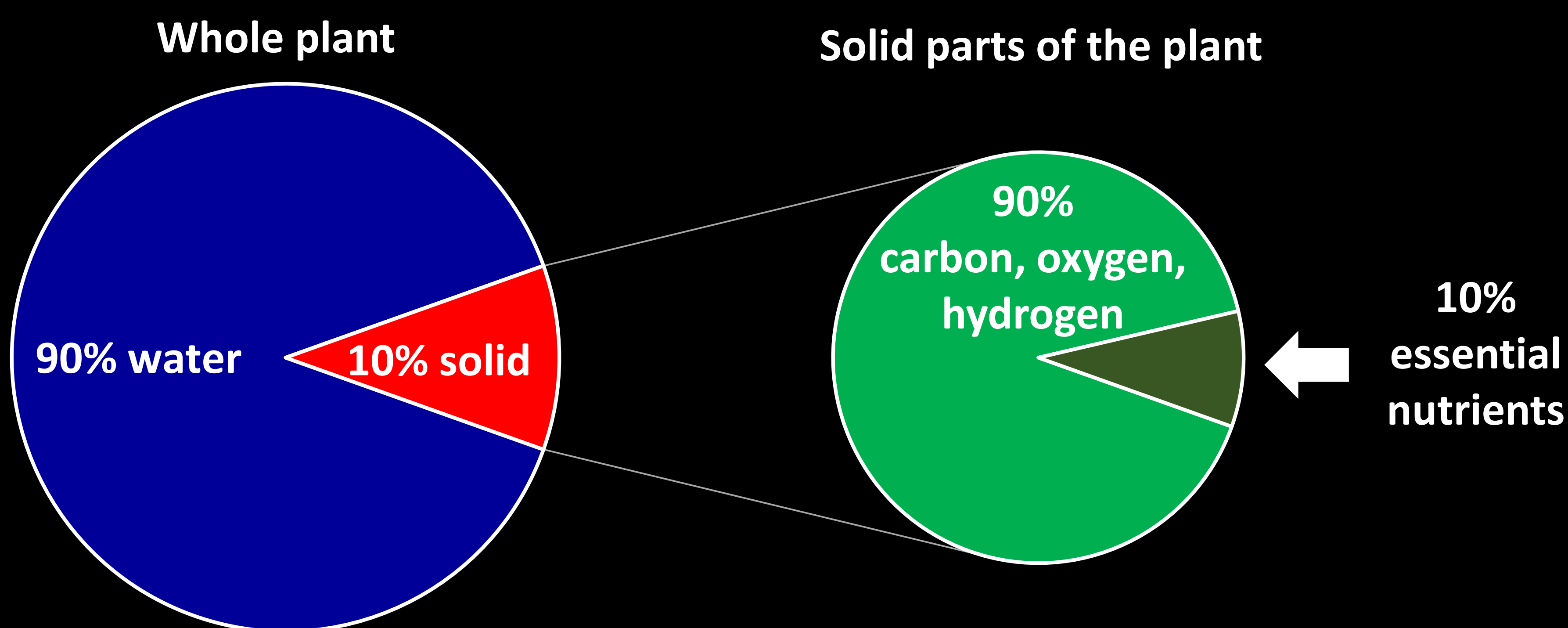
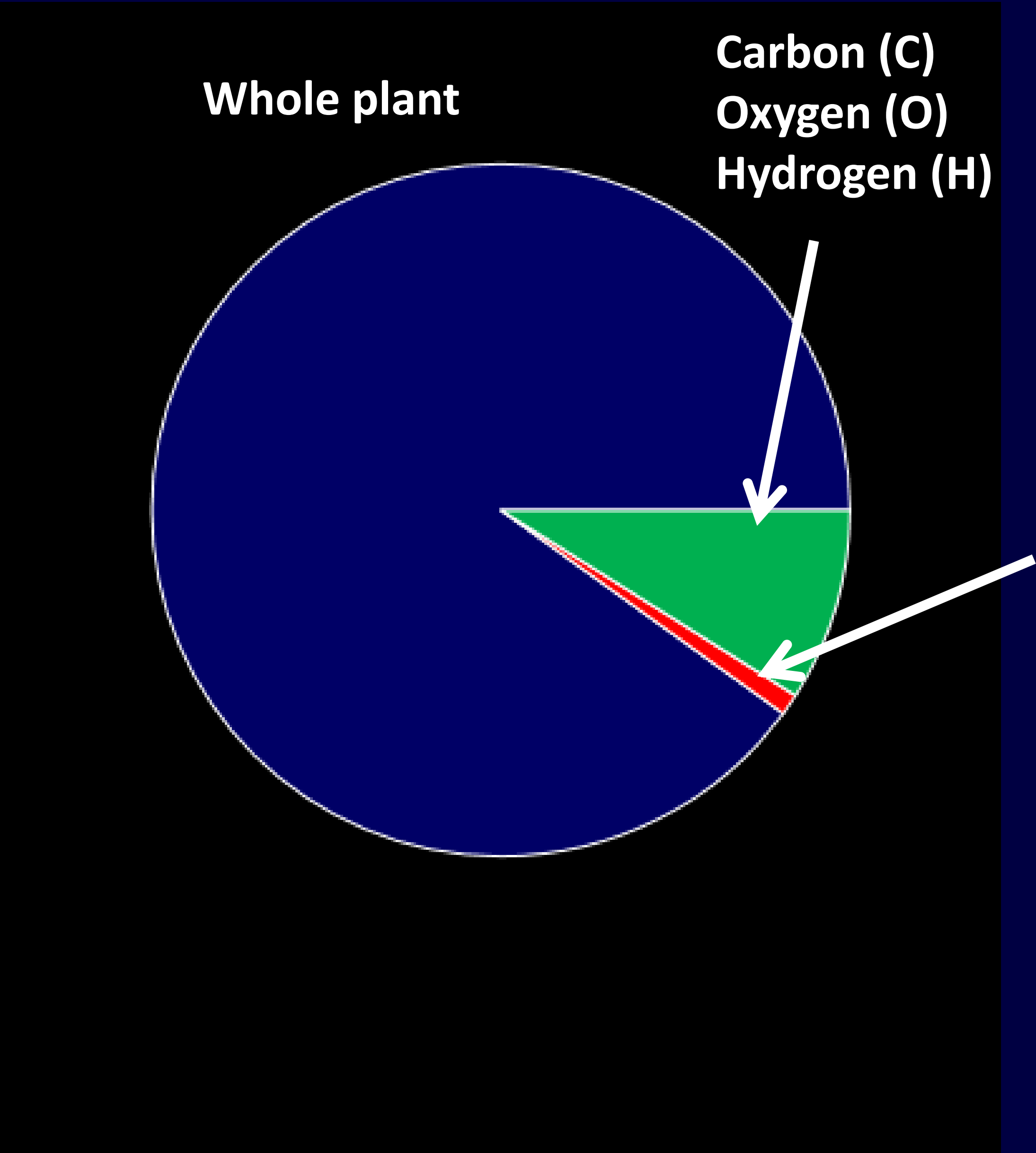


How much of the crop is made of nutrients?

Fertilizer nutrients = approx. 1% of the plant





Fertilizer nutrients

Nitrogen	(N)
Phosphorus	(P)
Potassium	(K)
Calcium	(Ca)
Magnesium	(Mg)
Sulfur	(S)
Iron	(Fe)
Manganese	(Mn)
Copper	(Cu)
Zinc	(Zn)
Boron	(B)
Molybdenum	(Mo)

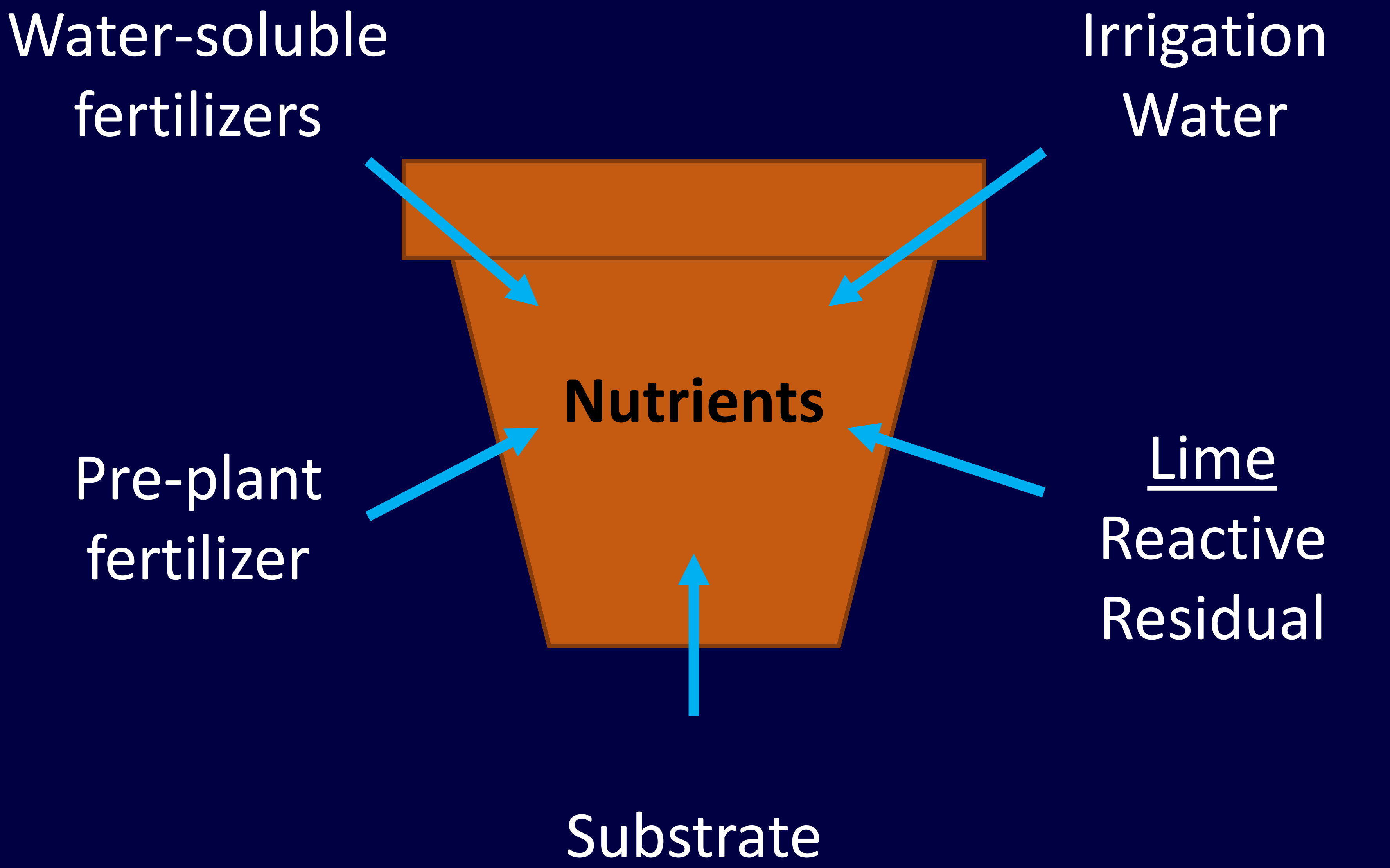
Not generally considered essential nutrients

Sodium	(Na)
Chloride	(Cl)
Silicon	(Si)
Nickel	(Ni)

Typical leaf nutrient concentrations (% of leaf dry weight)

Fertilizer nutrients		Nutrient %	
Nitrogen	(N)	4.0%	**Macronutrients**
Phosphorus	(P)	0.5%	
Potassium	(K)	4.0%	
Calcium	(Ca)	1.0%	
Magnesium	(Mg)	0.5%	
Sulfur	(S)	0.5%	
Iron	(Fe)	0.0200%	**Micronutrients**
Manganese	(Mn)	0.0200%	
Copper	(Cu)	0.0010%	
Zinc	(Zn)	0.0030%	
Boron	(B)	0.0060%	
Molybdenum	(Mo)	0.0001%	

Nutrients come from multiple places



ppm versus %

1 ppm (part per million)

= 1/1,000,000

= liquids: 1 mg/L (milligrams/liter) = 1 g/m^3

= solids: 1 mg/kg (milligrams/kilogram)

1% (per cent)

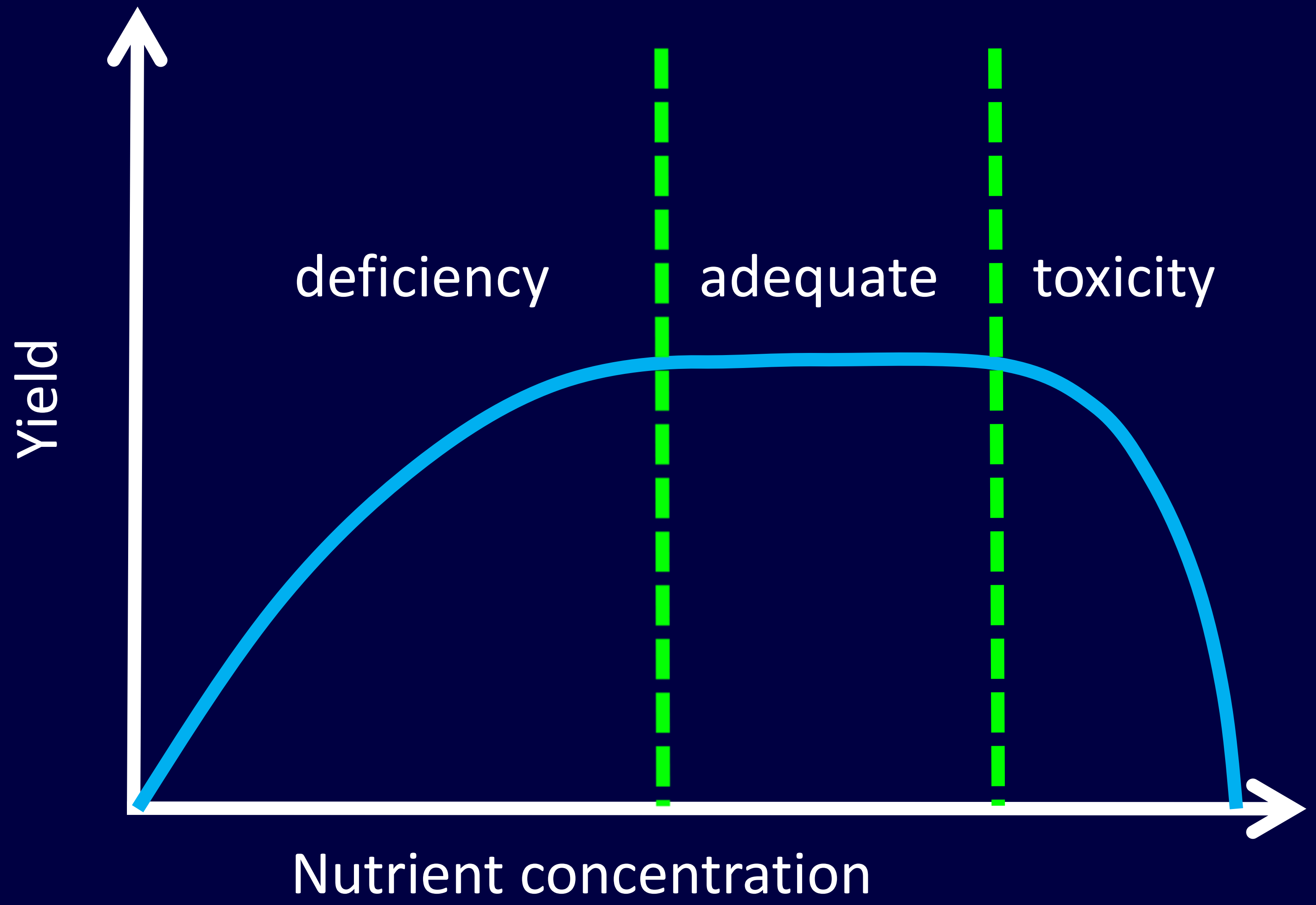
= 1/100

= 10,000 ppm

Examples of greenhouse water results from lab

Greenhouse	Well #1	Well #2	Target ranges	
			Min	Max
pH	7.6	7.1	5.0	7.0
Alkalinity (ppm $CaCO_3$)	35	242	40	120
EC (mS/cm)	0.11	1.0	0.0	1.0
NO3-N (ppm)	0.9	0.0	0	10
P (ppm)	<0.1	0.3	0	20
K (ppm)	2	17	0	150
Ca (ppm)	4.1	167	0	150
Mg (ppm)	2.3	8	0	75
SO4-S (ppm)	11	180	0	120
Fe (ppm)	<0.1	0.0	0.00	2.0
B (ppm)	0.001	0.1	0.05	5.0
Na (ppm)	15	28	0	100
Cl (ppm)	5.7	57	0	70

Effect of nutrient supply on plant growth



Nutrient deficiencies and toxicities

- Deficiency or a toxicity results from too little or too much nutrient for healthy growth

- Deficiencies can occur from:
  - Low fertilizer
  - Excessive leaching
  - Poor root health

- Toxicities can occur from:
  - Essential elements
  - Other contaminants (e.g. Al, Na, pesticides)

Nutrient deficiencies and toxicities

- Symptoms can vary:
  - Mobility of the nutrient in the plant
  - How nutrient is used in plant metabolism and growth

See http://www.ces.ncsu.edu/depts/hort/floriculture/def/ for deficiency symptoms of floriculture crops from NC State University

Online extension services www.e-GRO.com

We measure nutrients as total salt concentration

- Electrical conductivity (EC) in mS/cm, or Total Dissolved Solids (TDS) in ppm

- 1 mS/cm = 1 dS/m = 100 mS/m
  = 1 mmho/cm = 1000 microS/cm

- 1 mS/cm of EC = approx. 700 ppm TDS
  (but this varies between meters)

In greenhouse production, we mainly use EC units

- You need an EC meter to measure
  - EC of irrigation water (is the salt/contaminant level changing?)
  - EC of the substrate (are nutrients deficient or salts too high?)
  - EC of fertilizer solution (is the injector calibrated, are you supplying the right amount of water-soluble nutrients?)

Interpreting EC in the substrate

- You can test substrate-EC using a plug squeeze, saturated paste, 1 soil: 1.5 or 2 water, or pour-through method

- Target substrate-EC depends on the test, because each test differs in how much the sample is diluted

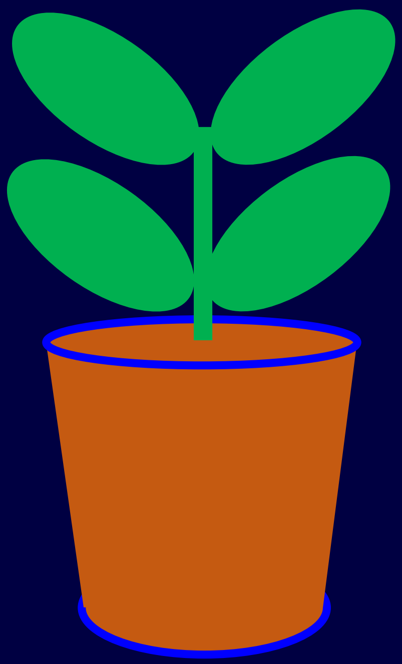
- With a pour-through (on-site test), a typical range is
  - 1.0 to 2.5 mS/cm for young plants

- With a saturated paste extract (on-site or lab test), a typical range is
  - 0.75 to 1.9 mS/cm for young plants

Balance nutrient level (EC) in the pot

Add nutrients

- Irrigation water
- Water-soluble fertilizer
- Top-dress fertilizer



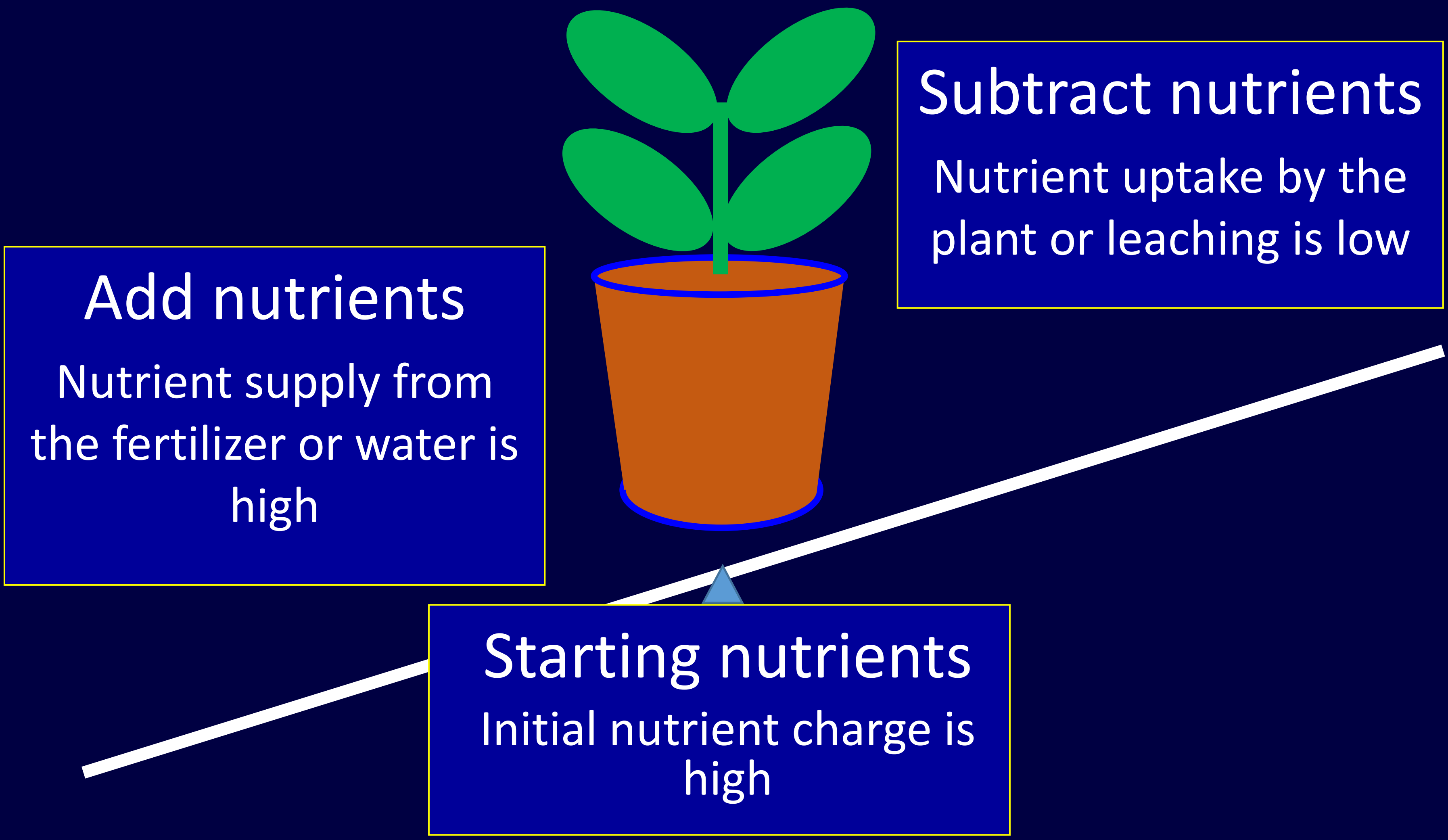
Subtract nutrients

- Uptake by plant
- Salt layer at top of medium
- Leaching

Starting nutrients

- Media components
- Pre-plant charge

High EC can happen in two ways…



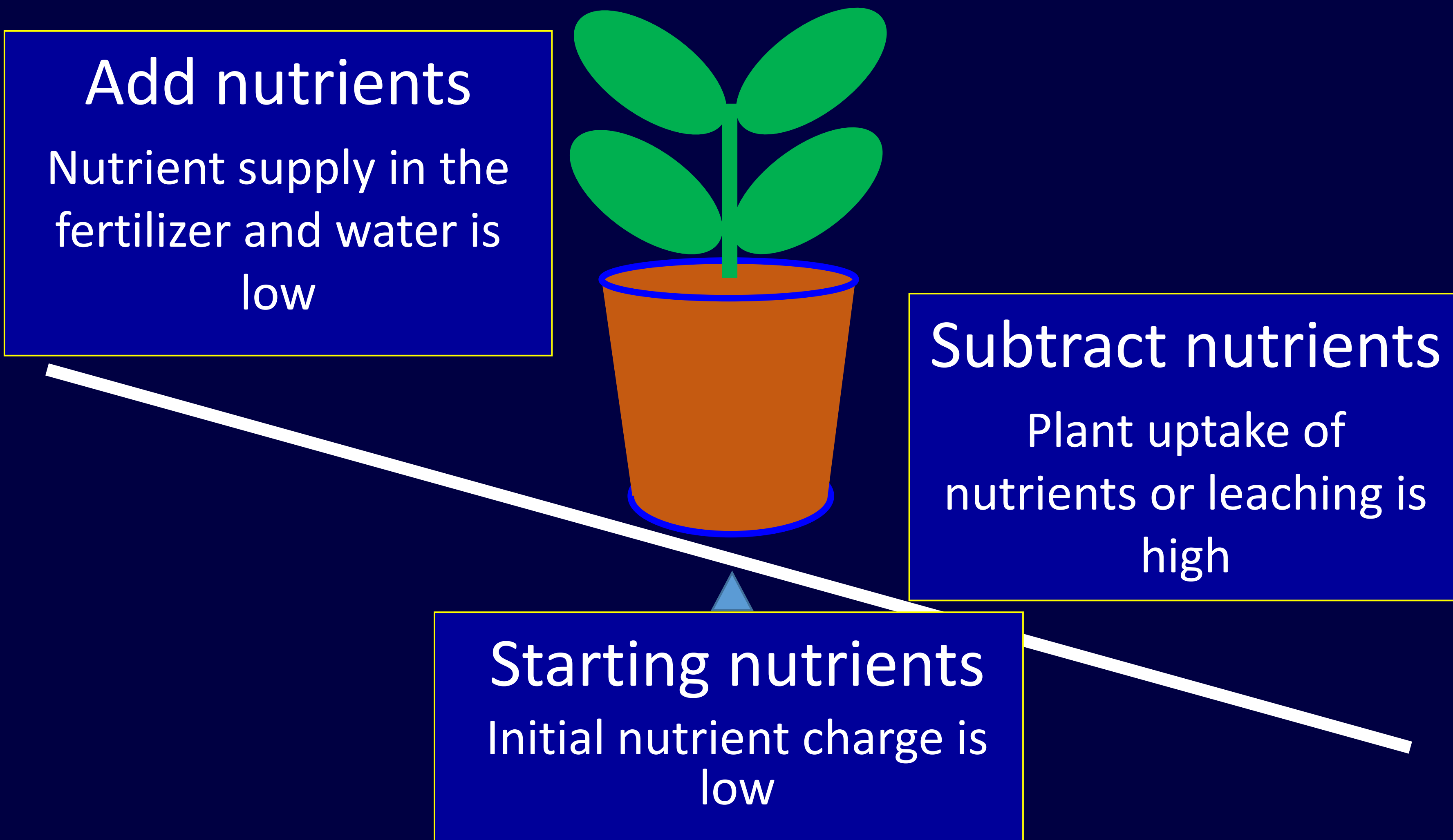
High EC can result in root rot

High EC can result in hard crispy or leathery leaves, stunting, chlorosis or necrosis

Leathery leaves, chlorosis and necrosis of older leaves

Aborted tips, uneven germination in impatiens plugs

Low EC can happen in two ways…



Low EC chlorosis and stunting

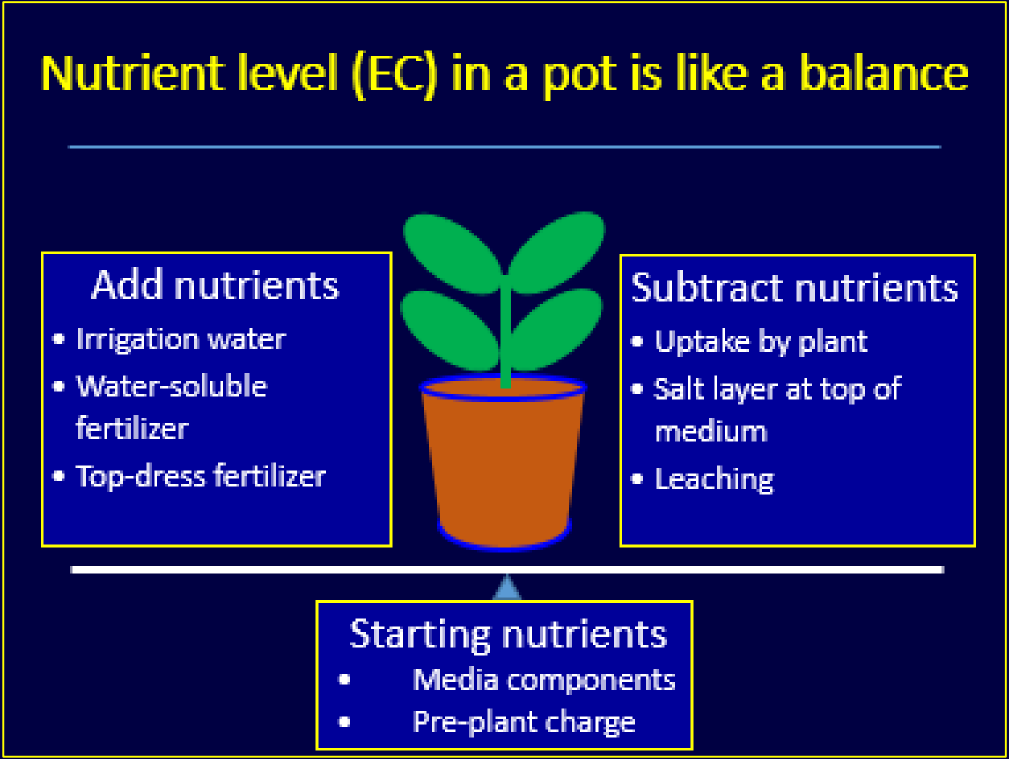
25 ppm N 150 ppm N

Interpreting EC: irrigation method

How may substrate-EC change if you switch from overhead sprinkler irrigation to…

a) Sub-irrigation (ebb and flow, flood floor)

b) Drip irrigation

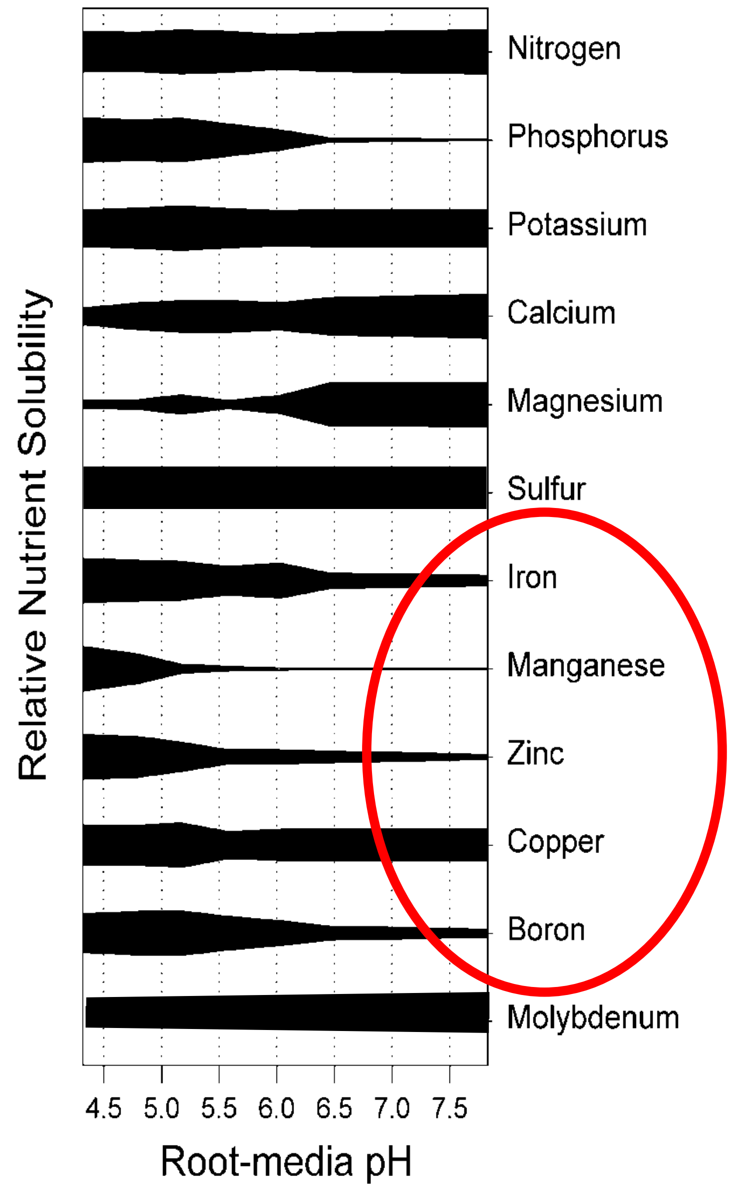


Take home message

- Provide all the essential nutrients in a moderate amount
- Use electrical conductivity or total dissolved solids as an on-site test
- Use complete nutrient analysis at a lab when problems arise

pH of the growing media ("substrate-pH") affects…

- Nutrient solubility
- Uptake by roots
- Plant health
  - Too much = toxicity
  - Too little = deficiency



J. Peterson

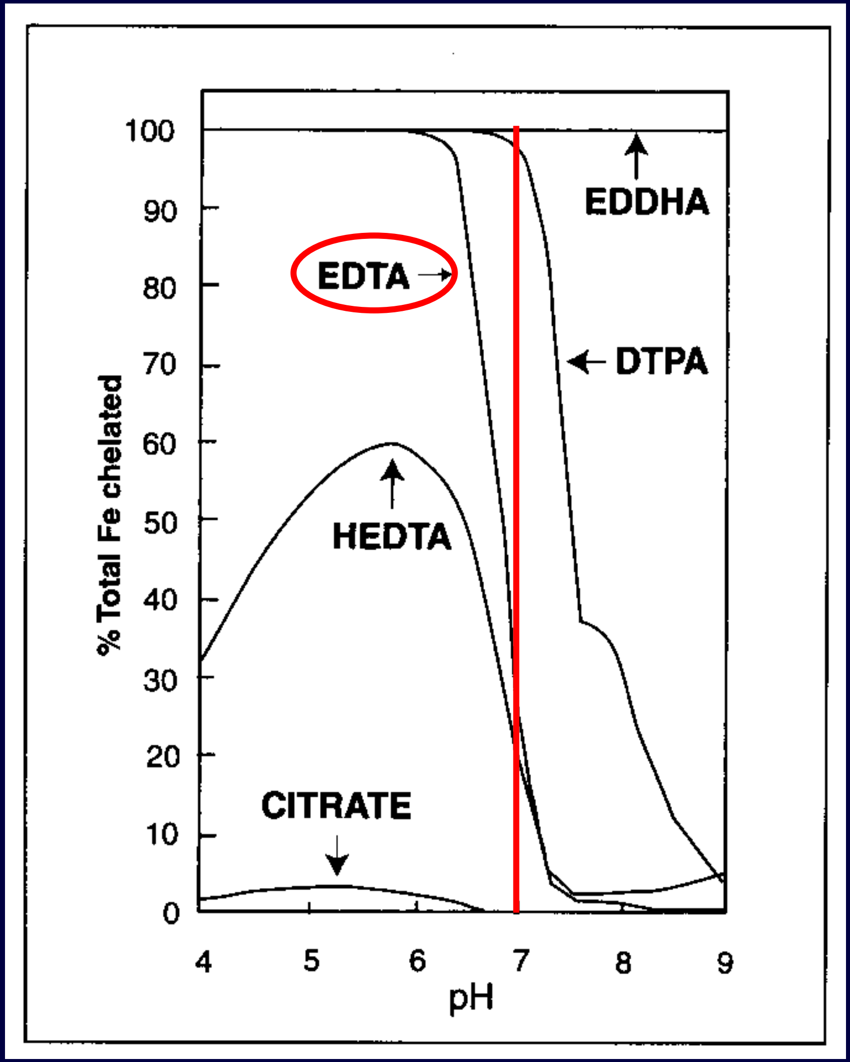
Effects of pH on iron solubility

pH 4
Highly soluble
Fe^{3+}, Fe^{2+}

pH 7
Highly insoluble
$Fe(OH)_3$

Iron solubility

- Synthetic chelates
- $FeSO_4$ and Fe-EDTA used on a continual basis
- Fe-DTPA and Fe-EDDHA used to correct iron deficiency



Norvell, 1991

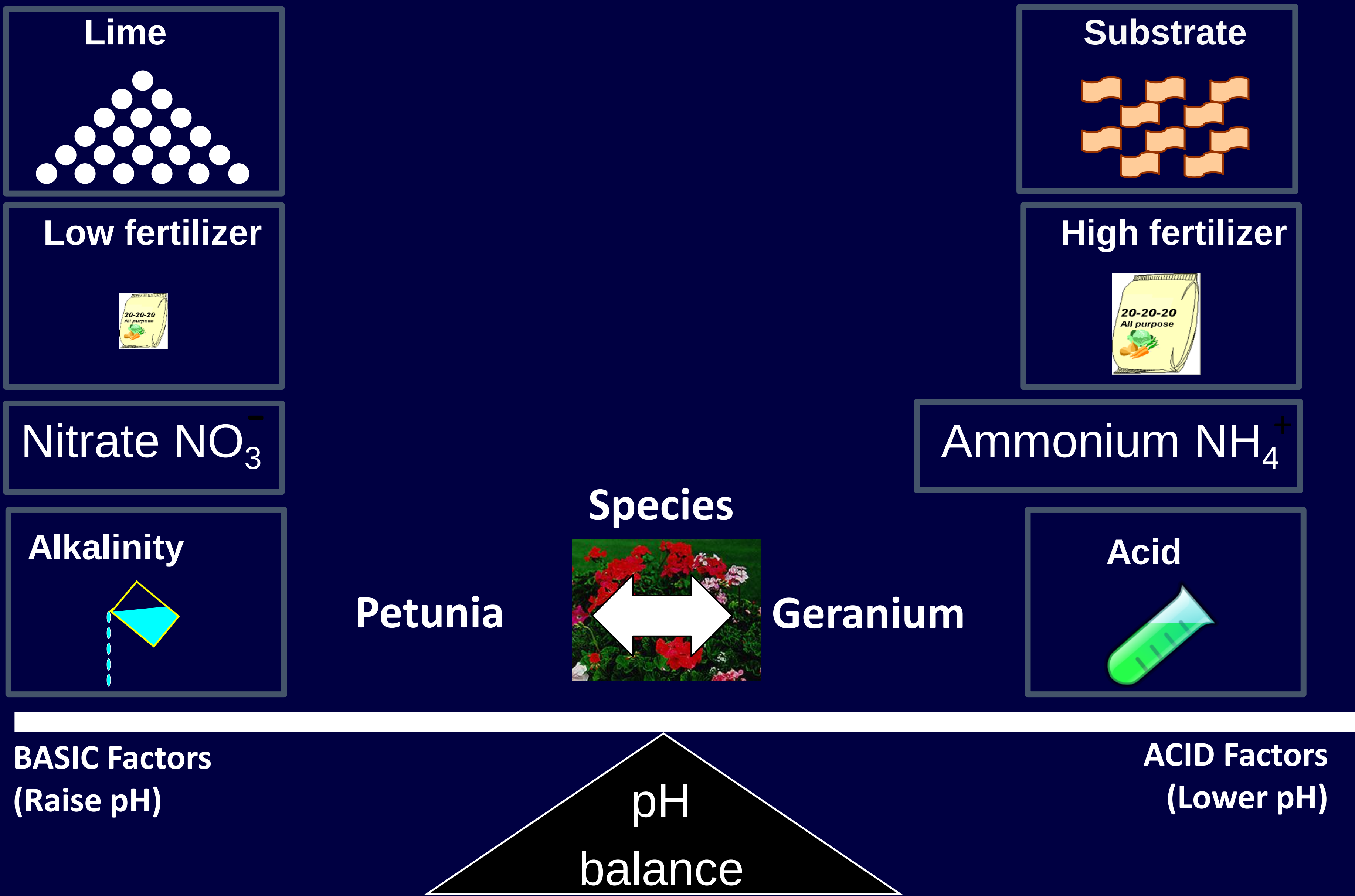
Iron/manganese deficiency at high pH

- Chlorosis in young leaves, often interveinal
- Low mobility in the plant
- Occurs at pH > 6.4 for sensitive species (petunia, calibrachoa)
- Common problem, especially with low EC

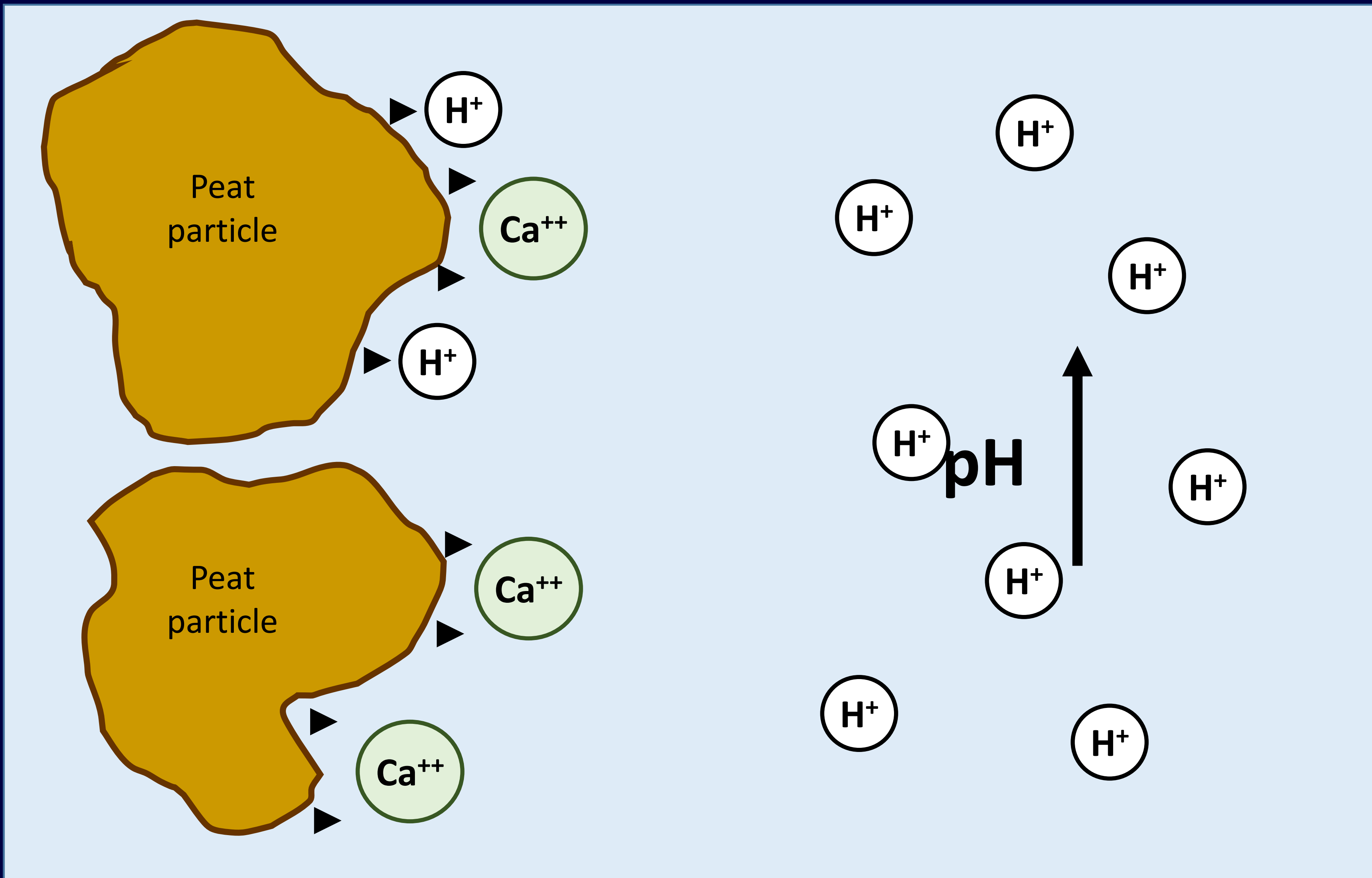
Iron/manganese toxicity at low pH

- Micronutrients accumulate in older tissue
- Necrosis, “bronze specking”
- Less common, occurs in iron-efficient crops

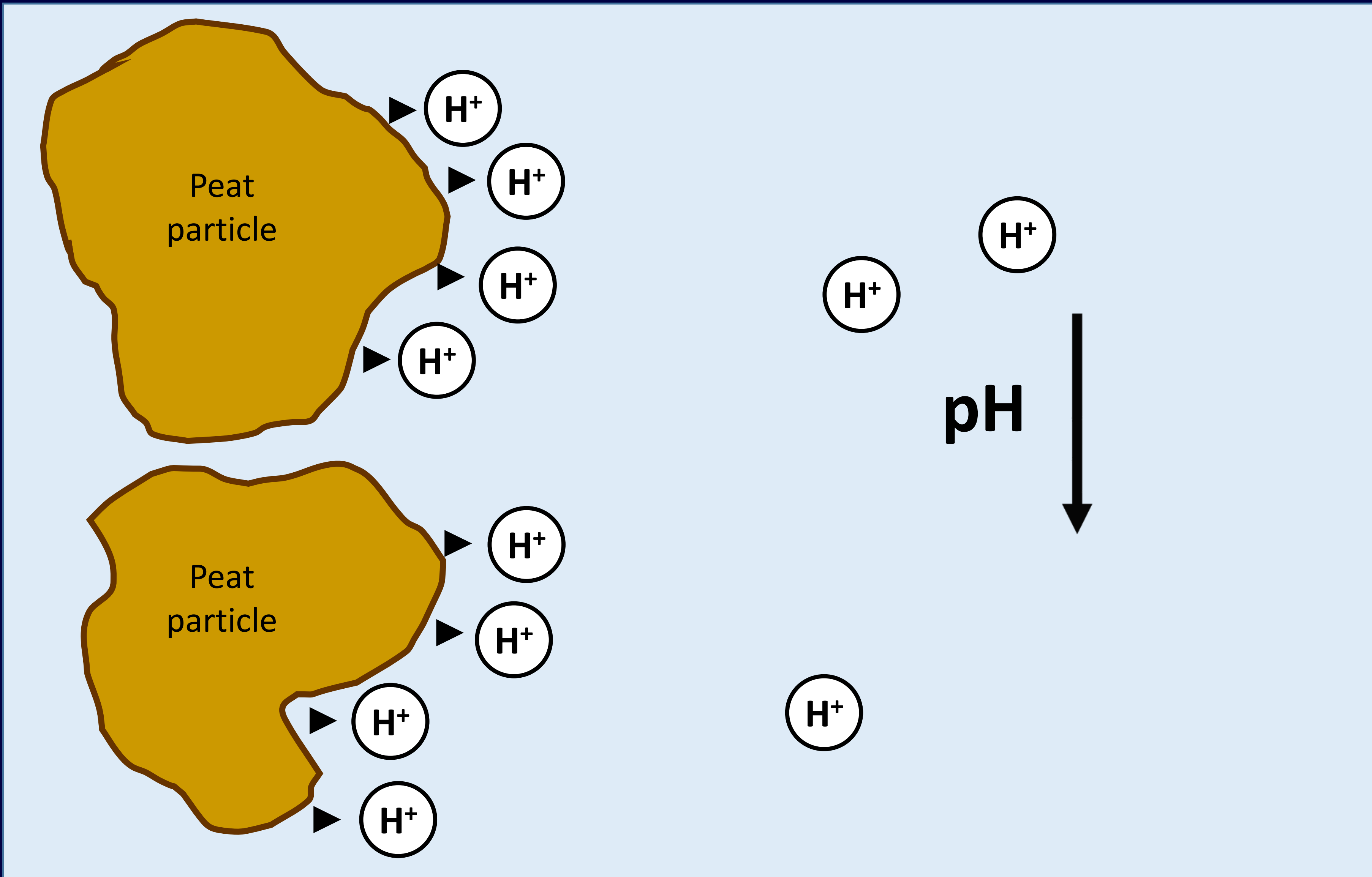
Many factors affect substrate-pH



Leaching with clear water washes away salts and raises pH



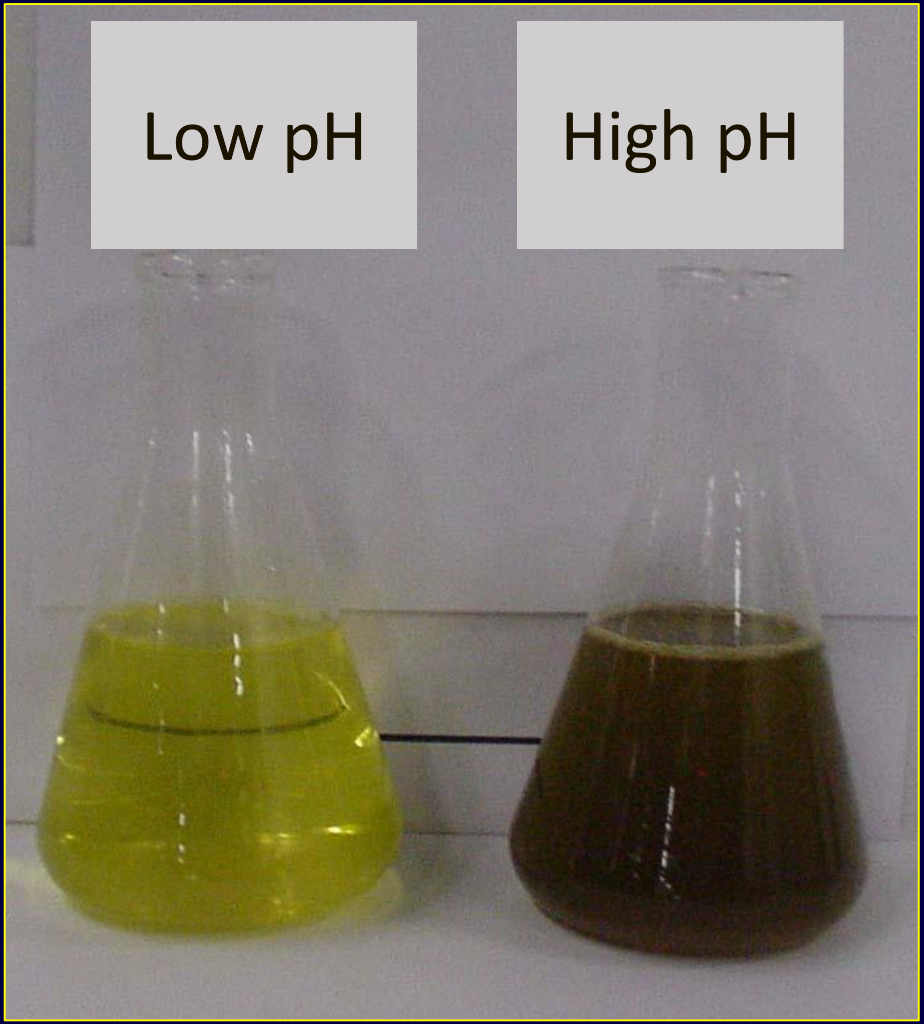
Adding fertilizer will lower pH, especially calcium (Ca^{++})



EC effects: Low salts raise substrate-pH

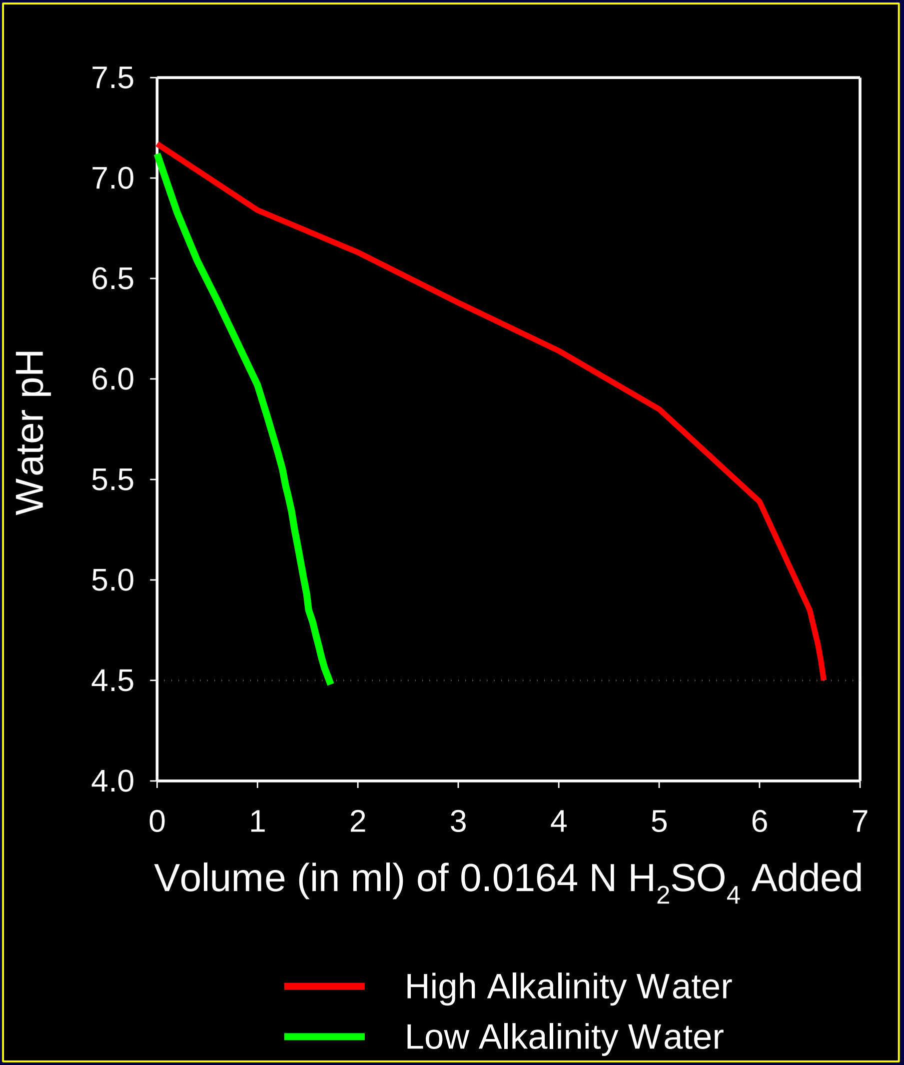
Water quality: Solution-pH

- Can be measured with a pH meter
  - Neutral = 7
  - Acid < 7
  - Basic > 7
- Affects solubility of nutrients in the fertilizer solution
- Has little effect on substrate-pH



Water quality: Alkalinity effects on substrate-pH

- Bicarbonates/carbonates
  - HCO_3^- and CO_3^{2-}
- Alkalinity is NOT measured with a pH meter
- Like applying limestone at each irrigation
  - Increases substrate-pH



Different alkalinity units

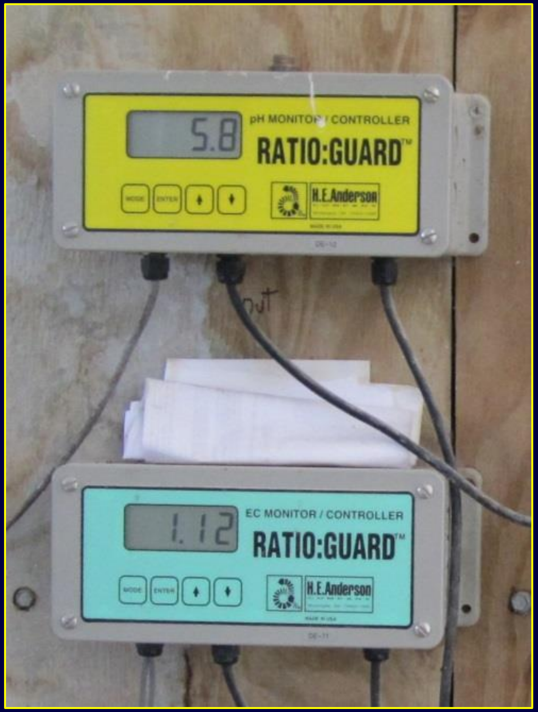
Milli-Equivalents alkalinity (mEq/L)	ppm alkalinity ($CaCO_3$ or CCE)	ppm bicarbonate (HCO_3^-)
1	50	61
2	100	122
3	150	183
4	200	244
5	250	305

How much acid to control alkalinity?

- Online AlkCalc from the University of New Hampshire

- Sulfuric (adds S)
- Phosphoric (adds P)
- Nitric (adds N)

- Acidify to water pH of ~ 6, or 2 mEq/L of alkalinity



N forms help determine pH effect

20-10-20

Guaranteed Analysis

FOR CONTINUOUS LIQUID FEEDING PROGRAMS

Total Nitrogen (N) 20%
- 8.0% Ammoniacal Nitrogen
- 12.0% Nitrate Nitrogen

Available Phosphate (P_2O_5) 10%

Soluble Potash (K_2O) 20%

Boron (B) 0.025%

Copper (Cu) 0.025%

Iron (Fe) 0.100%

Manganese (Mn) 0.050%

Molybdenum (Mo) 0.010%

Zinc (Zn) 0.050%

Derived from: ammonium nitrate, ammonium phosphate, boric acid, copper EDTA, iron EDTA, manganese EDTA, potassium nitrate, sodium molybdate, and zinc EDTA.

Potential acidity:* *425 lbs. Calcium Carbonate Equivalent per Ton

EC Chart (in mS/cm)

ppm N	50 ppm N	100 ppm N	200 ppm N	300 ppm N	400 ppm N
EC	0.32	0.64	1.28	1.92	2.56

$$\frac{8\%\ \text{ammonium-N}}{20\%\ \text{total-N}} = 40\%\ \text{ammonium-N}$$

$$\frac{12\%\ \text{nitrate-N}}{20\%\ \text{total-N}} = 60\%\ \text{nitrate-N}$$

Total Nitrogen (N) 20%
- 8.0% Ammoniacal Nitrogen
- 12.0% Nitrate Nitrogen

What is the “pH personality” of your crops?

	Sensitive to low pH (iron toxicity)	Tolerant of wider pH range (iron intermediate)	Sensitive to high pH (iron deficiency)
Tend to lower pH	Geranium	Coleus	
Intermediate pH effect	Marigold New Guinea Imp. Verbena	Dusty Miller Impatiens Salvia	Snapdragon
Tend to raise pH	Lisianthus Pentas		Petunia Pansy Vinca Zinnia

Correcting low and high pH problems

- First check substrate-pH and EC and root health
- Trial on a small number of plants before treating the whole crop

Options to correct high substrate-pH

1. Make sure substrate-EC is not low. Sometimes high pH occurs because the substrate is leached out. If EC is low, add fertilizer.

2. Ammonium fertilizer and low water alkalinity. Lower pH over 1-2 weeks. Have ammonium nitrate or ammonium sulfate on hand.

3. Correct micronutrient deficiencies. Mask symptoms with an iron drench at 20 ppm iron. Have iron-EDDHA (Sprint 138 or similar) on hand.

4. In extreme cases, consider acid drenches. Ferrous iron sulfate drenches at 120 g/100 L rapidly reduce pH, but foliar phytotoxicity is likely.

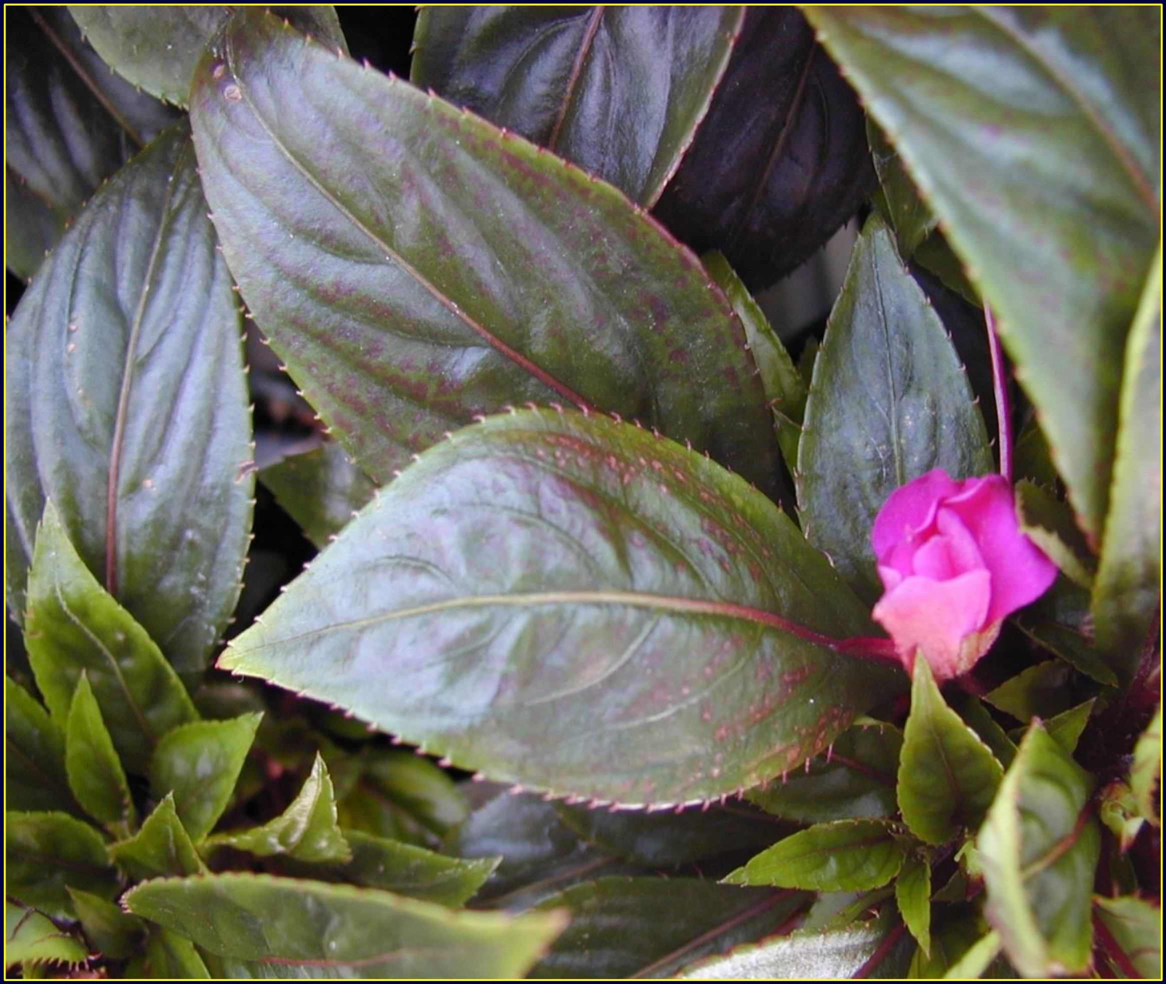
Tips on drenching with iron chelates

- 33 grams/100 Liters
  - Iron-EDDHA 20 ppm iron (best)
  - Iron-DTPA 37 ppm iron (OK)

- Apply with generous leaching. Immediately wash foliage.

- Do not apply to iron-efficient plants.

Phytotoxicity from iron drenching



- Drenched with 40ppm of Fe-EDDHA
- Brown speckling and necrosis, usually older leaves

Options to correct low substrate-pH

1. Flowable lime: Effective, messy to apply, may not be available in your area. Has residual activity

2. Potassium bicarbonate or carbonate: Effective, repeat applications often required, can raise EC

3. Nitrate-based fertilizer: Longer-term, helps prevent low-pH problems, not suitable for rapid increase in pH. Most effective in combination with alkaline irrigation water.

4. Hydrated lime in solution or top-dress: Can be inconsistent. Easy to source and low cost.

Tips for drenching potassium bicarbonate

- Delivered through emitters or ebb and flood.
- Apply in cool weather, immediately rinse foliage.
- One day after application, apply a basic fertilizer (high nitrate) with moderate leaching to wash out salts and to reestablish nutrient balance.

Leaf distortion from potassium bicarbonate residue

Nutrient management for container crops

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