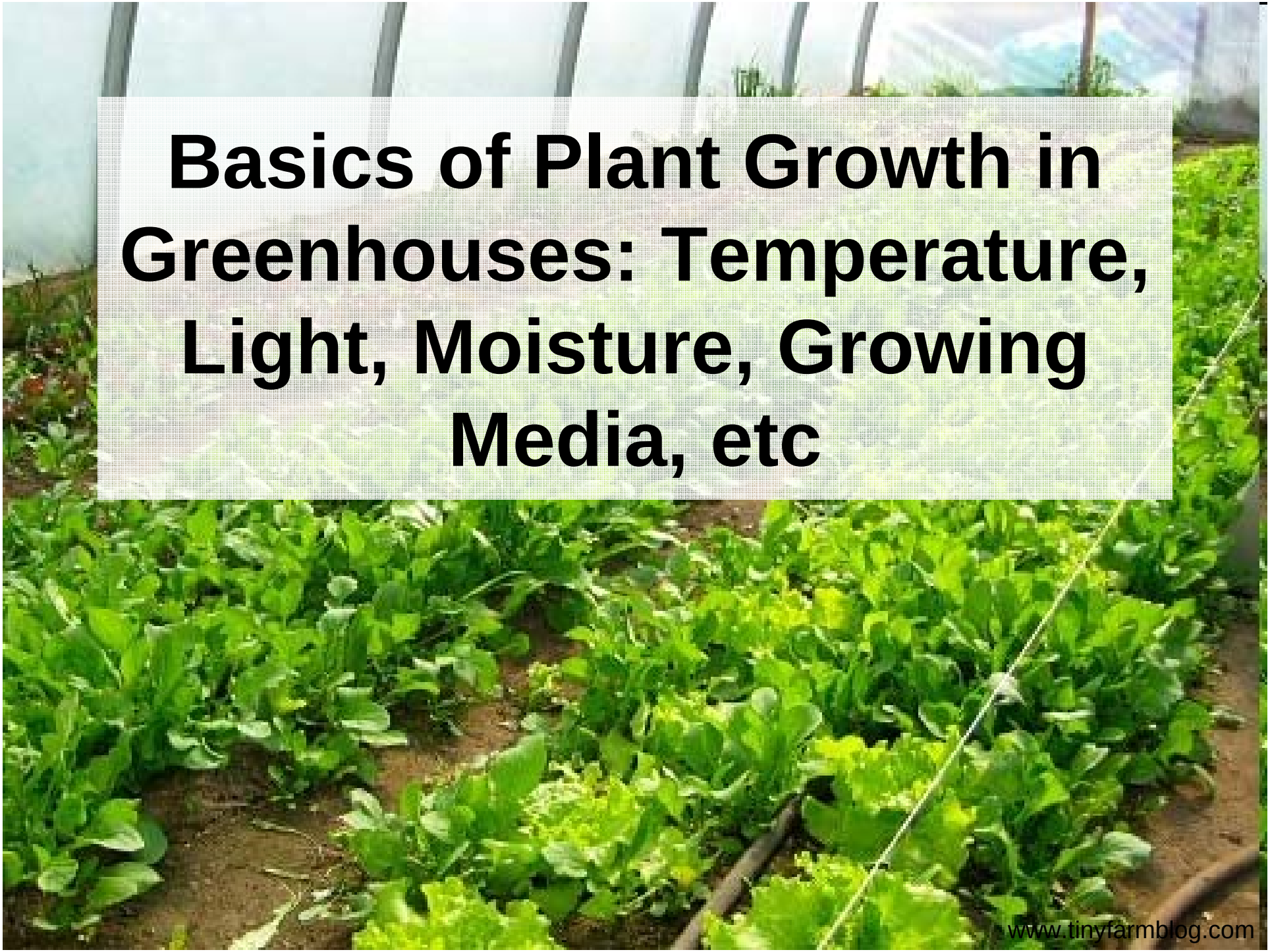
Basics of Plant Growth in Greenhouses: Temperature, Light, Moisture, Growing Media, etc



The law of limiting factors

- “Too much or too little of any one factor can limit the growth of a plant even if all other factors are at or near the optimum level required by that plant”

Environmental Factors

- Light
- Temperature
- Gases

What do plants need?

- Light
  - Plants need light to grow
  - Photosynthesis
    - The conversion of light (+ carbon dioxide and water) into energy (sugar)

$+ \ 6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

Measuring Light

- Most CO greenhouses will receive sufficient light for veggie crops
- If growing flowers or bedding crops:
  - Supplemental lights may be needed
- Handheld light meters are available

The effects of too little light

- Slow growth
- Spindly, slender growth and elongation of stems
- Yellowing
- Growth is softer, succulent, sometimes larger leaves
- Plants bend drastically toward light source

Too little light

- Possible solutions
  - Provide artificial lighting
  - Plan for optimum greenhouse location

The effects of too much light

- Slow growth
- Leaf burn
- Light green color
- Small and thick leaves

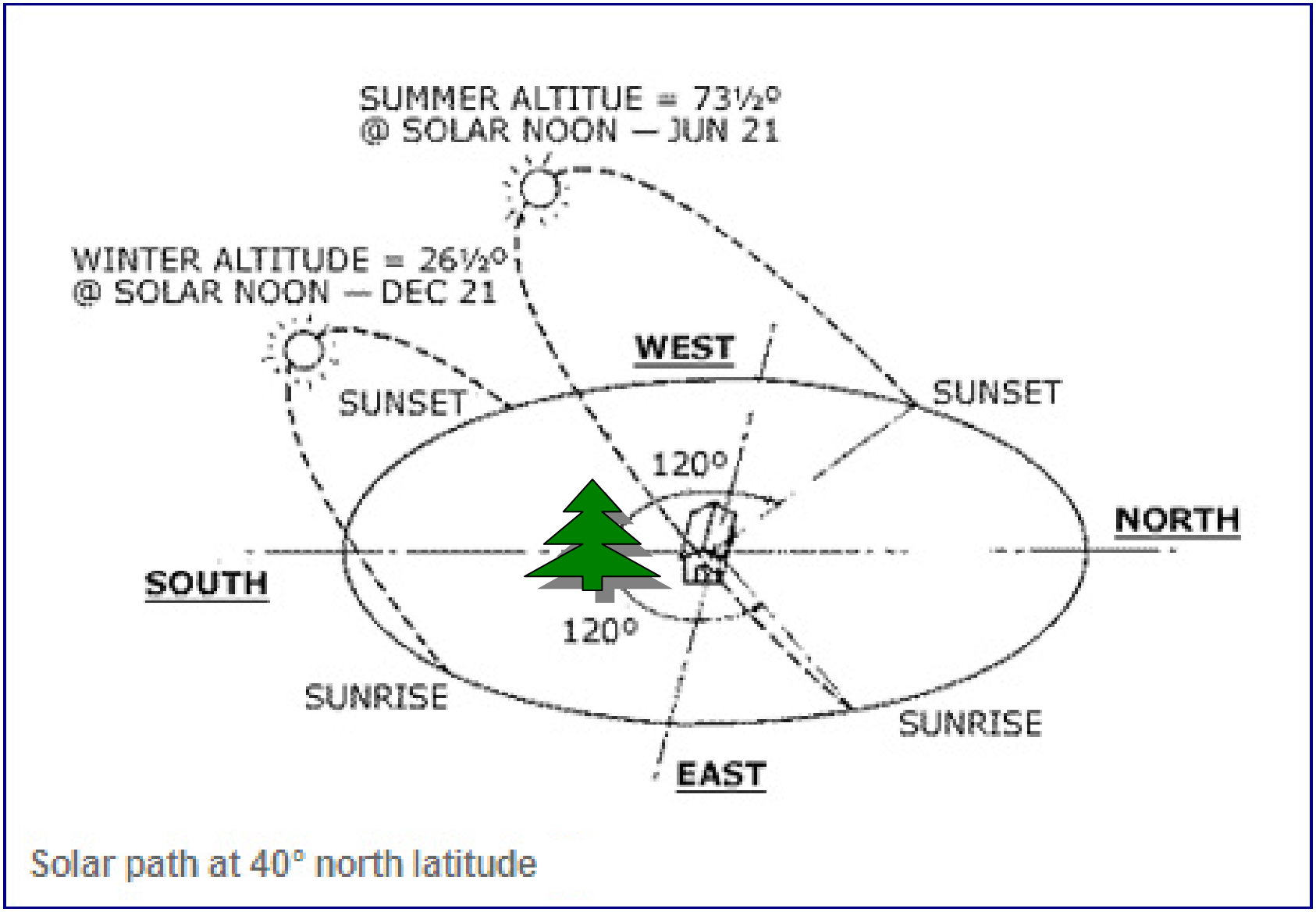

Citrus


Peace Lily

Too much light

- Possible solutions
  - Shading
  - Grow plants suited for light levels you have
  - Plan for optimum greenhouse location

Know the sun's path in all seasons



Solar path at 40° north latitude

Figure: Alward, Ron, and Andy Shapiro. 1981. Low-Cost Passive Solar Greenhouses. National Center for Appropriate Technology, Butte, MT. 173 p.

Temperature

- Controls most everything in the plant
  - Rate of water uptake
  - Rate of nutrient uptake
  - Photosynthesis
  - Cell division

Air Temperature

- Optimum high
  - 85^{o}F
  - Above 90 growth slows
- Warm season plants
  - Tomatoes
  - Peppers
  - Cucumber
- Optimum low
  - Between 50^{o} and 60^{o}F
- Cool season plants
  - Spinach
  - Cole crops
  - Peas

Air Temperature

- Many hobby greenhouses have inadequate or *missing* heating and ventilation (cooling) systems.
- Yes, they are expensive but make the difference between success and failure.

Air Temperature

- Measure at plant height
- Gradient may be seen
  - Cooler temps near walls, doors, vents
- Germinating seeds have special requirements

Soil Temperature

- More critical than air temperature, however, very closely related to the temperature of the air.
- Roots grow slower at temperatures below 45^0 F
  - Can’t take up water and nutrients

Gases

- Oxygen
- Carbon dioxide
- Harmful gases
- Wood preservatives

Soil oxygen

- Pore space is important for respiration
- Compaction
- Water-logging

Carbon Dioxide

- Fresh air exchange
- Especially in winter

+ 6 CO_2 + 6 H_2O → $C_6H_{12}O_6$ + 6O_2

Harmful Gases

- Natural gas
  - Leaky heating system
  - Epinasty
- Ethylene
  - Reduced blooms
  - Epinasty

Photo: B. Whipker

Wood preservatives

- Don’t use treated wood if certified organic
- Direct toxicity (roots in contact)
- Fumes given off
- Common preservatives
  - Pentachlorophenol
  - Creosote
- Can paint over with special paint (B-I-N)

Growing media

- Soils
- Artificial soils

Soil preparation

- Planting directly into ground in most hoophouses
- Need to prepare the soil
  - Weed control
  - Organic matter
  - Nutrients

Soil Prep-New Site

- Remove existing vegetation
- Reduce weed seedbank levels
- Increase OM & fertility levels
- Grading/slope for drainage
  - May need to tile perimeter

Soil Health

- Consider immediate & long term health
- Increase OM with annual compost applications
  - Carbon based compost
  - Mature compost
  - Limited animal manure compost

Why limited animal manure compost?

- High nitrate levels
- Limited leaching in hoophouse
  - Especially with drip irrigation
  - Buildup of soluble salts and excess nutrients in soil
  - Too much nitrates in plants (leafy greens)? Human health affected?

Soil health approaches

- Add compost to build OM to 10-15%
- Soil testing for nutrients, EC, & pH
- Incorporate green manures & cover crops
  - Year prior to production is best
- As needed: sidedressing w/ needed nutrients

Soil testing

- EC and pH pens
  - EC measurement of soluble salts
  - K, Na, Cl, NO_3, NH_4
  - <$100 for handheld meter
  - Calibration is important
- Full nutrient analysis
  - Send off to lab for best quality analysis
  - Many labs to choose from
  - Check “Alternative Soil Testing Laboratories” publication by ATTRA

- Effects of high EC?
  - Restricted water uptake and wilting
  - Reduced root growth
  - Poor seed germination
  - Leaf margin burning
  - Reduced flowering & yields
- Different testing methods
  - Saturated paste, dilutions (1:2 or 1:5)

EC levels

Testing Methods			
Saturated Paste	1:2 dilution	1:5 dilution	Comments
0-0.7	0-0.25	0-0.12	Very low
.7-2.0	0.25-0.75	0.12-0.35	Good for germination
2.0-3.5	0.75-1.25	0.35-0.65	Desirable for growth
3.5-5.0	1.25-1.75	0.65-0.9	Slightly high, too high for seedlings
5.0-6.0	1.75-2.25	0.9-1.1	Reduced growth, marginal burn

1 dS/m= 1 mmho/cm= 1 mS/cm

Adapted from A. Rangarajan, Cornell University

Relative EC tolerance

Non Tolerant (0-2 dS/m)*	**Slight Tolerant (2-4 dS/m)**	**Moderately Tolerant (4-8 dS/m)**	**Tolerant (8-16 dS/m)**
carrot	cabbage	broccoli	swiss chard
onion	celery	muskmelon	beet
pea	lettuce	spinach	
radish	pepper	squash	
green bean	sweet corn	tomato	
	potato		

*saturated paste extract

Adapted from A. Rangarajan, Cornell University

Artificial soils

Media serves the following functions:

- Provide water
- Supply nutrients
- *Permit gas exchange to and from the roots*
- Provide support for plants

Consists of Organic & Inorganic portions

Components

Organic

Peat moss

Manures

Leaf mold/composts

Wood by-products

Bark

Coir

Straw

Inorganic

Sand

Gravel

Perlite

Vermiculite

Rock wool

Soilless Media

- The amount of air and water held in a medium is determined (prior to placing the seed or plant in the container) by
  - The container
  - How the medium is handled
    - Compaction
    - Moisture content
    - Pot filling technique
  - Watering practices used by grower

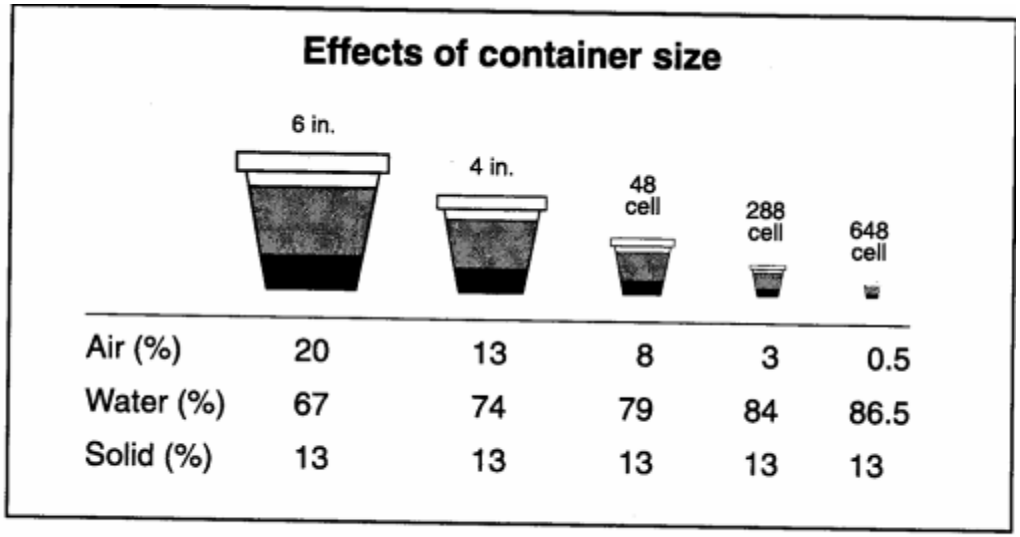


Fig. 5.6 Effect of container size on air-water relations of peat:vermiculite (1:1) media. Note as container height decreases, air space decreases, and water content increases.

Diagram from: Water, Media, and Nutrition for Greenhouse Crops, Chapter 5 Ball Publishing

What about Polymers?

- What about the addition of water holding polymers to media?
  - Do they work?
    - Appear to ‘work well’ in containerized systems?
    - Do not work well with turfgrass
  - How do they work?
    - Polymers hold several hundred times their weight in water and then release it slowly back to the plant.
    - Wet the crystals first, before incorporation into the media
    - ¼ cup absorbs 5 gallons of water
  - Are they economical?????

Nutrition & watering

Nutrients

Macro

Nitrogen

Phosphorus

Potassium

Calcium

Magnesium

Sulfur

Micro

Iron

Boron

Manganese

Copper

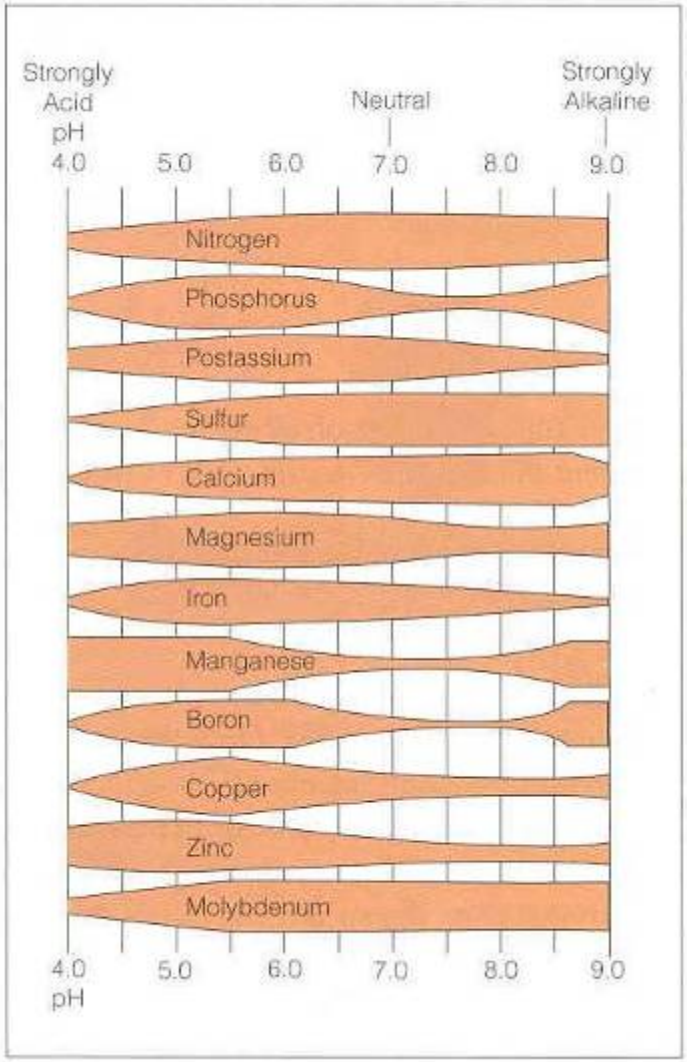
Zinc

Molybdenum

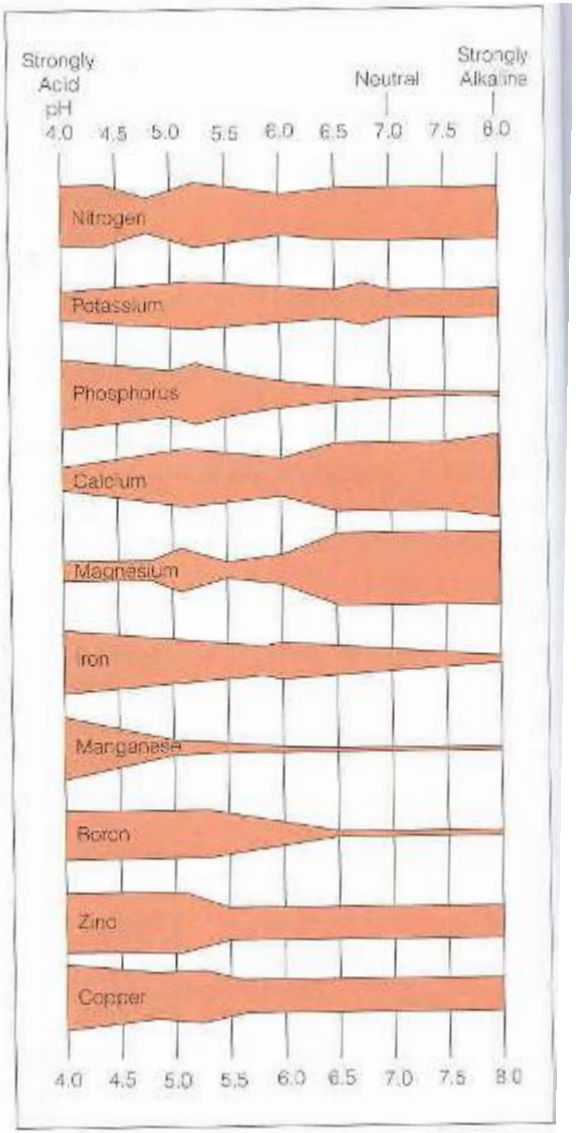
Chlorine

Others

Effect of pH on availability



Field Soil



Artificial Media

Greenhouse fertilization

- In-ground vs. containerized plants
  - Leaching
- Compost (nutrient test if possible)
- Organic options?
- Soil testing is key (know what you're starting with!)

Water

Number one area where mistakes are made

- Everybody “thinks” they know how to water
- *OVERWATERING IS EXTREMELY COMMON!*

Water related problems

- Symptoms of underwatering
  - Foliage off color
  - Foliage wilts
  - Stunting
  - Marginal or interveinal chlorosis
  - Premature leaf senescence

Photo: UCIPM

Water related problems

- Common symptoms of overwatering
  - Foliage yellows or wilts
  - Root system undersized
  - Roots black or dark brown
  - Nutrient deficiency symptoms
  - Pathogens develop

How to Water Properly

- When hand watering always use a water breaker to decrease the force of the water

Photo: UCIPM

Water Based on Need not Calendar

- What are the plants' irrigation needs?
- Depends on:
  - Frequency
  - Amount
  - Method of water application
  - Type of media
  - Plant cultivar
  - Environmental conditions
  - Water quality

How to Water Properly

- Watering frequency
  - Increase the period between watering to the maximum level that is consistent with good growth.
  - Before watering again, allow soil to drain and dry out to the point where most available water has been used.
- Amount of irrigation
  - Apply 10 – 15% more water to leach salts.
  - The rate of irrigation must be low enough to allow the water to percolate throughout the soil.

Irrigation water testing

- Quarterly, if possible
- Check for EC, pH, hardness, salinity
- Send to testing lab
  - Colorado Analytical Labs
- At home kits

Questions?