Advanced pH management

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Outline

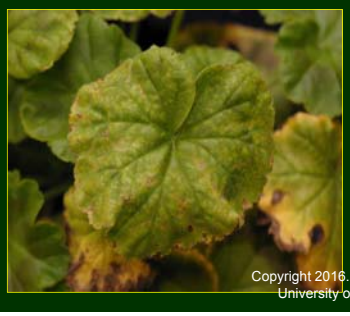
- Understand how substrate-pH affects chemical solubility, nutrient availability and plant growth
- Manage factors that affect substrate-pH
  - Fertilizer level
  - Water quality
  - Ammonium :nitrate ratio
  - Iron form

Iron deficiency at high substrate-pH

- Chlorosis, often interveinal, in new tissue
- Iron deficiency at high pH (>6.4 in iron-inefficient plants)
- Iron required to produce chlorophyll (green)
- Low mobility within plant
- Very common, especially at low fertilizer level

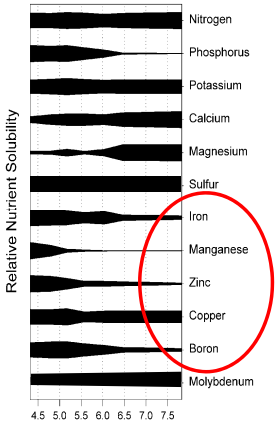
Iron/manganese toxicity at low substrate-pH

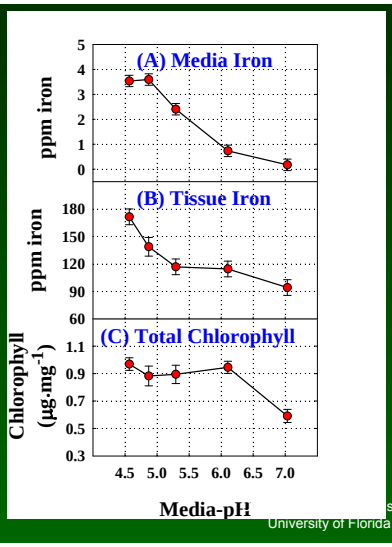
- Excess micronutrient accumulates in the tissue
- Chlorosis and necrosis occurs in older leaves
- Less common issue, in iron-efficient crops



pH of the growing media ("Substrate-pH") affects...

- Nutrient solubility
- Uptake by Plant
- Plant health
  too much → toxicity
  too little → deficiency





Substrate-pH affects

Nutrient solubility

Uptake by Plant

Plant health

Petunia hybrid

Substrate-pH affects micronutrient solubility and plant health

Impatiens Substrate-pH 4.4 4.7 5.1 6.0 7.0

Before we get too far…

- pH management is not that complex
- Maintain substrate-pH around 5.5-6.4, and you will be fine.
- But this is an advanced session.
- For more info…

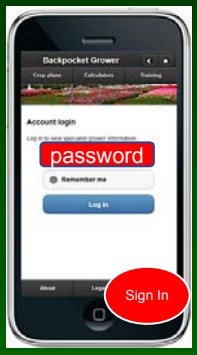
Greenhouse Training Online courses

- Designed for greenhouse employees in the US and internationally
- English & Spanish, Four weeks
- Classes accessible any time of day
- Customized certificate of completion
- $200 per person (SA discount $160)

Topic	Start date	End Date	Level
Greenhouse 101	30-May	24-Jun	•
Nutrient Management 1 (Intro)	18-Jul	12-Aug	••
Nutrient Management 2 (Advanced)	22-Aug	16-Sep	•••
Disease Management	26-Sep	21-Oct	••
Weed Management	24-Oct	18-Nov	••

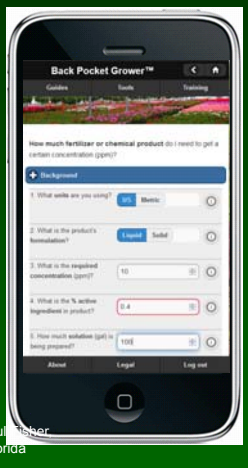
BMP account of Back Pocket Grower

- Go to backpocketgrower.org with your browser.
- Looks best on a mobile device.
- Log in (BMP account for 2016: gatorbait)

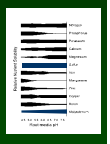


Training

Tools

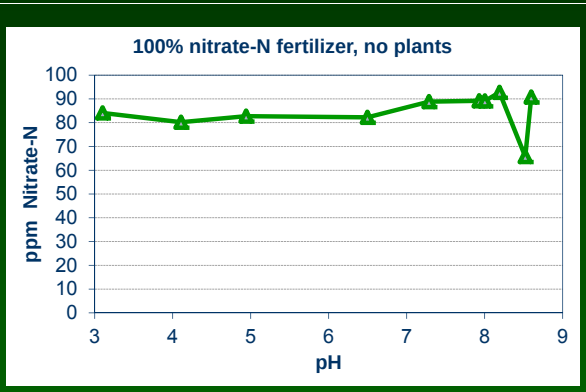


pH solubility curve: Did you know…



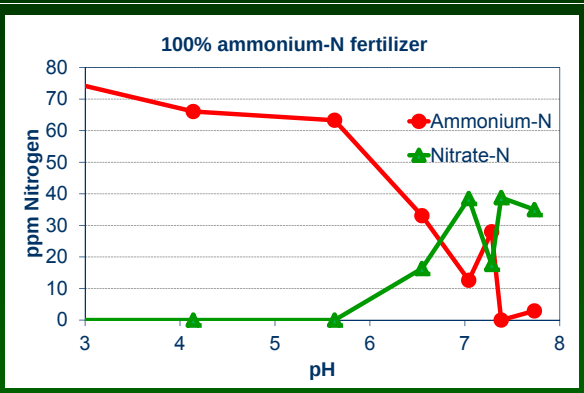
- Based on one mix (peat/bark/sand/vermicultite) and one fertilizer containing STEM (sulfate micronutrients) and dolomitic lime?
- Why do different nutrients have the reported shape in the curve?

Nitrate is not affected by pH



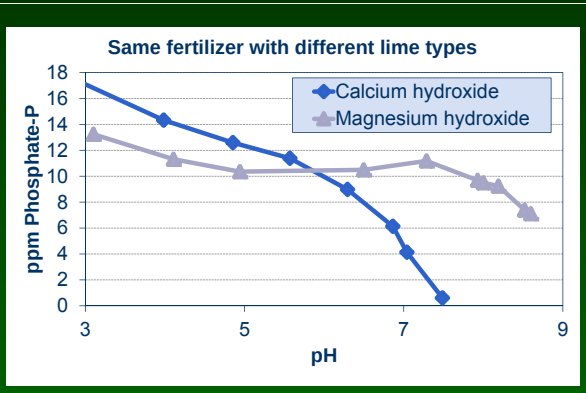
- Managing nitrate-N is a supply (EC) issue, not a pH issue

Ammonium tends to be nitrified (turned into nitrate) by bacteria at high pH



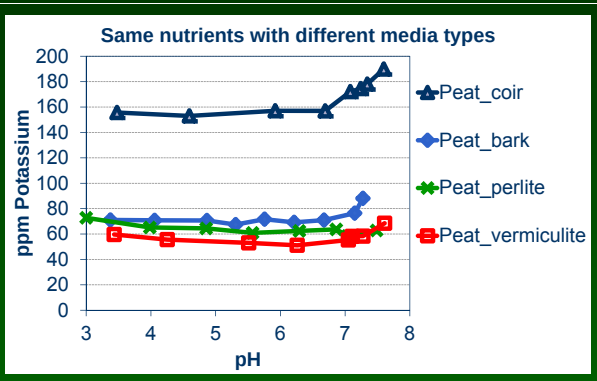
- Much of the acidity of ammonium can result from microbes
- Ammonium toxicity with high NH_4 fertilizer, low pH, cool & wet

Phosphorus reacts with calcium at high pH



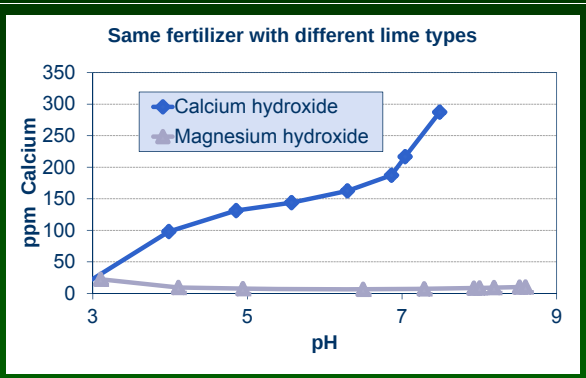
- Low P can be an issue at high pH

Potassium is not affected by pH, but coconut coir can contribute K



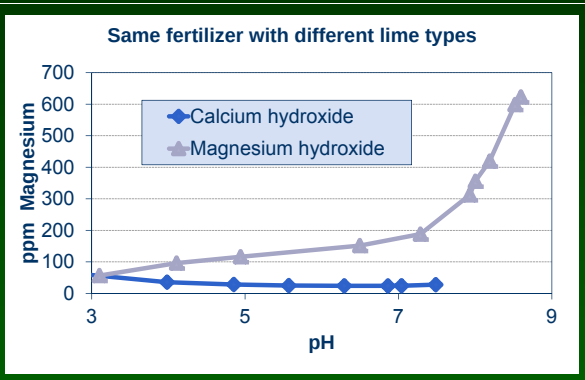
- Media components can sometimes add nutrients

Increasing Calcium at high pH is because of the lime source, not solubility



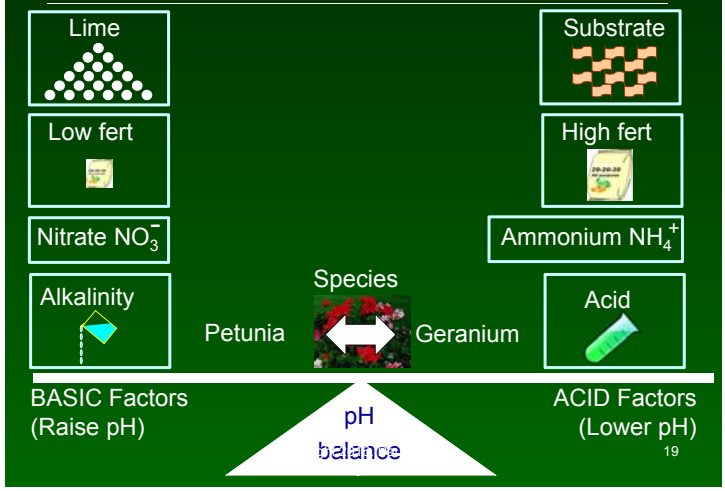
- Raising pH per se will not increase calcium availability
- Adding calcitic limestone, calcium nitrate, or gypsum increases Ca

Magnesium has the same trend as Calcium



- Raising pH per se will not increase magnesium availability
- Adding dolomitic limestone, mag nitrate, or mag sulfate increases Mg

Many factors affect substrate-pH



pH and EC crop cycle check up

- Plug squeeze each week of crop

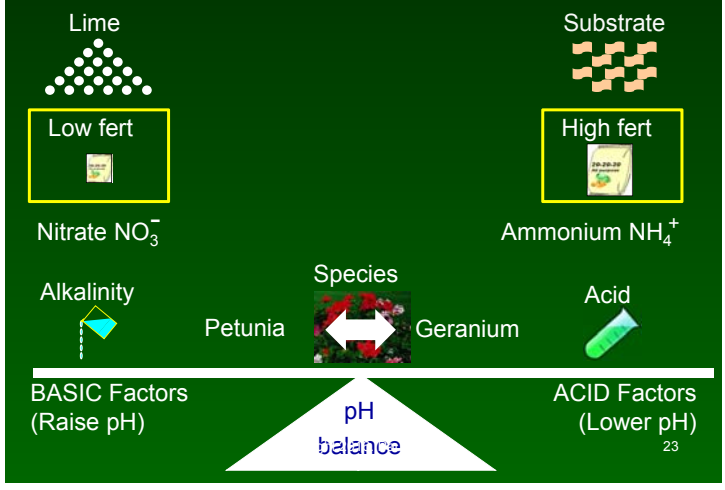
pH and EC crop cycle check up

Compartment	H2	H1	H1	H5	H10
Stick/Sow week:	Week 12	Week 11	Week 10	Week 9	Week 8
Crop age:	Week 0	Week 1	Week 2	Week 3	Week 4
pH plug squeeze:	5.3	6.8	5.5	5.8	6.5
EC plug squeeze:	1	0.4	1.5	0.6	0.16
Plant appearance:	Good	Rooted, slight yellowing new leaves	Good tone	Somewhat soft, well rooted	Soft, well rooted, stretched
Ffertilizer type and concentration:	clear water	clear water	17-5-17 150 ppm N +1.5 ppm Fe	17-5-17 150 ppm N +1.5 ppm Fe	17-5-17 150 ppm N +1.5 ppm Fe

Major pH factors during propagation

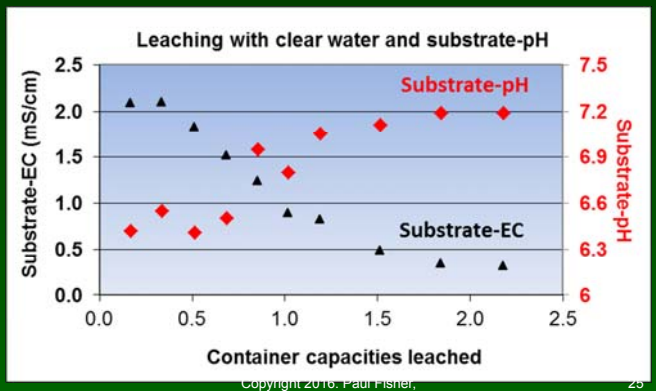
Mist phase	Finishing phase
Lime reaction	Lime residual
Substrate pH & cation exchange capacity (CEC)	Alkalinity
Electrical conductivity (EC)	Nitrogen form & concentration
Water quality	Plant Species

Many factors affect substrate-pH

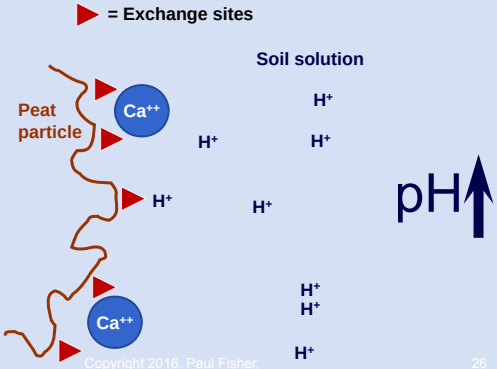


EC EFFECTS: High pH and low salts are common at the end of the mist phase

Why? Because pH increases as EC decreases with leaching



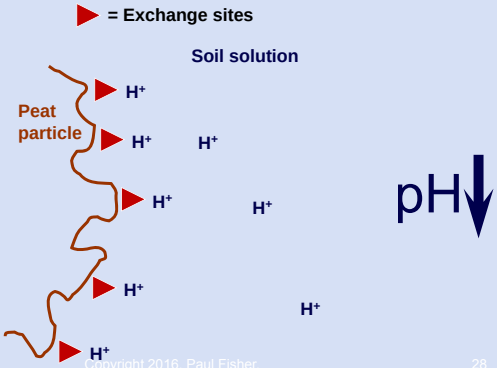
Leaching with clear water washes out salts and raises pH



EC: Pre-plant salts (especially Calcium) drop pH

Cation	Substrate-pH
Control (water)	5.8
Ammonium	5.5a
Potassium	5.5a
Magnesium	5.5a
Calcium	5.2b

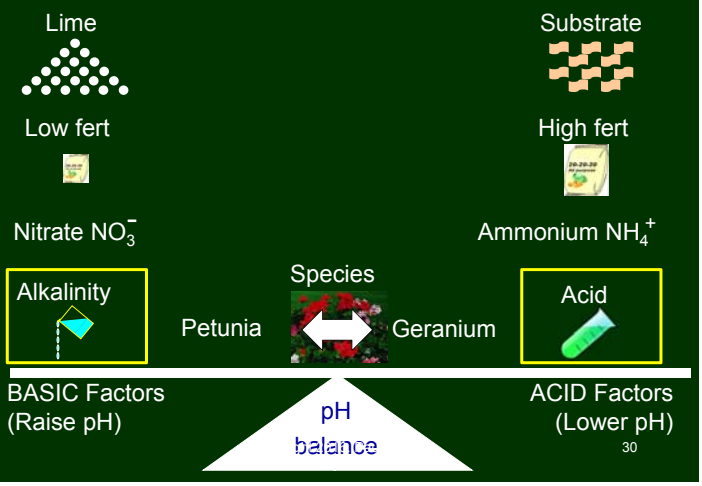
Adding fertilizer will drop pH



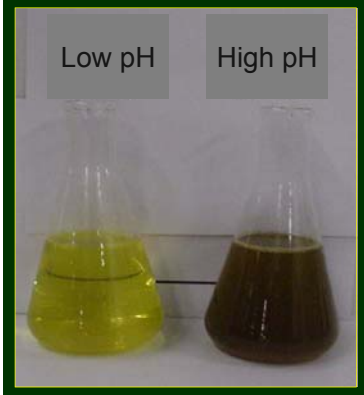
EC EFFECTS: What should you do about this high pH/low EC issue?

- Avoid excess leaching
- Fertilizer at end of mist phase

Many factors affect substrate-pH

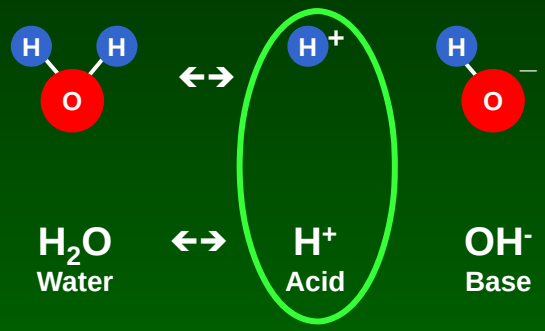


WATER QUALITY: Solution pH



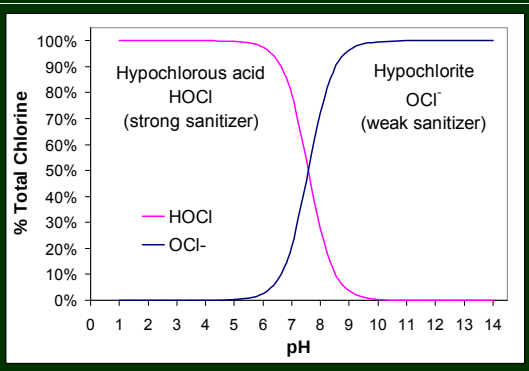
- Can be measured with a pH meter
  - <7 acid
  - 7 neutral
  - >7 basic
- Affects the solubility and activity of chemicals and fertilizer in solution
- Little effect on substrate-pH

What is pH?



Low pH values are ACID, high pH values are BASIC

Most agrichemicals are more effective at an acidic pH, for example chlorine



- Injecting acid can reduce chlorine cost, increase sanitizing effect, and reduce phytotoxicity risk.

Control the pH of your spray tank for maximum effect of agrichemicals

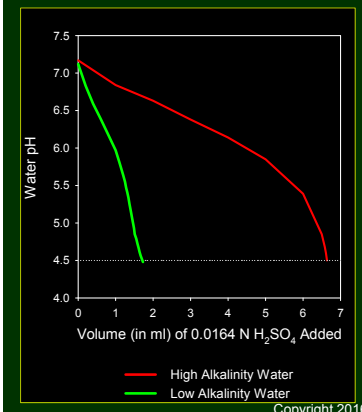
Pesticide	Optimum pH range
Azadirachtin (Azatin)	3.0 - 7.0
Abamectin (Avid)	6.0 - 7.0
Acephate (Orthene)	5.5 - 6.5
Thiophanate methyl (Cleary's 3336)	6.0 - 7.0
Chlorothalonil (Spectro)	6.0 - 7.0
Fenhexamid (Decree)	5.5 - 6.5
Ancymidol (A-Rest)	5.5 - 6.5
Ethephon (Ethrel, Florel, Pistill)	Less than 5.0

extension.umass.edu/floriculture/fact-sheets/effects-ph-pesticides-and-growth-regulators

Correct pH and hardness (Ca + Mg) of spray tank solutions

- Purdue University Extension
  - Impact of water quality on pesticide performance (https://www.extension.purdue.edu/extmedia/ppp/ppp-86.pdf)
  - Use acid or other water conditioners
  - Run a jar test to check complete dissolution

WATER: Alkalinity Affects Substrate-pH



- Can NOT be measured with a pH meter
- Can have a large effect on substrate-pH
- Often termed as bicarbonates
- Think of as dissolved limestone

Water Alkalinity is like dissolved limestone

Main ions that come under the term "Alkalinity":

Bicarbonates [HCO_3^- (Ca, Mg, Na)]

Carbonates [CO_3^{2-} (Ca, Mg, Na)]

Limestone (similar reaction)

$CaCO_3$ + 2H-Peat ► H_2O + CO_2 + Ca-Peat

Water quality

Irrigating with "high" alkalinity (>150 ppm $CaCO_3$) is like applying limestone to the substrate with each irrigation. Substrate-pH rises over time.

Alkalinity units

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

Water **alkalinity** is a much stronger base than water **pH**

- Example plant grown in 1 liter container
- Irrigated with 1 liter of water per week for 15 weeks
- With a water that has pH 9 and 200 ppm $CaCO_3$ alkalinity

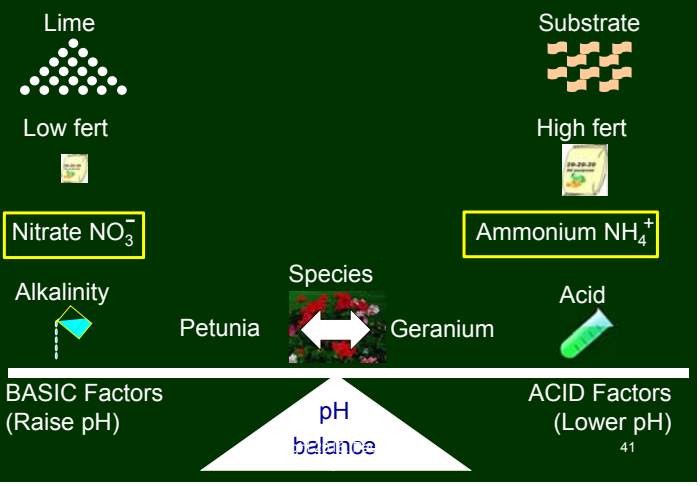
pH factor	Amount	Milliequivalents of base added per pot
Water pH	9.0	0.15 base
Water alkalinity	200 ppm $CaCO_3$	60 base
Lime ($CaCO_3$)	3 kg/m^3	60 base

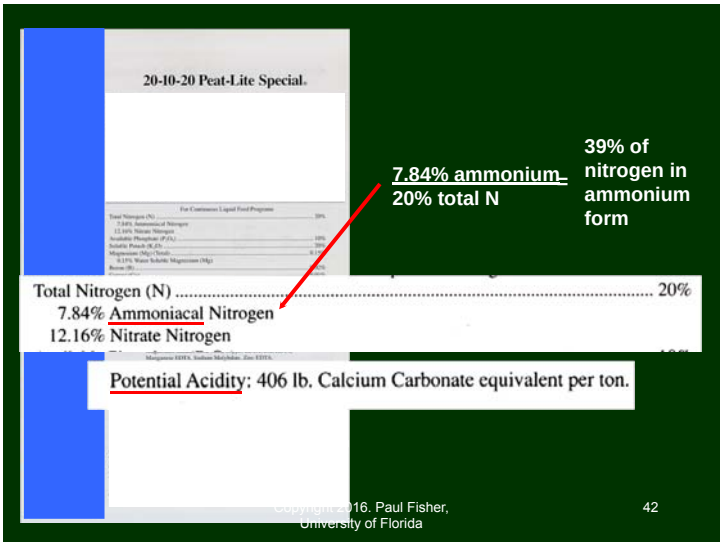
Control alkalinity with mineral acid

- How much to add? Use online **AlkCalc** from University of New Hampshire

- Sulfuric (adds S)
- Phosphoric (adds P)
- Nitric (adds N)
- Bring water pH down to around 6 (~ 2 mEq/L or 100 ppm $CaCO_3$ for some alkaline water sources)

Many factors affect substrate-pH





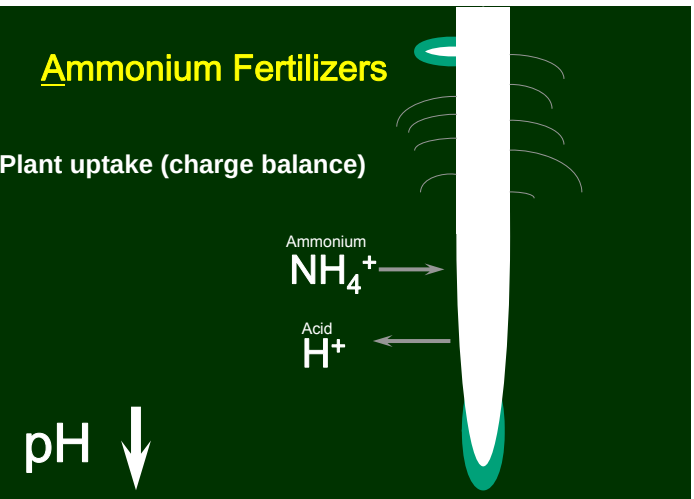
FERTILIZER: Potential Acidity or Basicity

$N\text{-}P_2O_5\text{-}K_2O$	(NH_4-N + Urea-N) / Total N	Potential reaction in lb/ton (A=acid, B=base) 1 lb/ton = 0.5 kg/tonne
21-7-7	100%	A 1560
20-10-20	40%	A 406
17-5-17	20%	B 0
15-0-15	13%	B 420

- Fertilizers containing more than 20% of N as ammonium tend to be acidic.
- The Calcium Carbonate Equivalency (CCE) of a fertilizer is its potential to change pH after it is applied, because of root uptake or microbes.
- Can not be measured in the fertilizer solution with a pH meter

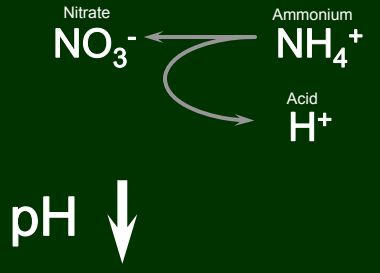
Ammonium Fertilizers

Plant uptake (charge balance)

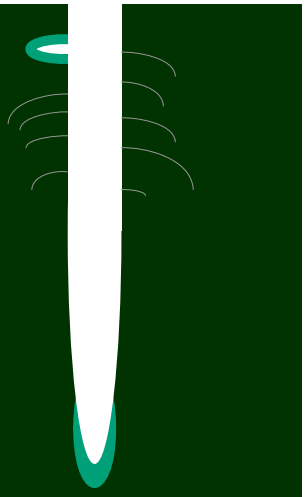


Ammonium Fertilizers

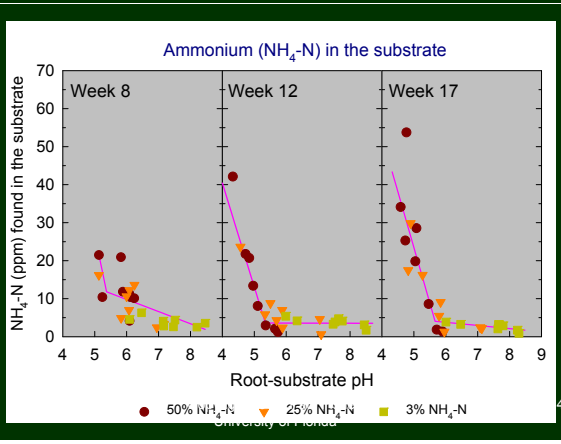
Nitrification by soil microbes



pH ↓

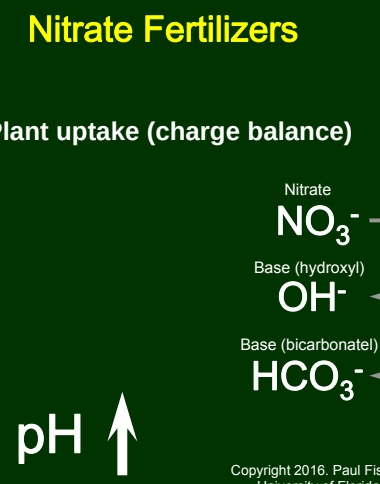


Microbes quickly convert ammonium to nitrate (nitrification) when pH is above 6

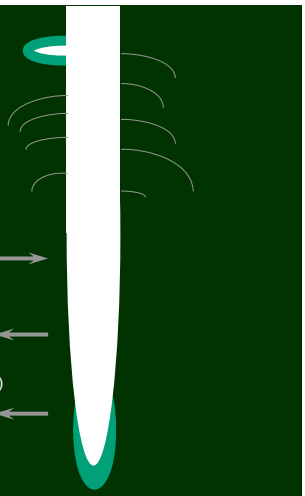


Nitrate Fertilizers

Plant uptake (charge balance)

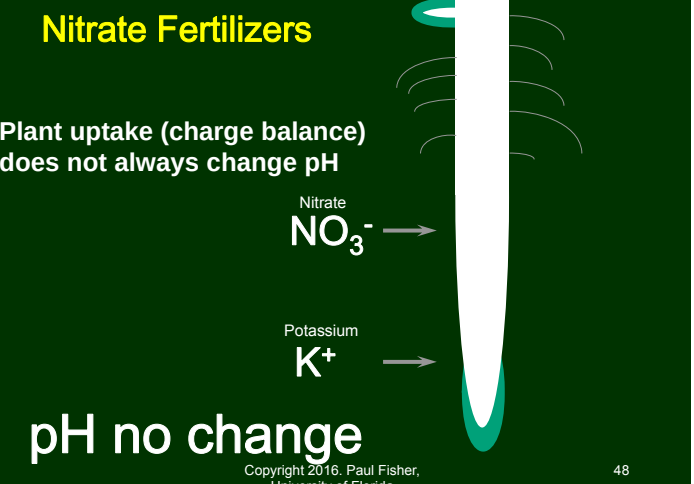


pH ↑



Nitrate Fertilizers

Plant uptake (charge balance) does not always change pH



pH no change

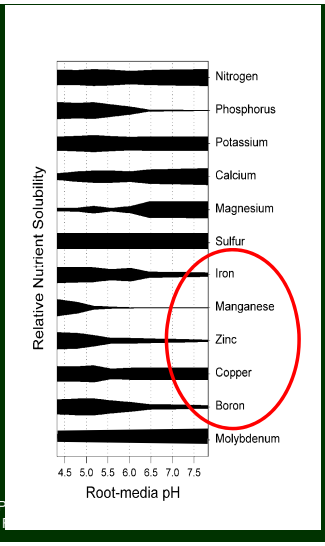
Match your fertilizer to your alkalinity

$N\text{-}P_2O_5\text{-}K_2O$	$(NH_4\text{-}N + Urea\text{-}N)$/ Total N	Potential reaction in lb/ton (A=acid, B=base)	Match to this ppm $CaCO_3$ of water alkalinity
21-7-7	100%	A 1560	300 ppm
20-10-20	40%	A 406	200 ppm
17-5-17	20%	B 0	100 ppm
15-0-15	13%	B 420	50 ppm

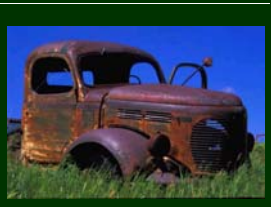
- High alkalinity can be balanced with high ammonium.
- BUT:
  - lush growth, ammonium toxicity in winter, and not effective when plants are small, substrate wet & cold.
  - If alkalinity is greater than 150 ppm $CaCO_3$, acid usually also needed.

pH of the growing media ("Substrate-pH") affects...

- Nutrient solubility
- Uptake by Plant
- Plant health
  too much → toxicity
  too little → deficiency



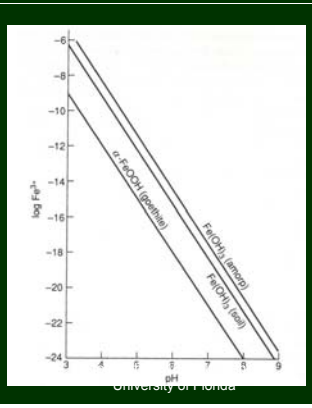
Inorganic Fe solubility



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

pH 7
Highly insoluble
$Fe(OH)_3$

Inorganic iron, such as iron sulfate ($FeSO_4$), rapidly decreases in solubility as pH increases

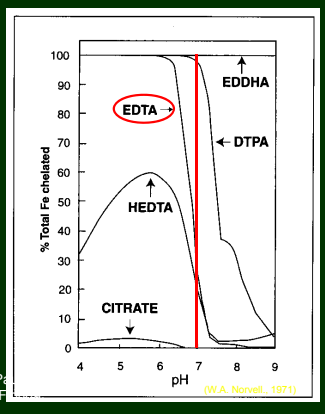


Lindsay (1979)

Iron solubility and chelates

- Synthetic chelates
- Most common fertilizers:

  $FeSO_4$, Fe-EDTA (constant)
  Fe-DTPA, Fe-EDDHA (corrective)



(Norvell, 1991)

1 ppm iron from Iron-EDTA

Impatiens media-pH **4.4** **4.7** **5.1** **6.0** **7.0**

At low pH (5.1) all iron forms soluble

At high pH (7.0) iron form matters

Calibrachoa, high pH 7.2

- Adding 0.5 ppm iron-EDDHA is a cost-effective method for iron-inefficient crops

At high pH, increasing micronutrient level can lead to improved growth and appearance

ppm iron 0.5ppm 1ppm 2ppm (pH 7.0)

- Consider having a separate injector for micronutrients v NPK.
- Control growth with N or P, maintain color with Mg and micros.

pH correction to rescue stressed crops

- First check substrate-pH and EC. Check root health.
- Usual disclaimer: Test on small group of plants first. Dead leaves won't come back to life.

Options to correct high substrate-pH

1. Make sure substrate-EC is not low. Sometimes high pH is simply 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. Consider acid drenches in extreme cases. Ferrous iron sulfate drenches at 120 g/100 L rapidly reduce pH but foliar phytotoxicity is likely.

Iron-EDDHA is most effective iron source at high pH

ppm iron 20 40 80

Iron-EDDHA

Iron-DTPA

Control

Calibrachoa pH 7
(10 days after application, 24 days after planting)

Iron drenches

- 33 grams/100 Liters
  - Iron-EDDHA 20 ppm iron (best), OR
  - Iron-DTPA 37 ppm iron (OK)
- Apply with generous leaching. Immediately wash foliage.
- Do not apply to iron-efficient plants.

Phytotoxicity from iron drench (40 ppm, iron-EDDHA)

Options to correct low substrate-pH

Flowable lime: Effective, messy to apply, may not be available in your area

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

Recommended for rapid correction

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.

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

Tips for Potassium bicarbonate

Can be delivered through emitters or ebb and flood.

Apply in cool weather and 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

In conclusion

- pH management is not that complex
- Maintain pH around 5.5-6.4, and you will be fine.
- Understanding how factors interact will improve your pH management