Fertigation Through Drip Irrigation Systems

by
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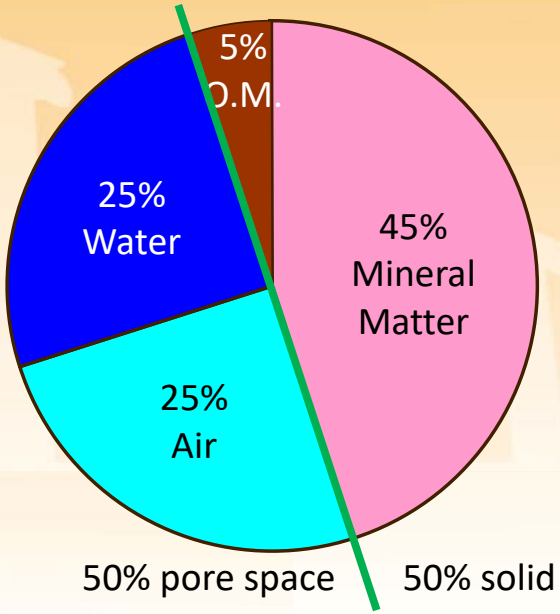
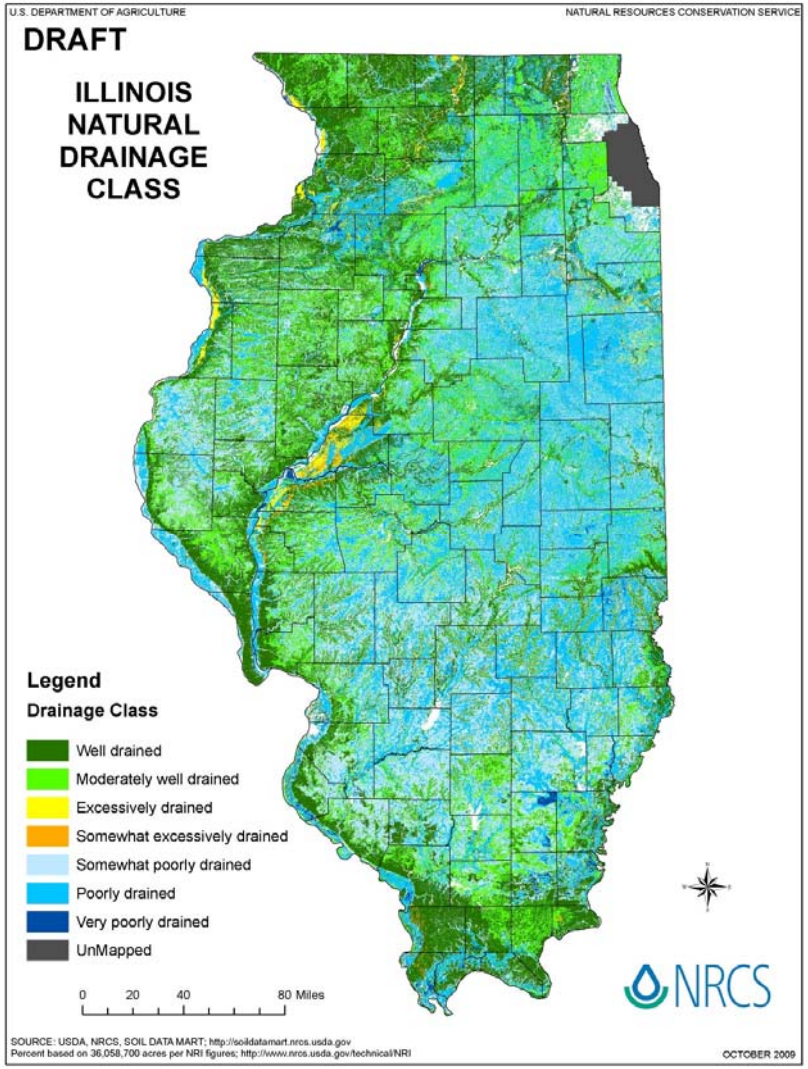
UNIVERSITY OF MISSOURI Extension

If you take care of your soil, the soil will take care of your plants.



Soil Drainage

Ag Site Assessment Tool
agsite.missouri.edu



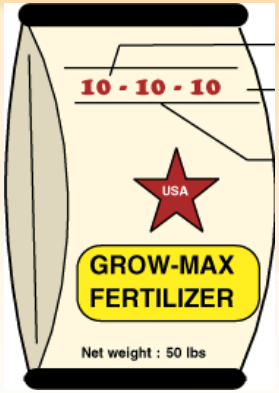
Plant Nutrition vs. Plant Fertilization

Nutrition:

Availability and type of chemical elements in plant

Fertilization:

Adding nutrients to growing medium in proper amounts



Why do we still have problems?

- Focus has been on solving problems
  - Delay crops
  - Reduce quality
  - Lower profits

❖ ***"Need to focus on preventing problems"***

What is Fertigation?

- Fertilizer + Irrigation = Fertigation
- Nutrient “spoon feeding”
- Can be done by:
  - hand
  - sprinkler system
  - drip irrigation system

Fertigation

Nutrient “Spoon Feeding”

Fertigation

- Advantages
  - Relatively uniform fertilizer applications
  - Flexibility in timing of applications
  - Less fertilizers used
  - Reduced costs
- Disadvantages
  - Potential contamination hazard from equipment malfunctions
  - Backflow prevention devices required
  - Careful handling of liquid fertilizers

Objectives of Fertigation

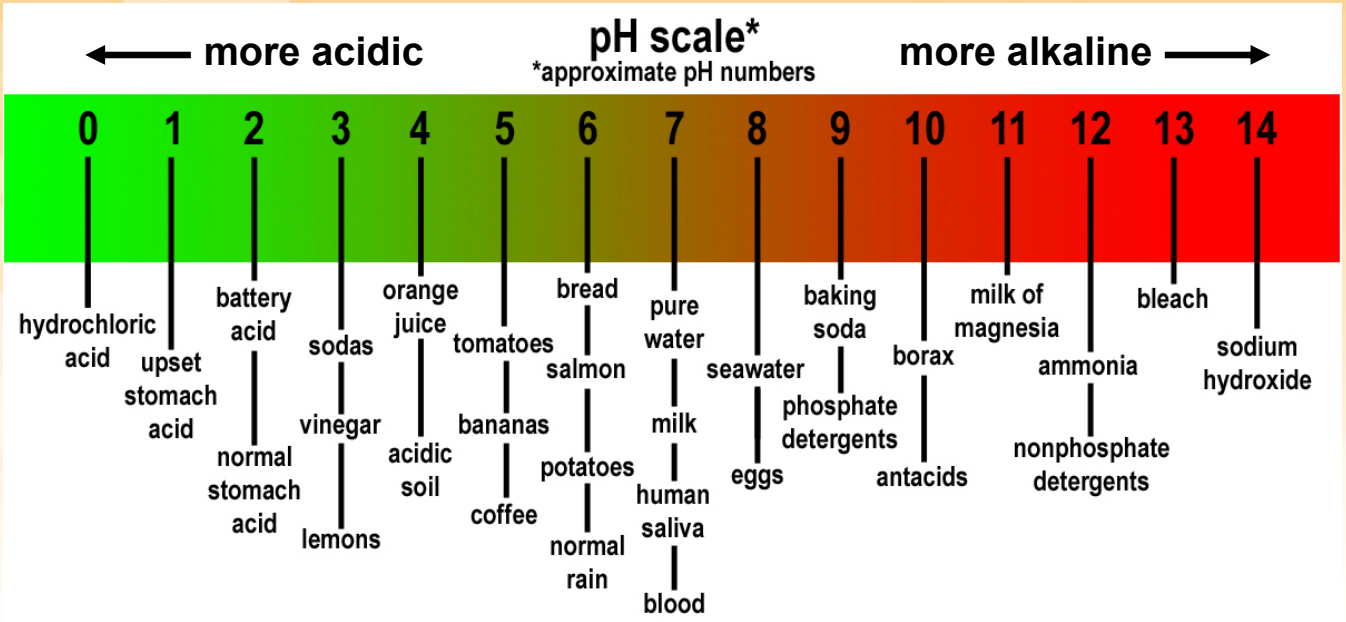
- Maximize profit by applying the right amount of water and fertilizer
- Minimize adverse environmental effects by reducing leaching of fertilizers and other chemicals

Nutrition Affected By

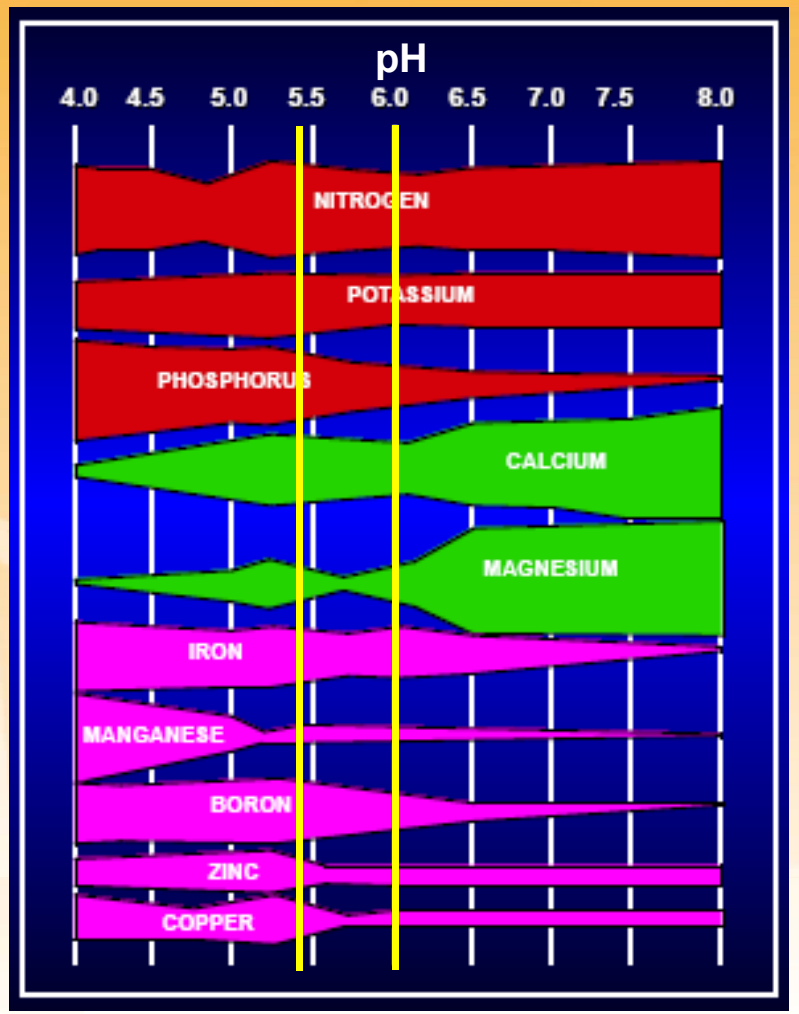
- Chemical considerations
  - **pH - water, fertilizer solution**
  - Alkalinity - water, fertilizer solution
  - Electrical Conductivity (EC) - water, fertilizer solution
- Fertilizer analysis
  - Macronutrients, micronutrients
- Non-nutritional elements – possible toxicities
  - Na, Cl, F, Al

pH

- pH affects the solubility of fertilizers and the efficacy of pesticides and growth regulators
  - The higher the water pH the less soluble these materials are



Influence of pH on nutrient availability*



*based on a soilless substrate containing sphagnum peat moss, composted pine bark, vermiculite, and sand

Reference: www.ces.ncsu.edu/depts/hort/hil//hil-558.html

Problems Associated With Improper pH

Low pH	High pH
• Toxic: – Iron – Manganese – Zinc – Copper • Deficient – Calcium – Magnesium • Sensitive – Ammonium-N	• Deficient: – Iron – Manganese – Zinc – Copper – Boron

pH Adjustment

- Raise pH
  - Use fertilizer with lower acid residue
    - ammonium vs. nitrate
    - calcium compounds
  - Apply limestone
    - calcitic -- $CaCO_3$
    - dolomitic -- $CaMg(CO_3)_2$
    - hydrated -- $Ca(OH)_2$

pH Adjustment

- Lower pH
  - Use fertilizer with acid residue
  - Apply sulfur-containing compounds

    $S + O_2 + H_2O \longrightarrow H_2SO_4 \longrightarrow 2\ H^+ + SO_4^{-2}$

    (requires action of microbes)
  - Sulfuric acid

GUARANTEED ANALYSIS

NET WEIGHT 25 POUNDS (11.34 KG)

PETERS® GENERAL PURPOSE SPECIAL 20-10-20

GUARANTEED ANALYSIS

TOTAL NITROGEN (N) 20%

12.00% NITRATE NITROGEN

8.00% AMMONIACAL NITROGEN

AVAILABLE PHOSPHORIC ACID (P_2O_5) 10%

SOLUBLE POTASH (K_2O) 20%

Primary Plant Nutrient Sources: Ammonium Nitrate, Ammonium Phosphate, Potassium Nitrate.

Potential Acidity 422 lbs. Calcium Carbonate Equivalent Per Ton.

Manufactured by: Peters® Fertilizer Products, W. R. GRACE & CO., Fogelsville, Pa. 180

GUARANTEED ANALYSIS

565-1015

NET WEIGHT 25 POUNDS (11.34 KG)

PETERS® ACID SPECIAL 21-7-7

GUARANTEED ANALYSIS

TOTAL NITROGEN (N) 21%

9.05% AMMONIACAL NITROGEN

11.95% UREA NITROGEN

AVAILABLE PHOSPHORIC ACID (P_2O_5) 7%

SOLUBLE POTASH (K_2O) 7%

Primary Plant Nutrient Sources: Urea, Ammonium Phosphate, Ammonium Sulfate, Muriate of Potash.

Potential Acidity 1560 lbs. Calcium Carbonate Equivalent Per Ton.

Manufactured by: Peters® Fertilizer Products, W. R. GRACE & CO., Fogelsville, Pa. 18051

Conclusions

- pH greatly affects plant nutrition
- Soilless media prone to pH changes
- Many factors influence pH change
- Monitoring pH important
  - Adjust according to crop and need

Nutrition Affected By

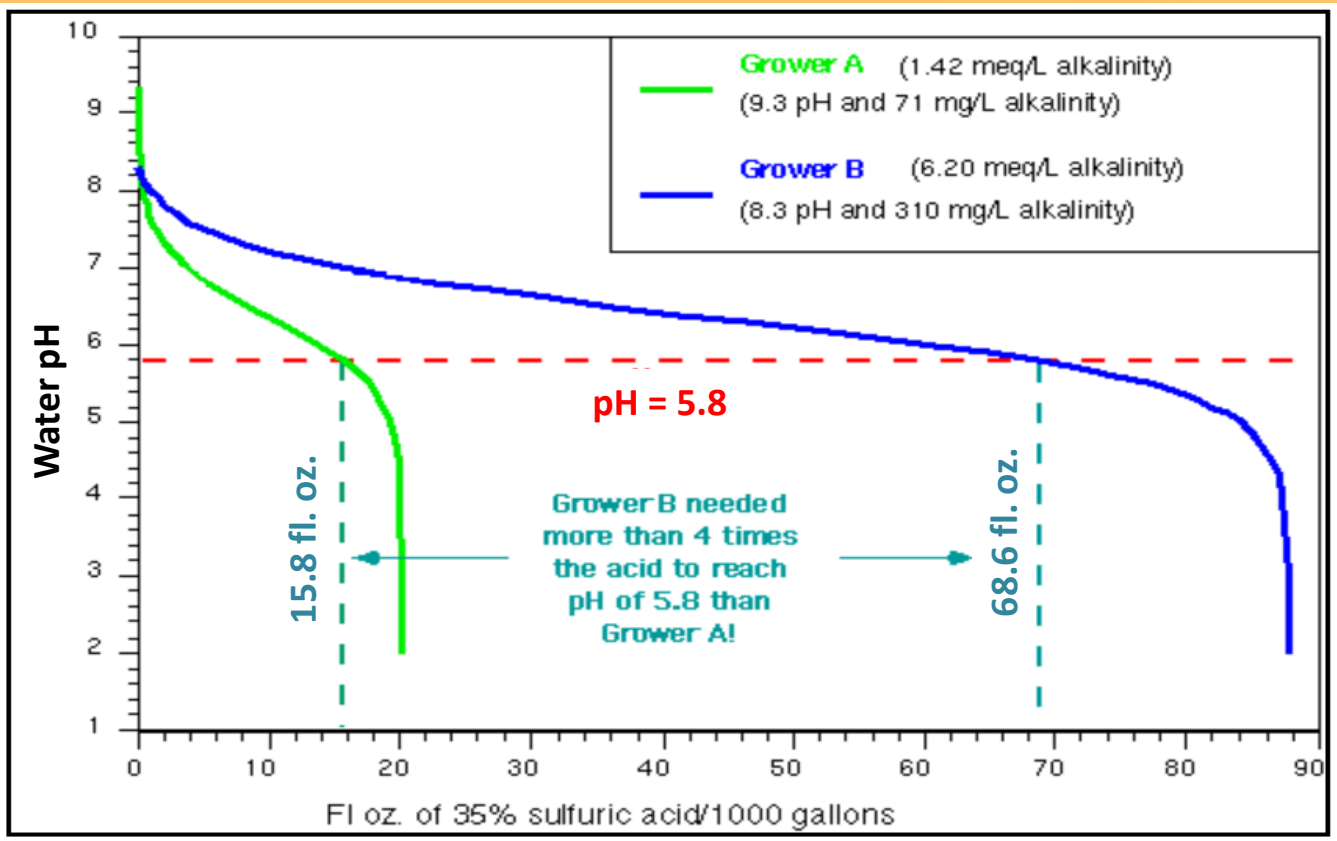
- Chemical considerations
  - pH - water, fertilizer solution
  - **Alkalinity - water, fertilizer solution**
  - Electrical Conductivity (EC) - water, fertilizer solution
- Fertilizer analysis
  - Macronutrients, micronutrients
- Non-nutritional elements – possible toxicities
  - Na, Cl, F, Al

Alkalinity

- Alkalinity establishes the buffering capacity of water and affects how much acid is required to change the pH
  - Don’t confuse with alkaline pH

Reference: www.ces.ncsu.edu/depts/hort/hil//hil-558.html

Influence of alkalinity on acidifying water



Reference: www.ces.ncsu.edu/depts/hort/hil//hil-558.html

Water Source Quality

Good

Poor

- Well = check pH & hardness
- Municipal = may be expensive
- Spring = may not be dependable
- River or stream = depends on runoff
- Lake or pond water = sand filters
- Pump to tank on hill = limited use

Water Quality Analysis

- Inorganic solids = sand, silt
- Organic solids = algae, bacteria, slime
- Dissolved solids (<500 ppm)
  - Iron & Manganese
  - Sulfates & Chlorides
  - Carbonates (calcium)
- pH (5.2-6.8 preferred in greenhouses)
- Hardness (<150 ppm or <9 gpg)
- E. coli bacteria

PVC Casing

Steel Casing

Resources:
http://soilplantlab.missouri.edu/soil/water.aspx
https://utextension.tennessee.edu/publications/Documents/SP740-B.pdf

Plugging Potential of Drip Irrigation Systems

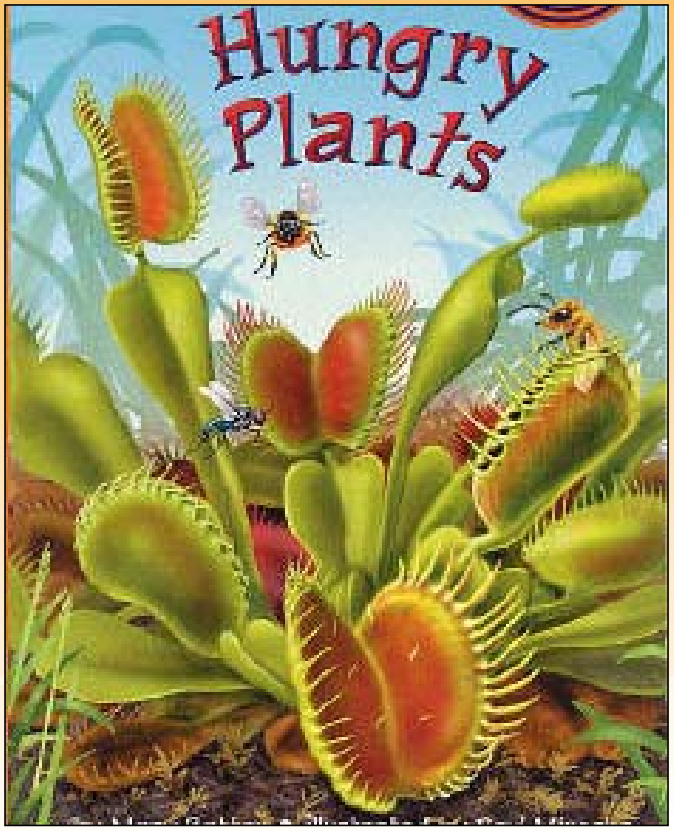
Factor	Moderate (ppm)*	Severe (ppm)*
Physical		
Suspended solids	50-100	>100
Chemical		
pH**	7.0-7.5	>7.5
Dissolved solids	500-2000	>2000
Manganese	0.1-1.5	>1.5
Iron	0.1-1.5	>1.5
Hardness***	150-300	>300
Hydrogen sulfide	0.5-2.0	>2.0

* ppm = mg/L ** pH is unitless *** Hardness: ppm = gpg x 17

Nutrition Affected By

- Chemical considerations
  - pH - water, fertilizer solution
  - Alkalinity - water, fertilizer solution
  - EC - water, fertilizer solution
- **Fertilizer analysis**
  - Macronutrients, micronutrients
- Non-nutritional elements – possible toxicities
  - Na, Cl, F, Al

How do we actually get the fertilizer to our plants?



Application Options

- Pre-plant
  - Substrate incorporation
- Post-plant
  - Top dress/incorporate
  - Liquid feed

  (Might use all three on one crop)

Substrate Incorporation

- Separately
  - Ground limestone (Ca, for pH)
  - Superphosphate (P)
  - Trace elements
  - Slow release materials
- Package
  - "Starter charge" - liquid or granular

Fertilizer Types

- Granular
  - Super phosphate, gypsum
- Slow (controlled) release
  - Osmocote®, MagAmp®
- Water soluble
  - Excel®, Jack's Classic®
- Organic
  - Bloodmeal, alfalfa meal
- Chelated
  - Sequestrene 330®

Slow Release Fertilizers

+ Extended release period
+ Fewer nutrients leached
+ Use instead of or with liquid feed
+ Form of automation
- Release rate varies
- Affects salts measurement
- Hard to leach excess salts

Slow Release--Types

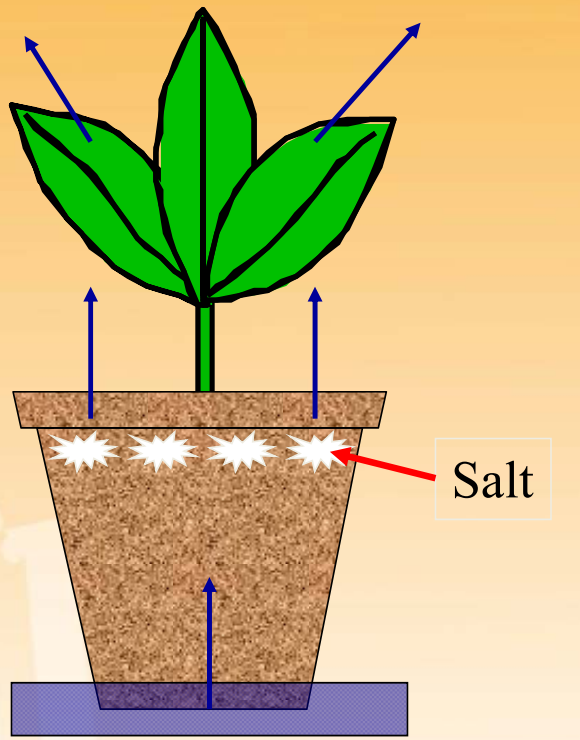
- Plastic encapsulated
  - Osmocote® (analysis varies)
  - 12-week to 9-month release
- Slowly soluble fertilizers
  - Mag-Amp®
- Sulfur-coated urea
  - Primarily for turf

Post-plant (Liquid)

- Most commonly used
- Constant feed (CLF)
  - dilute concentration
  - every watering
- Periodic feed
  - more concentrated
  - intervals (e.g. weekly)

Feeding Rates

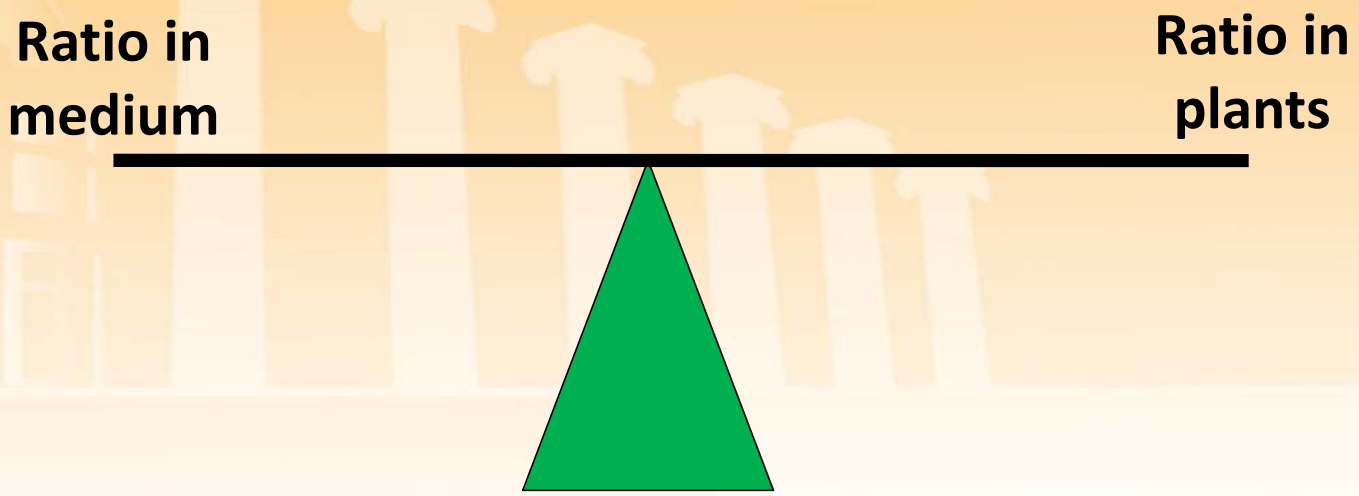
- Constant liquid feed
  - 250 ppm N (top)
  - 150 ppm N (sub)
- Periodic feeding
  - 500 ppm N weekly may top dress with Osmocote®
- Bedding plants
  - 150 - 250 ppm N as needed



Nutritional Monitoring

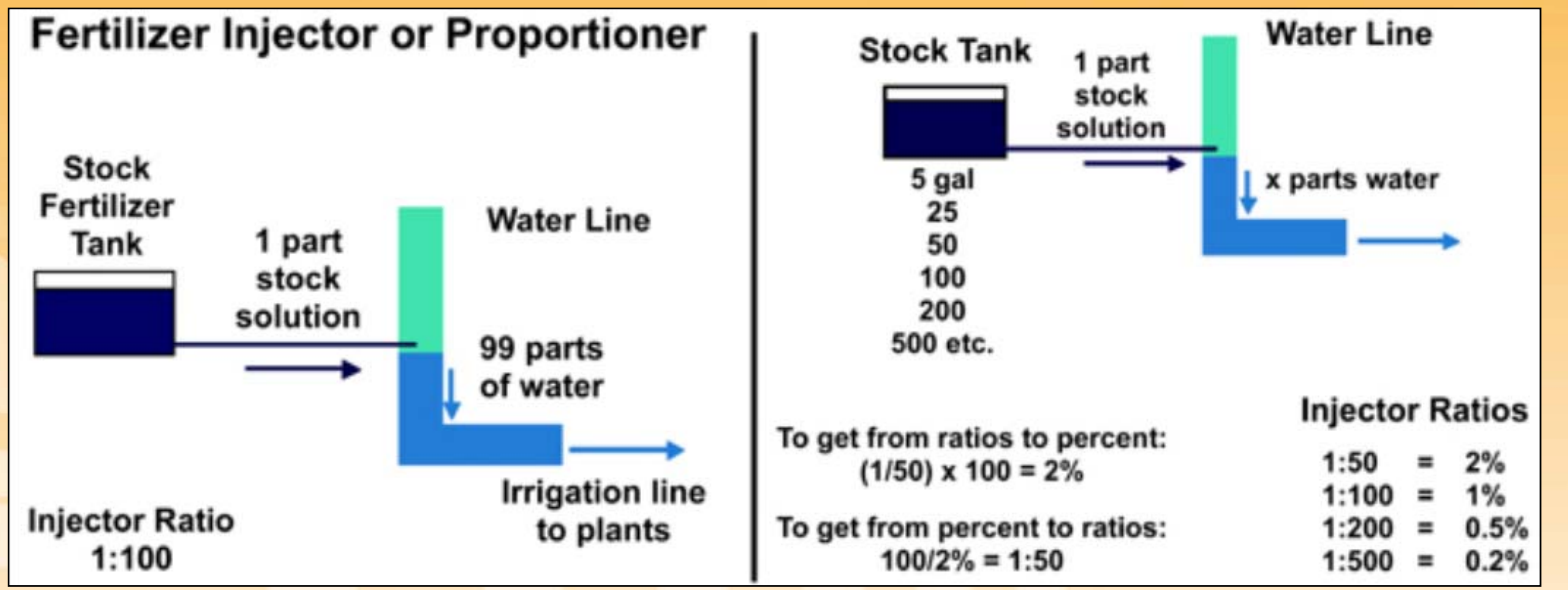
- Visual inspection
  - Too late
  - Symptoms = impaired growth
- Check “vital signs” of plant
  - pH and soluble salts
- Foliar (tissue) analysis
  - Once per crop (expensive)

It's All About Balance of Elements



Fertilizing Equipment

How Injectors (Proportioners) Work



- Two types
  - Venturi (Hozon®, Syphonex®, EZ-Flo®, Add-It®, Young®)
  - Positive displacement (Dosatron®, DosMatic®, Anderson®, Smith®)

Reference: extension.uga.edu/publications/detail.cfm?number=B1237

Conversions

To get from ratios to percent:

(1/50) x 100 = 2%

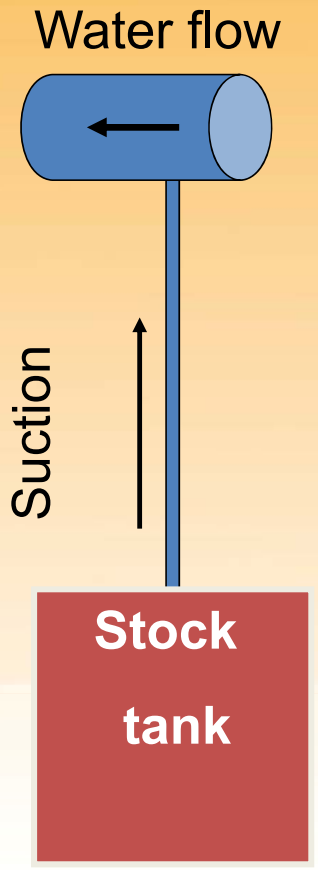
To get from percent to ratios:

100/2% = 1:50

Injector Ratios		
1:50	=	2.0%
1:100	=	1.0%
1:200	=	0.5%
1:500	=	0.2%
1:1000	=	0.1%

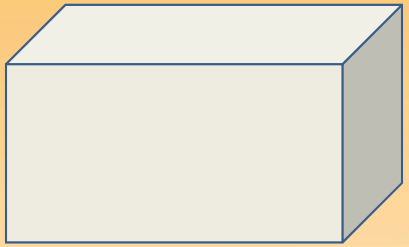
Venturi Proportioners

- Use pressure differences to draw stock solution into water line
- Pressure changes cause different uptake rate
- Must calibrate for local conditions
  - Water pressure
  - Hose length
- Can require large stock tank

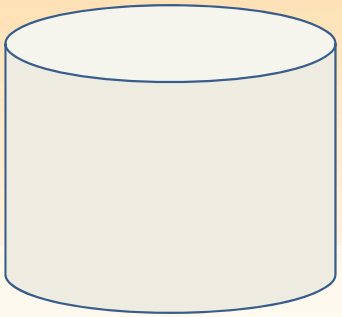


Estimating Stock Tank Size

- Gallon volume of square or rectangular tank = Length x Width x Depth in feet x 7.5
  - Example:
    6’ L x 4’ W x 2.5’ Depth x 7.5 = 450 gallons



- Gallon volume of round tank (approximate) = Diameter x Diameter x Depth in feet x 6
  - Example:
    2’ D x 2’ D x 3’ Depth x 6 = 72 gallons



Venturi Proportioner Examples

- Hozon®
  - 1:16 ratio, 35 PSI minimum
  - Unit not more that 50’ from hose end
  - Backflow preventer included
  - Do not use with drip irrigation system
  - http://hozon.com

- Grow More®
  - 1:16 ratio, 30-90 PSI range
  - Unit not more that 75’ from hose end
  - Backflow preventer included
  - Do not use with drip irrigation system
  - http://www.groworganic.com/siphon-mixer-injector.html

Venturi Proportioner Examples

- EZ-Flo®
  - 1:1000 to 1:100 variable ratio (2/3 tsp/gal to 2 TBS/gal)
  - 2 GPM min. flow rate
  - Backflow preventer not included
  - http://ezfloinjection.com

- Add-It®
  - 1:200 ratio, 10-80 PSI range
  - 0.5-20 GPM min. flow rate
  - Backflow preventer not included
  - http://fertilizerdispensers.com/services/add-it.htm

Venturi Proportioner Examples

- Young®
  - 1:30 to 1:200 variable ratio
  - 2 GPM min. flow rate
  - Backflow preventer not included
  - Very accurate
  - http://www.youngproductsinc.com/other_products.html

Positive Displacement

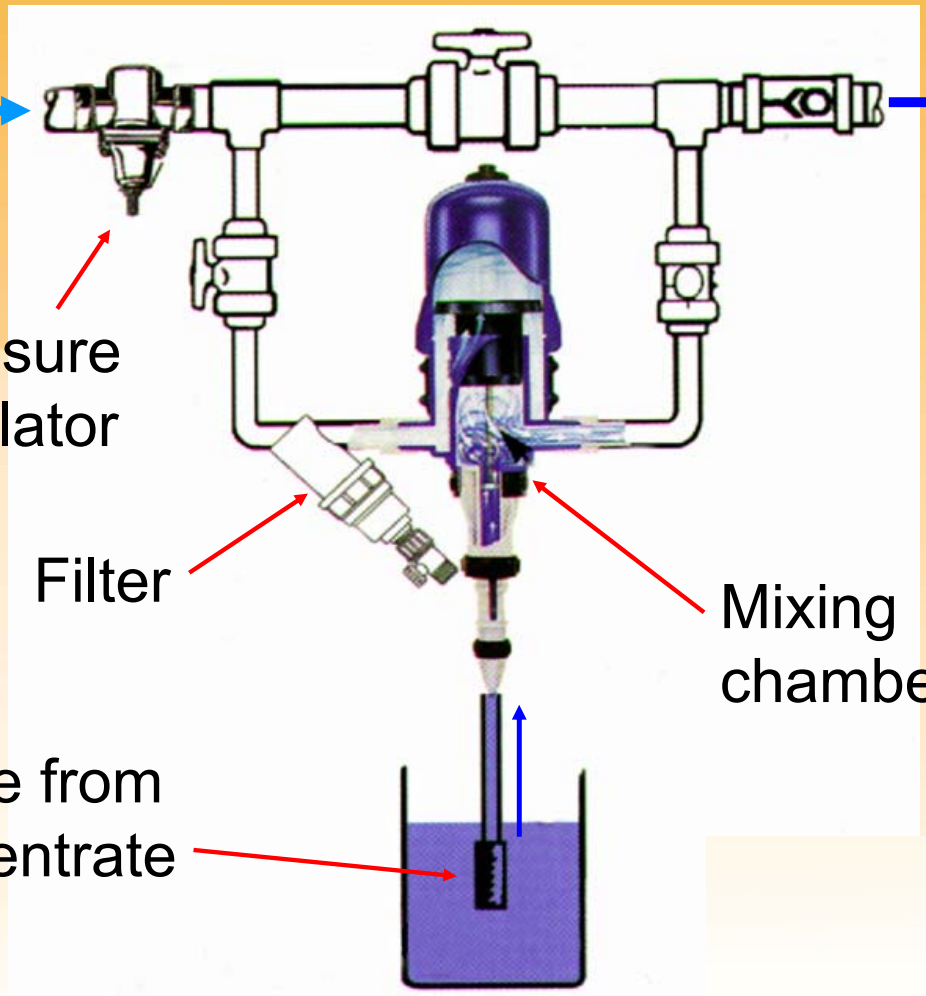
- Flowing water drives piston that pumps stock solution
  - No electricity used
- Rated with min. & max. flow rates depending on model
- Not affected by pressure changes (within range)

Positive Displacement Examples

- Dosatron® (variable)
  - 1:3000 to 1:4 ratios, 4.3-85 PSI
  - 0.04-14 GPM flow rate
  - Dosing proportional to water flow
  - Operates without electricity, using water pressure as the power source
  - http://www.dosatron.com


DOSATRON

Dosatron®


Intake water flow
Blended solution
Pressure regulator
Filter
Mixing chamber
Intake from concentrate tank

Positive Displacement Examples

- DosMatic®
  - 1:4000 to 1:10 ratios, 3-100 PSI
  - 0.4-45 GPM flow rate
  - Operates without electricity, using water pressure as the power source
  - http://hydrosystemsco.com/brands/volumetric-brands/dosmatic/
- Anderson®
  - http://www.heanderson.com/products.php
- Smith®
  - http://www.usgr.com/fertilization-feeding-injectors/smith-measuremix-injector.php

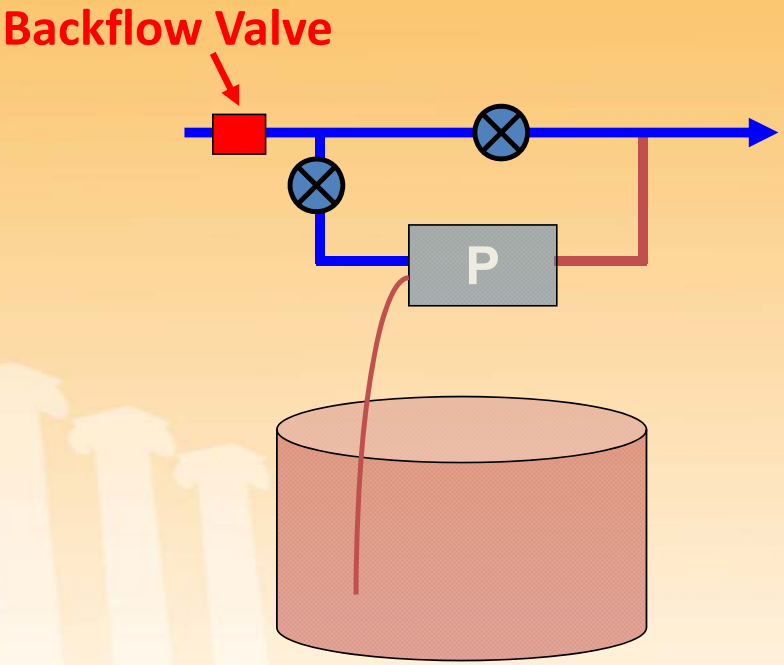
Proportioner Installation

By-pass line for clear water

Dual lines preferable

Backflow preventer

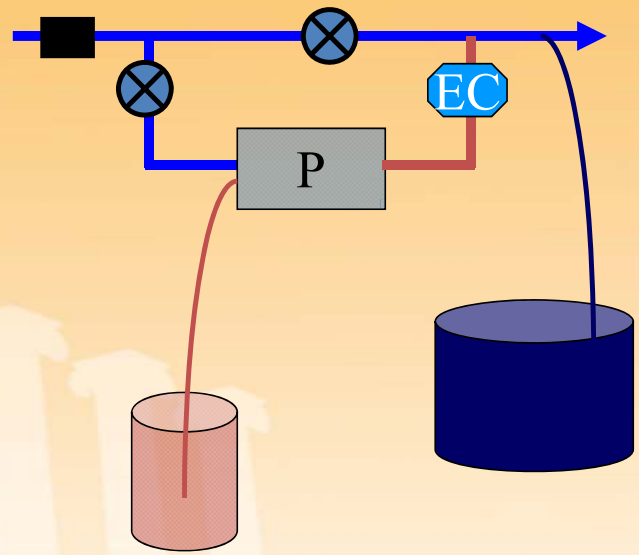
Siphoning from stock tanks



Proportioner Calibration

- Check frequently
- < 1:100 : volume uptake vs. volume output

- Measure EC of output solution
- In-line EC probe constantly monitors output



Checking Injector/Calculations

- Check accuracy with salts meter every time new batch of stock is mixed
- Fertilizer companies supply tables of EC values for each of their fertilizers at various concentrations

20-10-20 peat-lite special

- **200 ppm = EC of 1.30**
- **250 ppm = EC of 1.63**
- **300 ppm = EC of 1.95**

Reference: http://www.4oakton.com/proddetail.asp?parent=2&prod=352&seq=2&Totrec=13

Solubility of Selected Fertilizers

Solubility of Fertilizer in Pure Water, lbs./gal.	
Ammonium nitrate	9.8
Calcium nitrate	8.5
Potassium chloride	2.3
Potassium nitrate	1.1

- If two or more fertilizers are to be mixed in the same solution, test their combined solubility by first mixing them in 1-5 gallons of water

Reference: http://extension.uga.edu/publications/detail.cfm?number=B1130

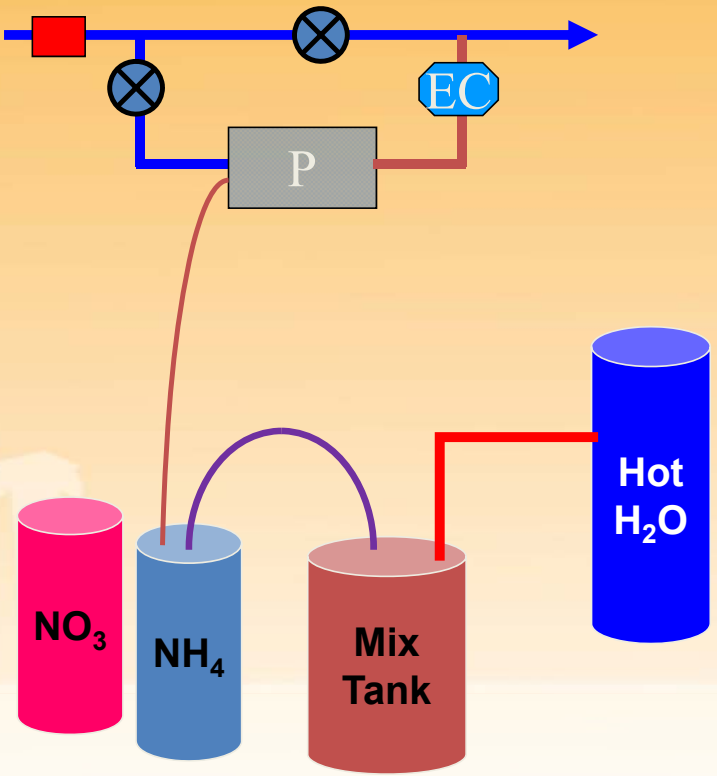
Stock Mixing

High quality, water soluble materials

Mix in separate tank - pump from another

Best to use warm water when mixing stock - increases solubility

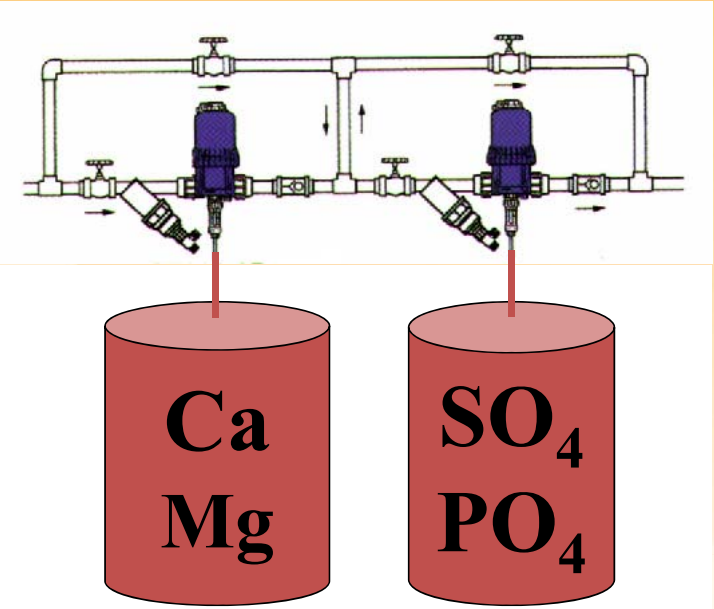
Use separate tanks for different fertilizers

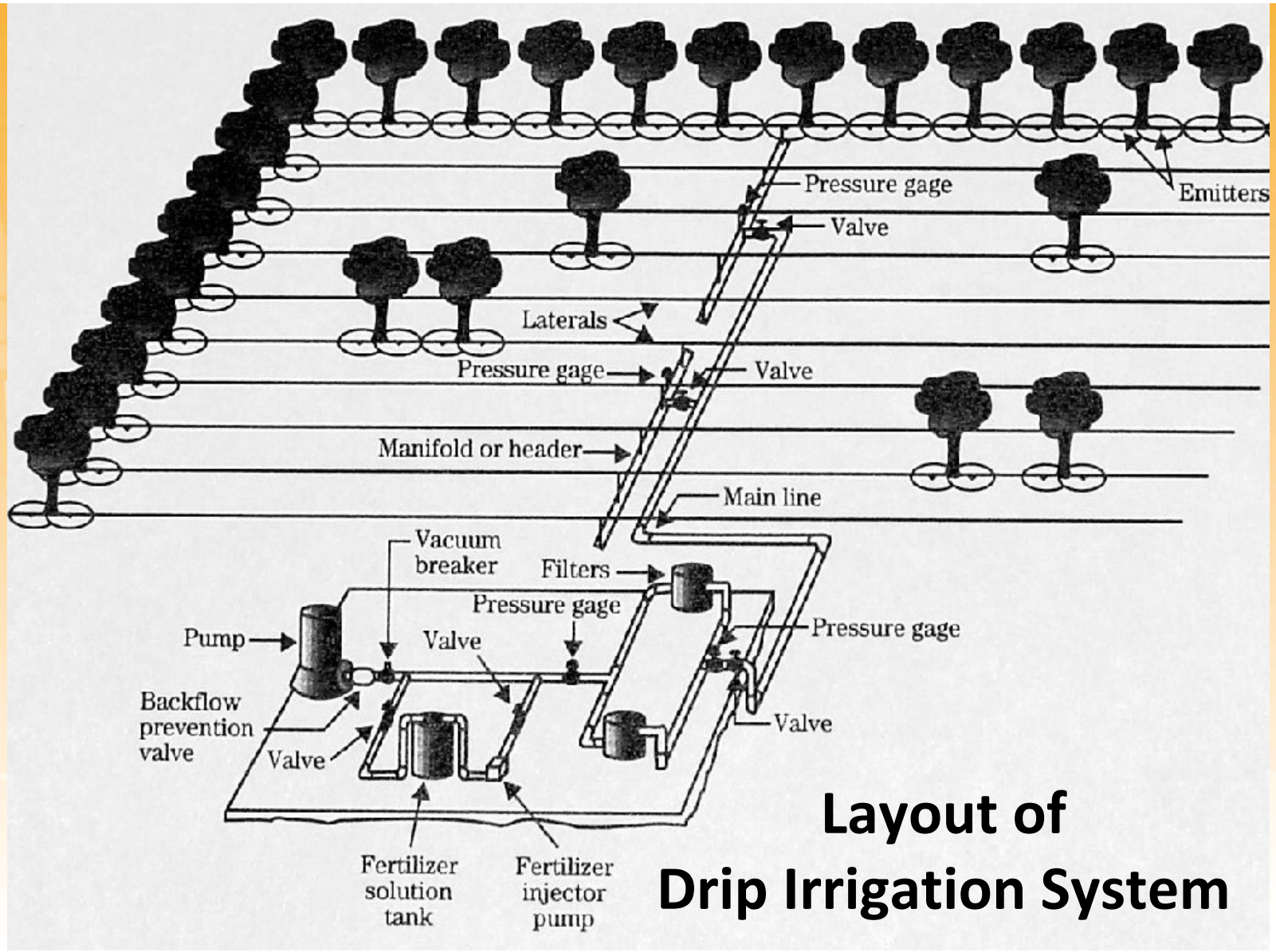


Stock Mixing Cautions

++ Ca & Mg vs SO_4 & PO_4 --

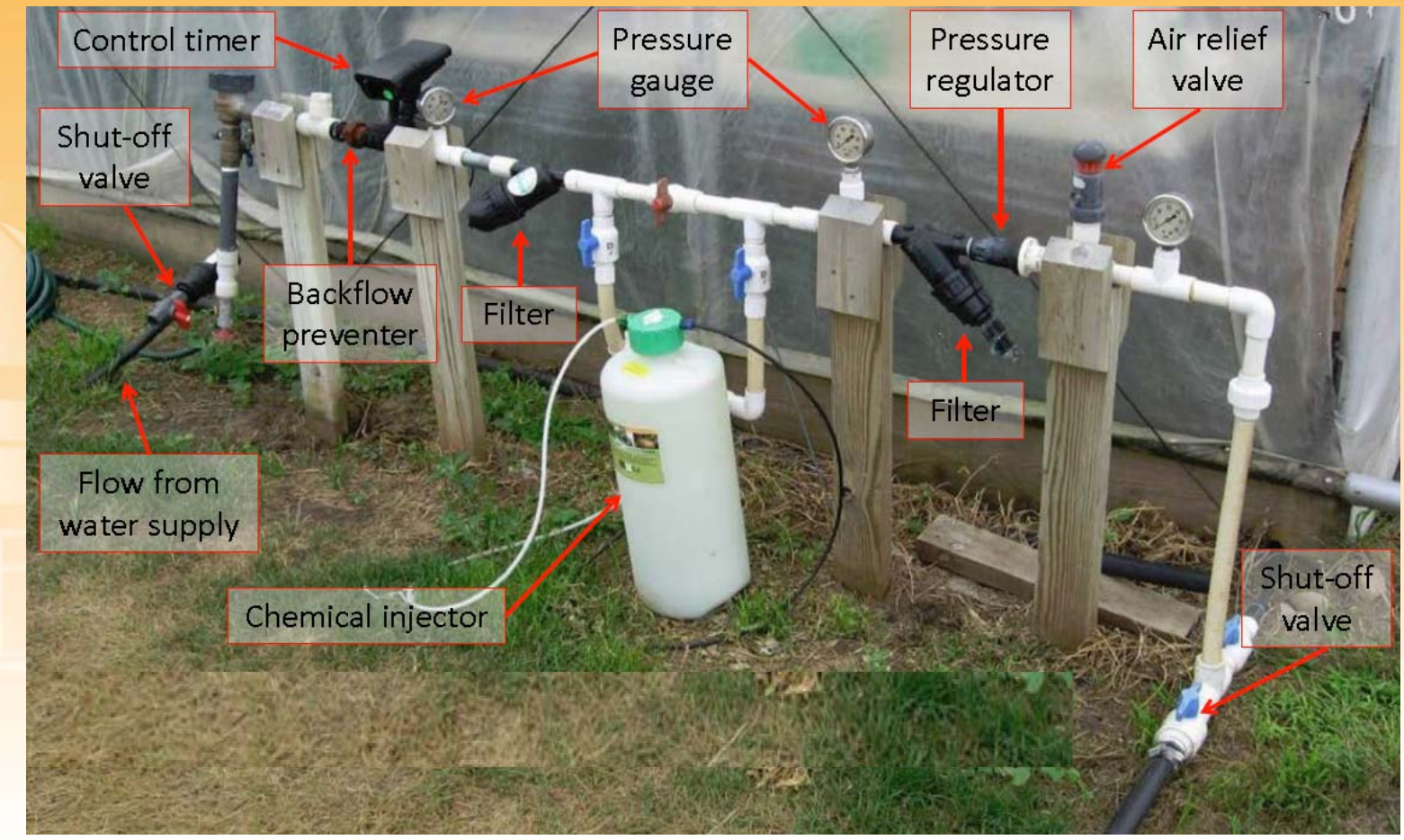
- High concentrations (>100:1) can cause precipitates
- Precipitates form sludge in tank bottom
- Use two injectors
- Use dual head injector





Layout of Drip Irrigation System

Drip Irrigation Control Assembly



Calculations

To determine amount of fertilizer to add to make stock solution:

$$\frac{\text{injector ratio (:1)}}{\text{\% element}} \times \frac{\text{desired ppm}}{100} \times 1.35$$

= ounces fertilizer/gallon stock

Calculations

How much fertilizer does one add to a 5 gallon bucket of stock to get 200 ppm N from a 20-10-20 fertilizer using a Hozon® injector (1:16)?

$$\frac{16}{20} \times \frac{200}{100} \times 1.35 =$$

$$0.8 \times 2.0 \times 1.35 = 2.16 \text{ oz/gal}$$

$$2.16 \text{ oz/gal} \times 5 \text{ gal} = \textbf{10.8 oz in bucket}$$

Calculations

How much fertilizer does one add to a 20 gallon tank of stock to get 250 ppm N from a 21-5-19 fertilizer using a Smith® injector (1:100)?

$$\frac{100}{21} \times \frac{250}{100} \times 1.35 =$$

$$4.76 \times 2.5 \times 1.35 = 16.1 \text{ oz/gal}$$

$$16.1 \text{ oz/gal} \times 20 \text{ gal} = 322 \text{ oz}$$

322 oz /16 oz per lb = **20.1 lbs fertilizer in tank**

Calculations

How much fertilizer do you add to a 50 gallon tank to get 200 ppm-N from a 15-0-15 fertilizer using a 1:100 injector?

2 bags +
45.5 gallons
water

Bags? (25 lbs each)

55.5 / 25 = 2+ bags

Set up proportion:

$$\frac{55 \text{ lbs}}{50 \text{ gal}} = \frac{50 \text{ lbs}}{X \text{ gal}}$$

55X = 2500

X = 45.45 gallons

Daily Operations

Which is easier, more efficient and more precise?

55.5 lbs in 50 gallons

2 - 25 lb bags

Weigh out 5.5 lbs from 3rd bag

Fill tank to 50 gal.

50 lbs in 45.5 gallons?

2 - 25 lb bags

Fill tank to 45.5 gal.

Less mess! No open bags!

Fertigation Tips [1]

- Get water supply tested (pH, alkalinity, TDS, etc.)
- Use vacuum breaker or backflow preventer to protect water supply
- Install the injector out of direct sunlight
  - Make sure stock tank is opaque and covered
- Install injector after the timer so tank does not stay under constant pressure
- Inject fertilizer two elbows ahead of the filter to ensure good mixing

Fertigation Tips 2

- Be sure fertilizer is 100% water-soluble
  - Make liquid concentrate first from water-soluble powders
  - Strain concentrate to remove undissolved granules
- Regularly check suction tube filter in stock tank for clogs and holes
- Completely pressurize the drip irrigation system before starting fertigation
- Regularly check the emitters for plugging and damage

Fertigation Tips 3

- Minimum injection duration of 45-60 minutes is recommended
- Maximum injection duration depends on soil type and nutrient and water requirements of the crop
  - A “reasonable” maximum should not exceed 2 hours per zone
- Always drain unit if there is a chance of freezing

Reference: www.ksre.ksu.edu/bookstore/pubs/mf1092.pdf

Final Thoughts

- Taking a plant from “seed to sale” involves proper fertilization
- Plan a reliable water supply
- Test water for problem minerals
- Match irrigation system to crop and time available; monitor soil moisture frequently
- Be prepared for the unexpected
- There are many ways to get the job done
- The best way is the one that works consistently for you


That’s a lot
to chew on!

Irrigation Resources on the Web

- Irrigation System Planning & Management Links
  extension.missouri.edu/webster/irrigation.aspx
- Ag Site Assessment Tool
  agsite.missouri.edu

Questions??

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  109 F. Whitten Hall, Columbia, MO 65211
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  130 Heinkel Bldg, Columbia, MO 65211

USDA

- Office of Civil Rights, Director
  Room 326-W, Whitten Building
  14th and Independence Ave., SW
  Washington, DC 20250-9410