Fertigation and Fertilizer Proportioning

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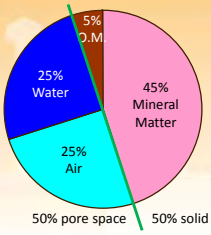
If you take care of your soil, the soil will take care of your plants.



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

- 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

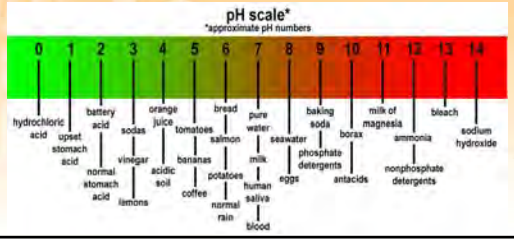
- Maximize profit by applying the right amount of water and fertilizer
- Minimize adverse environmental effects by reducing leaching of fertilizers and other chemicals

Nutrition Affected By

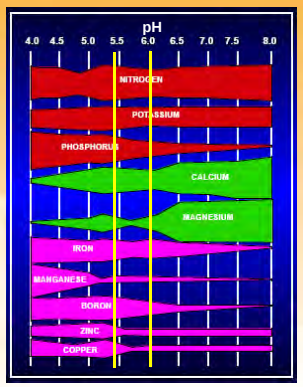
- Chemical considerations
  - **pH - water, fertilizer solution**
  - Alkalinity - water, fertilizer solution
  - EC - water, fertilizer solution
- Fertilizer analysis
  - Macronutrients, micronutrients
- Non-nutritional elements – possible toxicities
  - Na, Cl, F, Al

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

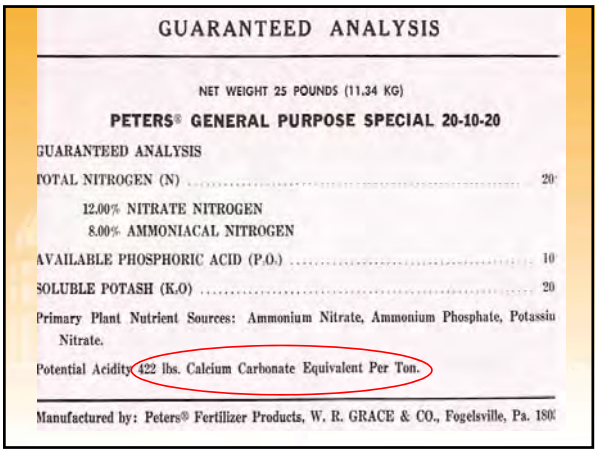
- Raise pH
  - Use fertilizer with lower acid residue
    - ammonium vs. nitrate
    - calcium compounds
  - Apply limestone
    - calcitic -- $CaCO_3$
    - dolomitic -- $CaMg(CO_3)_2$
    - hydrated -- $Ca(OH)_2$

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

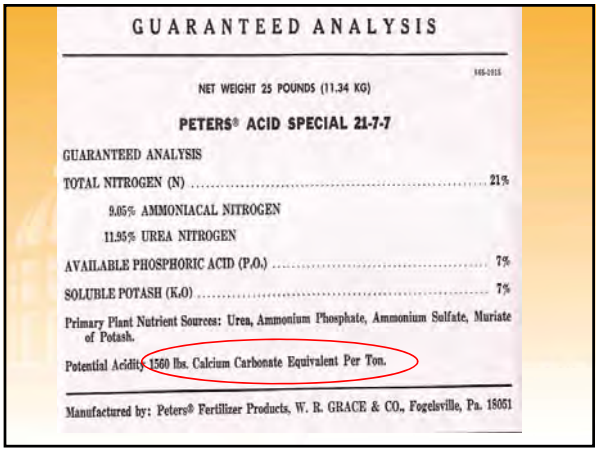
AVAILABLE PHOSPHORIC ACID (P2O5) 10

SOLUBLE POTASH (K2O) 20

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

Potential Acidity 422 lbs. Calcium Carbonate Equivalent Per Ton.

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



GUARANTEED ANALYSIS

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

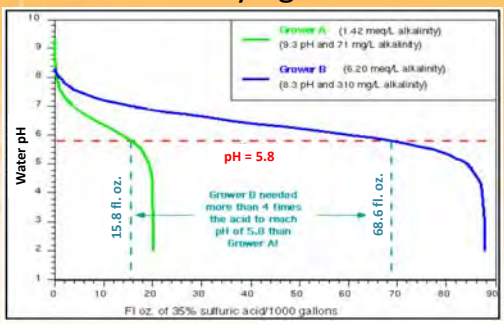
- Chemical considerations
  - – pH - water, fertilizer solution
  - – **Alkalinity - water, fertilizer solution**
  - – EC - water, fertilizer solution
- Fertilizer analysis
  - – Macronutrients, micronutrients
- Non-nutritional elements – possible toxicities
  - – Na, Cl, F, Al

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)
- 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

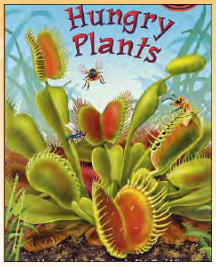
Factor	Moderate (ppm)*	Severe (ppm)*
Physical		
Suspended solids	50-100	>100
Chemical		
pH**	7.0-7.5	>7.5
Dissolved solids	500-2000	>2000
Manganese	0.1-1.5	>1.5
Iron	0.1-1.5	>1.5
Hardness***	150-300	>300
Hydrogen sulfide	0.5-2.0	>2.0

* 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

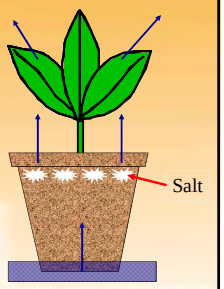
- Plastic encapsulated
  - Osmocote® (analysis varies)
  - 12-week to 9-month release
- Slowly soluble fertilizers
  - Mag-Amp®
- Sulfur-coated urea
  - Primarily for turf

Post-plant (Liquid)

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

Feeding Rates

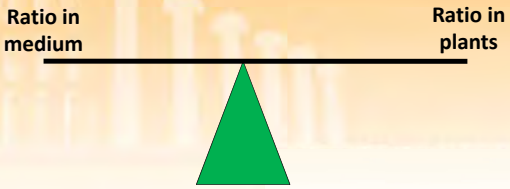
- Constant liquid feed
  - 250 ppm N (top)
  - 150 ppm N (sub)
- Periodic feeding
  - 500 ppm N weekly may top dress with Osmocote®
- Bedding plants
  - 150 - 250 ppm N as needed



Nutritional Monitoring

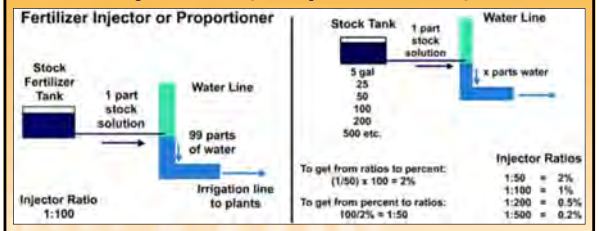
- Visual inspection
  - Too late
  - Symptoms = impaired growth
- Check "vital signs" of plant
  - pH and soluble salts
- Foliar (tissue) analysis
  - Once per crop (expensive)

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

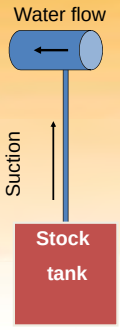
Conversions

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' D 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' D 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

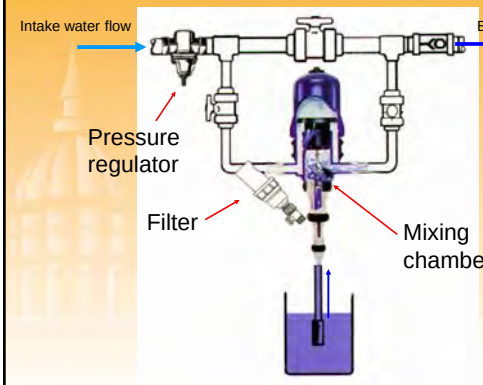
Positive Displacement

- 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®

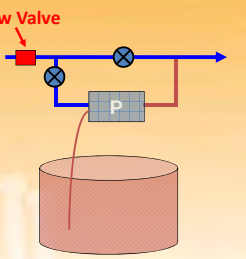


Positive Displacement Examples

- 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

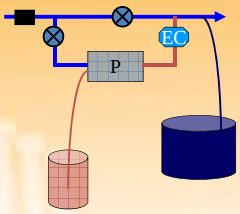
Proportioner Installation

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.4pakton.com/proddetail.asp?parent=2&prod=352&seq=2&Totrec=11

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

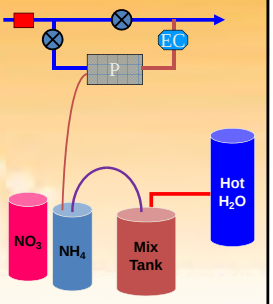
Stock Mixing

High quality, water soluble materials

Mix in separate tank - pump from another

Best to use warm water when mixing stock - increases solubility

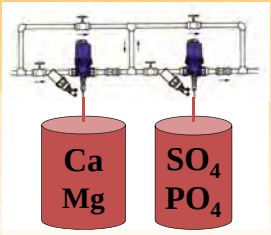
Use separate tanks for different fertilizers



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



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)?

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

$0.8 \times 2.0 \times 1.35 = 2.16$ oz/gal

2.16 oz/gal x 5 gal = 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)?

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

$4.76 \times 2.5 \times 1.35 = 16.1$ oz/gal

16.1 oz/gal x 20 gal = 322 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!

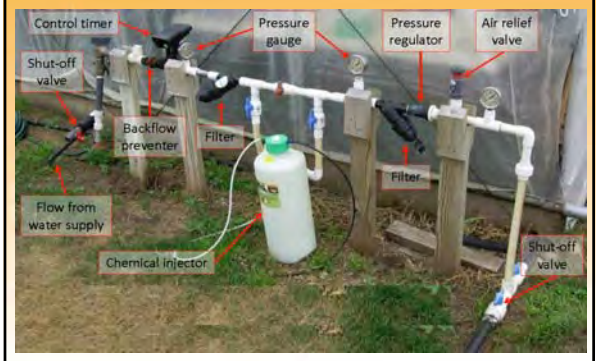
Fertigation Tips

- Get water supply tested (pH, alkalinity, TDS, etc.)
- Use backflow preventer if required
- 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
- Always drain unit if there is a chance of freezing
- Be sure fertilizer is 100% water-soluble
  - Make liquid concentrate first from water-soluble powders
  - Strain concentrate to remove undissolved granules

Fertigation Tips

- Regularly check suction tube filter in stock tank for clogs and holes
- 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

Drip Irrigation Control Assembly



Conclusion

- Taking a plant from "seed to sale" involves proper fertilization
- There are many ways to get the job done
- The best way is the one that works consistently for you

Questions??

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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

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