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

<table>
<thead>
<tr>
<th>Low pH</th>
<th>High pH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Toxic:</strong></td>
<td><strong>Deficient:</strong></td>
</tr>
<tr>
<td>• Iron</td>
<td>• Iron</td>
</tr>
<tr>
<td>• Manganese</td>
<td>• Manganese</td>
</tr>
<tr>
<td>• Zinc</td>
<td>• Zinc</td>
</tr>
<tr>
<td>• Copper</td>
<td>• Copper</td>
</tr>
<tr>
<td><strong>Deficient:</strong></td>
<td><strong>Deficient:</strong></td>
</tr>
<tr>
<td>• Calcium</td>
<td>• Calcium</td>
</tr>
<tr>
<td>• Magnesium</td>
<td>• Magnesium</td>
</tr>
<tr>
<td><strong>Sensitive:</strong></td>
<td><strong>Sensitive:</strong></td>
</tr>
<tr>
<td>• Ammonium-N</td>
<td>• Ammonium-N</td>
</tr>
</tbody>
</table>

- Low pH: pH levels below 5.0
- High pH: pH levels above 8.0
**pH Adjustment**

- **Raise pH**
  - Use fertilizer with lower acid residue
    - ammonium vs. nitrate
    - calcium compounds
  - Apply limestone
    - calcitic -- $\text{CaCO}_3$
    - dolomitic -- $\text{CaMg(CO}_3)_2$
    - hydrated -- $\text{Ca(OH)}_2$
**pH Adjustment**

- **Lower pH**
  - Use fertilizer with acid residue
  - Apply sulfur-containing compounds
    \[ \text{S} + \text{O}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4 \rightarrow 2 \text{H}^+ + \text{SO}_4^{2-} \]
    (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, Potassium Nitrate.

Potential Acidity **422 lbs. Calcium Carbonate Equivalent Per Ton.**

Manufactured by: Peters® Fertilizer Products, W. R. GRACE & CO., Fogelsville, Pa. 18061
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 (P₂O₅) .................................. 7%

SOLUBLE POTASH (K₂O) .................................................. 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

![Graph showing the influence of alkalinity on water pH](image)

- **Grower A**: (1.42 meq/L alkalinity) (9.3 pH and 71 mg/L alkalinity)
- **Grower B**: (6.20 meq/L alkalinity) (8.3 pH and 310 mg/L alkalinity)

**pH = 5.8**

Grower B needed more than 4 times the acid to reach pH of 5.8 than Grower A!

Reference: [www.ces.ncsu.edu/depts/hort/hil/hil-558.html](http://www.ces.ncsu.edu/depts/hort/hil/hil-558.html)
**Water Source Quality**

**Good**
- 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

**Poor**
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

Resources:
http://soilplantlab.missouri.edu/soil/water.aspx
https://utextension.tennessee.edu/publications/Documents/SP740-B.pdf
# Plugging Potential of Drip Irrigation Systems

<table>
<thead>
<tr>
<th>Factor</th>
<th>Moderate (ppm)*</th>
<th>Severe (ppm)*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspended solids</td>
<td>50-100</td>
<td>&gt;100</td>
</tr>
<tr>
<td><strong>Chemical</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH**</td>
<td>7.0-7.5</td>
<td>&gt;7.5</td>
</tr>
<tr>
<td>Dissolved solids</td>
<td>500-2000</td>
<td>&gt;2000</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.1-1.5</td>
<td>&gt;1.5</td>
</tr>
<tr>
<td>Iron</td>
<td>0.1-1.5</td>
<td>&gt;1.5</td>
</tr>
<tr>
<td>Hardness***</td>
<td>150-300</td>
<td>&gt;300</td>
</tr>
<tr>
<td>Hydrogen sulfide</td>
<td>0.5-2.0</td>
<td>&gt;2.0</td>
</tr>
</tbody>
</table>

* 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

Ratio in medium

Ratio in plants
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:
\[(1/50) \times 100 = 2\%\]

To get from percent to ratios:
\[100/2\% = 1:50\]

<table>
<thead>
<tr>
<th>Injector Ratios</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1:50</td>
<td>= 2.0%</td>
</tr>
<tr>
<td>1:100</td>
<td>= 1.0%</td>
</tr>
<tr>
<td>1:200</td>
<td>= 0.5%</td>
</tr>
<tr>
<td>1:500</td>
<td>= 0.2%</td>
</tr>
<tr>
<td>1:1000</td>
<td>= 0.1%</td>
</tr>
</tbody>
</table>
**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

Water flow: 

![Diagram](image)

Suction: 

Stock tank:
Estimating Stock Tank Size

- Gallon volume of square or rectangular tank
  \[= \text{Length} \times \text{Width} \times \text{Depth} \text{ in feet} \times 7.5\]
  - Example:
  \[6' \times 4'' \times 2.5' \times 7.5 = 450 \text{ gallons}\]

- Gallon volume of round tank (approximate)
  \[= \text{Diameter} \times \text{Diameter} \times \text{Depth} \text{ in feet} \times 6\]
  - Example:
  \[2' \times 2' \times 3' \times 6 = 72 \text{ gallons}\]
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](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
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
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](http://www.dosatron.com)
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

• Anderson®

• Smith®
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

Solubility of Selected Fertilizers

<table>
<thead>
<tr>
<th>Solubility of Fertilizer in Pure Water, lbs./gal.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium nitrate</td>
</tr>
<tr>
<td>Calcium nitrate</td>
</tr>
<tr>
<td>Potassium chloride</td>
</tr>
<tr>
<td>Potassium nitrate</td>
</tr>
</tbody>
</table>

- 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

- 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:

\[
\frac{\text{injector ratio}}{1} \times \frac{\% \text{ element}}{100} \times 1.35 = \text{ounces fertilizer/gallon stock}
\]
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)?

\[
\frac{16}{20} \times \frac{200}{100} \times 1.35 = 0.8 \times 2.0 \times 1.35 = 2.16 \text{ oz/gal}
\]

\[
2.16 \text{ oz/gal} \times 5 \text{ gal} = 10.8 \text{ oz in bucket}
\]
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)?

\[
\frac{100}{21} \times \frac{250}{100} \times 1.35 = 4.76 \times 2.5 \times 1.35 = 16.1 \text{ oz/gal}
\]

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

\[
322 \text{ oz} / 16 \text{ oz per lb} = 20.1 \text{ lbs fertilizer in tank}
\]
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?

Bags? (25 lbs each)

\[
\frac{55.5}{25} = 2 + \text{bags}
\]

Set up proportion:

\[
\frac{55 \text{ lbs}}{50 \text{ gal}} = \frac{50 \text{ lbs}}{X \text{ gal}}
\]

\[
55X = 2500
\]

\[
X = 45.45 \text{ gallons}
\]

2 bags + 45.5 gallons water
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

- Control timer
- Shut-off valve
- Backflow preventer
- Pressure gauge
- Pressure regulator
- Air relief valve
- Filter
- Flow from water supply
- Chemical injector
- Shut-off valve
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.

**Conclusion**
That’s a lot to chew on!
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Program Complaint Information
To file a program complaint you may contact any of the following:

University of Missouri
- MU Extension AA/EEO Office
  109 F. Whitten Hall, Columbia, MO 65211
- MU Human Resources Office
  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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