Fertigation Through Drip Irrigation Systems

by
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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”

• 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 substrate containing sphagnum peat moss, composted pine bark, vermiculite, and sand.
**Problems Associated With Improper pH**

<table>
<thead>
<tr>
<th>Low pH</th>
<th>High pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toxic:</td>
<td>Deficient:</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>Deficient:</td>
<td>Sensitive:</td>
</tr>
<tr>
<td>- Calcium</td>
<td>- Ammonium-N</td>
</tr>
<tr>
<td>- Magnesium</td>
<td></td>
</tr>
</tbody>
</table>

**pH Adjustment**

- **Raise pH**
  - Use fertilizer with lower acid residue
  - ammonium vs. nitrate
  - calcium compounds
  - Apply limestone
  - calcitic — CaCO₃
  - dolomitic — CaMg(CO₃)₂
  - hydrated — Ca(OH)₂

- **Lower pH**
  - Use fertilizer with acid residue
  - Apply sulfur-containing compounds
  - S + O₂ + H₂O → H₂SO₄ → 2 H⁺ + SO₄²⁻ (requires action of microbes)
  - Sulfuric acid

**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
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**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

**Influence of alkalinity on acidifying water**

Reference: 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 or <9 gpg)
- E. coli bacteria

**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>Physical Suspended solids</td>
<td>50-100</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Chemical 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
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**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-Am®
- 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®)

**Conversions**

To get from ratios to percent:

\[
\frac{1}{50} \times 100 = 2\% 
\]

To get from percent to ratios:

\[
\frac{100}{2\%} = 1:50 
\]

**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
  \[
  \text{Volume} = \text{Length} \times \text{Width} \times \text{Depth} \times 7.5 
  \]
- Example:
  \[
  6' \times 4' \times 2.5' \times 7.5 = 450 \text{ gallons} 
  \]
- Gallon volume of round tank (approximate)
  \[
  \text{Volume} = \pi \times \text{Diameter}^2 \times \text{Depth} \times 6 
  \]
- 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
  - [http://www.groworganic.com/siphon‐mixer‐injector.html](http://www.groworganic.com/siphon‐mixer‐injector.html)

- **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](http://ezfloinjection.com)

- **Add-It®**
  - 1:200 ratio, 10-80 PSI range
  - 0.5-20 GPM min. flow rate
  - Backflow preventer not included
  - [http://fertilizersuppliers.com/services/add‐it.htm](http://fertilizersuppliers.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](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](http://www.dosatron.com)

- 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

**Solubility of Selected Fertilizers**

<table>
<thead>
<tr>
<th>Solubility of Fertilizer in Pure Water, lbs./gal.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium nitrate</td>
<td>9.8</td>
</tr>
<tr>
<td>Calcium nitrate</td>
<td>8.5</td>
</tr>
<tr>
<td>Potassium chloride</td>
<td>2.3</td>
</tr>
<tr>
<td>Potassium nitrate</td>
<td>1.1</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

**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
Drip Irrigation Control Assembly

Calculations

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

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

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)?

\[
\begin{align*}
16 & \times 200 \\
20 & \times 100
\end{align*}
\]

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

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

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)?

\[
\begin{align*}
16.1 & \times 250 \\
100 & \times 100
\end{align*}
\]

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

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

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

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?

\[
\begin{align*}
55.5 & \times 25 = 2+ \text{ bags}
\end{align*}
\]

Bags? (25 lbs each)

\[
\begin{align*}
55 \text{ lbs} & = 50 \text{ lbs} \\
50 \text{ gal} & \times \text{X gal}
\end{align*}
\]

\[
55X = 2500
\]

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

Calculations
Daily Operations

Which is easier, more efficient and more precise?

- 55.5 lbs in 50 gallons
  - Fill tank to 45.5 gal.
  - Weigh out 5.5 lbs from 3rd bag

- 50 lbs in 45.5 gallons
  - Fill tank to 45.5 gal.
  - 2 - 25 lb bags

Less mess! No open bags!

Fertigation Tips

- 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

- 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

- 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


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