Hydroponics

NUTRIENT MANAGEMENT FOR HYDROPONICS
Nutrient Delivery is Controlled in Hydroponics

- No complex Soil Chemistry
- Controlled Nutrient Application
- Standard media behavior
- Less complex biological interactions
- The plant only gets what you give it
Fertilizer

- Premixed with Micronutrients
- or
- Individual Chemicals
Mixing Chemical by Chemical

- Specifically Tailored for your needs based on local water quality
- Should minimize waste and create the most idea nutrient solution for ideal plant growth
- More complicated and chances for errors
- More adaptable for nutrient adjustments
- Usually 2 or 3 Concentrate Tanks

# Example of using Elemental Fertilizers

## Table 1 & 2 - Pepper Formulation

<table>
<thead>
<tr>
<th>Element</th>
<th>Concentration (ppm)</th>
<th>Fertilizer Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO3-N</td>
<td>190</td>
<td>Calcium Nitrate</td>
</tr>
<tr>
<td>NH4-N</td>
<td>18</td>
<td>Calcium Nitrate/ Ammonium Nitrate</td>
</tr>
<tr>
<td>P</td>
<td>40</td>
<td>Monopotassium Phosphate</td>
</tr>
<tr>
<td>K</td>
<td>340</td>
<td>Monopotassium Phosphate/ Potassium Sulfate</td>
</tr>
<tr>
<td>Ca</td>
<td>170</td>
<td>Calcium Nitrate</td>
</tr>
<tr>
<td>Mg</td>
<td>50</td>
<td>Magnesium Sulfate</td>
</tr>
<tr>
<td>SO4</td>
<td>360</td>
<td>Potassium Sulfate/ Magnesium Sulfate</td>
</tr>
</tbody>
</table>

### Macronutrients

<table>
<thead>
<tr>
<th>Element</th>
<th>Concentration (ppm)</th>
<th>Fertilizer Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe</td>
<td>1.5-3.0</td>
<td>Iron Chelate (FeDTPA)</td>
</tr>
<tr>
<td>Mn</td>
<td>0.55</td>
<td>Manganese Sulfate/ Manganese Chelate</td>
</tr>
<tr>
<td>Zn</td>
<td>0.33</td>
<td>Zinc Sulfate/ Zinc Chelate</td>
</tr>
<tr>
<td>B</td>
<td>0.33</td>
<td>Boric Acid/Solubor</td>
</tr>
<tr>
<td>Cu</td>
<td>0.05</td>
<td>Copper Sulfate</td>
</tr>
<tr>
<td>Mo</td>
<td>0.05</td>
<td>Sodium or Ammonium Molybdate</td>
</tr>
</tbody>
</table>

http://www.howardresh.com/hydroponic-culture-peppers2.html
How do you know what and how much to of each fertilizer to use?

- Usually you send a water sample results to a company, who recommends a formula.
- There are programs.
- If you like chemistry, you can figure it out.

http://i.ytimg.com/vi/vYv9iu2NI3M/maxresdefault.jpg
Premixed

- Simple & Straight Forward
- Easier to make less mistakes
- Works Well but is not tailored to the Location
Fertilizer: Tank 1 - everything without nitrogen

Premixed Formula with Micronutrients

Magnesium Sulfate
Fertilizer: Tank 2 – Calcium Nitrate & Potassium Nitrate

Calcium Nitrate

Potassium Nitrate
Sample premixed formula for cucumbers

Analysis and Ingredients

<table>
<thead>
<tr>
<th>CHEM-GRO CUCUMBER FORMULA 8-16-36</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GUARANTEED ANALYSIS</strong></td>
</tr>
<tr>
<td>Total Nitrogen (N) ................. 8.00%</td>
</tr>
<tr>
<td>Nitrate Nitrogen .................. 7.00%</td>
</tr>
<tr>
<td>Ammoniacal Nitrogen ............... 1.00%</td>
</tr>
<tr>
<td>Available Phosphoric Acid (P2O5) ................................ 16.00%</td>
</tr>
<tr>
<td>Soluble Potash (K2O) .............. 36.00%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>TRACE ELEMENTS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Boron as (B) ....................... 0.05%</td>
</tr>
<tr>
<td>Copper as (Cu) ..................... 0.05%</td>
</tr>
<tr>
<td>Iron (Chelated) as (Fe) .......... 0.20%</td>
</tr>
<tr>
<td>Total Manganese as (Mn) .......... 0.10%</td>
</tr>
<tr>
<td>Soluble Manganese as (Mn) ....... 0.10%</td>
</tr>
<tr>
<td>Molybdenum (Mo) .................... 0.01%</td>
</tr>
<tr>
<td>Zinc (Zn) ......................... 0.05%</td>
</tr>
</tbody>
</table>

Derived From:
Potassium Nitrate, Potassium Phosphate, Ammonium Phosphate, Potassium Sulfate, Sodium Borate, Copper Sulfate, Iron DTPA, Molybdic Acid, Manganese Sulfate, & Zinc Sulfate.

Lettuce Fertilizer – Refilling the Stock Tanks

Mixing Instructions:

When the 30 gallon concentrate tanks are empty, **rinse and clean** them. Excess fertilizer can be placed in small buckets and distributed onto the gardens, even in the winter. It is better for the environment then dumping it down the drain. Certain fertilizers cannot be mixed together, so there are two tanks.
Weigh the fertilizers. Place the scale on a sold surface. Zero the scale with the empty bucket that will hold the fertilizer. You will need three clean buckets. Weigh each of the fertilizers into a separate bucket. Weigh out:

         9.3 lbs - Magnesium Sulfate - Epsom Salt (EpsoTop)

Tank B: 15 lbs – Calcium Nitrate (Calcinit)
Start filling Tank A with water. Once you have some water in the tank, add the Lettuce Chem-Gro. Stir VIGUROUSLY. Then add the Magnesium Sulfate. Stir VIGUROULY. It is important to get the fertilizers dissolved. Stir during the whole time that the water is filling. Don’t let the water get too high before you get the fertilizer all dissolved, since it can be hard to get it fully mixed without it sloshing the solution over the top, if the tank is nearly full. Top it off, as high as you can, while still being able to put the lid back on without overflowing the tank.

9.3 lbs - Magnesium Sulfate - Epsom Salt (EpsoTop)

Start filling Tank B with water. Once you have some water in the tank, add the Calcium Nitrate (Calcinit). Stir VIGUROULY. It is important to get the fertilizer dissolved. Stir during the whole time that the water is filling. Don’t let the water get too high before you get the fertilizer all dissolved. Top it off, as high as you can, while still being able to put the lid back on without overflowing the tank.

Tank B: 15 lbs – Calcium Nitrate (Calcinit)
Daily Testing

- Test EC
- Test pH
- Test 2-3 times a day on an NFT System, unless your systems automatic injection is very reliable, then less often.
- If your injectors are reliable on a Dutch bucket system; you can check once or twice a week or even less.

http://www.myronlmeters.com/v/vspfiles/photos/DH-UMII-6Pll-2T.jpg
**Recommended EC & PH**

- **LETTUCE** - EC should be 1700 µS (1.7 mS). The recommendation from Hydro-Gardens for the Lettuce Formula is a pH of 6.0-6.5. Other sources recommend a pH 5.5-5.8 in typical NFT systems.

- **TOMATO** - Test the water coming out of the spray stakes. It should come out at pH 6.2 and have an EC(conductance) of 1700 – 1900 µS.

- **CUCUMBER** - I have found that the European Cucumbers we grow are very vigorous and in order to prevent deficiencies and maximize production we need an EC of 2500 µS. The pH should be 6.4-6.7.
Electrical Conductivity (EC) mS

- Varies by formulation and crop
- Usually from 1500 – 2500 μS plus source water
  - Ex) Cucumbers like a high EC around 2500 μS
  - Ex) Lettuce and Tomatoes both like it around 1700 μS

http://kuvat.verkkokauppaan.fi/kuvat/213/t133199/truncheon.jpg
pH Testing

- Usually a pH of 5.5 to 6.5 in Hydroponics is fine (soil pH is often ideally higher)
- Different plants and solutions have different ideal target ranges
- Follow Label if you are using a premixed formula
- Check NFT Systems 2-3 times a day

What Can you test with?

- EC Meters, pH Meters, Combo Meters
- EC meters that can be calibrated
- EC Dip Sticks
- pH Color Chart Test Kits

https://4hydroponics.com/images/products/blueLabCombo.jpg
What is pH?

- pH is the measure of acidity/alkalinity of a solution.
- Specifically, pH is a measure of the hydronium ion H₃O⁺. It is based on a logarithmic scale from 0 to 14. "Pure" water has a pH of 7.0. If the pH is less than 7, the solution is acid. If the pH is greater than 7 it is alkaline. Because the scale is logarithmic and not linear, a pH of 6 indicates ten times more H protons than a pH of 7, and a pH of 5 indicates 10 times more protons than a pH of 6.

http://generalhydroponics.com/site/index.php/resources/qa/ph_dynamics_and_adjustment/
Why does pH matter?

- It affects nutrient availability

http://www.bghydro.com/media/wysiwyg/BGH/blog/no-stress-ph-tds/tdsp.gif
What can you use to adjust pH?

- Diluted Sulfuric Acid - Battery Acid – lower pH
- pH Down - Phosphoric Acid – lower pH
- PH Up - Potassium Hydroxide & Potassium Carbonate – raise pH
- Potassium Phosphate – raise pH
- Other acids and bases that don’t negatively effect the chemistry of the nutrient solution for the plants

http://www.powergrowsystems.com/media/catalog/product/cache/1/image/650x650/9df78eab33525d08d6e5fb8d27136e95/g/e/general_hydroponics_phkit.jpg
pH Considerations

- Fertilizers often contain buffering agent to lower pH so the nutrient solution will likely be lower pH than the source water.
- System with tanks can be pH adjusted in the solution tank.
- Systems with inline injectors may need the pH adjustment beforehand.
When the Acid Tank is out: Put on your safety goggles and rubber gloves. SAFETY FIRST! Add one container (blank) oz of Sulfuric Acid (Battery Acid) to a 5 gallon bucket of water. Mix gently. Put the lid on, when you move the bucket. One cup of the diluted acid solution should drop the system pH by .

1. Take it a little easy and test the main tank pH when adding acid from a new batch just in case it is a bit strong. The NFT system takes a little while to balance out after acid is added.
So what is EC anyway?

- PPM and EC meters measure the strength of a nutrient solution by measuring the flow of electrical current between two metallic probes. The higher the salt concentration in the nutrient solution, the better it conducts electricity.

- TDS (Total Dissolved Solids) is a measurement of the strength of a nutrient solution. It can be expressed in PPM (Parts Per Million) or EC (Electrical Conductivity), which states values in µS (MicroSiemens) or mS (MilliSiemens). PPM tends to be the most common in the United States while EC is more common internationally. PPM and EC meters measure nutrient strength in the same way with the same accuracy, but the readouts are displayed differently. For example, a nutrient solution that measures 1000 PPM on a TDS meter with a 0.7 conversion factor is the same strength as a solution that registers 1430 µS or 1.43 mS on an EC meter.

- Knowing your meter's conversion factor is also important when it comes time to calibrate it. Hanna calibration solutions are generally for meters with a 0.5 conversion factor while Genesis calibration solution is generally for meters with a 0.7 conversion factor.

Why does EC matter?

- It is the total amount of salts or essentially nutrients dissolved in the nutrient solution.
- EC doesn’t tell you how much of what nutrients you have in the water.
- EC affects the availability of nutrients and water to crops.
Tissue and Water Testing

- Helps you know if your nutrients are in normal range.
- Water Samples
  - Help you make needed adjustments to your formula
- Tissue Samples
  - Helps you see what the plants are taking up
  - Compare results to the range of sufficiency to see if you are within range
  - Ask you lab how they want you to collect and send in the sample: Usually you collect 10-15 of the newest mature leafs in a paper bag for each sample
How to read a Tissue Analysis?

- First of all send your sample to a lab to be tested for the important nutrients of concern.
- Then compare it to norms for the particular crop.
Plant Tissue Nutrient Sufficiency Ranges for Tomato

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Sufficiency Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (%)</td>
<td>3.5–5.0</td>
</tr>
<tr>
<td>P (%)</td>
<td>0.3–0.65</td>
</tr>
<tr>
<td>K (%) *</td>
<td>3.5–4.5; 2.8–4.0</td>
</tr>
<tr>
<td>Ca (%)</td>
<td>1.0–3.0</td>
</tr>
<tr>
<td>Mg (%)</td>
<td>0.35–1.0</td>
</tr>
<tr>
<td>S (%)</td>
<td>0.2–1.0</td>
</tr>
<tr>
<td>Fe (ppm)</td>
<td>50–300</td>
</tr>
<tr>
<td>Mn (ppm)</td>
<td>25–200</td>
</tr>
<tr>
<td>Zn (ppm)</td>
<td>18–80</td>
</tr>
<tr>
<td>Cu (ppm)</td>
<td>5–35</td>
</tr>
<tr>
<td>B (ppm)</td>
<td>30–75</td>
</tr>
</tbody>
</table>

* The sufficiency range for K changes depending on plant growth stage at the time of sampling. For tissue collected from seedlings (S), early growth (E) or plants in bloom (B), the target sufficiency range for K is 3.5–4.5%. For tissue collected from fruiting (F) or mature (M) plants, the target sufficiency range is 2.8–4.0%.

What do you do about the results?

- Fine tune your fertilizer use to bring your plant tissue tests within range.
- This is easier if you are mixing individual chemical fertilizers.
CO2 Supplementation

- A common fuel is propane
- General atmospheric CO2 is around 360-400 ppm
- Plant growth can be significantly improved from 700-1200 ppm CO2
- Over 1500 ppm CO2 is probably a waste, often over a 1000 ppm is a waste
- CO2 supplementation adds heat
- CO2 supplementation is best done when the vents are not opening (morning), when it is cool outside, and there is not yet solar gain pushing up greenhouse temperatures
Liebig's Law of the Minimum

A principle developed in agricultural science by Carl Sprengel (1828) and later popularized by Justus von Liebig. It states that growth is controlled not by the total amount of resources available, but by the scarcest resource (limiting factor).

http://en.wikipedia.org/wiki/Liebig%27s_law_of_the_minimum

http://upload.wikimedia.org/wikipedia/commons/thumb/1/1c/Minimum-Tonne.svg/640px-Minimum-Tonne.svg.png
CO2 can be depleted by plants, especially in the winter months when there are fewer air exchanges in the greenhouse.
Thanks for Coming!