# Organic Hydroponic Leafy Greens

*By Tyler Baras*

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*NOTE: This handbook is based on my personal growing experience and observations from fellow organic hydroponic growers. The best management practices for organic hydroponic production are still evolving and this handbook will be updated accordingly. If you find this book helpful, you might enjoy my full-length leafy greens book available through Hort Americas. Date of last revision: 4/13/2018*

## *About*

This handbook was created to help prospective and current organic hydroponic growers primarily focused on organic recirculating hydroponic production of leafy greens. Growing an organic crop is generally more difficult. There is less research available and less experience to draw from within the hydroponic industry. Many of the organic hydroponic growers do not have many years of experience and they are learning by doing. Learning by doing is great but it usually means there are some mistakes along the way and mistakes in commercial hydroponics can be very expensive. This handbook will hopefully help new organic hydroponic growers avoid some of these expensive mistakes. It should be noted that the increased difficulty in growing organically may not translate into an increased price for your crop. Most growers struggle to significantly increase the price of their product to justify increased expense of organic production. Growing organically may make it easier to sell the product but the unit price may not increase enough to justify the change.

# System Selection & Design

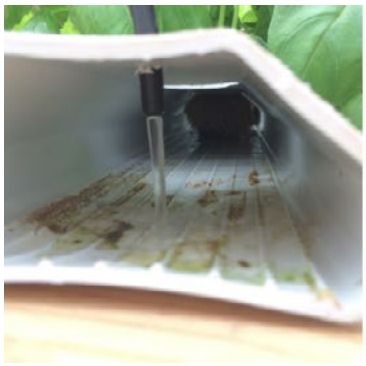
In the Hort Americas Texas demonstration greenhouse we ran organic fertilizers in our NFT system, small floating raft ponds, flood & drain grow racks and vertical towers. The best performing organic hydroponic system so far has been NFT but the floating raft systems are a close second. I believe organic hydroponic floating rafts could perform just as well as NFT with some additional tweaking. The big issue with organic floating raft systems is the large volume of water required which increases the fertilizer expense. In conventional hydroponics it is possible to precisely adjust the nutrients using a variety of inputs, this minimizes the need to dump out nutrient solution. In organic hydroponics there are less options for inputs and growers may need to dump their nutrient solution more frequently as nutrients accumulate past acceptable levels. In the Texas demo greenhouse we ran an organic floating raft pond for 10 months and we actually saw improvements in growth as the nutrient solution aged and accumulated nutrients. In my experience I've found the key to increasing the usable life of an organic nutrient solution is keeping the fertilizer concentration low. It is difficult to predict the flushing frequency for an organic hydroponic system as it depends on a lot of management decisions.

Some growers have success converting from conventional to organic hydroponics by simply switching to an organic substrate and fertilizer, but, there are several system modifications that can make it easier to grow with organic inputs. Below are a few suggested modifications to traditional systems for conversion to organics.

# *System*

## Nutrient Film Technique (NFT)

- Increase the flow rate per channel up to 1 L/minute (or higher, I've observed up to 2.5 L/minute)
- Use 2 or 3 feed lines per channel to protect plants from clogged feed lines
- Increase slope to avoid stagnation
- Switch to ¼", 5/16", or larger feed lines. Some systems come with smaller feed lines and they are more likely to clog with organic matter
- Channel plug hole size may need to be modified for organic plugs
- Depending on substrate selection it may be beneficial to set irrigation on a timer to avoid oversaturation



## Deep Water Culture (DWC) Floating Rafts

-Raft plant sites may need to be modified to fit some of the larger organic plugs
-Depending on substrate it might be better to place plugs higher in raft plant sites so they are not sitting in nutrient solution. I like to keep the bottom of the seedling about ¼"-½" above the surface of the nutrient solution. Young seedlings will require the growers attention to make sure they don't dry out after transplant before they have a chance to grow roots into the nutrient solution.

## Vertical Towers

- Use 2 or 3 feed lines per channel to protect plants from clogged feed lines
- Switch to ¼", 5/16", or larger feed lines to help reduce clogs

## Flood & Drain

- Organic substrates often hold more moisture than conventional substrates and irrigation frequency may need to be adjusted to avoid overwatering

## Media Bed

Media beds are one of the easiest systems for organic hydroponics as it has a lot of surface area for microbial activity and the media bed acts as a filter. Media beds are rarely used for commercial applications because they eventually accumulate too much organic matter (plant roots, leaves and fertilizer deposits) and need cleaning which can be messy and labor intensive. A small media bed works well as an addition to NFT or DWC so it can act as a filter for the rest of the system. Media beds are often used in aquaponic system designs.

## *Filtration*

- On all of the systems besides floating rafts it is generally beneficial to add a filter on the return line to avoid accumulating organic matter in the reservoir
- Filters can be as simple as cheesecloth or pantyhoes on smaller systems but larger systems may want to invest in a robust filtration system
- Check filters frequently

## *Aeration*

- Target a dissolved oxygen (D.O.) level of at least 6 ppm, ideally closer to 15 ppm.
- Don't use airstones & air pumps. Airstones tend to accumulate biofilms
- Do use venturis for aeration by either adding small submersible pump with venturi attachment directly to reservoir or add inline venturi to main irrigation line

- Cascades in NFT can help with aeration in NFT but I still like adding a small submersible pump with venturi attachment to reservoir in NFT system
- Aeration with ozone is popular in conventional hydroponics but I've not seen it used in organics. I'd be worried about harming beneficial microbial population but there may be a way to strategically use it in organic hydroponics
- Aeration with compressed oxygen has shown good results in conventional hydroponics but I've not seen it in organic hydroponics. A nanobubble injector (ex. Moleaer) combined with compressed oxygen tanks can easily raise the D.O. to 15 ppm or higher.

# Nutrient Solution

## *Water Source*

Please do not start a hydroponic farm without sending out a water sample for analysis. If your source water is far out of the acceptable range it may be necessary to use expensive filtration systems and it is best to include these systems in your budget before you start growing!

## *Fertilizer Selection*

During the last couple years in the demo greenhouse I've been able to trial many organic fertilizer options and although some options delivered good results, none of the other options delivered positive results as consistently as Pre-Empt. If and when better options become available I plan on sharing any information I can to fellow growers for there is little room for failure in leafy greens production.

Most of the organic hydroponic fertilizers that I have used successfully have been plant based meaning there are no animal derived inputs like bone meal or manure. The plant based fertilizers have a lower tendency of turning rancid in the reservoir.

### Guaranteed Analysis for Pre-Empt

**Guaranteed Analysis:**

| | |
|---|---|
| Calcium (Ca) | 0.02% |
| Magnesium (Mg) | 0.02% |
| Iron (Fe) | 0.01% |
| Manganese (Mn) | 0.01% |
| Zinc (Zn) | 0.01% |
| Boron (B) | 0.002% |

Derived from fermented sugarcane molasses.

**Non-Plant Food Ingredients:**

| | |
|---|---|
| Molasses | 25.00% |

*Derived from fermented sugarcane molasses.*

**Purpose: To increase microbial activity and enhance nutrient uptake.**

## pH Management

There are a few strategies for managing pH in organic systems. Some growers, including myself, simply don't manage pH and let it stabilize over time. This works with most water sources but I've worked with growers where this is not an option due to crazy pH swings. The pH swings are usually seen in nutrient solutions with low to no alkalinity (like reverse osmosis water), no inoculants or sudden large fertilizer doses. When managing pH is a necessity growers often use sodium bicarbonate (pH up), calcium carbonate (pH up), citric acid (pH down), and acetic acid/vinegar (pH down). Most organic hydroponic growers that need to adjust their pH have problems with the nutrient solution be too acidic so they need a base to raise the pH. Potassium bicarbonate would be a great option and it is allowed in organic production, but the organic protocols only permit its use for disease management. Sodium bicarbonate is not ideal because it adds sodium reducing the usable life of a nutrient solution before too much sodium accumulates. Calcium carbonate has poor solubility and isn't technically permitted for pH management but it is allowed as a calcium supplement.

## Water Temperature

Water temperature in organic hydroponics influences both plant growth and microbial activity. I prefer to run my organic hydroponic systems a little warmer than a conventional hydroponic system. In conventional systems I target 65-75 F depending on crop. In organic systems I prefer 70-78 F. I've had more issues growing in nutrient solutions that are too cold compared to nutrient solutions that are too warm.

## Inoculants

Inoculants is a very broad term for beneficial microorganisms that can be added to the nutrient solution. It is possible to grow in both traditional and organic nutrient solutions without any inoculants but I've found

this can make the crop more susceptible to root diseases. Originally I just used inoculants for preventative disease management but I heard from some fellow organic hydroponic growers that they were seeing huge benefits in biofilm management when adding inoculants. I tried a few different inoculants that advertised biofilm control and the top performer was TerraBella. TerraBella controls biofilms and contained microbes similar to those I'd used previously for disease management. Many conventional hydroponic farms use UV or ozone systems for disease management but I've not seen these used in organic hydroponics. I'd be worried about harming beneficial microbial population using these techniques.

**TABLE 1: Partial list of microorganisms present in TerraBella®**

| Process | Microbe | Specific activity |
|---|---|---|
| Nitrogen utilization | *Azotobacter vinelandii* | N fixation |
| | *Clostridium pasteurianum* | N fixation |
| | *Rhizobium ssp.* | N fixation |
| | *Azospirillum brasilense* | N fixation |
| | *Nitrosomonas spp.* | nitrification, denitrification |
| | *Nitrococcus spp.* | nitrification, denitrification |
| | *Nitrobacter spp.* | nitrification |
| Phosphorous utilization | *Micrococcus spp.* | P mobilization |
| | *Pseudomonas spp.* | P mobilization |
| Other | *Bacillus spp.* | Plant disease and pest control |
| | *Trichoderma spp.** | Plant disease resistance, pathogenic fungi suppression |
| | *Streptomyces sp* | Pathogenic fungi suppression |

* Fungal organism. All other organisms are bacterial.

## *Starting and Managing Nutrient Solution Reservoir with Pre-Empt and Terra Bella*

1. Prepare your inoculant.

    a. Fill a 5 gallon bucket with water and add 1 oz molasses. Let water sit for 24 hours to remove chlorine (unless using RO or distilled water). Add 2 oz. of TerraBella and let sit for 24 hours before adding to reservoir. This 5 gallon bucket can inoculate 300 gallons of nutrient solution.

2. Start a new system at a low fertilizer rate while establishing microbial population.

    a. First week bring reservoir to ¼ strength (~7.5 mL/gallon Pre-Empt). Add TerraBella at full strength.

    b. Second week bring reservoir to ½ strength (total of 15 mL/gallon Pre-Empt).

c. Third week add TerraBella at full strength. The pH should start to stabilize around this point if not using additional products for pH management.

3. Add TerraBella every two weeks for the first two months. Some growers reduce the frequency of TerraBella additions after the first two months, cutting back to once every month or month and a half.

4. After the first few weeks slowly bring up the EC to full strength. Some growers target an EC of 1.2-1.4 (with a source water EC of 0.3). I personally have not seen significant improvements in growth rate when I raise the EC up from 0.9 up to 1.4, but I do see an increase in biofilm development and pH swings. I'd recommend keeping the EC low to keep system stable but if plants are showing deficiencies it may be necessary to increase fertilizer rate. When adding fertilizer it is best to spread out the additions over several days instead of giving large fertilizer doses. Large fertilizer additions can lead to intense pH swings.

5. The flushing frequency will depend on growing environment, system, water source, and fertilizer rate. In general, using a water source with a very low EC and keeping the fertilizer rate low will help extend the life of the reservoir. Some growers flush their system once every 4-5 months and some growers flush every two weeks. The cost to build a reservoir with Pre-Empt may be up to 100x more expensive than conventional fertilizers so it is very important to reduce the frequency of flushes.

## Water Tests & Flushing

The nutrient levels in an organic hydroponic system usually shock traditional hydroponic growers (see Appendix for example nutrient solution analysis results). The nutrient levels measured in traditional water tests are drastically lower than the levels in traditional nutrient solutions. I remember when I saw my first nutrient solution analysis from an aquaponic system and I couldn't believe plants were growing in nutrient levels so low. Organic nutrient solutions usually have slightly higher nutrient levels but still they may be half or less than the traditionally recommended nutrient levels. I've seen butterhead lettuce grow well in an organic nutrient solution that only measured 10 ppm nitrogen… the standard recommendation for butterhead lettuce is 150-200 ppm nitrogen. Do not be shocked by the numbers but do keep track of them! Send out water tests to labs like Quality Analytics Lab (QAL), Ward, or Midwest Laboratories. Get a standard hydroponic fertilizer analysis (liquid analysis not analysis of dry fertilizer). Use water tests as a way to determine when a system needs a partial or full system flush. Generally organic growers need to flush, or partially flush, due to an accumulation of sulfur, sodium and/or chloride. Sulfur over 100 ppm can sometimes affect plants ability to access other nutrients and plants may show a general chlorosis (yellowing) of whole plant. When sodium and chloride cumulatively are over 100 ppm then it's not uncommon to start seeing some necrosis (death) on leaf edges. These thresholds were developed from my personal experience and should not be considered absolute.

## Optional Amendments

***Calcium Carbonate*** - One of the few organic certified bases for raising pH. It is not technically listed in OMRI for pH management but it is approved as a fertilizer input. Calcium carbonate has poor solubility.

***Calcium Chloride*** - The primary ingredient in a lot of organic calcium fertilizers. I prefer to use a calcium source that does not include chloride so I can reduce potential of harmful chloride accumulation.

***Calcium Sulfate*** - Solution grade calcium sulfate (gypsum) is one of the most popular amendments for Pre-

Empt. One pound per 1000 US gallons (0.45 g / gal) increases calcium by 26.96 ppm and sulfur by 21.57 ppm. Many organic hydroponic growers have had good results with calcium levels around 100-150 ppm.

***Diatomaceous Earth*** - Can be used as a silica source but it has poor solubility.

***Magnesium Sulfate*** - Can be used as a magnesium source if farm has documented records of magnesium deficiency.

***Potassium Bicarbonate*** - Potassium bicarbonate is allowed in organic production and it would be great for pH management but the organic protocols only permit its use in disease management.

***Potassium Sulfate*** - Good source of organic potassium.

***Sodium Bicarbonate*** - One of the few bases that can be used for pH management but it can contribute to sodium accumulation which will force growers to flush system more frequently.

***Sodium Nitrate*** - Popular option for adding organic nitrate nitrogen.

| **Product** | **OMRI** |
|---|---|
| Kimitec Bombardier | YES |
| Kimitec Caos | YES |
| Kimitec Espartan | YES |
| Kimitec Tundamix | YES |
| Diamond K Solution Grade Gypsum | YES |
| Diamond K Solution Grade KMS Potassium Magnesium Sulfate 0-0-21.5 | YES |
| Diamond K Solution Grade Ultra Fines Sulfate of Potash 0-0-50 | YES |
| Monterey Magnesium Sulfate | YES |
| SaferGro Biomin Boron | YES |
| SaferGro Biomin Cal-Boro | YES |
| SaferGro Biomin Calcium | YES |
| SaferGro Biomin Copper | YES |
| SaferGro Biomin Iron | YES |
| SaferGro Biomin Magnesium | YES |
| SaferGro Biomin Manganese | YES |
| SaferGro Biomin Zinc | YES |

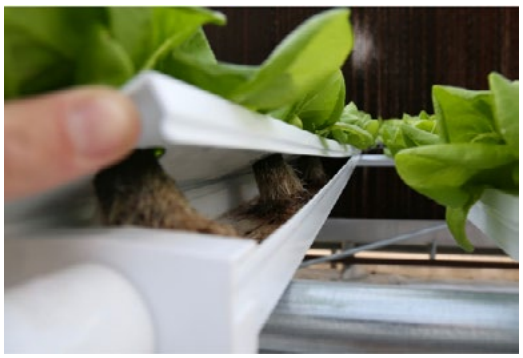
# Substrate

There are limited organic substrate options that are appropriate for hydroponics. 'Digging' into organic substrates will extend this short organic hydroponics manual by a lot, this is just a few notes.

***Net Pots*** - Reusable plastic pots are expensive and add labor to clean and reuse after harvest. Sometimes the net pots are sold with the crop (living plant) but that generally greatly increases cost per plant compared to other substrate options.

***Open Bottom Wraps*** - Can be very price competitive compared to other substrate options but generally requires more filtration in hydroponic system. Open bottom wraps have been used successfully by several organic NFT farms.

***Closed Bottom Wraps*** - More appropriate for use in a wide variety of hydroponic systems compared to open bottom wraps. Minimal particulates enter system from plugs and usually extra filtration is not necessary.



***Loose Mix*** - A loose mix may include coco fibers, coco pith, peat, perlite and/or wood fiber. A light quick draining mix generally works best. Using a loose mix in an organic hydroponic system will usually require extra filtration to avoid clogging irrigation lines. Sometimes seedlings need to remain in propagation longer when started in a loose mix to ensure the roots hold the mix together before transplant into the main system (to minimize release of particulates into system).

***Hemp Mat*** - One of the only organic microgreen substrate options that is suitable for recirculating hydroponics. Some growers use loose coco in a 10x20 tray but don't recirculate. Some growers use loose organic substrates for microgreens and they recirculate, but they add a lot of filtration to handle particulates.

## *Common Problems*

Poor root growth in lower half of plug often due to oversaturation. When plugs are overwatered the roots try to escape from the top half of the plug. Allow plugs to dry out between irrigations encouraging roots to grow downward using the full plug.

This seedling (right) has not developed sufficient roots to hold the loose substrate mix together when the seedling is transplanted into a hydroponic system. Growers can try giving their seedlings more light, adjusting irrigation frequency, changing the number of seeds per plug, changing plug size… there is a long list of potential fixes to this problem. Some growers prefer to avoid loose mixes altogether but other plug options are often more expensive.

Some organic 'sludge' is normal in organic hydroponic systems but too much can be a problem. Start a system slowly, gradually adding fertilizer over a couple weeks while building the microbial population with the addition of inoculants. Keeping the EC low will help reduce 'sludge' buildup but I generally find the greatest contributor to irrigation line clogs is substrate particulates, not fertilizers.

# Appendix

**Example Nutrient Solution Analysis Results from Hort Americas Texas Demo Greenhouse:**

*Nutrients in ppm*

| Nutrient | DWC 5/4/17 Conventional | NFT 5/4/17 Organic | NFT 6/12/17 Organic | DWC 5/4/17 Organic | DWC 6/12/17 Organic |
|---|---|---|---|---|---|
| NO3-N | 214.38 | 35.76 | 16.57 | 71.12 | 28.38 |
| NH4-N | Not Detectable | 34.27 | 5.35 | 36.68 | 6.80 |
| P | 73.52 | 34.21 | 70.22 | 64.77 | 56.37 |
| K | 222.35 | 112.69 | 34.61 | 174.81 | 76.46 |
| Ca | 275.28 | 30.49 | 70.54 | 50.73 | 50.47 |
| Mg | 69.44 | 7.27 | 9.27 | 11.83 | 10.41 |
| S | 101.01 | 27.68 | 40.92 | 39.62 | 46.20 |
| Fe | 2.11 | 1.40 | 3.50 | 3.10 | 2.75 |
| Mn | 0.76 | 0.07 | 2.30 | 1.71 | 1.10 |
| B | 0.78 | 0.32 | 0.55 | 0.51 | 0.49 |
| Cu | 0.50 | 0.65 | 1.43 | 1.17 | 1.19 |
| Zn | 1.08 | 0.72 | 1.58 | 1.39 | 1.35 |
| Mo | 0.19 | 0.03 | 0.01 | 0.06 | 0.02 |
| Na | 36.28 | 25.24 | 44.29 | 36.25 | 49.25 |
| Al | 0.16 | 0.06 | 0.37 | 0.13 | 0.28 |
| Cl | 36.00 | 43.00 | 50.00 | 56.00 | 59.00 |
| Si | 3.84 | 2.04 | 3.41 | 3.29 | 3.78 |
| pH | 5.74 | 7.09 | 4.07 | 5.31 | 3.61 |
| EC | 2.63 | 0.94 | 0.75 | 1.34 | 0.89 |

## Pre-Empt Fertilizer Analysis

There is variability in nearly all organic hydroponic fertilizers and it is possible that a batch may perform differently than previous batches. This variability is generally minimal enough that growers do not need to adjust practices. Below are the fertilizer analysis results of Pre-Empt over three years.

### *Nutrients in ppm*

| **Date** | **12/11/2017** | **11/29/2016** | **10/29/2015** |
|---|---|---|---|
| LAB | QAL | QAL | QAL |
| NO3-N | 7,903.78 | 6,698.20 | 10,317.00 |
| NH4-N | 4,307.75 | 3,776.50 | 3,037.10 |
| P | 8,428.26 | 7,920.22 | 7,770.81 |
| K | 20,831.39 | 20,083.41 | 21,573.95 |
| Ca | 1,731.15 | 1,686.38 | 3,106.53 |
| Mg | 660.28 | 543.91 | 2,104.61 |
| S | 846.87 | 866.63 | 2,142.68 |
| Fe | 355.97 | 332.27 | 354.32 |
| Mn | 326.70 | 291.09 | 294.56 |
| B | 51.77 | 52.39 | 58.94 |
| Cu | 141.86 | 134.40 | 150.73 |
| Zn | 145.59 | 145.64 | 155.85 |
| Mo | 6.11 | 9.26 | 7.98 |
| Na | 466.51 | 442.93 | 670.73 |
| Al | 3.57 | 7.80 | 13.63 |
| Cl | 1,040.00 | 1,100.00 | 840.00 |
| Si | 35.83 | 42.30 | 52.70 |
| pH | 3.90 | 4.19 | 4.41 |
| EC | 116.00 | 103.00 | 142.00 |

## Organic Matter in Pre-Empt

Organic Matter: 5.41 %

## Fulvic & Humic Acid in Pre-Empt

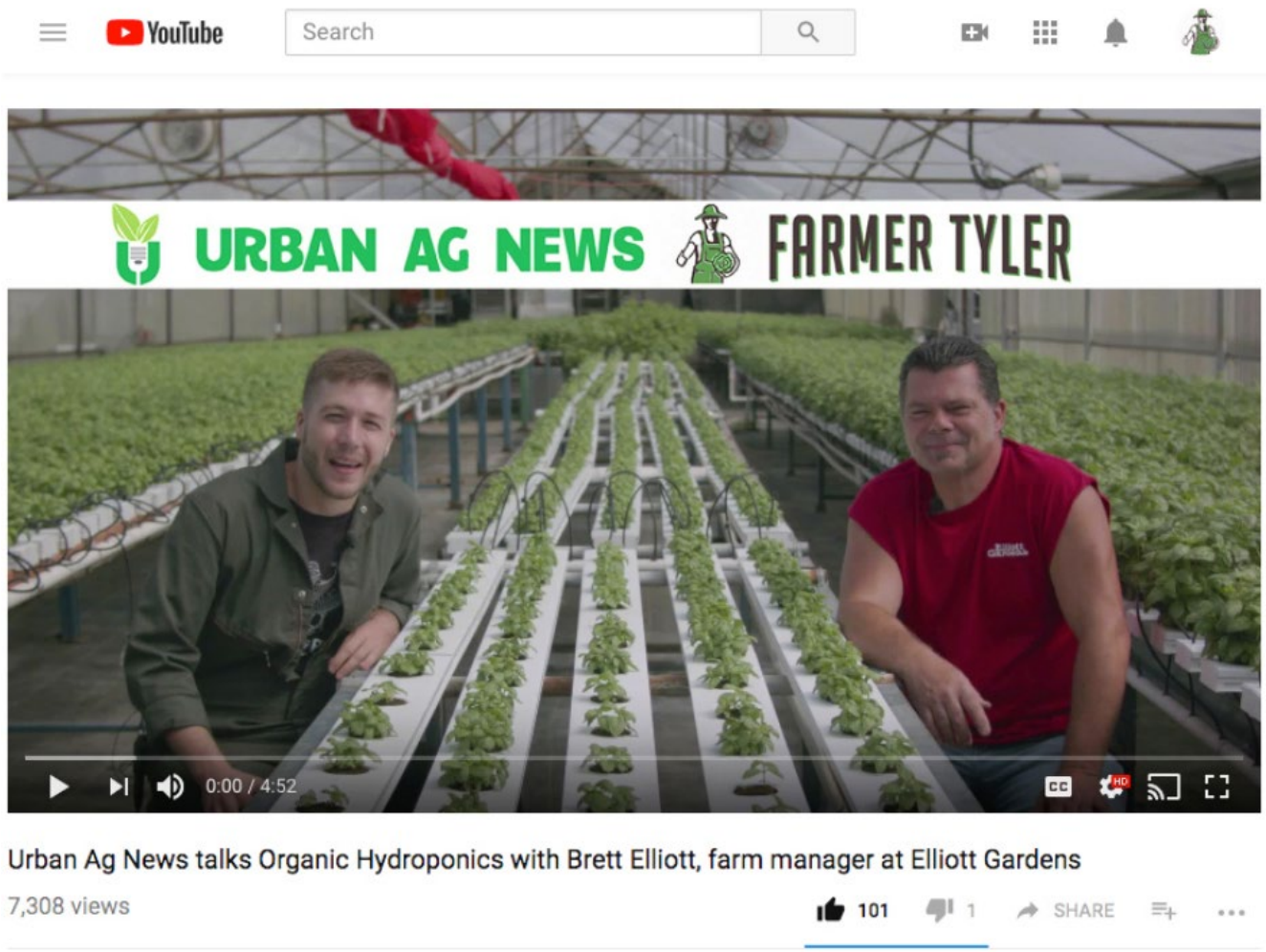
Fulvic Acid: 10.34 %
Humic Acid: 0.027 %
Tested 12/11/2017

## Amino Acids in Pre-Empt

| **Amino Acids** | **mgs/liter (ppm)** | |
|---|---|---|
| Aspartic Acid | ASP | 120.26 |
| Glutamic Acid | GLU | 10.00 |
| Asparagine | ASN | 265.19 |
| Serine | SER | 34.13 |
| Glutamine | GLN | 0.00 |
| Histidine | HIS | 0.68 |
| Glycine | GLY | 18.00 |
| Threonine | THR | 9.47 |
| Alanine | ALA | 54.98 |
| Arginine | ARG | 2.53 |
| Tyrosine | TYR | 5.57 |
| Valine | VAL | 25.53 |
| Methionine | MET | 1.63 |
| Tryptophan | TRP | 0.00 |
| Phenylalanine | PHE | 1.93 |
| Isoleucine | ILE | 3.91 |
| Leucine | LEU | 0.74 |
| Lysine | LYS | 0.00 |
| Proline | PRO | 0.00 |
| | **Sum:** | **554.53** |

## Additional Resources

Urban Ag News talks Organic Hydroponics with Brett Elliott, farm manager at Elliott Gardens




Learn how one growers produces organically certified leafy greens and culinary herbs in a Colorado greenhouse using hydroponic methods. https://www.youtube.com/watch?v=xukHKeJiUFA

### *More from Hort Americas and Urban Ag News*

Dissolved oxygen improves plant growth, reduces crop time

Hort Americas looks to be a connecter of products and knowledge for the horticulture industry

Choosing a substrate for hydroponic production

Essential Plant Nutrients 101 Educational Video – Part 1

Essential Plant Nutrients Educational Video – Part 2

***Disclaimer***

*Unlike traditional hydroponics, organic hydroponics has not yet become an exact science.*
*Individual growers will need to be prepared to manage an ever changing system with very specific individual needs and care.*