

Why are different hydroponic formulations required for different situations?

Hydroponic growers tend to have very different experiences with nutrient solutions. It is not uncommon to find a grower who “swears” by product A and another who says product A delivers terrible results but product B is “the best”. This causes a lot of confusion among new growers since there doesn’t seem to be any agreement about what the “best formulation” is. Shouldn’t we know by now what the “best nutrients” are? Given how many crop cycles are grown each year and how many iterations growers go through, you would think it would be only a matter of time before we know for certain how to create the “perfect recipe” to maximize yields and minimize problems and diseases. **Why haven’t we achieved an optimal formulation for each plant species? The answer, is that nutrition is not only about nutrients and optimal nutrients are only optimal for a very specific set of conditions.**



Commercial hydroponic fertilizer manufacturers would want you to believe that they have figured it out. They have a given set of formulations for people using Coco, another for people

using rockwool, some for hard water, some for soft water, a whole array of different products to choose from where you will certainly find one that suites your needs if you just follow their guidelines. However, these different products are formulated using very broad assumptions, for example that the Coco you use required initial pretreatment with Ca salt or that your input water will contain substantially large amounts of Ca and Mg, because it's a "hard water" formulation.

Commercial products are also often made with implicit assumptions that depend on the experience of the people formulating the nutrients. For example a nutrient manufacturer might formulate nutrients that delivered excellent results while working at high VPD conditions, without realizing this was even the case. Another might formulate nutrients for the entire opposite case. A person testing a product might also like to only irrigate to a small amount of run-off, while another will irrigate till a large amount of run-off is collected. All these things affect the concentrations of nutrients the plants are exposed to, because they fundamentally affect the amount of water that the plants have access to and the transpiration demand the plant is subjected to.

This is why a grower might swear by a given nutrient formulation and be completely right in that it delivers amazing results, while another will find this formulation just gives mediocre results with a bunch of nutrient deficiencies. The temperature, humidity, media, irrigations per day, irrigation volumes, input water composition and nutrient ratios, all play a role in determining whether the plant is able to properly uptake nutrients and whether these nutrients are ideal for this case. I've seen a person using a low K, low Ca formulation for rockwool with pretty limited irrigations be quite successful with it, while another using the same formulations under high irrigation volumes had substantial problems. The first person was relying on large dry-backs to

increase oxygenation and increase nutrient concentrations to a point that suited the plants very well, the second person failed with this formulation because nutrient concentrations were too low and were never able to reach the same values they reached for the first one with increased irrigation volumes and frequencies.

Nutrient	Hoagland & Arnon (1938)	Hewitt (1966)	Cooper (1979)	Steiner (1984)
	mg L ⁻¹			
N	210	168	200-236	168
P	31	41	60	31
K	234	156	300	273
Ca	160	160	170-185	180
Mg	34	36	50	48
S	64	48	68	336
Fe	2.5	2.8	12	2-4
Cu	0.02	0.064	0.1	0.02
Zn	0.05	0.065	0.1	0.11
Mn	0.5	0.54	2.0	0.62
B	0.5	0.54	0.3	0.44
Mo	0.01	0.04	0.2	Not considered

Table 2. Concentration ranges of essential mineral elements according to various authors (adapted from Cooper, 1988; Steiner, 1984; Windsor & Schwarz, 1990).

Different base solutions that have been used in hydroponic research. You can see not even research is homogeneous in terms of the nutrients used.

The development of an optimal formulation for a hydroponic crop is therefore a long process that needs to be guided by a considerable evolution from a given “good guess” base towards what is optimal for the specific conditions. More often than not, the formulation will be optimized alongside some constraints – like those dictated by climate control and light providing abilities – and will therefore be pretty tightly bound to the particular environment. My advice is to start from a good guess base, using the knowledge about the chemistry of the environment – input water, media – and to evolve that base using tissue analysis and crop yield results

in order to achieve better and better results. Finding an ideal nutrient solution can take a lot of time and effort but it can substantially increase yields and improve quality levels.

How tap water affects your hydroponic nutrient formulation

Tap water is often the most reliable source of water for hydroponic growers. However, especially in the North America and Europe, tap water can contain a significant amount of dissolved solids. These substances can fundamentally affect the properties of the water and require adjusting the nutrient formulation in order to achieve proper nutrient concentrations in the final nutrient solutions. In this post I'm going to walk you through some of the most important considerations when dealing with tap water and how you should adjust your nutrient formulations to make sure that the final nutrient concentrations are adequate for plant growth.

Water Quality Parameters x

Name

Input Quantities as ppm

N (NO ₃ -)	<input type="text" value="0"/>	S	<input type="text" value="0"/>	Na	<input type="text" value="0"/>
N (NH ₄ +)	<input type="text" value="0"/>	Fe	<input type="text" value="0"/>	Mn	<input type="text" value="0"/>
P	<input type="text" value="0"/>	Zn	<input type="text" value="0"/>	Si	<input type="text" value="0"/>
K	<input type="text" value="0"/>	B	<input type="text" value="0"/>	Cl	<input type="text" value="0"/>
Mg	<input type="text" value="20"/>	Cu	<input type="text" value="0"/>	<input type="button" value="Set pH/GH/KH"/>	
Ca	<input type="text" value="50"/>	Mo	<input type="text" value="0"/>		

Hydrobuddy allows you to set water quality parameters to ensure they are taken into account within your calculations

There are four important factors to consider when adjusting a nutrient formulation to your tap water.

Dissolved nutrients. Tap water often contains nutrients that are used by plants. The most common ones are Calcium, Magnesium and Iron. It is often fundamental to adjust your nutrient formulation to account for their presence. If you are using HydroBuddy to prepare your nutrient formulations you can use the “Set Water Quality Parameters” dialogue to introduce the ppm concentrations of these nutrients so that they are properly added when considering your nutrient targets. This will mean that less Ca, Mg and Fe will be added from salts, because the program will assume some will come from the water. An important fact to consider is also that the Ca, Mg and Fe concentrations in the water will tend to change with the seasons, as hotter temperatures means that underground limestone/dolomite deposits will dissolve more and therefore lead to more Ca/Mg rich water. Usually I will advice people to get two analysis – one in August, one in February – so that they can know the two extremes their formulation will be at

and adjust accordingly through the year depending on the temperature of the incoming water.

Alkalinity. Your water will also contain a substantial amount of carbonates and will tend to be basic due to this reason. It is often easiest to take the amount of moles of Ca plus the moles of Mg in the water and discount this by the moles of Sulfur, then calculate how much moles of acid you will need to neutralize this amount. This makes the assumption that all Mg and Ca in the water are carbonates, except for the amount that are present as sulfates. Knowing how much moles of acid are needed to neutralize this you can now calculate how much ppm of S, N or P – depending on the acid you are going to be using – will take to neutralize the water and set this into the “Set Water Quality Parameters” box in HydroBuddy. This will account for the acid addition that will be needed to remove all alkalinity from the water when you prepare the nutrient solution. Note that although HydroBuddy contains fields to set pH/gH/kH within the program, it actually does not take into account any of these values when calculating compensations (these are just there to store for reference).

Dissolved non-nutrient minerals. There can be a lot of minerals dissolved in the water that are not nutrients, which is why a complete chemical panel of the water is required if the water source to be used hasn't been evaluated before. In particular Na, Cl and heavy metals are the most important things to look for, as these can very negatively affect your plants. High presence of these substances will often make the water completely unusable for hydroponics, unless some specific pretreatment steps are taken to fix the issue. Make sure that the ppm of Cl are below 50 ppm, Na is below 100 ppm and all heavy metals are within quantities considered safe for human use.



Some typical soft/hard water concentrations of Ca+Mg

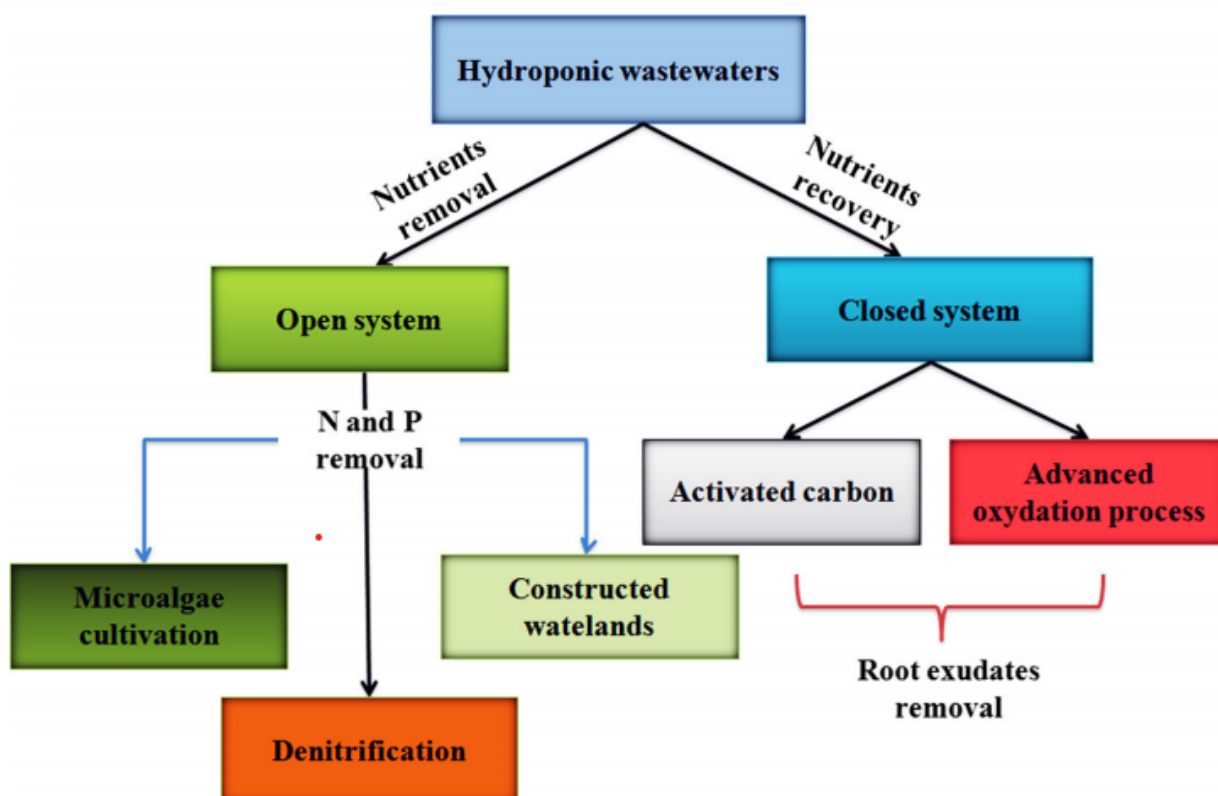
Dissolved organics. Perhaps one of the least evaluated aspects of tap water, dissolved organics can be particularly important when considering a tap water source. Substances like chloramines and herbicides can be fundamentally damaging to plant roots. While it is easy to test for oxidative substances like chloramines, normally it is hard to get a lab test for most specific organic substances, reason why the best solution for this problem is adequate pretreatment. Always make sure your tap water runs through both media – sand, ceramic – and activated carbon filters before it is used in your hydroponic crop. An adequate sterilization treatment, UV, ozone, etc, can also help reduce the risk of getting organic molecule contamination.

As you can see, tap water is a complex beast. Not only do we need to account for the nutrients and non-nutrients it can contribute, but we also need to account for its alkalinity and the ways in which these three things might change through the seasons. These complications are the main reason why so many growers end up deciding to use RO water instead – higher reproducibility, less problems – but they are certainly not insurmountable. Creating a hydroponic formulation and infrastructure that accounts for these problems can lead to great cost savings, as you can save both on fertilizers – because the tap water already contains some minerals – and energy.

How to deal with nutrient solution waste in hydroponics

Hydroponic nutrients contain a wide array of chemicals that are fundamentally contaminating to water sources and can

heavily contribute to [eutrophication](#). Both run-to-waste and recirculating systems eventually generate significant amounts of waste as nutrient solutions cannot be infinitely used – even when recirculation is done – due to the many ways in which a solution can deteriorate ([see here](#)). Because of this reason, it becomes important to figure out ways to treat this waste and ensure its nutritional content is adequately reduced before it is flushed down the drain. In this post I will go through the ways in which this can be done and which might be the more practical implementations for small/medium sized hydroponic installations. A lot of the content below will be based on information obtained from [this review article](#) on the subject.



Route for the treatment of hydroponic waste waters depending on whether nutrients are to be removed or recovered (taken from the review mentioned above). Note that eventually solutions need to be changed so the disposal of nutrient solutions cannot be endlessly avoided, even in close systems.

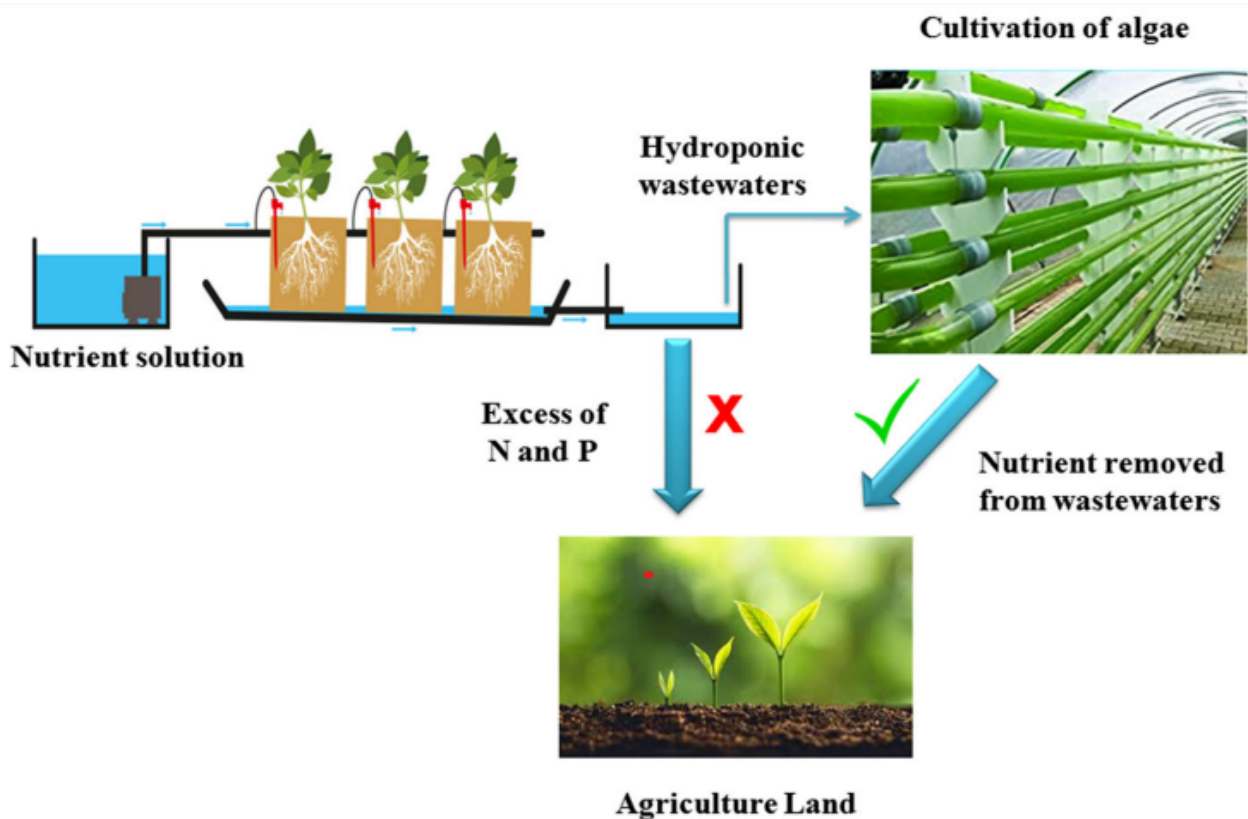
The main problem when dealing with hydroponic waste solutions are the nitrogen and phosphorous content, as these are

normally the nutrients limiting plant growth in bodies of fresh water. A hydroponic solution where most N and P is removed can be mostly considered safe for disposal as the contaminating power of the solution will be substantially lower once these two nutrients are removed. This is why most of efforts – both in the academic literature and in real life situations – are focused on the removal of these nutrients whenever nutrient solution is to be discarded. The following are the most tested methods for the treatment of hydroponic waste solutions.

Denitrification using anaerobic organisms. In this process the solution is treated with bacteria that denitrify the nutrient solution by reducing the nitrate to nitrite and then to nitrogen gas. The process usually requires some sacrificial substance for oxidation – such as a thiosulfate or elemental sulfur granules – the process can be quite successful, removing more than 90% of the nitrogen from solutions. An issue however is that a carbon source is also needed – because the bacteria need to be fed – and this is the most important cost for this method of removal. This process also fails to address the removal of phosphorous from solution as it's mainly focused on the removal of nitrogen.

Artificial wetlands. This is the method with the lowest cost as it makes use of plants to consume all the nutrients left within the solution. It not only addresses N and P but also removes other macro and micro nutrients from the solution, generating the best effluents in terms of mineral content. Usually either common reed (*Phragmites australis*) or common bulrush (*Scirpus lacustris*) are planted and fed the waste nutrient solution so that they can process it for a predetermined period of time before the solution is fully disposed of. This process can achieve a removal efficiency greater than 90% for both N and P. Its main disadvantage is the need for a considerable amount of space and issues working when temperatures drop significantly, as these wetlands are

not built inside greenhouse environments to keep costs low.



Scheme showing nutrient removal by algae. Taken from the review mentioned in the first paragraph of this post.

Algae. In the same way as artificial wetlands, microscopic algae can also remove N and P from nutrient solutions. The algae are usually grown in transparent tubes, where the waste nutrient solution is run through. The algae can be very efficient at removing these nutrients although they will not be very efficient at removing some micro nutrients from the solution. Efficiencies greater than 90% have been achieved for both N and P removal in the academic literature. These organisms can also then be harvested in order to obtain an additional product for the hydroponic installation, which gives this process the unique opportunity to add value instead of just being an additional cost to the grower. *Chlorella vulgaris* and *Dunaliella salina* are the two most studied algae species for hydroponic nutrient solution waste treatment.

Any waste treatment process will introduce an additional cost to a hydroponic crop. However this might not be optional in

the future, as regulators in the US and Europe tighten their monitoring of hydroponic waste and restrict the amount of pollutants that might be dumped into the sewage system. With this in mind, it's good to start thinking about ways in which your hydroponic waste could be treated and what might be the lowest cost method to do so. If you have significant amounts of area then an artificial wetland might be the best method to follow while if you are short on space, algae will offer you the best method to treat your solution with a small footprint. However algae also have light needs, which means you might need to provide artificial light to them if you do not have the outdoor or greenhouse space to accommodate them.

Polluting is something none of us wants to do and ensuring hydroponic waste effluents are properly and economically treated is going to be important for hydroponic cultivation to be sustainable going forward.

Factors limiting the life of a recirculating hydroponic nutrient solution

Hydroponic systems that use recirculating nutrient solutions can be more efficient in terms of water and nutrient usage. However, despite how good the management of a solution is, there are certain factors that will limit the time that a solution can be maintained without performing a full change of the entire recirculating nutrient solution within the system. By performing actions to attenuate some of these factors the life of the nutrient solution can be increased but trying to keep a nutrient solution endlessly is often impractical, both

from a technical and economic perspective. In today's post I will talk about the factors that limit the life of a recirculating nutrient solution and some of the actions that can be taken to increase the life of the solution.

Selective nutrient uptake. Plants will uptake some nutrients significantly faster than they do others. This will lead to a substantial accumulation of certain nutrients within the solution if nutrients are replenished to keep the EC of the solution constant at constant volume. Most commonly phosphorous will tend to accumulate within the solution. This is because plants will uptake this nutrient significantly slower than the others, while it will be replenished in full strength every time nutrients are added. This will tend to increase the ratio of phosphate to other nutrients, eventually causing phosphorous, calcium and magnesium issues within the solution. Micronutrients will also be replenished more than they are consumed and micros like Molybdenum and copper can dangerously accumulate in solutions that are kept for long periods of time (months).

The above is the main reason why nutrients are often replaced every 2-4 weeks in recirculating hydroponic setups. Chemical analysis can help expand this time – by allowing the grower to selectively replace only the things that have been taken – but this requires growers to have experience in the calculation and creation of nutrient formulations and to be able to effectively adapt the nutrients as required.



A small scale, recirculating hydroponic crop

Contamination by pathogens. Nutrient solutions will get contaminated by external pathogens as they recirculate and come into contact with the media and the air. This contamination with pathogens might grow to the point that plants start developing disease, which can lead to substantial losses as diseases are spread incredibly efficiently within recirculating nutrient solutions. Potential solutions such as ozone and UV filtration can help eliminate the pathogens, but these oxidative actions will also destroy important aspects of the nutrient solution, such as the chelating agents that are used to wrap around heavy metal ions. This means that – as you destroy pathogens – you will lose heavy metal availability as it will become easier for the free metal ions to precipitate under these circumstances. When using in-line UV or ozone in a recirculating environment it often becomes necessary to be careful with the analysis and replenishing of chelated heavy metals, especially iron.

Plant root system contributions (exudates). The plants will also contribute chemicals to the nutrient solution, which will increase both the carbon content and the biological activity of the nutrient solution. These substances can severely impact

the growth and development of the plants as well, as these exudates can contain hormonally active molecules that trigger biological processes within plants. You can eliminate most of these molecules by the use of carbon filters and oxidative sterilization processes but this will cause some of the same issues mentioned in the previous paragraph about pathogen contamination. Carbon filters will also need to be checked and replaced regularly otherwise they will just fill up and become ineffective.

Accumulation of non-nutrient substances. Some ions that are added with water will not be used as nutrients and will just tend to accumulate in a nutrient solution until they become poisonous to plants. The most important accumulation problems are related with sodium and chloride in regions where water contains a significant amount of these ions (like Southern Europe, see [here](#)). This is problematic because you will always tend to add these ions with new water additions, so you have limited power to control their accumulation. This might require the use of reverse osmosis systems to add water that contains low levels of these contaminants or – often way more economically – will force the replacement of the solution at some point. Note that poisonous heavy metals – like As, Hg, Cd – can also accumulate with time, reason why the life of a nutrient solution should always be limited, regardless of the efforts made to never replace it. Impurities in your salt inputs can also play an important role in contributing with this non-nutrient accumulations.

I hope the above serves as a good explanation of the common factors that limit the life of a recirculating solution in hydroponics. Maintaining a recirculating nutrient solution is not just “adding water with nutrients to top it off” or “add nutrients to maintain a certain EC”, it requires a substantial amount of care in the evaluation of the nutrient evolution as ions accumulate, other are used and the plants themselves also contribute their own organic molecules to change the makeup of

the nutrient solution. In most cases, the solution to just “change the solution every 2 weeks” is just the most economically viable answer but this can be undesirable if both water usage and contamination of water resources wants to be minimized. With good management, solution lifetimes can often be extended to 8-16 weeks, but going beyond that can be risky due to aspects of ion accumulation that are hard to control (as those mentioned in the last problem).

Preparing your own low cost A+B generic hydroponic nutrients at a small scale from raw salts

In a [recent post](#) about the cost of custom hydroponic nutrients, I talked about the cost of preparing nutrients equivalent to those of a commonly used brand (general hydroponics Flora series) at a small scale. We saw that the cost savings are not very significant when doing this with small amounts of salts, given that the cost of the salts only drops significantly at larger scales. However there are low cost alternatives to prepare viable hydroponic solutions. In today's post I want to write about the DIY preparation of hydroponic nutrients and how you can do this from raw salts to arrive at a generic formulation that you can use for flowering plants.

Substance Name [click for url]	Formula	Mass (g) [Edit to fine-tune]	Preparation Cost
B - Potassium Monobasic Phosphate	KH ₂ PO ₄	10.985	0.5
B - Ammonium Sulfate	(NH ₄) ₂ SO ₄	2.331	0.1
B - Magnesium Sulfate (Heptahydrate)	MgSO ₄ .7H ₂ O	31.694	0.1
B - Potassium Sulfate	K ₂ SO ₄	25.698	0.5
B - CH - micro	Ch micro	2.225	0.1
A - Calcium Nitrate (ag grade)	5Ca(NO ₃) ₂ .NH ₄ NO ₃ .10H ₂ O	68.705	0.5

Element	Result (ppm)	Gross Error	Instrumental Error
N (NO ₃ -)	158.296	0%	+/- 0%
K	235	0%	+/- 0%
P	40	0%	+/- 0%
Mg	50	0%	+/- 0%
Ca	208.863	0%	+/- 0%
S	150.686	0.5%	+/- 0%
Fe	2.492	0%	+/- 0%
Zn	0.142	0.3%	+/- 0%
B	0.463	0%	+/- 0%
Cu	0.039	0.4%	+/- 0%
Mo	0.018	-1.1%	+/- 0%
Na	0	0%	+/- 0%
Si	0	0%	+/- 0%
Cl	0	0%	+/- 0%
Mn	0.712	0%	+/- 0%
N (NH ₄ +))	20	0%	+/- 0%

Total Cost is 1.8

Values calculated for the preparation of 0.25 liters of A and 0.25 liters of B solution. Please use 4mL of A and B within every Liter of final solution

Predicted EC Value

EC=2.246 mS/cm

Stock Solution Analysis

Nutrient Ratio Analysis

Detailed Per Substance Contribution Analysis

Generic A+B formulation prepared using

The formulation shown above is meant to be a low cost formulation that is close to a Hoagland solution in as many nutrient concentrations as possible, using as few inputs as possible. The concentrated solution is meant to be prepared in distilled water and it is meant to be used in R0/distilled water as no mineral contributions from the incoming water have been taken into account for its making. The solution is prepared at a 250:1 concentration factor, meaning that a gallon of A and a gallon of B can be used to prepare 250 gallons of final nutrients. This is a concentration factor pretty similar to that of the General Hydroponics Flora series, with an intended dosage of around 15mL/gal of A + 15mL/gal of B. At this dosage the EC is expected to be around 2.2 mS/cm (but this should be experimentally determined!). With 250mL of concentrated solution you can prepare up to

62.5L of final solution (~16.5 gallons).

Note that I have decided to use a “chelated nutrient mix” instead of preparing a solution adding micros one-by-one, as this is not very convenient for people new to nutrient solution preparation, plus, some micros are only available in relatively larger quantities that are unnecessary to store for someone who is only interested in the preparation of small amounts of nutrient solution. The above preparation has a cost of around 25 USD/(gal A+ gal B), which is less than one third the cost of one gallon of Flora series. This cost will be significantly lower if you buy the fertilizers in larger quantities and/or if you buy all the micros and weight them independently.

To prepare this accurately at a small scale – as shown in the image above – you will need the following materials and chemicals:

- [Class A Volumetric Flask \(250mL\)](#)
- [Beaker set](#)
- [A scale adequate for this range \(+/- 0.01g , max 500g\)](#)
- [Customhydronutrients chelated micro mix](#)
- [Calcium nitrate](#)
- [Ammonium sulfate](#)
- [Epsom Salt](#)
- [Monopotassium phosphate](#)
- [Potassium sulfate](#)
- Distilled water
- air-tight 250mL Glass container for storage

You can follow this process to prepare the nutrients:

1. Prepare a clean and dry 250mL beaker, wash with distilled water (no soap)
2. Weight each raw salt on your scale, transfer to the beaker (use distilled water as necessary to ensure everything is transferred)

3. Add more water and heat – if necessary – to ensure everything is dissolved (add less than 200 mL of water)
4. Transfer the liquid to the volumetric flask (use distilled water as necessary to ensure everything is transferred)
5. Take to the final volume using distilled water and homogenize
6. Transfer to the final storage container

I have also made a video to show you how this entire preparation process is carried out, which I will be sharing shortly! Note I used a potassium sulfate I had previously purchased, which was of significantly low purity (mined potassium sulfate), the link above is for a refined potassium sulfate source, which should give you significantly less problems than it did for me and lead to higher quality solutions (my B solution was cloudy and contained some solids, which were impurities from the potassium sulfate).

If you want to prepare these solutions at a larger scale, then you will face other problems. For example how to accurately measure the final volume of these solutions. **Lines in tanks and buckets are terrible volume indicators**, flow meters also are also not enough since the salts take a very significant amount of the volume as well (remember we care about the volume of water+salts!). How to properly mix, homogenize, heat and dissolve larger amounts of solution is also not trivial. These are all problems we will be discussing in future posts and videos!

How to correctly prepare

dilutions from concentrated solutions in hydroponics

Accurately preparing dilutions of concentrated nutrients is no trivial task. For example, if you want to prepare a 10 gallon solution at “2mL per gallon” of a hydroponic nutrient, ensuring that you’re adding 20mL and actually having a final volume of 10 gallons is not trivial, given the inherent errors in the measurement of both the transference volume and the final volume. *If you’re using non-standardized methods to measure volume (buckets, gallon jugs or “tank markings” to measure volumes), you could be off by +/-20% the volume you want.* However you can accurately prepare dilutions at whatever volume you want by first measuring the conductivity of an accurately prepared solution at a small scale. A solution prepared using calibrated volumetric material.

The cost of reproducing the label of a commercial hydroponic fertilizer with raw salts at a small scale

Creating your own hydroponic nutrients can dramatically change the amount of money you spend in fertilizers per crop cycle. Commercial pre-blended hydroponics nutrients carry significantly high margins, so making your own nutrients can often save you a lot of money down the line. Raw fertilizer salts are not expensive at all – millions of tons of some of them are produced per year – so it is quite possible to save

big amounts of money by just preparing the basic fertilizers yourself. But how much money can you save? In this blog post we will be looking at the price points of some commonly used hydroponic nutrients, I am also going to share with you the cost of reproducing the fertilizer composition specified in their label. **Note that this is not necessarily going to reproduce the actual fertilizer, since the label information is very often not accurate** (read this post to learn more [about this](#)), but it can give an idea about the order of magnitude of the cost difference.



Let's use the General Hydroponics Flora series, which is one of the most popular hydroponic brands use by small growers, as an example. The Flora Series has a cost of 79 USD per one pack of three (total three solution, each one gallon) (I got this price from Amazon US). This includes one gallon of FloraMicro, one gallon of FloraGro and one gallon of FloraBloom. The summary of the label information for the three fertilizers can be seen in the table below. How much would it cost to recreate a fertilizer that would reproduce this exact label information? (meaning it could be sold with the same

composition values).

To make the costs comparable I have used the costs of salts that are directly available for purchase at Amazon US, not including the cost of shipping (I also did not include it for the General Hydroponics products). These costs are therefore for relatively small amounts of the raw fertilizers, which could be realistically purchased and used by anyone, the costs are expected to be lower if salts are bought in bulk (more about this at the end of the post). Also note that the cost per gallon only includes the amount of grams per salt used to prepare each gallon of concentrated solution but does not consider if the minimum purchasable amount is significantly higher than that. The compositions I arrived to are identical to the GH label compositions within +/- 0.1%. *I have made reasonable assumptions to make my salt choices, but beware that the reported label concentrations are often purposefully misleading to make any attempts at reverse engineering from them use more expensive inputs.*

Element	FloraBloom	FloraMicro	FloraGro
N (Nitrate)	–	4.7	1.75
N(Ammonium)	–	0.3	0.25
P (P2O5)	5	–	1
K (K2O)	4	1	6
Mg	1.5	–	0.5
Ca	–	5	–
S	1	–	–
Fe	–	0.1	–
B	–	0.01	–
Zn	–	0.015	–
Mn	–	0.05	–
Mo	–	0.0008	–
Cu	–	0.01	–

Composition values (in %) from the labels of the FloraBloom, FloraMicro and FloraGro fertilizers from the GH Flora series. For the FloraBloom bottle – the least complicated of the three – I have used 4 different salts to reproduce the formulation, which gives me a final cost per gallon of 22.1 USD. For the FloraMicro I had to use 9 different products, with a total cost of 24.7 USD per gallon of solution. Finally, for the FloraGro I ended up using 6 different salts, with a total cost of 24.7 USD per gallon of solution. Adding all of these up, the total cost to prepare three gallons of fertilizer with the same composition as mentioned in the General Hydroponics labels would be 71.5 USD, which is surprisingly not that big of a saving from the retail cost of 79 USD for the three gallons. *At a retail scale, the savings are not very evident, given that we're purchasing more expensive, small packages of raw salts.*

The most expensive fertilizer salt I used had a cost of 12.8 USD/gallon in the FloraBloom, at a retail cost of 0.04 USD per gram of salt. However, if you bought this salt in a larger amount (5 pounds instead of the 1 pound bag in amazon), the cost would drop to 0.01 USD/gram of it, it can drop even more if you buy it at a larger scale (>25 pounds). As the scale grows, so does the drop in the cost of these salts, if you are willing to spend moderately large amounts of money – say 1000-2000 USD in raw salts – the cost of exactly reproducing something like the GH Flora series label composition could go below 10 USD for the three gallons. ***This shows you that scale is very important when making concentrated fertilizer solutions since the price per gram of fertilizers drops dramatically as we go to larger volumes.***

With that said, the biggest savings can be achieved, *NOT* by copying a commercial nutrient solution's label, but by instead designing a fertilizer formulation that best feeds your needs and that uses the inputs that make the best sense for your growing situation and budget. This is why I encourage you to

think about creating your own formulations by thinking about your needs, rather than attempting to copy something like the GH series, which might be less cost effective and more complicated for a small grower.

Five things to consider when trying to copy commercial hydroponic nutrients

There are hundreds of different formulated hydroponic fertilizers out there and most of them are very expensive. Due to these very high costs, growers will often want to copy a set of hydroponic products they are very familiar with or a set of products that other growers – ideally growing under similar conditions – have had success with. However, the process of copying a commercial hydroponic nutrient with raw inputs is not as straightforward as many would like it to be and the procedure to do this accurately can be complicated due to both the nuances of the fertilizer industry and potential measures manufacturers might take to make reverse engineering of their products significantly harder. In this post I want to talk about five things you should consider before attempting to copy a hydroponic nutrient formulation, so that you can be very aware of the potential issues and problems you might find along the way.

The labels are often not accurate (enough). A fertilizer's label contains the minimum guaranteed analysis of the fertilizer. Depending on the legislation, this usually means that the fertilizer must contain, at a minimum, this amount of every one of the specified nutrients, but there is no problem

if the fertilizer contains *more* than what the label discloses. If a company is selling a fertilizer that has an NPK of 12-12-12 they can actually register that fertilizer as a 10-10-10 fertilizer and sell it as if it was a 10-10-10. The fertilizer will in reality be a 12-12-12, but the manufacturer can be sure that it will always be above the 10-10-10 specification. This is often not done out of malice, but out of the fact that the fabrication process itself might create a significant amount of variance within the composition of the actual fertilizer being produced and the manufacturer always wants to be above the minimum. This means that if you want to get the true mineral composition of the product, you'll need to send the actual fertilizer you want to copy to the lab. *Never rely on the label when copying a fertilizer.*

0 - 5 - 4
GUARANTEED ANALYSIS

Available Phosphate (P₂O₅).....5.0%
Soluble Potash (K₂O).....4.0%
Magnesium (Mg).....1.5%
1.5% Water Soluble Magnesium (Mg)
Sulfur (S).....1.0%
1.0% Combined Sulfur (S)

Derived from: Magnesium Carbonate, Magnesium Phosphate, Magnesium Sulfate, Phosphoric Acid, Potassium Carbonate, Monopotassium Phosphate, and Potassium Sulfate.

Information regarding the contents and levels of metals in this product is available on the internet at <http://www.aapfco.org/metals.htm> F-1109

This product is concentrated to the limit of solubility. Protect from freezing and direct sunlight. If crystallization occurs, mix entire contents with an equal amount of hot water and double the amount used.

FloraGro FloraMicro FloraBloom

Basic Applications Table	FloraGro		FloraMicro		FloraBloom	
	tsp/gallon	ml/100 liters	tsp/gallon	ml/100 liters	tsp/gallon	ml/100 liters
Cuttings and Seedlings.....	1/4	33	1/4	33	1/4	33
General Purpose - Mild Vegetative...	1	132	1	132	1	132
Aggressive Vegetative Growth.....	3	396	2	264	1	132
Transition to Bloom.....	2	264	2	264	2	264
Blooming and Ripening.....	1	132	2	264	3	396

These values are intended to be used without supplements. When using supplements, please refer to genhydro.com for complete Feed Programs.

Label of a very popular hydroponic fertilizer. Trying to copy this fertilizer directly using this composition and “derived from” information, would lead to substantially higher costs, manufacturing problems and errors. This is common to a very large array of commercial hydroponic products.

Not everything that can be claimed is claimed. When a manufacturer decides to create a fertilizer product, it might

decide to leave out a specific nutrient within the formulation that is there, but that they do not want to claim to prevent reverse engineering. This is often not illegal – you're getting more than what you paid for from the point of view of the regulators – but it does mean that you're going to be completely missing something if you just copy what the label says. This is a very common trick that is done with micronutrients, where a manufacturer will claim, for example, that the fertilizer has Fe and Mn, but will make no claims about Zn, B, Cu or Mo. A person copying the label would be missing these nutrients, so their plants would end up dying from deficiencies.

The “derived from” is usually not what it's derived from. Usually a hydroponic product will contain a list of the inputs that were “in theory” used for its fabrication. This will be a list of commonly available raw fertilizers, but more often than not, fertilizer manufacturers might include a product from which the composition might be derived, that is significantly more expensive than the raw inputs that the fertilizer is actually derived from or add unnecessary inputs to the list. A simple example would be a fertilizer that is made with potassium sulfate, magnesium sulfate, and monopotassium phosphate. The manufacturer might choose to say it's derived from potassium sulfate, monomagnesium phosphate, potassium carbonate and magnesium sulfate. You can probably derive the same final composition from both salt mixes, but the monomagnesium phosphate is a very expensive input compared to the monopotassium phosphate and the potassium carbonate is unnecessary in this product and will generate pH issues. This is a very common trick, designed to make reverse engineering attempts more expensive and to difficult manufacturing for people who try to copy using this information.

Inputs with non-fertilizer components. A fertilizer can often have nutrient ratios that appear to be impossible to get to given the “derived from” section they have given. This often

happens when there are inputs within the fertilizer that contain non-fertilizer components that are not reflected within the label, or even within an analysis of the nutrient solution. For example a manufacturer might decide to create a calcium supplement containing calcium nitrate and magnesium nitrate and then the label might say it has way more Ca than what is possible from just the calcium nitrate. This means there is another source of Ca present but, what is it? In this case, the manufacturer might be using something like calcium chloride, which they completely neglect to mention within the label. However you should not make assumptions about what these things are, but actually perform an analysis to try to confirm your suspicions. Often assuming the “missing part” is something like calcium chloride can lead to you formulating something that is actually toxic to plants.

Additives that are not part of the mineral makeup. Many fertilizer formulations will also contain additives that do not have any mineral content and that therefore are completely avoided within the label. This is very problematic, since the effect of some hydroponic formulations might be largely related with some of this non-mineral content. The reason why a formulation might work significantly better than another of very similar nutrient composition might be the use of some additional substances within the formulation, such as undisclosed plant growth regulators, gibberellin inhibitors or other substances with very strong effects on plants. Even things as simple as non-ionic surfactants – which can significantly increase the wetting in media like rockwool – can make a big difference between two fertilizers with the same mineral composition. Knowing that these substances are there and copying them can be quite complicated and requires a lot of relatively expensive analysis to figure out.

As you can see, copying hydroponic nutrients is not just a matter of reproducing something that mimics what the label specifies (that would be very easy). It generally requires

chemical analysis of the actual fertilizer to determine its mineral composition, judicious evaluation of the available raw inputs to evaluate which ones might be appropriate to reach the required composition and special consideration about the possibility of other additives that might be present within the product and the analysis to find out what these additives might be.

Why most of the time a “deficiency” in hydroponics is not solved by just “adding more of it”

I am routinely approached by hydroponic growers who believe that a “deficiency” in their hydroponic crop needs to be fixed by adding something to their nutrient solution. The logic is simple, a plant is showing some set of symptoms that are often associated with a lack of that element in tissue. The response, seems to be evident – add more of whatever is supposed to be missing to the nutrient solution – the results, often mixed whenever this is done. Why is it that a plant showing symptoms meaning it “lacks” something, is often not fixed by just adding more of that to the nutrient solution? The answer, which we will be discussing within this post, can be complicated and shows why diagnosing and *solving problems in hydroponics is not as straightforward as matching a plant’s symptoms to a nutrient deficiency chart.*

Let’s start by asking what it means to have a deficiency in leaf tissue. This means that the plant, for whatever reason,

has been unable to meet its needs of some given element within its leaves. There are several reasons why this can happen. Is it completely absent, is there not enough or is it there but not able to get to the leaves because of some other reason? How do we even find out which one of these cases is the answer? For this you need to look into what is usually expected for the concentration of an element in a nutrient solution – the so called sufficiency ranges – and then evaluate whether that element is in an adequate concentration in the nutrient solution (which means getting a chemical analysis of the nutrient solution, never trust what you think is “supposed to be there”).



A potassium deficient leaf in tomato, this can often be caused by antagonistic relationships with other nutrients, exacerbated by environmental conditions

More importantly we now need to consider the ratios of that element with everything else, because plants sense both the absolute and relative concentration of the elements as the concentration of an element affects the kinetics of both its absorption and the absorption of others. For example you might have a concentration of Mg that is 50 ppm, which would be within the sufficiency range of this element and seemingly not a problem to contend with. However, if this is paired up against Ca at 200 ppm and K at 400 ppm, then that amount of Mg

might be insufficient given that it's being paired against very strong competition from the other elements. In this particular case, adding more Mg might not solve the problem, because it might increase the strength of the solution to a point where the plant is stressed too much. The correct solution in this case could be to lower Ca and K to 150 and 300, so that the Mg:K and Ca:Mg are at a more acceptable level.

You can see that the cure to a deficiency is solving the transport problem, which is not necessarily solved by increasing concentration. This is also not exclusively possible with nutrient ratios, the environment can also play a key role in determining whether transport is possible or not. Another example is a deficiency of K, despite there being 350+ ppm of K in the nutrient solution and all the ratios of the other elements with K being normal (Ca at 150 ppm, Mg at 60 ppm). In this case the problem can come from a very high temperature with low humidity, which increases the vapor pressure deficit so much that Ca transport is inevitably favored over K. This means that the plant goes K deficient, despite there being enough K, because the transport of another element is just able to out compete it due to the environmental circumstances. The solution is not to increase K, nor is it to decrease Ca. The solution in this case is to bring the VPD to an adequate level, so that the absorption of those nutrients can be normalized.

Other environmental factors can also play a key role in determining transport. For example, low nutrient solution temperature often causes a deficiency of P in plants, not because there is not enough P in the nutrient solution, because the ratios are wrong, or because the VPD is wrong, but mainly because P absorption at the root level is hindered by the low temperature. The correct solution here is not to add more P – that often makes it even worse – but actually heating up the nutrient solution to make absorption easier or – if

that's not possible – it can often be helped with the establishment of beneficial fungi to help with the transport of this nutrient.

As you can see, the failure of some nutrient to show up in leaf tissue is not so commonly due to its absence in the nutrient solution but more commonly related with some other factor that is wrong. Excess of other nutrients, which causes skewed ratios, bad environmental configurations – too low/high VPD values – problems with solution temperature or solution pH are some of the most common ways in which nutrient deficiencies can affect plants without the element in question being absent in any significant way. The ultimate goal is to determine why the transport of an element is not working and, in doing so, eliminate the block so that the plant can again process its nutrients successfully.

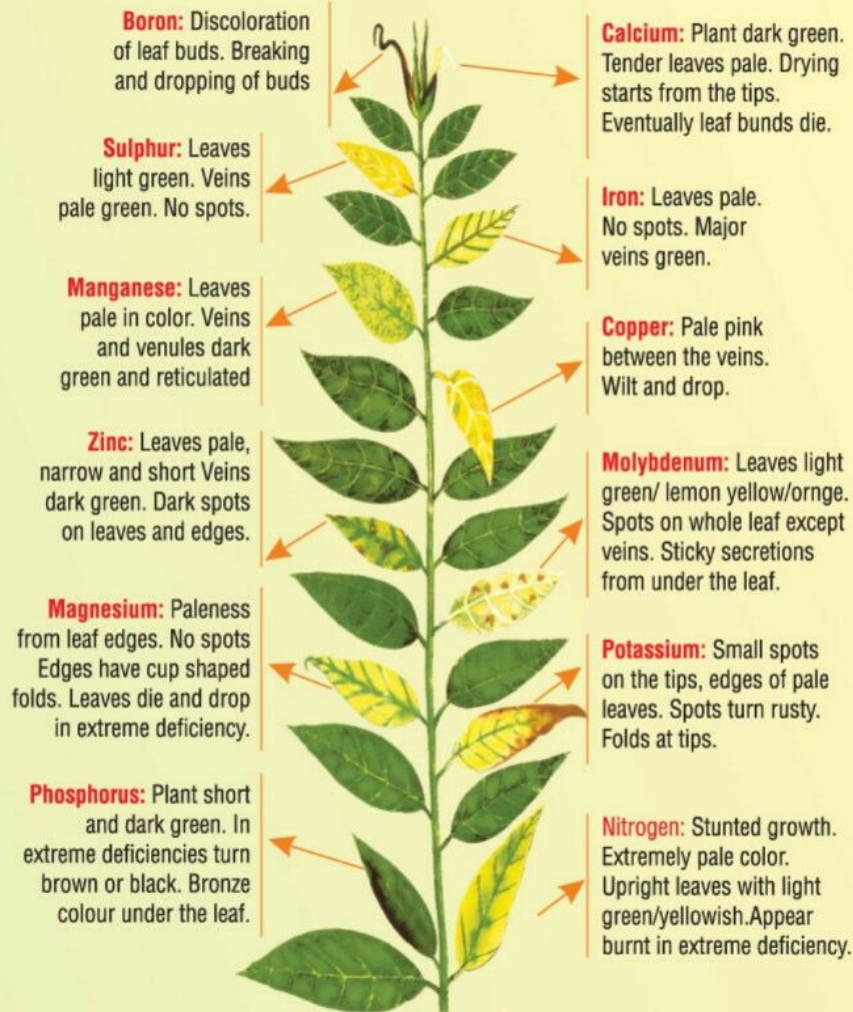
Getting all the data to evaluate a problem in a hydroponic crop

Problems are an inevitable part of being a hydroponics grower. Even experienced growers will sometimes face issues when moving between environments or plant species as things change and new challenges arise. A big part of being a good grower is to be able to think about these obstacles, find out their causes and successfully respond to them. In this post I want to share with you some information about the data you should gather in order to properly diagnose a problem in your hydroponic crop. This is important as not having enough data often makes it impossible to figure out what's going on, while

simple measurements can often give a very clear view of what's happening with the plants.

Take detailed, well documented pictures. What you see is a very important portion of what describes a plant's status and issues. The first thing you should do is document what you're seeing – take pictures of the plants showing the problem – and write down the symptoms you are observing. This documentation process should be organized, give each plant an ID, take pictures under natural light or white light of the new leaves, old leaves and root zones (if possible). Take pictures across different days showing the evolution of symptoms. Have all this information so that you can then better interpret what is going on. Also remember that symptoms do not necessarily mean deficiencies and deficiency symptoms does not necessarily mean more of a nutrient needs to be added to a nutrient solution (for example a P deficiency can show under low nutrient solution temperature even if P in the solution is actually very high).

Deficiency Chart of Micronutrients



THE COLOUR REPRESENTED ARE INDICATIVE.
THEY MAY VARY FROM PLANT TO PLANT

Taking detailed pictures can help assess whether a nutrient deficiency is present by gauging the changes in a plant as a function of time. However these should be confirmed with leaf tissue analysis as some of these symptoms can have causes not related with a nutrient deficiency.

Record all environmental data. When a problem happens, it is often related to the environment the plants are in. Having recorded data about the environment is a very important part of evaluating the issue and figuring out what went wrong here. Getting a good view about the environment usually involves having measurements for room temperature, temperature at canopy, relative humidity, carbon dioxide concentration, nutrient solution temperature, PPF at canopy, and root zone temperature. All of this data should be recorded several times

per day as they are bound to change substantially between the light and dark periods.

Get nutrient solution analysis. Diagnosing a problem is all about having a complete view of what's going on with the plants. The nutrient solution chemistry can often be a problem, even without the grower knowing a problem is brewing there. Sometimes nutrient solution manufacturers might have batches with larger errors than usual, or the input water might have been contaminated with something. There is also the potential of human error in the preparation of the solutions, which means that getting an actual check of the chemistry of the solution can be invaluable in determining what's going on.

Get leaf tissue analysis. Even if the nutrient solution analysis does not reveal any problems, there are often issues with plants that are related with interactions between the environment and the solution that can go unnoticed in a chemical analysis of the solution itself. Doing a leaf tissue analysis will show whether there are any important nutrient uptake issues within the plant, which will provide a lot of information about where the problem actually is.

Critical nutrient foliar concentration for Blueberry (source: Penn State University)

Element	Deficient	Below Normal	Normal	Above Normal	Excessive
N (%)	1.65	1.7	1.9	2.1	>2.1
P (%)	0.05	0.06	0.1	0.18	>0.18
K (%)	0.35	0.4	0.55	0.65	>0.65
Ca (%)	0.35	0.4	0.6	0.8	>0.80
Mg (%)	0.18	0.2	0.25	0.3	>0.30
Mn (ppm)	45	50	250	500	>500
Fe (ppm)	65	70	200	300	>300
Cu (ppm)	4	5	11	15	>15
B (ppm)	29	30	40	50	>50
Zn (ppm)	14	15	25	30	>30

Critical nutrient foliar concentration for Brambles (source: Cornell University)

Element	Deficient	Below Normal	Normal	Above Normal	Excessive
N (%)	1.80	2.00	2.50	3.00	>3.00
P (%)	0.23	0.25	0.35	0.40	>0.40
K (%)	1.45	1.50	2.00	2.50	>2.50
Ca (%)	0.57	0.60	1.70	2.50	>2.50
Mg (%)	0.27	0.30	0.70	0.90	>0.90
Mn (ppm)	45	50	150	200	>200
Fe (ppm)	48	50	150	200	>200
Cu (ppm)	6	7	30	50	>50
B (ppm)	28	30	40	50	>50
Zn (ppm)	18	20	35	50	>50

Critical nutrient foliar concentration for Strawberries (source: Cornell University)

Element	Deficient	Below Normal	Normal	Above Normal	Excessive
N (%)	1.50	1.80	2.00	2.80	>2.80
P (%)	0.20	0.25	0.35	0.40	>0.40
K (%)	1.20	1.50	2.00	2.50	>2.50
Ca (%)	0.60	0.70	1.50	1.70	>1.70
Mg (%)	0.25	0.30	0.45	0.50	>0.50
Mn (ppm)	40	50	150	250	>250
Fe (ppm)	50	60	150	250	>250
Cu (ppm)	5	7	10	20	>20
B (ppm)	20	30	60	70	>70
Zn (ppm)	15	20	35	50	>50

Expected nutrient ranges for leaf composition of different species. Leaf tissue can often help tell whether there are some important abnormalities in progress and may help the grower assess which causes to look at.

Take well documented pictures of tissue samples using a microscope. A microscope can be important in determining what's going on with plants, because it can show developments in roots/tissue that cannot be seen with the naked eye. Microscopes can often reveal very small insects or fungal structures that would have otherwise gone unnoticed. For this reason, a microscope and the taking of microscopy images can

be of high value when dealing with a problem in a hydroponic crop.

With all the data mentioned above, most hydroponic crop problems will be much easier to diagnose. Some of the biggest failures in dealing with problems in hydroponic crops come from not gathering enough data and just guessing what the problem might be given how the plants look. Sadly plants can show similar responses to a wide variety of problems and – in the end – nothing replaces having the data to actually diagnose what's going on in order to deal with the issue appropriately. Lacking an evidence-based picture is often the biggest difference between success in diagnosing/fixing an issue and failure or even worse problems caused by taking actions that have nothing to do with the real problem at hand.