Cobalt in Hydroponics : Better or Worse ?

On yesterday’s article we talked about silicon, one of the most beneficial non-essential nutrients you can use in your hydroponic crops. Although Silicon has proved to give marked benefits in peer-reviewed scientific studies, other elements are usually commented on being beneficial without a thorough investigation around current scientific literature. One of this particular cases is Co, with this element being often portrayed as a way to “increase flowering” or “increase fruiting”, something which studies have shown to be false for several different plant species. On today’s article we will talk about cobalt, its potential use in hydroponics, the conclusions of the studies that have been done and the potential danger involved with the use of cobalt in hydroponic solutions.

Cobalt is a transition metal from the same group as Rhodium and Iridium with chemical properties similar -yet quite different- to these other elements. As a chemist specialized in the area of organometallic chemistry – and especially through my work with this group – I have always enjoyed the chemistry of this element. Cobalt has many uses in pigments, radiotherapy, batteries, etc. Biologically its most important role comes as the metal center of the vitamin B12, cobalamine, which is essential to human life. Vitamin B12 is a large coordination complex in which Cobalt is tightly bound by an organic macrocyle, interestingly enough, this is one of the very few examples of a carbon-metal bond in nature with one of the axial ligands of cobalamin being a methyl organic group (in methylcobalamin at least).

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So now that we know that cobalt is an essential part of a vitamin, it may seem obvious to use it as a minor constituent of our hydroponic formulations. However careful studies have shown that – if cobalt is needed by plants – it is only needed in the most minute quantities with concentrations of only 5 ppm already being markedly detrimental to plant growth (L.Gómez shows this effect in two studies in both lettuce and tomato). Other studies in the lower concentration range (>5 ppm) are contradictory and none show conclusive evidence that the additions of cobalt may be a good idea to increase plant yields in general.

Some people argue that cobalt is essential for some nitrogen fixing bacteria and that plants that rely heavily on these organisms might see improvements with cobalt additions not because of their "personal use" but because of the added benefit of having a healthy microbial population. Although these claims seem to "make sense" to a certain extent there haven't been any studies that confirm that this is true and that a strong and obvious effect exists due to the addition of cobalt to a nutrient solution. If anything current studies point to the fact that cobalt additions can be detrimental and that -if beneficial- it would only be in the smallest quantities which might already be present in your formulation through mineral impurities.

You have to take into account that most people and companies use fertilizer grade chemicals for the preparation of their hydroponic formulations (otherwise it is not cost effective). These chemicals are most of the time around a purity of 80-98% with most of them being in the 95-98% zone. Since some of these minerals hold cobalt as some of their natural impurities (copper and manganese salts for example) it is not surprising if adequate cobalt levels are already present in your solution through the mere impurities you introduce with your own formulations.

In the end it seems that cobalt additions are unnecessary and the person doing them runs the risk of decreasing their yields and possibly causing a toxic accumulation of this nutrient within the plant’s system that may later be detrimental to the consumer’s health. In this case the no-harm principle should apply, if a given additive is suspected of having detrimental effects then avoiding it is the best possible course of action while conclusive evidence of any positive effect (and the dose in which they are achieved) is revealed. Right now we know plants grow very well without additions of Co and we also know that even low concentrations of Co are not beneficial.

Silicon in Hydroponics : What Silicon is Good For and How it Should be Used

Certainly if you have been involved with hydroponics for a while or even if you have just started to research this awesome field you might already know that science has only discovered a handful of elements to be necessary for plant growth. From the first 92 elements of the periodic table, plants have only been proved to require C, H, O, N, K, P, S, Mg, Ca, Fe, B, Cu, Mo, Zn and Mn for their adequate growth. However it is certainly true that some other elements have proved to be beneficial – in certain quantities – for the development of several different crops. Such elements include Co, Si and Na. On today’s article I am going to introduce you to Si, the way in which plants absorb it, how it should be administrated and the positive effects it is bound to have on your hydroponics plants.

Silicon is definitely one of the most abundant elements on the Earth’s crust, forming – with aluminium – a very large portion of the earth’s heavier elements. Silicon is mainly present in nature as the silicate ion (SiO_3^{2-}) forming solids with different degrees of polymerization known in the geological world as silicates. From these silicates we have a very large variety of minerals, from the aluminosilicates formed with aluminium to the very fine quartz particles (white sand) making up some of the most beautiful beaches throughout the world.

However when thinking about silicon and our plants we need to think about the way in which plants would be able to absorb this element. The minerals in which silicon is found are quite insoluble at room temperature and for this reason they cannot be absorbed efficiently by plants. If we want our plants to get some silicon we need to provide it in a form which is soluble and readily available for absorption. Such a form is sodium silicate (Na_2SiO_3) usually available as a pure solid or a solution in water called “liquid glass”.

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Studies in the field of hydroponics have shown that different types of cultivars such as wheat, tomatoes and cucumbers react positively to a moderate addition of silicate ions. When water glass is applied at a concentration of around 100pm (measured as SiO_2), positive effects are found including increased weights of fruits, increased nutritional composition and – most importantly – a very important increase in the resistance to bacterial and fungal diseases. It seems to be that plants use the silicate ions to “line-up” their cell-walls offering a strong additional mineral resistance to any incoming pathogens that would want to get into their cells. Since plants lack and active immunological system, passive measurements like this which increase cell-wall strength are likely to be key to increase disease resistance for many crops.

However most people are quite careless about the way in which they apply this “liquid glass” since they are mostly unaware of the very sensitive equilibrium that takes place to maintain silicate ions in solution. Silicates are by definition very insoluble and the acidic pH in hydroponics is bound to cause some precipitation of different reaction products of this ion with other ionic species present within the hydroponics solution. The silicate ions can also form silicic acid and start to polymerize into complex macromolecular constructs. As a matter of fact, several studies do include information about the problems with drip systems, sprinklers, nozzles, etc, when using silicate ions since they tend to precipitate easily outside the hydroponic solution.

I would suggest – and so I have done with my own systems – that it is better to apply small quantities of silicate ions every 2-3 days, instead of applying a large amount during the beginning process. Applying a large amount of “liquid glass” (the 100ppm for example) would most likely end in most silicate falling out of solution and only a small part becoming available for plant absorption. I believe that the best thing to do is apply about 5ppm (measured as SiO_2) every 2-3 days until the solution needs to be changed. This provides both higher stability and a better control over the solubility of this tricky ion within the hydroponic solution. Of course this is purely anecdotal evidence and no controlled study has yet shown this to be better. If you want to obtain results as those of the scientific literature available then applying the 100ppm on every reservoir change might be the wisest thing to do.

The NPK Mystery – What Do These Numbers Mean and How are they Calculated ?

When you go into a forum about hobby hydroponic or soil growing one of the first things you will notice is that there is a big confusion regarding the meaning of the traditional NPK notation and the way these values are actually calculated. Some people believe this is supposed to be merely an N to P to K ratio measurement while others erroneously use ppm information directly to get their NPK fertilizer information. On today's post I want to talk about the real meaning and nature of the NPK measurement as it is used in traditional agriculture, how it is calculated and what it tells us about a fertilizer. (below a fertilizer made with pelletized nutrients in clay, traditionally described using the NPK ratio, this ratio is important because it is necessary to know how much is clay and how much is fertilizer)

The NPK measurement was invented as a way to gauge the quality and concentration of the 3 most important nutrients relevant in agriculture within a particular solid or liquid fertilizer. These three numbers represent the percentage composition by weight of any given fertilizer, telling us its percentage composition of N as nitrogen, K as K_2O and P as P_2O_5. The reasons why K_2O and P_2O_5 were used to represent potassium and phosphorous instead of referring to the simple quantities of these elements are that, first of all, the traditional

analysis methods used to determine K and P give the values of the oxides in a more straightforward manner and second, the actual percentages of K and P when expressed as the oxides give “good ratios for the plants in soil” when the values are close to the value of N (making comparisons easier).
It is now important to note that the NPK reading must be calculated taking into account the weight of the given nutrient within the solution and the WHOLE weight of the fertilizer used. For example if you have a liquid concentrated fertilizer that has a composition of N = 12000 ppm, K = 20000 ppm and P = 4000 ppm which was prepared with 200g of added salts. The NPK ratio of this solution would be :

Total Solution Weight = 1000g (1L of water) + 200g (added salts)

N = 12000 ppm = 12000 mg/L = 12 g/L
K = 20000 ppm = 20000 mg/L = 20 g/L
P = 4000 ppm = 4000 mg/L = 4 g/L

Percentage of Nitrogen = (12g/1200g)*100 = 1%
Percentage of K as K2O5 = (20g/1200g)*1.2046 (K to K2O conversion factor)*100 = 2%
Percentage of P as P2O5 = (4g/1200g)*2.2914 (P to P2O5 conversion factor)*100 = 0.76%

The final NPK ratio is therefore 1-0.76-2. As you see you need to know the total weight of the solution and the elemental composition in order to be able to obtain this number. It should also be clear that the traditional NPK ratio is a PERCENTAGE COMPOSITION measurement and NOT a mere comparison of the ppm concentration ratios of N, P and K. Knowing a fertilizer’s NPK not only allows you to know the ratio between these three elements but it also allows you to know how much of each one is contained within the solution so that the relative strength of different fertilizers can be calculated.

The traditional NPK ratio however has very limited use in hydroponic cultivation since it was invented to gauge the quality of soil intended fertilizers. Nonetheless it can be used to compare the relative strengths of different fertilizers and the ratio of the three main nutrients within them. However it should be clear that if you want to communicate a measurement that compares ppm concentration ratios you should not refer to this as an NPK measurement since this will cause confusion against the "traditional NPK" which was explained above. In hydroponics it would be easier to talk about ratios of ppm which should be expressed as N/K-P/K-1 for example which would give us the ratio of N to K and P to K without giving information about the percentage composition of the solution.

Truly Cleaning Your Hydroponic System : The Fenton Process and Chemistry

When most people clean their hydroponic systems they use a hypochloride or hydrogen peroxide wash that they think kills all the bacteria and potentially hazardous substances within their setup. However few people realize that – although the system is indeed sterilized – the bast amount of harmful substances and chemicals (even those coming from the plastics themselves) remain intact after the attack of either hypochloride or peroxide. For example, many of the harmful plasticizers and complexes used for the making of PVC and other polymers remain intact after a rigorous wash with these two cleaning agents. So what can we do to truly clean our hydroponic systems and get rid of all the bad things that may be quietly waiting their turn to get into our plants ? The answer comes in the form of a very well known process used world-wide to clean water supplies from toxic chemicals : the Fenton process.

In the late 19th century, Henry John Horstman Fenton discovered a chemical process which was able to oxidize the most resilient organic molecules and turn them into harmless chemicals. As a matter of fact, Fenton's process was so revolutionary that it sprouted a whole new area of research called Fenton chemistry in honor of its discoverer. What was this wonderful discovery ? Within the next few paragraphs you will learn what the Fenton reagent and process are all about and – most importantly – how this process can help you clean, I mean REALLY clean, your hydroponic system between growth cycles.

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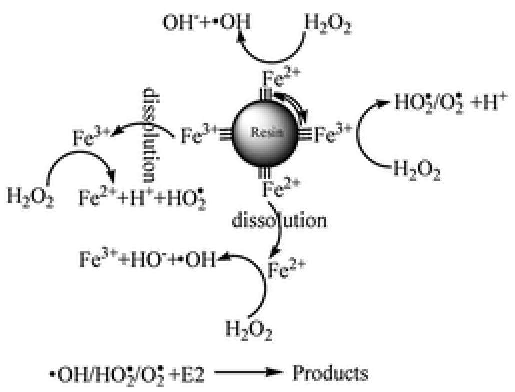

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If you have been preparing your own hydroponic solutions and you have been using hydrogen peroxide then you already have most of the things you need to do some Fenton chemistry. The process basically works by adding a source of iron ions (they must NOT be chelated, like iron (II) sulfate) and hydrogen peroxide to a water solution. The iron ions then catalyze a series of reactions that generate powerful oxidizing radicals that destroy almost all harmful organic substances within your system. The iron ions are KEY to the Fenton process since they allow peroxide to generate this extremely reactive substances that are never present when peroxide exists on its own (reactions shown above). Research has found – for example – that phenol (a common chemical used as a model contaminant) remains unchanged in the presence of large concentrations of hydrogen peroxide while it is quickly destroyed in the presence of the Fenton reagent (Iron ions plus hydrogen peroxide). So what do you need to do ?

- First of all you should add about 0.2g of Iron (II) sulfate per liter of solution you will be using to clean your system.
- Then you should set your pH to a level between 3 and 3.5 using a STRONG non-organic acid such as nitric or sulfuric acid. You should NOT use citric, acetic or phosphoric acids since they lower the effectiveness of the Fenton reaction.
- Add as much peroxide as you would add to regularly clean your system. About 70mL of 50% hydrogen peroxide for each liter of solution works very well.
- Circulate the Fenton cleaning solution for at least 6 hours.
- Wash your system with water until no Fenton solution remains.

It is key for you to use a non-chelated iron source since chelated iron sources such as FeEDTA or FeEDDHA do NOT work well since the chelate does not allow the iron ions to properly react and participate in the Fenton chemistry that should be going on. The pH adjustment step is also vital since a pH above 5 would cause the formation of FeOH3 instantly upon the addition of H2O2 with the subsequent catalytic decomposition of all the H2O2 by the iron hydroxide (this is NOT something we want !). After you use the Fenton reagent to clean your system you will be certain that a lot of the harmful organic molecules that were present have been destroyed and your system will now be able to play as a sterile and harmless host to your new set of beautiful plants.

Iron Sources in Hydroponics :

Which One is the Best ?

Definitely one of the most important problems dealing with the stability of hydroponic solutions is the availability of the iron (Fe+2 or Fe+3) ions. Since iron easily forms hydroxides and insoluble salts with other ions present in hydroponic media it becomes essential for us to provide iron in a way which is accessible to the plant and does not “come out” of the hydroponic solution through precipitation. Within the next few paragraphs I will talk to you about different iron sources available to hydroponic growers and which source is actually the best one we can use in hydroponic nutrient solutions. We will go through the different factors that make an iron source better or worse and finally we will be able to choose one as the ideal source for our nutrient needs.

What is the problem with iron ? The main problem we have with iron is that – unlike most other transition metal ions in hydroponic solutions – it is a very strong hard lewis acid which easily forms insoluble salts with many of the hard lewis bases within our hydroponic solutions. When iron is added to a nutrient solution in its “naked” form (for example when adding iron (II) sulfate) the ion easily reacts with carbonate, phosphate, citrate, oxalate, acetate or hydroxide ions to form insoluble compounds that make the iron effectively unavailable to our plants. To put it in simpler terms, iron ions have a chemical nature which is similar but opposite to that of many other constituents of our hydroponics solution meaning that when they meet together they form a “perfect match” that does not easily separate.

There is not only a problem with the higher inherent chemical match-making of iron with the anions present within the solution but we also have the problem that iron is always present at a much higher concentration than the other micronutrients. So even though some transition metals like copper would suffer from similar problems the fact is that they do not simply because of their much lower concentration (Fe is usually around 3-5 ppm while Cu is usually around 0.05-0.01 ppm).

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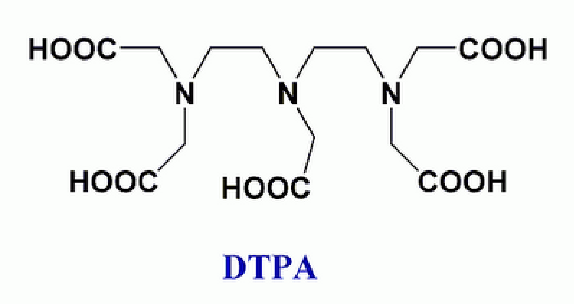


The solution to this problem is actually easy and comes in the form of chelating agents that “wrap” around the iron ions and make them disappear to anions that may want to form stable salts with them. There are many of these chelating agents with the most commonly used being EDDHA, EDTA and DTPA. They are different due to the fact that their stability is different and their abilities to dissolve iron are also different. While all of them make sure iron stays within solution EDTA only allows this to happen until pH 5-6 while, DTPA takes it until about 8 and EDDHA to more than 9. The most stable iron complex is definitely FeEDDHA but this does not make it necessarily the best candidate for hydroponic growing.

The fact is that although EDDHA binds iron much more strongly it decomposes easier within the hydroponic solution than EDTA or DTPA (this is due to the fact that EDDHA is composed of several different isomers, some of which are not very stable), reason why this complex appears to be but is not the best solution for hydroponic nutrient solutions. The best compromise between stability and durability is earned by DTPA which gives us a very stable complex and a strong resistance to decomposition. So next time you are looking into getting a new complex for your Fe needs, try FeDTPA (this salt can also be used with my hydroponic calculator).

Chemical Buffers in Hydroponics : What is the Best, Cheapest Buffer

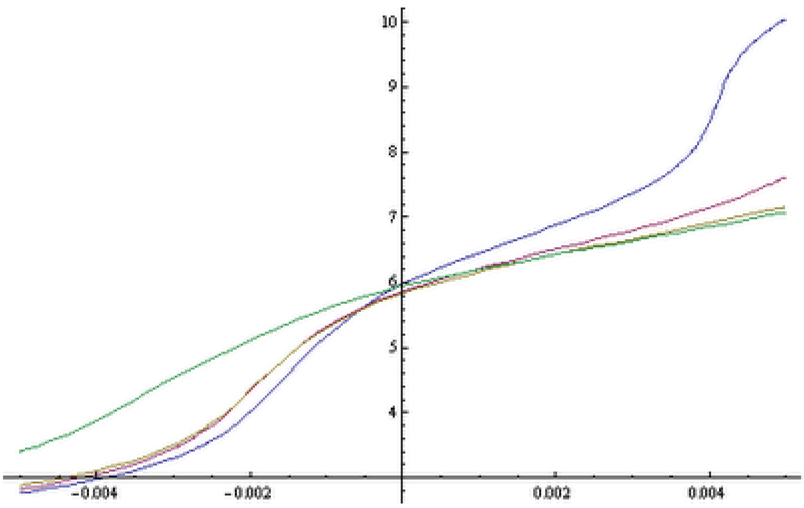
One of the biggest questions people ask when starting to grow hydroponic crops deals with the stabilization of pH and the use of chemical buffers to keep pH levels at acceptable ranges during long periods of time. The question is very relevant since changes in the pH of a nutrient solution can cause a lot of problems related to nutrient availability and having to add large quantities of acids or bases to correct the deviations is also not something plants will enjoy very much. What we need to do then is to keep pH levels within an acceptable range, for a period at least long enough to last a few weeks.

On previous posts I have talked about the way in which I do this using ion exchange resins but these can be too expensive or hard to find for most hydroponic growers out there. More over, chemical buffers are often much easier to use, get and apply although their actual mechanism of action is much less effective and much more aggressive than that of the ion exchange resins. A chemical buffer is mainly a substance which is added into your solution that distributes itself as different ionic species that can react either with acids or with bases at certain pH levels. The buffer however is also available for your plants to absorb and therefore we are limited to chemical buffers which are not phytotoxic (toxic to plants) and which allow us to control pH within the range we want.

From the very large library of chemical buffers available to the modern chemist, only a handful are suitable for their use in hydroponics and – even then – most of these are actually not practical in the sense that they are extremely expensive for the home grower. Certain organic buffers like MES offer extremely good results although they are hard to buy and very expensive, a reason why they are not used widely in hydroponic culture (this buffer is used mainly on hydroponic research where precision – and not cost – is the main determinant factor).

The buffers we are left with are then very simple organic and inorganic substances that have low phytotoxicity and some compatibility with the other ions present in our hydroponic setup. From these ions phosphate species, citrate species and carbonates are the most important ones we can use within our hydroponics setup. However we are limited by the actual concentration values of each we can use and for this reason we cannot have unlimited buffering capacity from these sources.

Which one is best ? We can actually carry out simulations to show us the pH vs acid-base addition for different hydroponic solution constitutions using mathematical equations. Running these simulations requires the solution of highly complex systems of equations which contain all the information relative to the chemical equilibrium of all the different existing ionic species. The below shown simulations were carried out using the Mathematica computer program (all solutions are assumed to be adjusted to an initial pH of 5.8 with a strong acid or base).



The blue curve represents the behavior of a poorly buffered hydroponic solution with only about 0.002M phosphate concentration (about 50 ppm of P). The red and yellow curves represent two solutions with increasing levels of carbonate showing us that if you are battling pH increases, having more carbonate will definitely help you deal with this. However it is also clear that carbonate concentrations at pH 5.8 are restricted to around 100 ppm since values above this are bound to cause toxicity due to the very large presence of the hydrogen carbonate ion. The green curve represents an increase in the amount of phosphate from 0.002 to 0.004M (about 100 ppm) with carbonate, showing us that phosphates are not good at buffering increases towards the upper side but they do increase buffering towards acid territory. Overall I also noticed that citrate concentration increases to the maximum threshold allowed by calcium citrate solubility did not afford a very good buffering effect with only a mild effect that prevented shifts towards the downside.

In the end, the conclusion seems to be that in a regular hydroponics system where pH increases generally happen towards the upside it is better to use carbonate as a buffering agent than to use citrate or phosphate although phosphate at its regular concentration in hydroponic does provide some buffering against pH moves (without phosphate increases are much more dramatic). For this reason I believe that a phosphate/carbonate buffer seems to be the best choice for most hydroponic growers, taking care to keep the concentrations at levels that do not cause precipitation or phytotoxicity problems.

Preparing Your Own Hydroponic Nutrients : A Complete Guide

for Beginners

Chances are that if you are into hydroponic gardening and you live in Europe or in the US you have been buying your nutrient solutions from one of the many hydroponic nutrient sellers available locally. Generally people do not prepare their own nutrients because they consider this task “terribly difficult” and they prefer to keep buying previously made formulations so that they don’t have to deal with the technical problem of making their own fertilizers. What most people don’t realize is that the profit margin of hydroponic nutrient producing companies is HUGE. You would be surprised to know that each one of those concentrated nutrient gallons you buy costs only a few dollars to make (sometimes even only pennies) and you are probably paying a few times what the whole fertilizer is worth.

Obviously if you are going to be growing plants for a long time or if you simply want to grow a large garden the buying of this commercial nutrient solutions is not an option and starting to make your own formulations – adjusted to your own needs – becomes the main priority. On today’s article I will be speaking to you about how to prepare your OWN solutions using my nutrient solution calculator, carefully explaining to you what you need, where to buy it and what you should expect. I will guide you through making your own first A+B solution by YOURSELF getting all the chemicals and utensils you need easily and economically.

So what do you need to make your own nutrients ? The list below shows you the things you will need to start making your own A+B solutions. You will notice that you will need two scales since we are going to have to weight two “nutrient sets” with different precision, micro nutrients (which are used only in small amounts, need to be weight more precisely) and macro nutrients (which are used in larger amounts and therefore need scales with larger capacity).

Note, the links below are amazon affiliate links. This means you help out this blog by buying through these links at no extra cost to you.

- Scale that can weight down to 0.01 g at a +/- 0.01g precision (something like this is perfect) with a max weight >100g.
- Two Empty one gallon containers with caps
- Plastic Spoon
- Plastic small container (to weight salts)
- A source of RO or distilled water (your tap water will NOT work)
- Download my hydroponic nutrient calculator here.

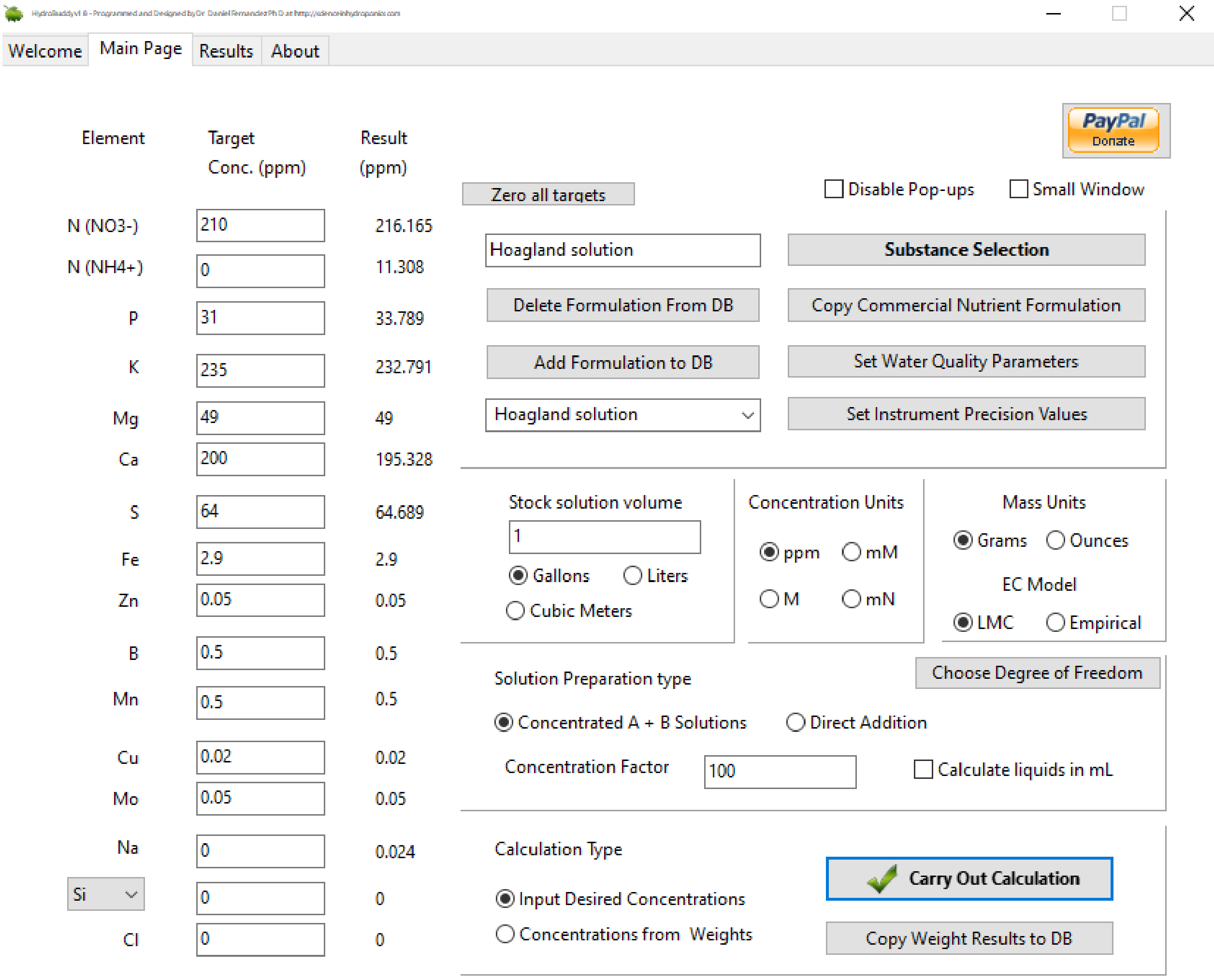
Now these are the chemicals you will need (an online purchase link is included for each one) :

- Calcium Nitrate (here)
- Magnesium Sulfate Heptahydrate (here)
- Potassium Nitrate (here)
- Copper Sulfate Pentahydrate (here)
- Mono potassium phosphate (also known as Potassium Monobasic phosphate) (here)
- Manganese EDTA (here)
- Zinc Sulfate Monohydrate (here)
- Sodium Molybdate (dihydrate) (here)
- Boric Acid (here)
- Iron EDTA (here)

These chemicals can be bought in a variety of places but there is a link next to each one showing you a link where you can actually make the purchase. Often it is also possible to get these chemicals on ebay. The purity may not be as guaranteed as when purchased from a regular supplier but it is good enough for practical purposes in hydroponics.

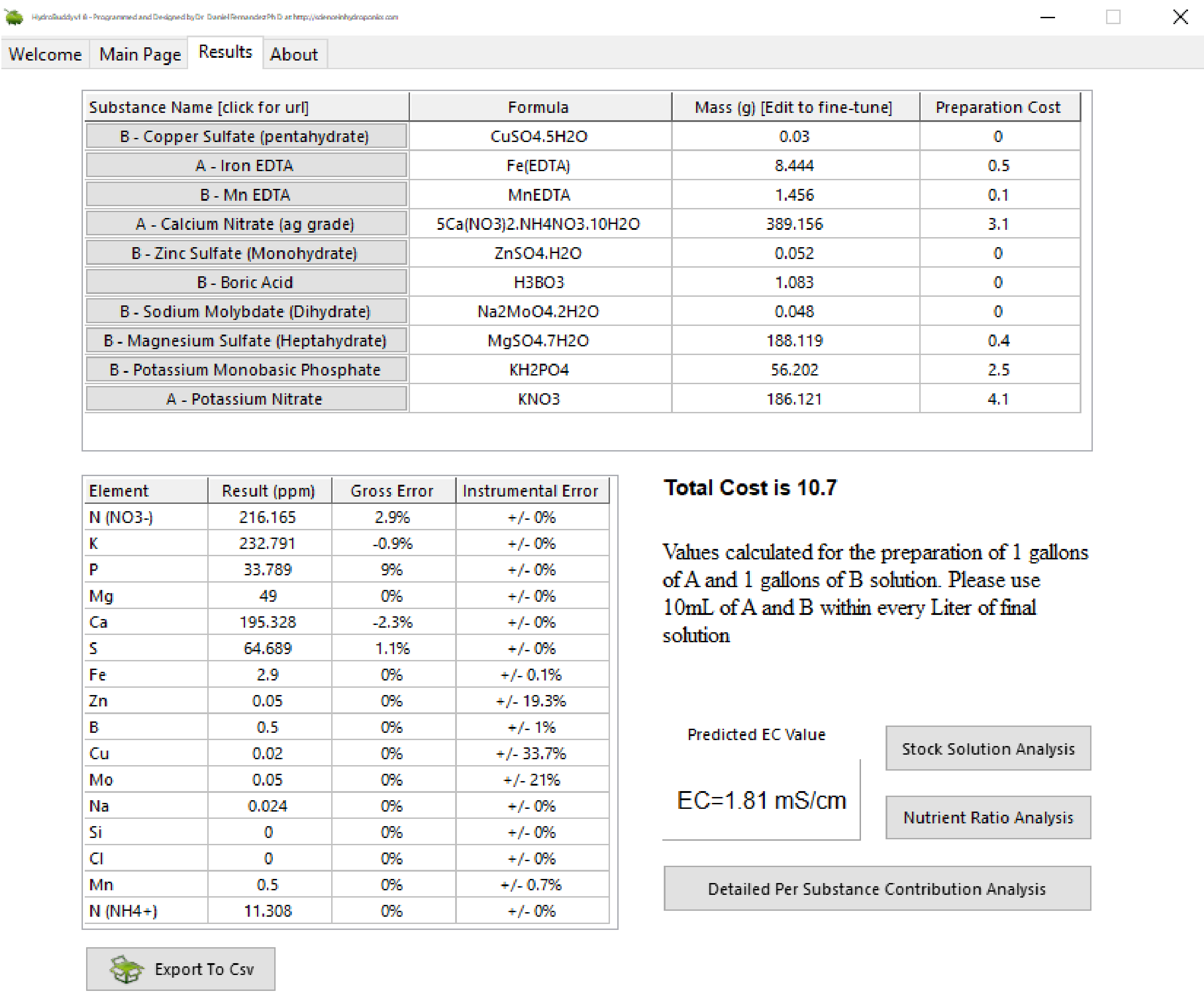
Of course you may see right now that the initial investment might be significant (from 100 to even more than 500 USD depending on whether you buy 50lb or 1lb quantities of macro nutrients) however after this purchase you will be able to produce more than one hundred gallons of concentrated A+B solutions which would cost you more than 10 times the price you will be paying if you bought them commercially. After doing the math you will see that this is a GREAT way to save money and produce your own solutions ! Hey you could even start selling to the neighbors !

After you buy the chemicals, open my hydroponic calculator and select the “Hoagland Solution”. Then click the “Concentrated A+B Solutions” radio button and make sure you select the “Input Desired Concentrations” option. Set the amount of stock solution volume to 1 and the radio button to “Gallons”. Then click the “Substance Selection” button and make sure you add all the substances that are from the above list into the “Substances Used for Calculations” list. Now click the “Carry Out Calculations”. Your screen should look like the picture shown below .



This is how the calculator should look after you click the "Carry out Calculation" button. Note the selections that are active.

Now that you have calculated the weights needed you should go to the "calculation results" tab where you will be able to find the weights of the different nutrients you need to prepare the solution in the amount you specified. The results of the calculation to prepare 1 gallon of A and 1 gallon of B stock solutions are shown below.



Substance Name [click for url]	Formula	Mass (g) [Edit to fine-tune]	Preparation Cost
B - Copper Sulfate (pentahydrate)	CuSO4.5H2O	0.03	0
A - Iron EDTA	Fe(EDTA)	8.444	0.5
B - Mn EDTA	MnEDTA	1.456	0.1
A - Calcium Nitrate (ag grade)	5Ca(NO3)2.NH4NO3.10H2O	389.156	3.1
B - Zinc Sulfate (Monohydrate)	ZnSO4.H2O	0.052	0
B - Boric Acid	H3BO3	1.083	0
B - Sodium Molybdate (Dihydrate)	Na2MoO4.2H2O	0.048	0
B - Magnesium Sulfate (Heptahydrate)	MgSO4.7H2O	188.119	0.4
B - Potassium Monobasic Phosphate	KH2PO4	56.202	2.5
A - Potassium Nitrate	KNO3	186.121	4.1

Element	Result (ppm)	Gross Error	Instrumental Error
N (NO3-)	216.165	2.9%	+/- 0%
K	232.791	-0.9%	+/- 0%
P	33.789	9%	+/- 0%
Mg	49	0%	+/- 0%
Ca	195.328	-2.3%	+/- 0%
S	64.689	1.1%	+/- 0%
Fe	2.9	0%	+/- 0.1%
Zn	0.05	0%	+/- 19.3%
B	0.5	0%	+/- 1%
Cu	0.02	0%	+/- 33.7%
Mo	0.05	0%	+/- 21%
Na	0.024	0%	+/- 0%
Si	0	0%	+/- 0%
Cl	0	0%	+/- 0%
Mn	0.5	0%	+/- 0.7%
N (NH4+)	11.308	0%	+/- 0%

Amounts of salts to be weighted to prepare 1 gallon of A and 1 gallon of B solution.

You should now follow these steps to prepare the solution:

- Mark one gallon container with an A and the other with a B. One gallon will contain all the A salts, the other all the B salts.
- Fill each one gallon container with half a gallon of RO or distilled water
- Weight one salt on the plastic container you set apart for measuring. Make sure you always DOUBLE check the weights and the appropriate A or B gallon container you need to add the salt to.
- After you measure the salt transfer it to either the A or B gallon container (depending on which one it should go into). Use a little bit of water (RO or distilled) to

transfer any remains that cannot be easily added and dry the container you are using to weight before measuring the next salt.
- Shake the container where you added the salt and make sure it is fully dissolved before measuring and adding the next one.
- Do the same as above for all the salts
- After you are done adding the salts add half a gallon of water (again RO or distilled) to each container
- Then seal the containers and shake them vigorously
- You have just prepared your first batch of self-made nutrient solution !

The above formulation is a general multi-purpose blend – a Hoagland solution – that should allow you to grow a large variety of plants. You simply need to add 10mL of A and 10mL of B for each final LITER of nutrient solution. You should use your pH meter and EC meter to adjust these values as you do with your regular commercial nutrients.

It is very important now to keep your solid chemicals stored in air-tight container in a dark and cool place. Some chemicals like calcium nitrate will absorb moisture and become useless if you leave them in contact with air for prolonged periods of time!

Of course, once you are more comfortable with preparing your own nutrients you can research the available literature for some custom formulations available to grow each one of your plants under its favorite nutrient levels. I hope this tutorial has allowed you to reach a new level in your hydroponic gardening experience, hopefully accompanied by a drastic reduction in your soil-less gardening costs !

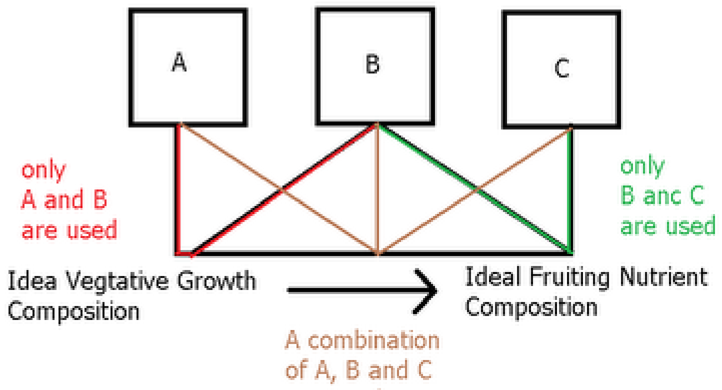
Make sure you also checkout this youtube video for a similar tutorial using a premade chelated micronutrient mix.

Preparing A, B and C (three part) Concentrated Nutrient Solutions, a Tutorial for my Hydroponic Nutrient Calculator

On the last tutorial dealing with my hydroponic nutrient calculator we learned how to prepare A and B concentrated nutrient solutions for any given formulation we would like. We learned about the different incompatibilities that need to be avoided and why this leads to the creation of two separate solutions. After learning how to prepare these solutions many of you may be interested in knowing how to make the three part formulations commonly made available by most hydroponic nutrient sellers. For example, companies like Advanced Nutrients and General Hydroponics offer three part formulas which are meant to be combined to ensure adequate nutrition during a plant's whole growing cycle. Today I am going to explain to you the main objectives of a three part formula, the difference with a two part formula and how you too can prepare your OWN three part nutrients to feed your hydroponic plants through their whole vegetable, flowering and fruiting cycles. As with the past two tutorials you will need to download my hydroponic nutrient calculator available here for free.

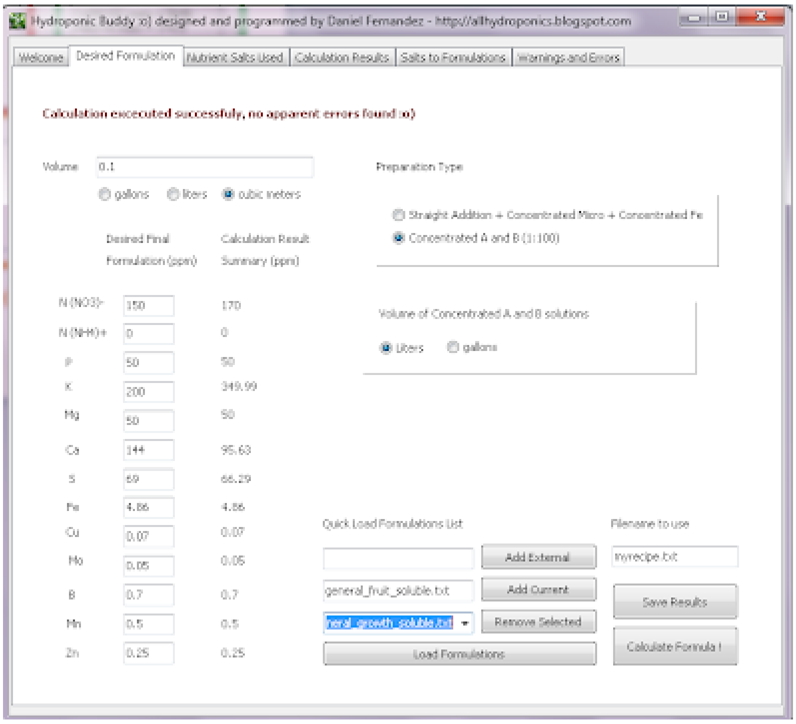
What is the difference between a 2 and a 3 part formulation ?

What we need to understand here is that plants usually have different needs through their whole life cycle and therefore they require different nutrient ratios as they grow older and face different stages of their development. With a two part concentrated nutrient based formulation we can only vary this ratios in a certain way and doing any variations outside this scope will not be possible. With the default approach in my calculator you can vary nutrient ratios by varying the "desired formulation" every time you prepare your reservoir again (since most nutrients are added directly) but with the A and B concentrated solutions you are bound to "stick" to a certain set of concentration values for each nutrient.

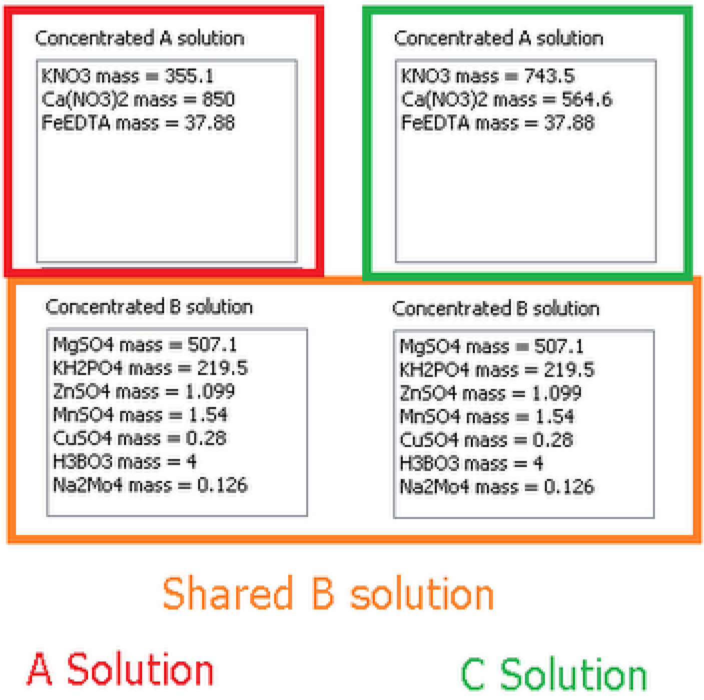


The solution to this problem is quite simple and this is what most commercial fertilizer sellers have come up with. You have two solutions with the same salts but varied nutrient ratios and a third solution that remains constant. What we have then is two possibilities of final compositions A-B and C-B and a whole new possibility for nutrient ratios by combining A-B-C. What is done most of the time is that A-B becomes an ideal formulation for vegetative growth while C-B is an ideal formulation for fruiting. When you start to grow you generally do so with A-B and then you move towards C-B by increasing C and decreasing A as reservoir changes happen.

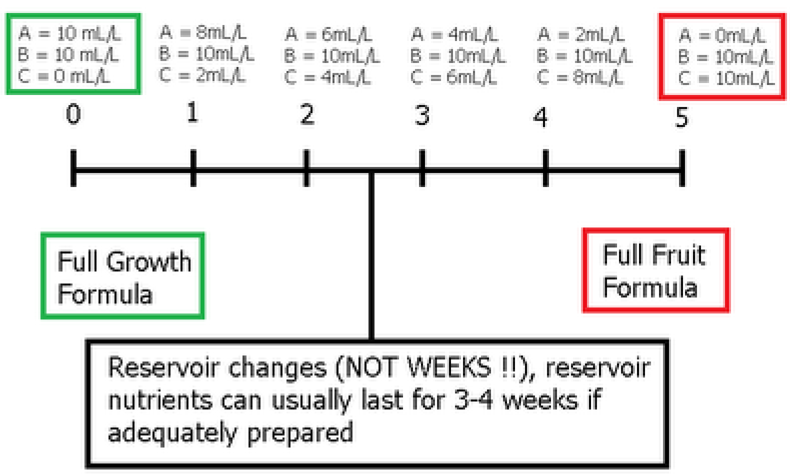
In my program this sort of solution scheme is easily achieved. What you need to do is simply to have two desired formulations, one for ideal growth and one for ideal flowering and then you just need to make two sets of A and B calculations where B is shared amongst the two. To do this we will first load the general_growth_soluble.txt and general_fruit_soluble.txt desired formulations as indicated on the tutorial for the preparation of A and B formulations (you can download them here and here). After loading the general_growth_soluble.txt composition you should have the formulation composition displayed below.



Then follow the same procedure outlined on the “A and B solution tutorial” to arrive to the salt-weight compositions of the A and B formulations (save the results using the “save results” button) . Now load the general_fruit_soluble.txt formulation and repeat the calculation, also saving your results. A summary of the results of both calculations is shown in the image presented below. You will notice that both calculations share the same weights for the B solution (meaning they use the same B solution) while the composition of the A solution changes. What you have now is a basic three part formulation. You could now think about a regime to change from an A-B growth solution to the C-B fruiting solution in the amount it takes your plants to bear fruit.



For example, if your plants took aproximately 5 reservoir changes you would then use different quantities of A and C to go from a 100% A feed to a 100% C feed during that time. A timeline if it takes your plants 5 reservoir changes to get to fruiting is shown below. Note how in the beginning we use 10mL of A per liter and then in the end we use 10mL of C per liter, meaning that we have done a full gradual change from a growth to a fruiting formulation.

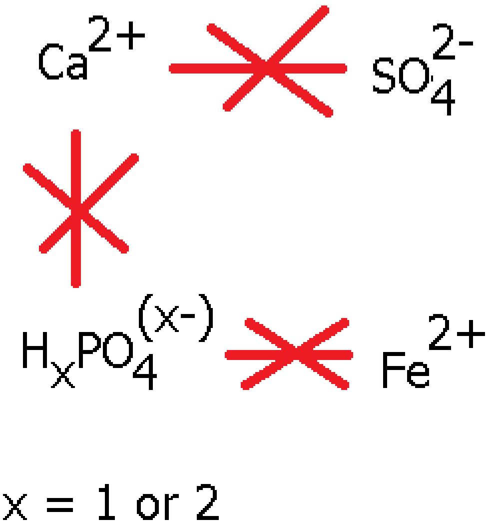


As you see from the above, you can easily use my hydroponic calculator to prepare your own three part concentrated nutrient blends which you can use to build your own nutrient schedule to go from vegeative growth to fruiting. However if you are currently using a fixed composition of a three part commercial nutrient blend then you can easily prepare an A and B solution to replace it, three part nutrients are ONLY needed when you want to do a varying schedule like the one introduced above, using three part nutrients without doing this is simply an overcomplication since a fixed composition can be prepared using just two custom concentrated solutions.

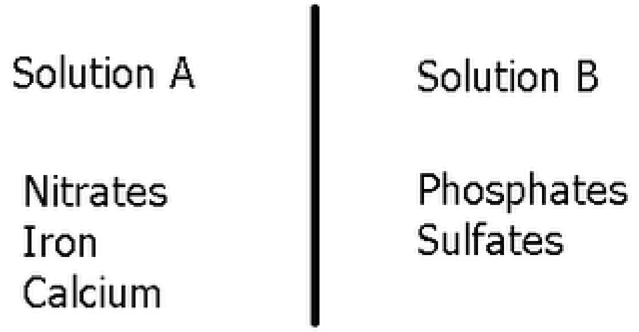
Preparing A and B Solutions Using My Hydroponics Nutrient Calculator

The default way in which solutions are prepared using my hydroponic nutrient calculator involves the direct addition of some component in your nutrient reservoir plus the preparation of some micro nutrient and iron concentrated solutions from which 10 and 100mL are added per batch. This way of preparing solutions is especifically suitable for people with large reservoirs and commercial hydroponic growers since when reservoir levels go above 4 cubic meters all nutrients can be added directly to the reservoir, saving the time and cost of preparating any concentrated solutions. The approach is also good for people with small reservoirs since you can prepare the micro and iron concentrated solutions, dissolve other salts directly and in the end you will have a very accurate amount of micro and macro nutrients prepared with your own custom formulation. However upon the request of several people I implemented an approach that allows people to prepare traditional formulations using an A+B concentrated nutrient solution approach in which two concentrated solutions at a 1:100 ratio are prepared and then simply diluted to prepare the final hydroponic reservoir’s contents. On today’s post I will discuss this approach and how you can use it if you have the appropiate nutrient salts. Please download my hydroponic nutrient calculator here to follow this tutorial.

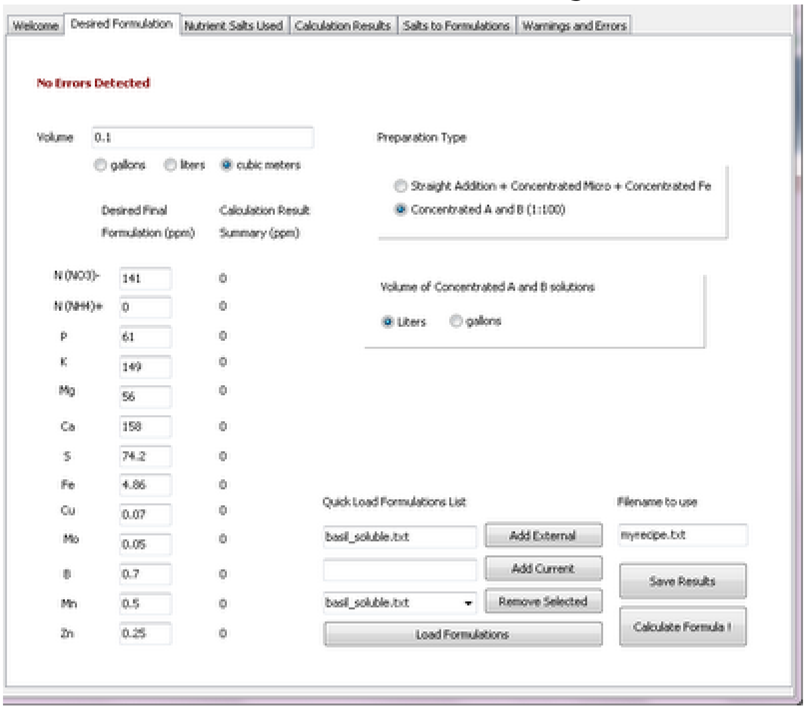
Before we go into the main aspects of the preparation of concentrated solutions we must first understand the incompatibilities that are present within concentrated solutions that restrict the salts that can be used. The program checks for these incompatibilities automatically when using any of the saved salts and for this reason custom salts cannot be used for the A and B custom preparation. The main incompatibilities are shown on the image below. Mainly what we want to ensure is that certain ion pairs that would precipitate insoluble salts are never present together. For this we should avoid putting calcium and sulfate ions together as well as calcium and phosphate species and iron and phosphate species.



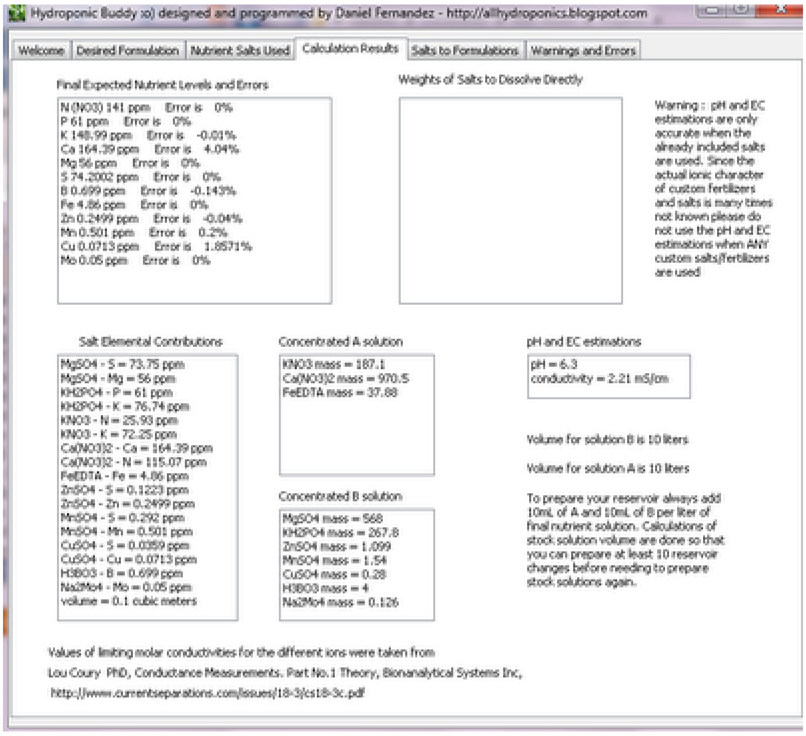
What we have left is the layout shown below that describes the general distribution of ions relevant to solubility of an A and B hydroponics formulation makeup. As you see what we achieve by dividing the concentrated solution into two is to keep away the ions that would precipitate when put together. This of course also restricts our ability to use iron sulfate and a different source of iron, either a chelate (FeEDTA, FeDPTA, etc) or iron nitrate must be used. It also restricts our sources of Calcium to calcium nitrate and therefore our sources of phosphate and sulfate are reduced to potassium salts.



Now let us use our basil_soluble.txt example to calculate the composition of the given A and B solutions needed for this formulation. Unzip the calculator and txt files to any given directory and input basil_soluble.txt under the field next to the “add external” button in the “Desired Formulations” tab, then click the “add external” and “Load Formulations” buttons and select the basil_soluble.txt formulation from the drop down menu. The end result of this process is shown on the image below. Also make sure you check the “Concentrated A and B” option so that the program calculates the results for these solutions instead of the regular method.



After doing this go to the “Nutrient Salts Used” tab and uncheck Calcium Monobasic Phosphate and Iron Sulfate and check Iron EDTA, Potassium Sulfate and Potassium Monobasic Phosphate. Now go back to the “Desired Formulations” tab and click the “Calculate Formula!” button. The program will now calculate the volume of A and B solutions you should prepare so that it will last for 10 reservoir changes of the volume you have input under the “Desired Formulations” tab. So for this case in which we left the input as 100L the final concentrated solution volume is 10L since it will last for 10 changes of the 100L nutrient reservoir, adding 1L per reservoir change. It should also be clear that the concentration ratio of 1:100 cannot be increased due to solubility limitations of salts. The results of the calculation are shown below.

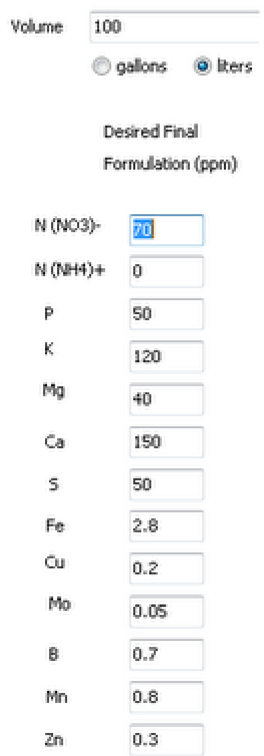


Hopefully with this tutorial you will be able to prepare any A and B solution for any final formulation you would like. It is also clear that this approach has less flexibility than the “default” since it restricts the character and distribution of the salts used, making the use of very cheap fertilizers like calcium monobasic phosphate effectively impossible. However it also provides an “easy way” to make reservoir changes since concentrated A and B solutions only need to be prepared once every 10 times this happens. So it is clear that both approaches have their advantages and with the help of my calculator you’ll be able to choose whichever approach fits you best :o)

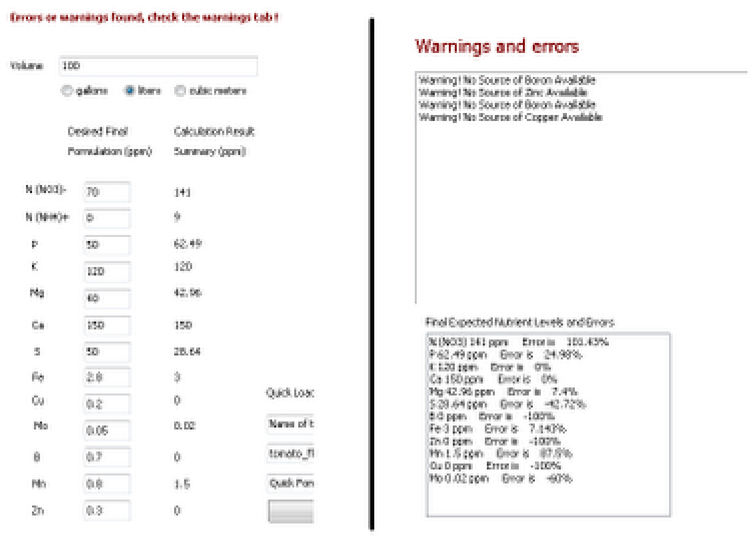
Using my Nutrient Calculator with Commercial Fertilizers : Part No.2

On the last part of this tutorial series I talked about how you could use my hydroponic nutrient calculator to figure out the ppm values of a commercial fertilizer. Today I am going to talk about how you can achieve a given ppm formulation using a commercial preparation figuring out what additional salts you would need to arrive at an adequate composition. I am also going to show how you can figure out the final concentrations of nutrients when using combined commercial fertilizers and salts and how this approach can be used to arrive at full, accurate and complete formulations for your hydroponic reservoir. In the end you will see how my hydroponic calculator (hydroponic buddy) is a great tool for the preparation of your hydroponic nutrients even if you rely solely on commercial formulations. You will need my hydroponic nutrient calculator to follow this tutorial, you can download it here.

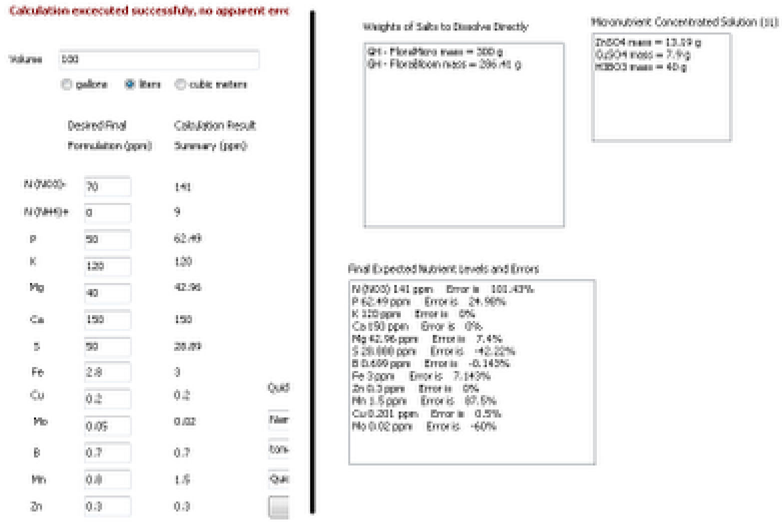
Today we are going to use a few commercial fertilizers from General Hydroponics and Advanced Nutrients as well as a hydroponic formula to grow tomatoes. The formula – applied for tomato growth in Florida for the first cluster growth stage – can be found here. We are going to use the FloraBloom and FloraMicro nutrients from General Hydroponics (labels here and here) . As with yesterday's tutorial the first thing we are going to do is add all the custom fertilizers within the "Nutrients Salts Used" tab by using the "Add New Salt" button by entering the composition percentages found on the label and composition pages of the above mentioned fertilizers. After doing this we input the desired tomato formulation under the "Desired Formulation" tab like it is shown below.



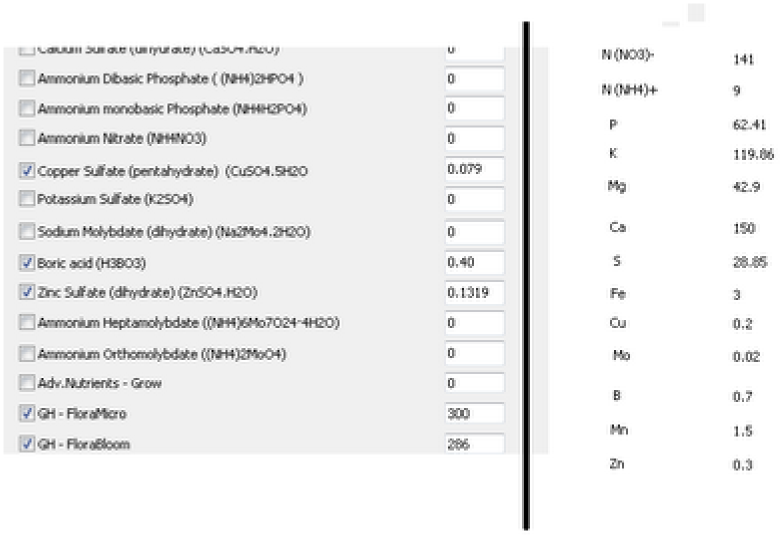
Once we have the formulation we select the custom fertilizers, uncheck all other salts and input a volume of 100 liters. After doing this we press the “Calculate Formula !” button which produces hte results shown below. The software also warns us about errors so we need to go to the “Warnings and Errors” tab where we see that certain nutrients are missing from the formulation. In particular we see that we are missing Zn. B and Cu. You will notice that many combinations of hydroponic fertilizers miss one or several essential nutrients for plant growth (even micro-grow-bloom combinations often miss B, Zn and Cu).



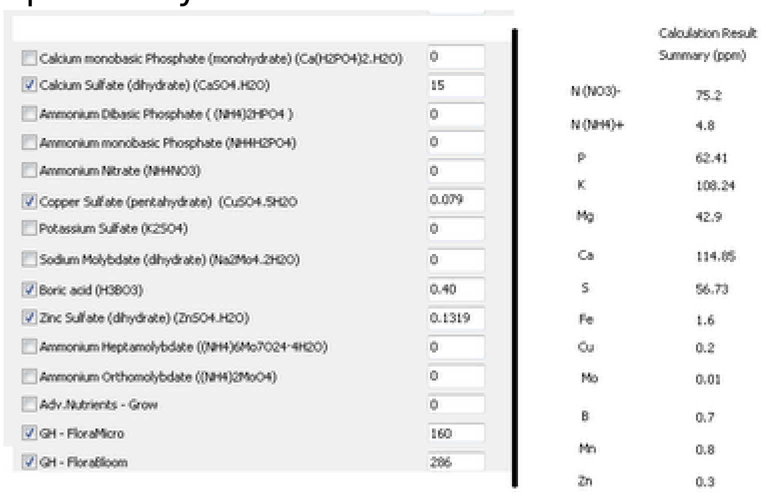
So right now we need to add sources of these elements to have an adequate formulation. Go to the “Nutrient Salts Used” tab and select Zinc Sulfate, Boric Acid and copper sulfate and press the “Calculate Formula !” button again. This now produces the results shown below where all elements are present and the program tells us to prepare an additional 1L concentrated solution of Zinc Sulfate, Copper Sulfate and Boric Acid.



However we see now that the formula is not very well balanced since we have a 100% excess of N and a defect in S so to achieve the desired composition it might be necessary to tweak the results slightly in a manual fashion and use some additional salts like Calcium Nitrate. To do this tweaking you should input the weight values obtained on the “Mass” boxes next to each salt’s name (the mass of Zn, Cu and B salts is the mass of the concentrated solutions divided by 100 since the 1L concentrated solutions are prepared with a 1:100 dilution factor taken into account). The input and the results of the “salts to formulation” calculation are shown below.



Now we need to increase S and decrease N. To decrease N we need to reduce the amount of the most important Nitrogen source (FloraMicro) to about half. Since this reduces the amount of Ca significantly we can now add calcium sulfate to the formulation to make up our now acquired Ca and S deficiencies. Select calcium sulfate and give it a value of 15g. After doing this you will notice that Ca and S concentrations will be much closer to the desired end values given by the original formulations. The final result is shown below. Eventhough the amount of nutrients are not absolutely the same as the ones on the formulation we were able to achieve the same “global ratios” for all important nutrient levels and the solution will now contain ALL the necessary nutrients for adequare plant growth and – in this case – especially for the first cluster development of tomato plants.



I hope that this tutorial allows you to understand better how my hydroponic nutrient calculator can be used for the preparation of a wide array of formulas and the correction of commercial nutrient fertilizers that lack some essential nutrients for plant growth. It also shows you how you can modify the results of the automatic calculator to further correct a formula if you believe that better results and pairings can be achieved. As you see, the calculator gives you tremendous flexibility and makes the preparation of hydroponics nutrients with precise ppm nutrient values a simple exercise.