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 K2O and P as P2O5. The reasons why K2O and P2O5 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.

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).



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).

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) :

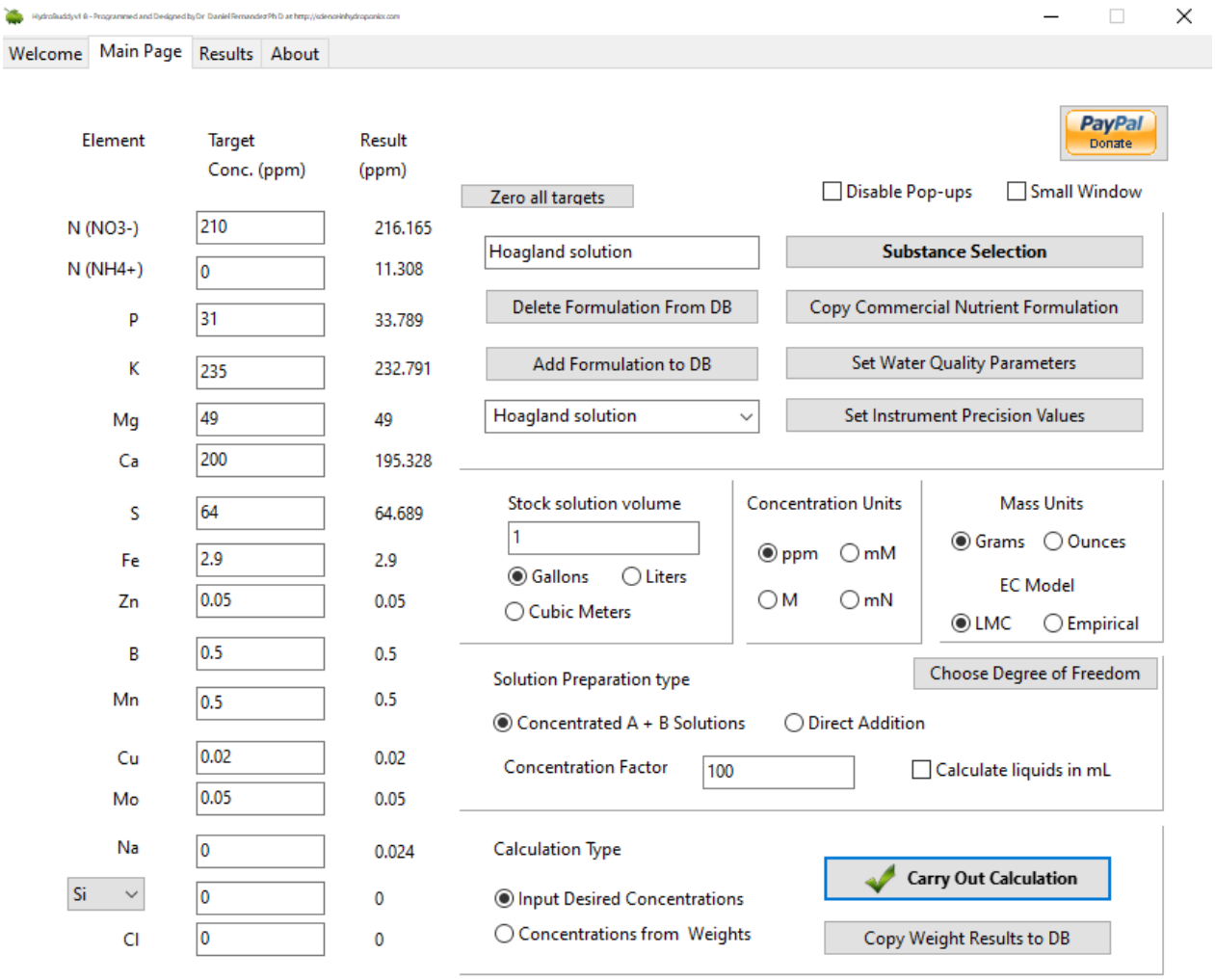
- Calcium Nitrate (here)
- Magnesium Sulfate Heptahydrate (here)
- Potassium Nitrate (here)
- Copper Sulfate Pentahydrate (here)
- Mono potassium phosphate (also known as Potassium Monobasic phosphate) (here)
- Manganese EDTA (here)
- Zinc Sulfate Monohydrate (here)
- Sodium Molybdate (dihydrate) (here)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

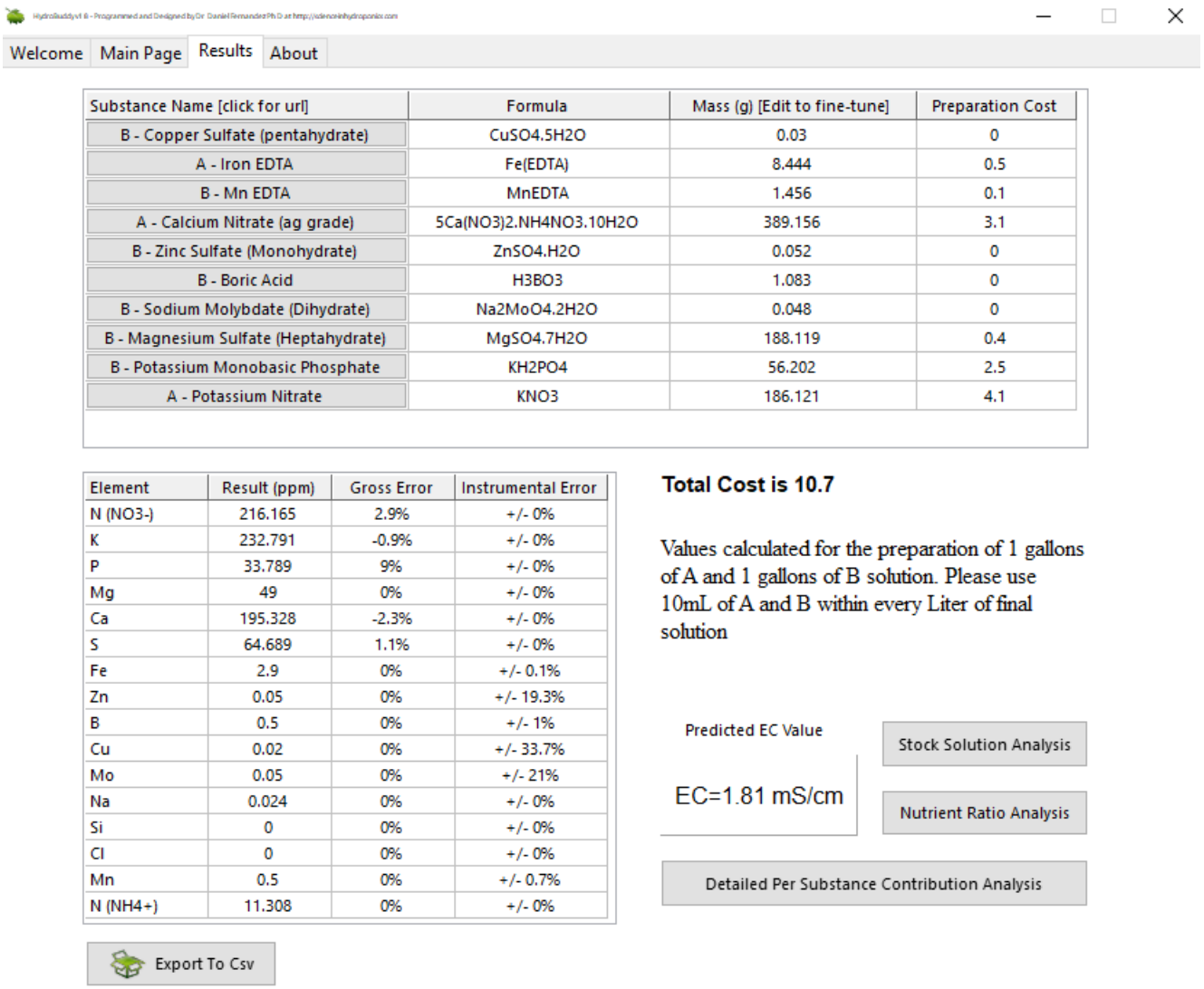
Of course you may see right now that the initial investment might be significant (from 100 to even more than 500 USD depending on whether you buy 50lb or 1lb quantities of macro nutrients) however after this purchase you will be able to produce more than one hundred gallons of concentrated A+B solutions 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.



Welcome | Main Page | Results | About

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%

Total Cost is 10.7

Values calculated for the preparation of 1 gallons of A and 1 gallons of B solution. Please use 10mL of A and B within every Liter of final solution

Predicted EC Value

EC=1.81 mS/cm

Stock Solution Analysis

Nutrient Ratio Analysis

Detailed Per Substance Contribution Analysis

Export To Csv

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 !

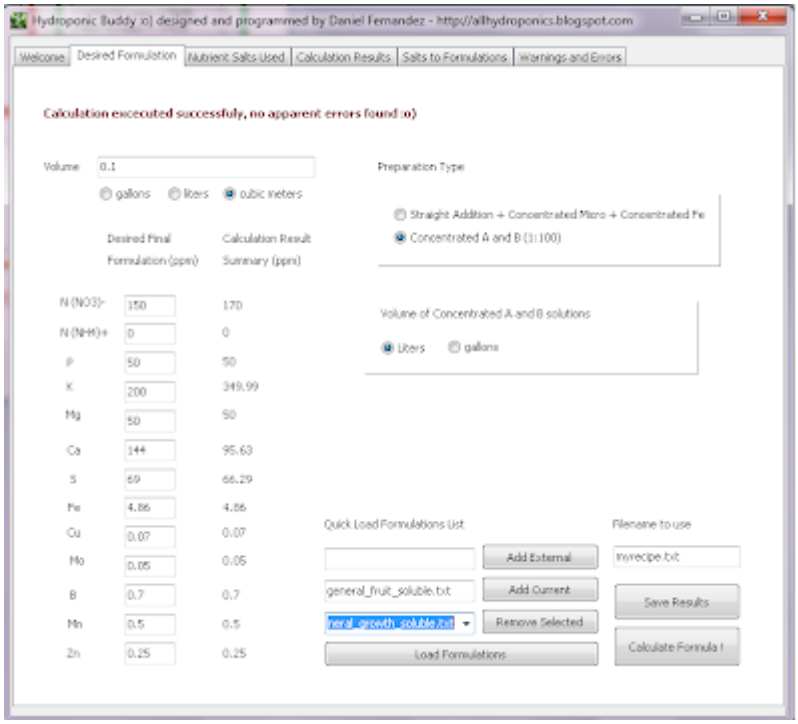
Make sure you also checkout this youtube video for a similar tutorial using a premade chelated micronutrient mix.

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.
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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.

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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 precipiate 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.
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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.

Using my Nutrient Calculator with Commercial Fertilizers : Part No.1

One of the main reasons why I wanted to develop a nutrient calculator for hydroponics was to allow people to understand the amount of nutrients they are adding to their solutions and to use the calculated amounts to either use common salts to achieve the same nutrient percentages or to understand which salts are needed to adequately compliment the nutrition achieved by their hydroponic nutrients. On these posts I intend to show you how you can use my hydroponic nutrient calculator with your commercial hydroponic nutrient composition, figure out the amount of nutrients given by a certain amount of the fertilizer, adapt your fertilizer to a given formulation you want, supplement your nutrient with other salts and get a similar composition yourself with easily available salts (which are used to make your hydroponic

nutrients most of the time). **For this tutorial you will need my hydroponic nutrient calculator available here**.
First of all, lets learn how to add a given nutrient commercial fertilizer to your list of hydroponic salts/nutrients. After you open the program go to the "Nutrient Salts Used" tab and select the "Add New Salt" button. A screen will pop up in which you can input the percentage composition values of your fertilizer. As an example, let us use the FloraBloom fertilizer from general hydroponics and add it to our fertilizer list. The fertilizer composition given on the product's label is available here. Below you can see an image of the added percentages on my nutrient calculator, note that the K2O, P2O5 check box is used as the percentage values on the label are given as oxides for K and P. After finishing the addition the "GH – FloraBloom" item becomes available in the bottom of the page.



We are now going to calculate the ppm values for the different nutrients we would get for the recommended addition of 1 tbsp/gallon for regular growth. Since 1 tbsp is 15 mL and we assume the fertilizer density to be 1 g/mL we get an addition of about 15g per gallon of solution. We input 15 in the field next to the fertilizer name, leave the purity at 100% and go to the "Salt to Formulation" tab where we input a volume of 1 gallon. We then get the results shown below. You can see that this preparation would give us around 87 ppm of P, around 131 ppm of K, 60 ppm of Mg and 40 ppm of S. Now that you know how to get these values it becomes easy for you to know the amount of nutrients you are getting for a given amount of any commercial fertilizer simply by using the composition values available on the label.



Getting these values is only the first and easiest thing we can do with commercial fertilizers using my calculator but you will see within the next few tutorials that much more powerful things are possible. Right now you can also get the ppm values of different mixes of commercial fertilizers as well as current ppm values you are getting with any custom regime you are using. For example you could upload the whole General

Hydroponics series to the calculator and see the different ratios you can achieve with different proportions of their products.
On the next tutorial we are going to use the above mentioned fertilizer as well as a predetermined formula to determine which salts are needed to compliment the above solution and obtain a well-balanced custom formulation. After that we are going to see how we can use the above obtained ppm values to makeup our own copy of this fertilizer as well as how we can improve it. I hope you are enjoying my free hydroponic calculator and that you leave any comments you may have :o)

Understanding pH in Hydroponics – Part No.2

Yesterday – on the first part of this article – we talked about the nature of pH, the origin of pH changes in hydroponics growing and why these changes happen with time within a hydroponic culture, I also talked a little bit about how to prevent pH changes by building a balanced solution with a given percentage of nitrogen given as ammonium. On the second part of this article I am going to talk about the adaptation of plants against pH changes, why certain pH levels are needed and why there is an important over-focus on the importance of pH which does not need to be maintained in ranges as narrow as most growers believe.
What is the ideal range of pH for plant growth ? The fact is that plants can grow ideally from a pH of 5.5 to about 7.0. Above or below these values certain changes start to happen within the chemistry of the solution that makes nutrients less available to the plant. The large importance of adequate – yet not excessive – control of pH values is to maintain an optimum absorption of nutrients for your plants. When we go below a pH of 5.5 certain nutrients like iron become very readily

available while nutrients like phosphorous and nitrogen become much less available. This lack of availability has two main causes. The first one is the overall change of chemical species within the solution, with the newly generated species being difficult or impossible to assimilate by the plant while the second one is that species that become extremely available generate a strong antagonic effect against some nutrients. For example, iron is antagonic with phosphorous and with a pH decrease below 5, the absoprtion of iron becomes extremely easy and therefore the aborption of P becomes more difficult, the overall formation of acid phosphate species which are also not so readily available by the plant further reduces P availability. An image shown below gives you a good idea of the availability of nutrients for plant growth as pH changes.



However most growers tend to believe that the pH level of their nutrient solution is the pH level that plants have around their roots, something which is actually not correct in the sense that plants have evolved local pH adaptation mechanisms to survive to changes in soil pH. When you measure the pH of your nutrient solution you are measuring the pH of the “bulk” while the pH of the actual root-zone of your plants might be within the ideal zone for nutrient absoprtion. Therefore growers usually underestimate the actual capacity of their plants to correct pH and spend an enormous amount of time tinkering with pH to make it “ideal”.
The fact here is that plants do not like abrupt pH changes like those that happen when you add pH up/down to continuously adjust your nutrient solution’s pH levels. Plants can deal perfectly with a slow pH increase caused by nutrient absorption from 5.5 to 6.5 but when you – in a matter of seconds – revert the pH back from 6.5 to 5.5 in a matter of seconds you are causing your plants significant levels of stress since they are simply not used within their natural environment to such quick pH changes.

The easiest way I have found to deal with pH is to simply not obsess with it. Most solutions that are well balanced and contain about 10-15% of the nitrogen as ammonium and about 20-40 ppm of phosphorous will adequately contain pH within the

5.5 to 7 pH region from the beginning of your nutrient cycle to the time when the nutrient solution has to be changed. As a matter of fact – beyond the initial adjustment – the changing of pH can be avoided if the nutrient solution is adequately formulated and given in a quantity of at least one gallon per plant. Plants develop well around these pH levels and the improvement you gain from obsessing about perfect pH zone levels will be lost by the stress you put into your plant roots with pH corrections. Of course, there are easy and almost perfect solutions to pH control like the method using ion exchange resins I mentioned in a previous post. A method that mimics the way in which pH is naturally buffered within soil.

Therefore if you want to have a great hydroponic crop with little maintenance and a very good yield I would advice you to prepare your own nutrients taking pH-self balancing and adequate nutrient ratios into account. Certainly this method will give you a lot of control over your composition and a great saving in solution costs.

I hope that after reading these two posts on pH in hydroponics you have now grown a much better understanding of how pH is, how it works and how it evolves in a hydroponic culture. It is very important for you to understand that pH plays a vital role in nutrient absorption but that obsessing with strict pH zones is not beneficial for your plants in the sense that constant additions that cause quick changes in pH values cause stress to their root zone. Adequate nutrient design and a good understanding of how nutrient interact is therefore important for the correct use and low maintenance of a hydroponic crop.

Understanding pH in Hydroponics – Part No.1

When water reacts with itself to create the H3O(+)(hydroxyl) and OH(-) (hydroxide) species, one of the most fundamental and important characteristics of aqueous solutions is generated. The reactivity of a solution and its interaction with living organisms is determined in a great extent by the concentration of these two species, a variable usually measured as pH which is nothing but the negative value of the logarithm of the concentration of the H3O(+) ion. In hydroponic culture – where our plants are in great contact with aqueous solutions – the understanding of the role of the H3O(+) and OH(-) ions and their measurement as pH becomes very important if an in-depth understanding of what is going on wants to be attained. On today's post I will attempt to guide you into this micro world of pH and how and why pH changes within a hydroponic crop. Tomorrow -on Part No.2 – I will try to explain to you how plants adapt to pH changes and what a pH change actually means for a living organism.

What determines pH ? This variable is inversely proportional to the concentration of H3O(+) ions and directly proportional to OH(-) ions, the more hydroxil ions you have the more acidic your solution will be (the lower the pH) while more hydroxide ions will increase your pH and give you a higher pH reading. It is important to understand here that hydroxyl and hydroxide ions determine each other's concentration. Since water's self-reaction equilibria must be maintained, the sum of pH and pOH must always be equal to 14 (a neat consequence of chemical equilibrium theory). When the concentration of hydroxyl and hydroxide ions is equal, pH and pOH contribute equally to the solution and they are therefore both 7, reason why the pH of a neutral solution has this value.

Now that we know a little bit about pH we can understand

better what happens when plants interact with a nutrient solution. When a plant is put within a given solution it wants to absorb the nutrients it needs to grow. These nutrients are avilable as ions that have a given charge. For example, nitrogen is absorbed as the nitrate ion (NO3(-)) while potassium is absorbed as the K(+) ion. When a plant takes potassium in, it deplets the solution of a positive charge. Since the solution must remain neutral the plant gives the solution an H3O(+) ion to compensate. The plant has therefore decreased the pH of the solution by absorbing a potassium ion. When nitrate is absorbed – an ion with a negative charge- the plant does the opposite and exchanges the nitrate for an OH(-), the pH of the solution is increased.



If plants absorbed nutrients in a perfectly symmetrical fashion, they would not increase or decrease pH as overall charge changes would be compensated. However – as no one is perfect- plants absorb nutrients at different rates and they therefore create a “pull” towards a certain pH region. If a plant absorbs nitrate heavily it will start to contribute far more OH(-) than H3O(+) ions into the solution and the result will be a net increase in pH. Depending on the composition of the nutrients and the overall growth stage of the plant, different net movements in pH can be achieved by the plant.

The most influential factor in the changes of pH within a solution is generally the composition of the nitrogen component of the solution. When plants absorb ammonium ions NH4(+) they tend to decrease pH while nitrate – as mentioned above – tends to increase pH when absorbed. If you contribute a percentage of the nitrogen in your solution as ammonia the net effect will be a beneficial “absorption pH buffer” since plants will take nitrogen in both forms, effectively delaying the onset of important pH variations. Of course, the ratio of nutrients also performs a vital role since plants’ nutrient absorption mechanism are largely non-specific and they are greatly influenced by the different concentrations of

nutrients within the solutions. Having a nutrient solution designed to provide an adequate balance will be vital in helping you control pH fluctuations.

On part two of this “understanding pH in Hydroponics” post I will talk about the range of pH plants can live in, how they adapt to changes in pH and other interesting aspects that will help you better understand the role and true importance of pH within a hydroponic crop. I hope that today you have acquired a rough idea of what pH represents, the nature of pH changes and some basic things that can be done to improve the pH balance within your hydroponic culture.

Fruit Quality and High EC values in Tomatoes

You may remember an article I wrote last year about the effect of salt concentration in tomatoes and how several different studies have been done about this matter. On that article I talked about a paper released in 2007 showing that tomatoes raised at an electrical conductivity value of 4.5 dS/m had the best tasting and fruit quality. However, this study was not conclusive in the sense that quality parameters used on the plants where not extensive and adequately analyzed. On today’s post I want to talk to you about a previous study done in 2006 which does include fruit quality parameters and a clear explanation about which conductivity levels give you the best tomatoes and why this is the case.
The relantionship between high conductivity and high fruit quality clearly depends on how you evaluate fruit quality. In general, the nutritional quality of a fruit is measured by the concentration of important nutrients within it. In the case of tomatoes, important nutrients such as lycopene, vitamin C,

carotenoids and phenolics determine most of the tomato's nutritional value. However, fruit quality – from a market perspective – relates to size, shape, uniformity and firmness and market duration.
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On a study published on the Journal of Agricultural and Food Chemistry in 2006, Woitke *et al* discussed the effect of electrical conductivity on the yield and quality of tomato crops. Their conclusions after analyzing the concentration of several nutrients at different salinity levels was clear : tomato crops which are raised at higher EC levels have lower overall yield but the concentration of nutrients (vitamin C, lycopene and beta-carotene) was increased by as much as 38% on high conductivity treatments (again at about 4-4.5 dS/m). They also found a nutrient-quality increase as the antioxidative capacity of the phenols and carotenoids increased on the plants with high nutrient treatments.

Another very important fact is that not only nutritional value was increased but total dissolved solids and organic acids – which contribute significantly to the fruit's flavor – also increased significantly. Overall the study concludes that all quality related parameters increased with the increase in salinity pointing out clearly that raising tomatoes at high salinity levels is an excellent way to increase fruit quality. The reduction of yield can be compensated for by the higher inner quality of the fruit allowing it to compete more effectively with other higher-yielding yet lower quality productions within the market.

So next time you want to increase the taste and nutritional qualities of your tomatoes just raise your EC levels so that your fruits accumulate the higher levels of nutrients and flavor producing substances that reside within every small tomato. Certainly your tomatos will be the envy of all other growers with their higher nutrient and flavor levels and increased antioxidative capacity.