What are Hydroponic nutrients ? The nature of nutrient salts

When researchers first started to study how plants grow and what plants exactly need to develop, they found out that plant needs are very different from our own. We, as humans, need minerals, vitamins, carbohydrates, proteins and fats amongst other substances. However, plants seemed to require a small assortment of inorganic substances from which they synthesized a very large variety of organic materials.
Many hydroponic growers are confused by the fact that nutrient needs and nutrient solution compositions are provided in the form of elemental concentration. That is, hydroponic solutions are often described in the form “N 200 ppm”, “K 100 ppm”, etc. Compositions are expressed as the amount of milligrams present of a given element per liter of solution. Nonetheless, this does not mean that the element is present as a pure substance. For example, the fact that a hydroponic solution contains 100 ppm of Nitrogen, does not mean that the solution contains nitrogen as elemental nitrogen, that is, N_2 gas. This in fact, does not express the form in which nitrogen is present, it may be present either in the form of $NO_3(-)$, $NH_4(+)$ or other molecules. This has caused some confusion since some people are unaware that hydroponic nutrients are mainly inorganic salts that, when dissolved in water, form ionic substances which are the actual nutrient assimilated by the plant.

It is important then to have a clear mental perspective about the way in which things are expressed and the way in which they really are. For example, you can have a hydroponic solution with 100 ppm of P. That is, a hundred milligrams of phosphorous present per liter of solution but in no way does this express the way in which phosphorous is present within the solution. Phosphorous may actually be located as a large assortment of ions, either $H_2PO_4(-)$, $HPO_4(2-)$ or $PO_4(3-)$.

The reason why nutrient solution concentrations are often expressed as mere element concentrations instead of actual available form concentrations is because it is much simpler to think about the sum of all the available forms of a nutrient than each nutrient form by itself. In the light of the previous example, it is much easier to say 100 ppm of P than to state a specific concentration of each ion, given that (in this case) all ions are indistinguishable for the plant.

The really important thing about this is that the grower should have a clear understanding of the nature of hydroponic nutrients. Nutrients are really ions, which are formed by the dissolution of salts in water. So when you go out to buy nutrients for your hydroponic solution you should look out for inorganic salts of the desired elements ! (below, an image that graphically shows ion dissolution)
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Keeping the pH of your hydroponic nutrient solution stable

A nightmare for many growers inside the hydroponic industry is the fact that pH adjustments need to be made every now and then to nutrient solutions. In fact, people often adjust the pH of their nutrient solutions several times a week in an effort to keep the values close to those considered ideal. However, most growers are unaware of the basic facts surrounding pH changes and how they can be avoided (please refer to the pH FAQ for more information).
The concentration of H3O(+) ions, which are the ions that determinate pH, changes according to other ions present inside

the hydroponic solutions. Since plants take ions (which are charged species), outside of the solution, they cause a charge imbalance which is compensated by the generation of either H3O(+) (if the plant absorbs an ion with positive charge) or an OH(-) (if the plant absorbs an ion with negative charge).
One of the ways in which this pH change can be effectively controlled is by the addition of a specie which balances out this charge and offers reactivity against either OH(-) or H3O(+) species. Such addition of species to a solution in order to offer a chemical equilibrium protection against pH changes is called “buffering”. In hydroponics, solutions are most often “buffered” using ammonia, however, we can carry out simulations to see how this two ions act against “acid” or “base” additions and see how the entire hydroponic system reacts to this.

The simulations are carried out using the Maxima software and all the equation systems are generated according to equilibrium equations, mass balance equations and charge balance equations (this is called systematic study of the chemical equilibrium). Concentrations for all the buffering agents were treated as 0.1 mM.

Long story short, the graph below shows the results for my simulations of “acid” or “base” additions using three different buffer agents. The blue line shows the change when citric acid/citrate is used as a buffering agent, the orange line shows when ammonia is used as a buffering agent and the yellow line shows when carbonate/citric acid is used as a buffering agent.
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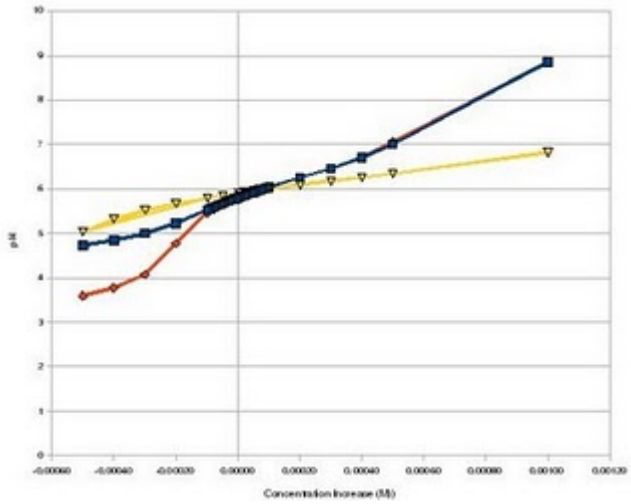

As it can be seen, citrate provides very good buffering capacity towards acid pH values while it’s buffering potential towards basic pH values becomes lesser. Ammonia provides almost no buffering potential towards acid pH values while it provides almost the same buffering effect towards basic pH values than citric acid. Note that basic pH buffering seems the same for both buffers because here the effect of the phosphate ions inside the solution becomes more prominent.

However, when carbonate/citrtic acid is used as a buffering agent, it suddenly turns the solution’s buffering power towards both acid and basic pH values, extremely high. That said, it should be expected for a solution with this buffering mix to last several times more than a regular solution without needing any pH adjustments. In practice, the preparation of this solution has given me at least three weeks of plant intake without any need for pH adjustment.

Hydroponic Nutrients, Are

they Unnatural ?

In today’s world, things seem to have started to shift towards a more “natural” look at things. People are starting to reject synthetic and “artificial” things in favor of the more “natural” and “earthy”. Well, as a scientist, I have to say that most people have some very bad misconceptions about these definitions and their “evilness” or “goodness”. Let us start from the beginning.

What is Natural ?

This is usually defined as something that comes from nature without any fundamental modification caused by humans. Therefore, you could say that blood is natural, algae oil is natural, bones are natural, etc.

What is Unnatural ?

Something unnatural can be defined as not coming or not belonging in nature. You could then say that a bee swimming is unnatural or that a plant growing inside a PVC pipe is unnatural.

What is synthetic ?

Something synthetic can be defined as chemically manufactured by humans from chemically different materials. For example, plastics are synthetic, pure sodium is synthetic, carbon nano tubes are synthetic, etc. Now see that this definition is not exclusive, something can be synthetic but present in nature, like synthetic hormones, synthetic vitamins, etc.

Now which is bad and which is good ?

This is where most people have it wrong. Natural things are good ? Well, that depends, which natural thing. You eat and orange and it’s good, you swallow a scorpion and its bad. Both things are natural. Nature produces things that are toxic and lethal, but nature also produces things that are good for you.

You cannot judge something to be good just because it belong inside a group, every category has both good and bad things.

Are unnatural things bad ? That depends. You smell a neurotoxin, you are dead, you use a sulfonamide antibiotic when you have an infection and your cured. It all depends on the specific thing your talking about and the specific use your giving it. There is no sense in judging something as being good or bad for the sake of it.

Now, are hydroponic nutrients unnatural ?

No ! Hydroponic nutrients have the exact same chemical form nutrients have in soil. Plants cannot absorb these nutrients if they don’t have these specific forms so hydroponic nutrients are indeed natural. They are the exact same molecules that are found in soil. Hydroponic gardening is just a form of manipulation in which plants are given an amount of these nutrients that fits their needs optimally. It differs from their natural conditions in that hydroponic growth conditions are better. The plant gets all it’s nutrients in the same form it gets them from the soil without needing to break up organic matter to get them or fighting pathological microorganisms. Indeed, hydroponic gardening has both positive and negative qualities, just like everything else !

Hydroponic Gardening for Small Spaces

People everywhere enjoy the pleasure of growing plants. Most people use their backyards for this purpose, growing ornamental as well as plants used for eating. However, many people around the world don’t have a backyard because of space

limitations, something which is becoming more common everyday with the growth of world population.

For people who want to grow beautiful flowers, healthy vegetables, herbs and spices in reduced spaces, hydroponic gardening becomes an evermore interesting option.

Hydroponic closet for a small space

Hydroponic gardening, which does not use any soil, is ideal for growing many plants. This type of culture has the advantage of not needing any soil and of letting the grower choose the precise composition of the nutrients received by the garden. When this is coupled with a tight space, hydroponic gardening opens up the possibility to grow plants in much higher densities and in much better quality and uniformity than soil based plants.

With living spaces being more populated everyday and commercial soil based vegetables becoming more polluted and damaged, it is evident that the use of currently unused city spaces (such as rooftops) will become very important for the food provisions of the future.

Small hydroponic systems for people with drastic space limitations can be easy to install. From the inside of a closet to a small patio or a window edge, soilless gardening offers the solution to the problem. Systems known as

hydroponic grow closets are becoming more and more popular everyday.

Indoor Hydroponic gardening, the cheap way !

Hydroponic gardening is a great way in which plants can be grown and cultivated with yields far superior to those of traditional soil based culture. However, the last frontier of hydroponics remains being indoor growing. Light, which we take for granted because of the sun, is a crucial factor for plant growth and becomes dramatically diminished or non existent inside our house's or building's interiors.
The solution, of course, is using artificial lighting to grow our crops. Unfortunately, the amount of light needed by plants (which is measured in Lumens) is quiet high. In order to fulfill a plant's light needs, high power consuming artificial lights must be used. In fact, most indoor growers use halide lamps which are in the range of 1000 to 2000 watts of power.
The amount of energy consumed by these growing lights is so huge because most of the energy provided to the lights is wasted as heat and little of this energy becomes usable to the plant as light. Other problems also arise because of the excess heat eliminated by this high-powered illumination devices.

The solution for this problem is actually very simple. The use of LEDs (light emitting diodes) for hydroponic growth has become popular because of their low energy consumption (almost 20 times less than regular growing lights). They are simple to install and provide all the necessary wavelengths your plants need for adequate growth. For instance, two tomato plants can be grown with as little as 50 W of growing LEDs while this same tomatoes would consume in excess of 1200 W with

traditional lighting. If you are wondering where these lights can be purchased, just search ebay for “growing LED’s” and a bunch of sellers that offer these products will come up.

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Hydroponic Floating System for Lettuce Production

Lettuce is one of the most common vegetables produced in hydroponics. It is amongst the first 3 vegetables produced in hydroponic crops around the world with tomato and bell peppers. Most lettuce production systems are designed around two ideas, either the NFT (nutrient flow technique) system or the floating raft system. The later system is of particular interest because it is highly economical and can produce bast volumes of hydroponic lettuce.

One of the main problems with raft systems is that the fact that the nutrient solution is constantly stagnant demands the use of pumps to circulate water and generate significant aeration. Without this precious oxygen reaching the plant’s roots, floating raft systems experience high loses of yields in the form of dry weight, nutrients, etc.

Nonetheless, raft systems can be improved dramatically in order to avoid the recirculation of solution and aeration of the roots by mechanical means. This is done in an exceedingly

simple way, by placing the raft not directly above the hydroponic solution but a few centimeters above from the solution itself.

The results are incredible. Without any mechanical aeration or movement, this hydroponic system achieves dry weights superior to any floating raft system published in peer reviewed literature. This research was done by horticulturist B. A. Kratky and was published in the year 2005.

So if you are searching for a cheap hydroponic system which can offer you lettuce in high yields with no power usage, this is precisely the way to go. I will publish a post soon showing how this can be done and how you too can enjoy this great system for lettuce cultivation.
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Hydroponic Nutrient Solution Toxicity

It has become a common practice for many hydroponic enthusiasts, hobbyists and even commercial growers to dispose of the nutrient solutions they have that “are not adequate anymore” by throwing them down the drain. Most of them are not aware than hydroponic solutions are environmentally contaminating.
Hydroponic solutions contain all the basic nutrients necessary for the development of photosynthetic organism. This of course, means that hydroponic solutions are the ideal source of nutrients for algae growth. When they are disposed of down the drain, the solutions cause algae blooms which are terrible for the environment because when algae populations dye massively, they deprive water of oxygen and cause the death of aquatic organism.

The solution ? It is actually very simple. Have a hydroponic growing container in which plants that you “don’t care for” are grown. For example, have a hydroponic growing container in which grass, weeds or other type of “low nutrient requirement” plants are grown. This way, when your hydroponic crop has a solution it can no longer use, pour that solution into your other hydroponic container. Now leave the solution for those plants to take care off for two months. Once this happens, the solution should be very depleted of nutrients and unable to cause any algae bloom of importance.

Even better, the “waste solution” container, can have plants you can use. For example, you can cultivate herbs with low nutrient requirements that are for indoor use and have them as the “byproducts” of your main hydroponic system. It is also excellent for growing grass for any cattle or horses you may have. (below a picture of papyrus, a plant that naturally deals with solutions with low nutrient concentrations)

Preparing a Hydroponic Nutrient Solution

Every hydroponic grower should know how to prepare his or her own solution in order to save money and improve crop results. Preparing a nutrient solution is an exact science involving some basic chemical knowledge that is in fact, not so hard to do. One of the main problems in preparing hydroponics solutions (besides knowing the formulation) is knowing how much to weight of each available nutrient salt in order to achieve the desired concentrations.
In order to solve this problem, you can use the hydroponic

nutrient calculator I created called Hydroponic Buddy. The hydroponic calculator is located here.

It is fairly easy to use, the calculator includes links to tutorials you can find within this blog which will tell you how to do many things, from the calculation of simple formulations to the creation of A+B+C concentrated solutions, the copying of commercial nutrients, etc.

And that's it ! Press the calculate button and you'll be shown the final concentration results coupled with the amount of grams you should weight of each salt in order to obtain the concentration results you desire. Now you just need to go to your local supplier and buy each one of the salts in order to prepare your hydroponic solution. This let's you experiment with different nutrient concentrations as well as with recommended and optimum nutrient concentrations for different plant species.

Hydroponic Nutrient Solutions for Lettuce

Most hobby and some commercial hydroponic growers often get their nutrient solutions from stores that sell "generic" hydroponic nutrients. In some cases, this standard solutions are "compensated" with the aid of some additional help coming from additive solutions that are formulated to add certain qualities that the original standard solution is missing.
Well, the sad thing here is that by not preparing his or her own nutrient solution, the hydroponic grower is wasting his main edge in soiless culture. The composition of the nutrient solution.
In the particular case of lettuce, different nutrient solution compositions have varying effects on the plant, this, of

course, because the particular chemistry of your nutrient solution must be fitted for your plant in order to achieve optimum results. The use of generic solutions to feed your plants will more often than not end with some loss in product quality (dry weight, nutrient content, marketability, etc).

In a peer reviewed study published in 2004, M.S. Karimaei *et al* [1] compared different nutrient solutions for lettuce cultivation under hydroponic conditions. Amongst their conclusions, was that the Hoagland solution offers the best conditions for lettuce cultivation amongst the solutions they tested. They also found some important factors such as the electrical conductivity being inversely correlated to dry weight and K concentration. This shows the utmost importance that using the correct and not the "generic" nutrient solution has on your lettuce growing potential.
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[1] Karimaei, M.S., Massiha, S. and Mogaddam, M. 2004. COMPARISON OF TWO NUTRIENT SOLUTIONS' EFFECT ON GROWTH AND NUTRIENT LEVELS OF LETTUCE (*LACTUCA SATIVA* L.) CULTIVARS. Acta Hort. (ISHS) 644:69-76

Hydrogen Peroxide in Germination

As I published earlier, the use of hydrogen peroxide is extensively known in hydroponic cultivation as a disinfectant. However, this little molecule has far more uses and some of them also pertain to plant grow. For example, as it was discussed in the fourth International Symposium on Seed, Transplant and Stand Establishment of Horticultural Crops; Translating Seed and Seedling Physiology into Technology in February 2008, the use of hydrogen peroxide has been studied

as an agent to aid the germination of seed.
Indeed, the chemical qualities of hydrogen peroxide make it ideal for the replacement of the stratification of certain seeds. In a peer reviewed article published about the use of hydrogen peroxide for the germination of eastern gamagrass seeds, the authors discovered that the use of hydrogen peroxide 15% for 18 hours indeed helps the seeds germinate by "dissolving" the outer coat of the seeds and therefore facilitating water's access to the seeds embryo.
In fact, hydrogen peroxide is so effective at this, that the above mentioned treatment substitutes a four week period of stratification at 4°C. The seed containing cupules treated with Hydrogen peroxide effectively germinated after only 2 weeks, when such a time was impossible before the treatment. The article mentions that hydrogen peroxide was the "most effective" mean of breaking up seed dormancy and effectively carry out germination. (Below a picture of eastern gamagrass)