Using Peat Moss in Hydroponic Culture

There are several different types of media available for hydroponic culture and from these peat moss is one of the most popular due to its low cost and high availability in some countries. This media is made up of decaying mosses and is used mainly in drop irrigation systems of both a recirculating and non-recirculating nature. However the organic nature of the media provides several important challenges to the hydroponic grower which – when not controlled – can lead to important problems associated with nutrient availability, inhibiting plant growth. Today we are going to talk about the characteristics of peat moss as well as how we can amend this media to make it suitable for hydroponic cultivation.

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Peat's main characteristic is its organic nature. Since it is made up of decaying organic matter this means that the chemical nature of the media will change depending on the degree of decomposition of the media and also depending on the particular moss species that were used to produce the peat moss. You can know the degree of decomposition of a peat moss sample by using a simple procedure. Place a handful of wet peat in your hand and then squeeze it, the result – how the exuded water looks and whether peat is squeezed between your fingers – will tell you all about your peat. The von Post scale – developed in the 1920s – will then allow you to tell how decomposed your media is in a scale from H1 to H10.

Highly decomposed peat will tend to remain more chemically stable as the organic decomposition process has already been

carried out. For this reason you want to buy what is commonly known as “black peat” (H7-H10) where microbial activity has already dialed down and the peat moss more closely approaches what we would call an “inert media”. This however does not mean that Peat moss is chemically inert at this point as it does contain as a significant amount of substances that can affect your nutrient solution.

One main characteristic of peat is that it’s acidic. This means that the pH of untreated peat will usually be between 3 and 4.5, too low for use in hydroponic applications. Peat is generally amended with calcium carbonate (lime) to make its pH go up and remain there but this process can be ineffective if the peat can still decompose very significantly (if you buy peat with decomposition < H7). This also contributes high amounts of Ca into the media which might lead to nutritional problems if Ca is also applied normally in solution. To alleviate these issues peat is also sometimes treated with lime/dolomite mixtures so that the counter-ions are both Mg and Ca. Alternatively – but more expensively – this problem can be solved by using phosphate buffer solutions that are run through the peat for a significant period of time. A potassium monobasic/dibasic phosphate buffer at a pH of 6.5 with a 100 mM concentration can buffer the peat moss. For this the buffer needs to be applied until the run-off pH out of the peat comes out unchanged. Then tap water should be applied to remove the K/P from the media. Note that this will only work for black peat that’s already gone through most of the decomposition process as lighter peats will simply decompose further and acidify the media again.

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However if all you can get is already treated peat moss then

you should run nutrient solution through your peat for a while before putting your plants in to ensure that the peat's cation exchange capacity has already balanced with your nutrient solution's composition, this will also help remove nutrients applied to the peat that deviate the nutrient concentrations from what we want within the media. Peat can have a significant cation exchange capacity as showed in the table above – even more so for black peat – so a commercial source of peat may exchange a significant amount of nutrients with your solution. Peat is also not very good at retaining anions so the media will be unable to supply any N or P which will be leached very easily from the media. This inability to retain anions basically means that they will only be available when the plant is watered, reason why you should take care to correctly monitor moisture in your media to maximize your productivity.

For hydroponics it is therefore best to find untreated black peat and treat it yourself. If this is not possible then try to find unfertilized black peat – which has had only lime but no other nutrients added to it – and then use that. A great characteristic of peat moss for hydroponics is that its nutritional content is low – allowing great control over the nutrients added through the composition of the nutrient solution – but this advantage is eliminated when the peat moss is filled up with fertilizers by companies that produce it for non-hydroponic purposes.

If you're using black peat also make sure to check how the peat behaves when watered, if the peat compacts too much you might want to add some perlite to your peat to increase the aeration of the media and prevent excessive compacting from happening. Add perlite until you get the desired balance between aeration and moisture retention. This is not necessary with all black peat sources but it can often be required.

Automated media moisture monitoring in hydroponic crops

Irrigation control is one of the most important things to control in a hydroponic crop. Irrigate too frequently with a media that has high water retention and your plants will start to wilt as their roots die due to lack of oxygen and reductive conditions, water too sparingly and your plants will not grow as much as they could and maybe even die from the drought conditions you're imposing on them. On today's post we will discuss the topic of irrigation, more importantly how to know when to water your crops and how to control this process using sensor based approaches instead of just using look-and-feel to determine when to water your plants.

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Plant roots need to have access to water and nutrients. This means that the root zone needs to be saturated with nutrient-rich water as often as possible while avoiding oxygen depletion and salt accumulation. This means that irrigation needs to be controlled to ensure that plants get as much as possible, as often as possible, without going into any excess that would be detrimental to growth. Sadly there is no solution that is true for all crop setups and gauging irrigation frequency requires a close monitoring of what is going on within the crop.

To really know when to irrigate crops you should have a way to properly monitor moisture levels. This can be achieved through several methods, for example with tensiometers or with simple weighting of the plants, but many of these methods are often not cheap or practical for routine practice. Manual inspection of plants can also be misleading since top level moisture perception is subjective and can often lead to very suboptimal results.

In today's world the best way to monitor moisture without having to pay a high cost is to use simple capacitive moisture measuring sensors. These sensors are corrosion resistant and independent of salt concentrations in solution and therefore provide you with a good measure of moisture within your root zones without having to worry about the conductivity of the nutrient solutions. My favorites right now are this small capacitive sensor for smaller media containers and the chirp for larger containers. If you don't want the chirp features and just want sensor readings you can also get this simpler I2C sensor for larger containers. Both of these sensors are cheap and can be installed in crops with many plants.

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If you want to go with the simplest possible setup the chirp

provides auditory signals when plants need to be watered, although this is not the ideal way to setup the sensors. Ideally you would want to connect these sensors to an arduino so that you can process the data. The arduino mega is particularly well suited for this task as you can connect up to 16 analogue input sensors to it, however you can use less analogue inputs with a normal arduino. Both sensors provide sample code for measuring values from an arduino, you can then output them to an LCD screen or save them within a computer. You can even connect the arduino's digital outputs to a relay so that you can automatically trigger your irrigation system when a custom set moisture level is reached.

Obviously you do not have to place a sensor within each plant. Just monitoring around 10-20% of your crop will give you enough information to know exactly how moisture levels behave within your crop and when you should ideally water them. This will eliminate all the guessing from your watering and will allow you to water your media perfectly while completely accounting for how long it takes for water to leave your plants. This means you no longer would need to just guess when to water, but your watering will be perfectly tailored to what your media allows and what your plants need.

Hydrobuddy v1.60: A new update with important changes

During this past few weeks I have been working on modernizing Hydrobuddy in order to get it to compile with the latest versions of Lazarus and the Free Pascal Compiler (FPC) so that

other people can more easily build the software from source. Today I want to talk about the latest release for Hydrobuddy (v1.6) that comes with some important changes that take the software a step forward and seek to make usage and building of the program much easier. If you're interested in downloading the source or binaries for the new version of Hydrobuddy please visit its official page here.

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I have decided to greatly simplify the program in order to remove sections and features that were complicated and really not used very often. This helped eliminate libraries that were previously required, some of which are no longer compatible with the latest version of the Lazarus IDE. I have therefore removed the program's ability to automatically update on startup and have also completely eliminated the data log section of the program. The elimination of the automatic updating makes the program much easier to compile as it eliminates some complicated requirements that were significantly difficult to install for those unfamiliar with the Lazarus RAD environment.

In addition to these changes I have also eliminated the Windows and Linux installers since these two made the overall setup and building process more complicated while they provided little additional benefit. The elimination of the installer means that the program can now be installed by simply extracting a zip file – how it was installed in the very beginning – something that makes it suitable for portable applications while before there might have been permission issues when attempting to run the installers on Windows/Linux.

In addition to the above I have also created separate versions

of the program databases for Linux and Windows since these files are not compatible between operating systems and trying to build on Linux/MacOS – with the databases present that were Windows files – caused issues when testing the program. There are now suitable conditional headers that use the appropriate table files depending on the operating system being used.

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I have also implemented a few additional features that improve some practical aspects when using the program. The substances used form now allows for multiple selects within the two substance columns so that you can perform multiple substance additions and deletions at the same time. This becomes very useful when you're changing your substance selections all the time since it allows you to easily add/delete multiple substances at the same time. In addition to this I have also implemented a "Zero all targets" button in the home page which basically sets all the ppm targets to zero. This can be very useful when you want to target particular single nutrients or you want to write targets from scratch.

Hydrobuddy's source is also now available via a github repository to enhance the level of contributions from other programmers. This means that others can now checkout the source, modify it and contribute their own code changes to the program so that we can implement additional features or functionality.

Do you really need to be using RO water?

One of the most common practices in hydroponics is to use reverse osmosis (RO) water in order to create your hydroponic nutrient solutions. This water is made by running another water source – most commonly tap water – through a reverse osmosis system that removes a very large portion of the ions within the initial water source. The RO process is very energy intensive and also uses a large volume of water, only around one third of the water input ends up as RO water while the rest ends up as a more highly concentrated solution. Today we are going to discuss whether using RO makes the most sense, when it doesn't and how you can make sure that using tap water does not cause you any important issues.

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The idea behind using RO water is to have the best "base" for the construction of a nutrient solution. If your water starts up with some substances within it then the amount of control you have over composition is limited and therefore your results might suffer because of that. If for example your nutrients add 150 ppm of Ca but your water already contains around 40-60 ppm then adding so much Ca might place you within a suboptimal spot. If your water contains a lot of carbonates, sodium, fluorides or other substances they can also cause significant problems within your hydroponic crop. Using RO water brings a "clean slate" that ensures that what you add is what you get.

So what is wrong with RO water? There are two main issues with using RO water. The first is that it's a very energy intensive

process – therefore a costly process – and the second is that the waste products of the RO process can create environmental problems. Additionally tap water already contains many nutrients necessary for plant life – mainly Mg and Ca – so why would you remove these elements only to later add them again later on? Surely you would rather save the energy from the RO process and use the nutrients within your water as part of your nutrient solution.

The above map shows you the mean hardness of water (as ppm of calcium carbonate) across the United States. The people with the highest Ca concentrations have around 100ppm of Ca while those who have the least have around 0 to 24ppm. This means that for the people with the highest Ca, the Ca from tap water could contribute more than 50% of the Ca needed by a flowering crop while for the other states the contribution would be rather small. If your water is high in Ca then chances are it is also high in Mg so performing a water analysis will be necessary. From my experience with customers Mg is usually around one fourth to one third the concentration of Ca in solution, but the proportion can change significantly depending on the zip code. The table below shows the Ca/Mg content of water sources at different overall hardness levels in Germany.

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Mineral content in water also changes substantially as a function of temperature since rocks that contribute Ca/Mg carbonates will be more soluble during the warmer months of the year. It is therefore ideal to get two analysis, one during February – usually the coldest month – and another during August, the hottest month, to get a good idea of the range of Ca/Mg concentrations that you will be getting in your

tap water. This will allow you figure out how to adjust your nutrients as a function of the average temperature where you live.

Carbonates are also something you should worry about, if you have a high water hardness you might have more than 150ppm of carbonate within your nutrient solution. This is not ideal since carbonate ions can cause issues in your crop. To deal with this you can simply work at a slightly more acidic pH (say 5.6-5.8) this will limit the amount of hydrogen carbonate ions that can be present within the water as it will shift the equilibrium significantly more towards the evolution of carbon dioxide (since carbonic acid in solution is in constant equilibrium with atmospheric carbon dioxide).

There are however some circumstances where using RO water is unavoidable. If you water contains more sodium than your crop can deal with (read here for more info), more than 50 ppm of chlorides or if there are more than 10 ppm of fluoride then you will need to use RO water because those elements in those quantities are not going to be good for your plants. If these elements are absent or in low enough quantities then there is no reason why you would want to use RO instead of tap as using RO would be an unnecessary energetic and environmental expense given that you can just compensate for the ions already within your water through adjustments in your nutrient solution.

Hydroponic micro and macro nutrient sufficiency ranges

When you want to prepare a nutrient solution one of the first things you want to know is which concentration ranges are

appropriate for the growth of the specific plant specie you want to cultivate. You will definitely want to make sure that you do not feed either too much or too little of any of the essential nutrients a plant requires. Lucky for you there is a ton of research surrounding what we call “sufficiency ranges” in hydroponic culture. The sufficiency range of a nutrient is simply the range of concentration where a plant does not show a toxicity or a deficiency but develops in a normal manner. On this blog post we will talk about the different sufficiency ranges that are provided across the scientific literature and what they tell us about plant nutritional needs.

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The first thing to be clear about is that there is no single “sufficiency range” table. There have been many people who have worked on this subject using different plants and each one of them will tell you that the sufficiency range is slightly different. The above hydroponic nutrient concentration table shows you the minimum, optimal and maximum nutrient values that were determined by the Canadian ministry of Food and Agriculture using NFT systems. These requirements were determined for flowering plants – mainly tomatoes – reason why you can see the optimum Ca range at 150-300 and the optimum K range at 300-500. Also notice the very high optimal Fe requirement of 6 ppm. This is almost certainly using either a form of unchelated Fe or an Fe chelate that is not so stable in the hydroponic conditions under study. The sufficiency range of micro-nutrients also depends on exactly what form of the micro nutrients you use since some forms are absorbed much more efficiently than others (it’s not the same to have 3 ppm of simple Fe+2 or 3ppm of FeEDDHA).

In general you’ll see that micro-nutrient sufficiency ranges

have the most disparity between different sufficiency range tables. This is mainly because both the form of the micro nutrient and the specific cultivation media play a huge role in determining sufficient and toxic levels in hydroponic culture. For example a media like peat moss will contain a far greater amount of micro-nutrients than something like say, rockwool, so it is very important to account for media contributions when assessing micro-nutrient sufficiency ranges. While plants require so much macro nutrients that the sufficiency ranges are fairly coherent between different studies in the case of the micro nutrients the media choice itself could provide the entire requirement of a micro-nutrient through the plant's growth cycle.

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The second image shows another sufficiency range table for hydroponic nutrients. This time we can see the source salts being used. As you can see we have a fairly good agreement in the macro-nutrients – with perhaps the exception of the ammonium minimum being set at zero – but in the case of the micros we see that the recommended amount of Fe is actually 3 ppm instead of the 6 ppm that were recommended before. This is most probably because in this case some percentage of this was given as FeEDDHA, which is much more effectively absorbed than either unchelated Fe sources or Fe EDTA. The boron range is exactly the same and this is undoubtedly because boron is always supplied in the same manner in hydroponic crops, therefore its sufficiency range tends to be coherent as long as the same plant specie is used for determination.

Macro nutrient suggestions are also not free from variations. Depending on the method used to determine the sufficiency range there can also be differences. The table below shows you

yet another sufficiency range table which was geared towards maximum yields in terms of product weight. In this case You can see optimum K concentrations in the 50-200 range which is confusing given that the two tables before had suggested a much higher range of 300-500 ppm. Who is right here then? Do plants require 300-500 ppm of K for optimum growth or can they do fine with 50-200?

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The answer is that both can be right. Under some growing systems plants might require the solution to have more K because the setup might make K absorption harder while in other setups you might want to have lower K. This sort of contradiction surfaces constantly in hydroponic nutritional studies, simply because the variability in the subject of study (yields of a certain plant) will tend to vary very significantly depending on exactly which plant is grown and under which conditions. Just the plant and its development phase can make a huge difference in what has actually been found to work better.

Checkout for example the Israeli service recommendations for growing three different plants across their life cycle. You can see that the amount of nutrients they use can be different from what we have learned before. In this case their recommendations for all plants fall within the sufficiency ranges in the previous table but notice how for strawberry plants we use a potassium level that is at most 90 ppm while for tomatoes we go as high as 250 ppm within the fruit ripening stage. Also notice how in the case of sweet peppers the P can go as high as 150 ppm while for tomatoes we always stay within the 30-40 ppm range. If we had followed the previous recommendations we would have never considered something like a 150 ppm of P to be an acceptable value for this element, since all of these sufficiency range studies point to the optimum P being 50 ppm. However a sweet pepper is

not a tomato. In the same way that a house cat isn't a tiger.

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So although sufficiency range tables are good to determine starting points, you should be well aware that these tables need to be considered in the context in which they were created. The plant used, the exact nutrient salts used and the growing system can all play significant roles that may cause two sufficiency studies to tell you very different things. In the end the best thing that can be done is to use the values for the plant that is taxonomically closest to the one you want to study in the system that resembles your system the most and then go from there to establish what the best values are in your particular case.

What is the effect of chloride in hydroponics?

I recently wrote a post about the effect of sodium ions in hydroponics and how it is important to keep an eye on sodium levels due to the potentially negative effects they can have on plants. However you may have noticed that sodium is never added alone into nutrient solutions and there is always a counter-ion that accompanies sodium, which is – more often than not – chloride. This ion is very special and it has some clear effects in hydroponic culture. Today we are going to be talking about chloride, how it can dramatically affect plants and why it does so in such a special way.

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Chloride – not to be confused with chlorine – is a reduced form of the element Cl, an ion with negative charge (Cl-). Unlike elemental chlorine, which is a strong oxidant, chloride is extremely inert in terms of its chemical reactivity and does not appreciably react with anything in a hydroponic nutrient solution. This however does not mean that it is inert when you put it in contact with plants, as a matter of fact chloride is a micro-nutrient – essential for plant life – but it plays such a small role that any important increase in concentration can be detrimental. Usually there is no need to add chloride but simply the chloride present in the water – or as impurities within the other salts – will be more than enough.

But what effect does chloride have? Chloride is special in that it behaves chemically in a similar way to ammonium when in contact with plants, that is, chloride can go through plant cells very easily. This means that whatever chloride you put in solution is very readily absorbed, meaning that it counteracts the absorption of other anions very strongly. This is why the expected effect of plants dropping a solution's pH due to the addition of ammonium is completely negated if instead of ammonium sulfate you add ammonium chloride. This is because you add both an anion and a cation that are absorbed very fast, hence you do not affect the cation/anion absorption balance of the plant and the pH will continue to drop or increase in exactly the same manner as before.

This anion absorption of chloride implies that it readily competes with anion absorption. This means that if you have chloride and nitrate in solution plants will tend to absorb the chloride instead of the nitrate and you will see symptoms

of nitrogen deficiency – not because you don't have enough in solution – but because nitrogen absorption is being hindered by the presence of a very competitive anion. Not only this but other anions, particularly phosphates, will also suffer and therefore you will also start seeing problems with P absorption as well. If you're interested in reading more about this I recommend this chloride replacement study showing the dramatic effect it has on nutrient absorption.

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In many cases, deficiency problems in salinity studies can be attributed to the action of chloride and not so much the direct action of sodium ions. See here for a study that does a direct comparison on seedlings. However since sodium and chloride are very often present in equimolar ratios it is important to always search for both to know what type of problems you are dealing with. Chloride can cause problems at much lower concentrations than sodium, with just chloride concentrations above 20-30 ppm already causing very substantial issues for a wide variety of plants. If you have chloride it is wise to consider this when gauging the concentration of the other anions in solution as their concentration will need to be increased to account for the presence of this ion.

As in the case of sodium there is not much you can do to decrease the amount of this ion in solution since almost all chlorides are soluble. Some zeolites – like clinopitolite – might be able to remove some of these ions from solution but the most effective method if your water contains an important concentration of chloride is to use a reverse osmosis machine. If this is not possible – due to costs or water availability – then the best chance you have is to try to increase anion

concentrations to try to compensate for chloride absorption. However this will not work if the Cl concentration is very high as the osmotic pressure will be too high for the plants to handle after compensating.

Some things you should know about sodium in hydroponics

Sodium is a ubiquitous element, you can find it in your tap water, in the sea and in most eatable foods. It is also necessary for animal life where it plays a key role in many biological processes. However – despite its overwhelming abundance – sodium is in fact not required for plant life in general (although some species, like C4 plants, do require it in small measure), meaning that it can act in a detrimental manner when present in significant quantities in hydroponic culture. Today I want to talk about what problems sodium can cause, how they can be attenuated and how we can deal with it in hydroponic crops.

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So what is the problem with sodium? Sodium in its cation form (Na+) is an extremely soluble ion with an ionic radius that is intermediate between those of lithium and potassium. Being from the same group it chemically behaves in a similar way to these two elements and can therefore act in a similar manner when in contact with plants. Sodium – when present in large enough quantities – will enter plants in significant

quantities and replace potassium in some biological roles. Although this might work in your favor when potassium is scarce it does not replace it very well and ultimately costs you dearly in terms of plant growth when compared to plants grown without sodium. You can read this 1976 review for some good information about some general effects of sodium on plants.

Since sodium is so ever-present it is a significant concern in agriculture. This is a reason why there are so many salinity studies – which is what the abundance of salts like sodium chloride is usually called – often aimed at finding ways to attenuate the effects of sodium to make plants grow effectively under high salinity conditions. This is not because people will add things like table salt to agricultural crops but because many areas around the world simply don't have a choice and need to deal with higher salinity conditions. Things like additives, substrates, irrigation cycles and light treatments are investigated to figure out how they affect plant behavior under these conditions. For example this recent study sought to find out if silica nano-particles could help with this problem (and they do!).

In your hydroponic crop sodium might be an important concern in two main ways. The first is if your water source contains a significant amount of sodium. In general sodium starts to be worrisome above 5 mM which is around 120 ppm which is the point where it can start to significantly affect yields and growth. However sodium even at 12 ppm can start having some micro-nutrient like effects, but these can be mostly beneficial in flowering plants like tomatoes and peppers, even increasing fruit quality when given in moderation (see here). However many plants are resistant to even moderate levels of sodium if these are not kept for too long so if your source water has something like 20-60 ppm of sodium (common in the US), you shouldn't really worry too much about it. In reality huge problems usually start at around 75mM of NaCl which is

closer to 1725ppm of Na, although with some Na sensitive crops this might be much lower (like lettuce where 100ppm is already very detrimental to growth).

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The second problem you might face only happens if you have a system that recirculates nutrient solution. Since sodium is not absorbed so readily by plants it can easily accumulate in a nutrient solution that is recirculated for a significant period of time. During one month of operation a 1 gallon per plant deep water culture system can increase the concentration from tap water 5 fold. This presents a problem since this implies that a hydroponic system that initially had 50 ppm of Na can easily end up with 250 after a single month of solution recirculation. This poses a limit to the life of a nutrient solution, even if other nutrient concentrations are adequately controlled through routine lab analysis. This means that if you want to keep solutions for longer than a few weeks you probably need to use reverse-osmosis water to avoid this problem – although more about the issue of solution life in a future post.

In the end sodium is an element that might be good to have in small measure in most cases, if you are growing C4 plants – like maize or sugar cane – then it is essential in a small amount (20-60 ppm) but you will want to avoid having sodium in any bigger amount or it can start to affect your growth. For plants where sodium isn't biologically necessary it can still provide some useful supplemental roles but in this case it might be best to keep it close to micro-nutrient levels, at 5-15 ppm. However if you are growing a halophilic plant – like say swiss chard – then you might want to have even more than 1000ppm of sodium to increase your growth (see here).

Using UV sterilization in your recirculating hydroponic crop

In general most growers want their hydroponic setups to remain fairly sterile. This is because maintaining a sterile environment discourages problems such as algae growth and can eliminate bacterial and fungal problems even before they appear. This is especially important in recirculating hydroponic setups where algae can cause important nutrient balance issues within hydroponic solutions and root pathogens can spread very quickly across an entire hydroponic operation. Today we will be talking about one of the least invasive methods to maintain sterility within a hydroponic solution, UV light.

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This days hydroponic growers have access to a wide variety of in-line UV lamps that can be used in all hydroponic system sizes. An inline UV lamp like the one above – which uses 18 Watts of power – can be used to effectively sterilize at a 750 GPH flow rate and can therefore provide appropriate sterilization for even moderate system sizes of 200-300

gallons. Larger inline setups also exist but if you cannot find them there is also no reason why you cannot use several of these – each one with its own pump – in order to maintain an even larger reservoir sterilized.

Research has also shown that UV light sterilization is effective in reducing bacterial and fungal populations (see here). But this research also shows that the use of UV lights also affects native bacterial populations so if you're using any type of beneficial microbes these will need to be systematically replenished to compensate for their loss due to the sterilization system. There have been some reports of 99.99% of pathogen inactivation in water in hydroponic crops when using adequate doses of UV radiation, so this is definitely a good way to keep pathogens at bay, even if it can somewhat compromise root bacteria populations.

Iron stability has also been an important concern in UV sterilization for a while. This is because UV irradiation of chelated iron species can destabilize and destroy the chelate, leading to non-chelated forms of iron that can much more readily precipitate from solution. The image below – taken from this article – shows the degradation of 3 different Fe chelates at pH values of a (3.0) and b (6.0) as a function of time. Note that the fact that free Fe is generated does not mean that the Fe is precipitated but merely that the chelate has been destroyed, which is the first step before the Fe can precipitate. From this it is clear that different chelates have very different stabilities and in this case chelate i-Fe-EDDHA had the largest stability while other chelates had much poorer stability against UV radiation.

In the end UV sterilization offers many advantages with only a few disadvantages if the formulation is properly prepared and

the crop is properly managed. Fe depletion can be a problem if chelates like EDTA and DTPA are used but this problem can be alleviated in great measure by using a chelate like Fe-EDDHA. Micro-organism depletion from the roots can also be a problem if symbiosis are important for yields but this can also be alleviated by the periodic introduction of new beneficial microbe populations within the plant root environment.

However UV is definitely not the only way to go for nutrient solution sterilization. There are other methods that can be used, some of which do not generate the problems that UV has – but different problems – and others that are less generic in their protection, implying that they must be somewhat targeted towards a particular pathogen in order to be effective. You can read this review about nutrient solution sterilization in hydroponics if you want to learn more before I post about these alternatives.

What is an ORP meter and why is it useful in hydroponics?

Hydroponic growers are used to using pH and EC meters to control their growing conditions but very few use ORP meters in order to learn more about their nutrient solution. An ORP meter can give you very useful information and cheap ORP meters can usually be bought on ebay or amazon for less than 20 dollars each. Today we will talk about ORP meters, what they are, what they are useful for and how you can use them in your hydroponic crop.

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An ORP meter or “Oxidation-Reduction Potential” meter characterizes the electrochemical environment within a solution. An ORP meter has two electrodes, a traditional reference electrode with a known potential and a platinum electrode whose potential changes depending on how hard the solution is pushing either to take electrons from the platinum electron or give it electrons. A solution that has a lot of substances that are willing to give electrons will tend to give a more negative reading and a solution that has more substances willing to take electrons will tend to give a more positive reading. The ORP reading is given in mV.

So how is this useful in hydroponics? It is useful in the sense that we can know exactly how the chemical environment is behaving. The ORP of potable water is generally around 600-700mV, this is because oxidants – substances that are willing to take electrons – are added to solutions in order to kill pathogens. The chemical environment needs to have an ORP of above 600mV to eliminate harmful fungal spores and bacteria. Of course this means that if you want to run a sterile hydroponic environment you’ll want to keep the ORP of your solution probably in the 300-500mV range, large enough to prevent any micro-organisms from growing but low enough to prevent any damage from happening to your roots.

In this way you can use things like hypochlorous acid and hydrogen peroxide to increase the “killing power” of your solution while knowing how harsh you’re making the chemical environment. The ORP will also give you signs about water oxygenation and biological activity within the water. A reductive environment – ORP below 100mV – will mean that there is a significant number of substances in the solution that want to give electrons and these substances are generally organic acids, bacteria, viruses or other organics molecules, like reductive sugars. If this is the case then it means that oxygen in solution has a short lifetime so you will want to

increase your oxygenation significantly or your roots might be starved of this essential nutrient.

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The chemical environment is determined by the sorts of half reactions that can happen in solution and this is also determined by the pH of your solution. The above table shows some of the most common electrochemical half-reactions that can happen in solution. For example in order to reduce molecular oxygen and obtain 4 electrons we need to produce hydroxide ions. This means that oxidation reactions will tend to increase the pH and therefore they are expected to become harder as the pH rises. We also have the opposite case for hydrogen peroxide where a more acidic solution is bound to prevent the oxidation of peroxide to molecular oxygen. It is worth noting that these are half reactions so in reality what always happens is that two half-reactions – for example oxygen reduction and Fe oxidation – are brought together to generate a chemical change in the environment.

In the end the ORP measurement gives you something that pH and EC measurements do not tell you, which is what the chemical environment looks like from an oxidation-reduction perspective. With this information it becomes easier to tell things like whether you’re lacking enough oxygenation, whether you’re adding too much hypochlorite or peroxide and whether or not you should be adding more or less microbes to your environment.

How to prepare your own solutions for EC meter calibration

On a recent post I talked about how you can prepare your own solutions for the calibration of your pH meter. However hydroponic growers not only need to calibrate their pH meters but they also need to use EC meters to control their growing environment. Today I want to talk about how you too can prepare solutions for the calibration of your EC meter so that you don't need to depend on expensive commercially prepared solutions for EC calibration. I will also give you some important tips about how to maintain these solutions so that they last for a longer time period.

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As in the case of pH meters the correct calibration of an EC meter ideally requires the use of two solutions. Most people however use only one solution or use two solutions in a rather wide range. Ideally both solutions would need to be within the range in which we would want to measure so ideally we would want to have solutions in the 0.5-3.0 ms/cm range for the calibration of an EC meter used in hydroponic. We also need to make sure we use substances that show both a linear relationship between EC and concentration and that do not affect the pH of the solution considerably as the EC can also vary significantly with the pH of a solution.

As in the case of pH meters the easiest – but definitely not most analytically correct – way to carry out this preparation is to work with a calibrated EC meter to start with. In order to do this buy a single calibration solution so that you can ensure that your EC meter is at least calibrated properly over a single point. After the EC meter is calibrated we will use it to prepare a calibration solution with a specific EC level that we can then use for calibration. Since there is nothing special about any specific EC points – not the same case as with pH electrodes where pH 7 is the electrodes isoelectric point – preparing EC calibration solutions is easier.

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Start with a water source – distilled would be preferred – and add around 1g per liter of NaCl, you can use any store-bought variety to carry out this process (the small amounts of additives won't affect this process significantly). This should give you a conductivity reading in the range that is generally used in hydroponics, depending on your tap water it should be somewhere between 1.5-2.5 mS/cm. You can also prepare another solution with 0.5g per liter of NaCl which should allow you to perform a two solution calibration. Note that the addition values do not need to be exact. If you are using tap water make sure you let it sit for around a day before using it so that any chlorine is eliminated from the water.

After preparing the solutions take note of their EC levels, these are the levels you will use for calibration. A problem with EC solutions is that they have a fundamental dependence on the concentration of ions in solution and cannot compensate for this so the EC values will vary and become unknown if you

let the solutions evaporate. When storing EC solutions it is therefore important to use airtight containers and additionally put electrical tape around the cap after every use, this will make sure that the loss of ions within the bottle is minimal. After some volume of solution is used make sure you discard it and never put it back inside the same bottle.

As in the case of pH meter calibration solution preparation this is definitely not the way in which these solutions would be prepared in a lab – as you can prepare solutions with extremely accurate predicted conductivity if you have very pure salts and double distilled water – but it’s a very good way to create cheap calibration solutions that offer low enough errors to allow for their use in hydroponic culture.