# What is the ideal amount of media per plant in hydroponics?

When designing a hydroponic crop, the amount of media is a crucial variable to consider as it will determine a lot of the capital costs involved as well as play a key role in determining how irrigation is setup and how big the plants can get. However, how can we figure out what the ideal amount of media in a crop actually is? In today's post I am going to talk about the amount of media per plant in hydroponics, which factors play into deciding what size to use and what different choices will affect other aspects of your crop, such as irrigation frequencies and plant densities.

The first question we need to ask ourselves is, why do we need the media? The function of the media is to provide the root system with structural support and environmental protection. Plant roots cannot generally survive in the open air, so the media provides a cozy home where the roots can prosper and give the plant the water and nutrients it requires. The volume of media you provide will determine the size of this "safe space" and the actual media choice will determine how "safe" the space actually is. Plants require media to allow for enough air – because nutrient uptake requires oxygen – but it also requires the media to allow for some water retention in order for water and nutrient uptake to actually take place. How optimum this oxygen/water/nutrient relationship is for a given media choice, will determine how big the media needs to be in order to sustain the plant.

Plants that are large also require a lot more water/nutrients, so the media and root system will need to provide enough absorption. A small amount of media will demand more from the root system – every cubic inch of root will need to work more efficiently – and it will also demand more from the irrigation scheduling, because ideal conditions will need to be more closely monitored since the root system will affect them quicker. You can sometimes see huge plants grown in 6′ x 6′ x 6′ rockwool cubes, these offer a small amount of volume (0.9 gallons), so to support a big plant, ideal media conditions need to be maintained all the time, which means very judicious monitoring of water content and frequent irrigation periods. As the cubes are irrigated the plant quickly uptakes water/nutrients, so the cube needs to be irrigated again. However, irrigate too frequently and oxygen content will drop and the plant will start to suffer as the root system won't be able to cope to maintain the plant's needs.

An evaluation of the media volume therefore requires an evaluation of other growing conditions. Consider when irrigation cycles will happen, how is monitoring going to be done and how does the media need to be managed to reach ideal conditions. *More media, means bigger costs but more forgiving root zone conditions, so less experienced growers can often do better with larger amounts of media*. Novice growers will often fail when attempting to grow plants using less media, because they lack the experience to maintain the conditions needed for this to happen. *When growing larger plants, media volume per*

*plant in the order of at least 5 gallons is recommended for people who don't have a lot of experience* or for conditions where close monitoring of the plants and automated irrigation is not going to be a choice.

Take this study on tomatoes grown using different volumes of media, the authors were able to achieve the same results with either 10L or 15L containers, but they got lower yields when moving to smaller container sizes. Someone starting out under these conditions would be better off erring on the higher side – using more media than less – in order to avoid reducing their yields due to insufficient volume being present for the irrigation conditions used. This might mean a higher expense, but a successful crop is always preferred to a crop with lower yields/failure. It's easier to plan for more media and then reduce it than the opposite.

If you are already growing and you want to lower the amount used per plant, you need to consider whether your media will allow for this or not. Only media that allows for significantly high water retention will allow for this to happen under intermittent irrigation, while media that do not retain water very well will only be able to do this under basically constant drip irrigation. If you're already doing 10+ irrigation cycles per day in intermittent irrigation with adequate dry-back between periods, then the media might already be reaching its limits in terms of what the root system can do in that volume. *Watching how the water content changes as a function of time will help you assess whether your media can be pushed harder or not*. If run-off EC/pH values are getting too extreme, this might also be a sign that you're reaching extreme regions in your media.

Remember that plants need to uptake the same amount of water/nutrient per unit of time to sustain growth. This means that a plant that requires 3 gallons of nutrient solution per day will still require this amount, regardless of whether the volume of the root zone is 1 gallon or 5 gallons. If you go

from 5 gallons to 1 gallon then the drybacks will be significantly faster, so you need to adapt in terms of irrigation frequency.

*In summary, media volume is a complex topic and requires a careful examination of different factors.* Think about what ideal conditions are like for the media you chose and whether the irrigation system can provide enough oxygen/water/nutrients for the root zone in a given volume to fulfill the plants needs per day. *When in doubt, use more media*. If media reductions are being considered, remember that this will mean quicker dry back periods and therefore more frequent irrigation required. This means much higher stress for plants if irrigation cycles are missed or if problems in the root zone arise (for example problems with solution pH). Less media used means a more technical approach with more judicious monitoring will be required.

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# The media exchange solution test: A better measurement of media effects in hydroponics

In the traditional hydroponic paradigm we want media to be as chemically inert as possible. The ideal media in this view would absorb no nutrients, give off no nutrients and would not decompose or react with the nutrient solution in any way. However none of the commonly available media sources comply with these properties, reason why we must be vigilant and properly adjust the media we use to fit the needs of our hydroponic setup. In this article I am going to talk about the idea of using a direct comparison test of the nutrient

solution against the media, to understand the effect the media will have when exposed to the target nutrients and how this can help us adjust our solutions to better play with the selected growing medium.

Different types of growing media

First, let us understand how the media interacts with a hydroponic solution. The media can do all of the following things:

- **Dissolve into the solution** (this is what happens if your media is something like sand or limestone). In this case the media is chemically reacting with the nutrient solution, therefore media is being irreversibly lost in the process. This can happen very fast, with something like limestone, or very slowly, with something like sand.
- **React and take something away from the solution**. In this case the media can use ions within the solution to perform reactions that create new substances that are insoluble. For example if you have media containing large amounts of rock phosphate this phosphate can cause the precipitation of heavy metal phosphates.
- **Release ions in exchangeable locations into the media.** This is different than dissolving because the media is

not getting destroyed in the process but it is emptying "storage sites" that contain some ions that prefer the solution instead of these sites. This process is fundamentally reversible and – under the proper conditions – these sites could be replenished with the same or different ions.

- **Take ions into exchangeable locations in the media.** This is the opposite of the process above. In this case the media will receive some ions into "storage sites" because these ions prefer the media to the hydroponic solution. The solution will therefore be depleted of these ions because they are being stored within the media.

Of most interest to us are the third and fourth points above, this is generally understood as the "exchange capacity" of the media. This determines how many and which nutrients the media can store. Different media can have storage sites with different affinities and in hydroponic setups we generally want to aim for the minimum energy state of these storage sites as they relate to our nutrient solution. Media that is already in equilibrium with the nutrient solution will tend not to change it while media that is far away from equilibrium with the solution will change it strongly towards the equilibrium point.

Think about coco coir, a commonly used media in hydroponics that can have a wide variety of different ion exchange capacity values and a lot of different ions initially in its "storage sites" due to the differences in sourcing materials and treatments done by different companies. Coco coir initially contains high amounts of potassium and sodium ions, but some companies treat it with Ca nitrate, which changes all these "storage sites" to contain Ca instead. These two sources of coco would interact very differently with our nutrient solution. In the first case the coir would exchange a lot of its potassium for Ca and Mg ions in solution – because these

ions have higher affinity for the “storage sites” – while in the second case a little Ca would be exchanged for other ions (because all ions are in equilibrium with all the storage sites). The changes to the solution are very different and totally different approaches in nutrient composition changes are required.

Traditional soil tests could provide some answer to us, they would definitely show the ions that could be exchanged to be different in both cases. But they tell us little about the equilibrium position of the media against our target nutrient solution. To make things more realistic we can actually do a test where we pass our actual nutrient solution through a column of media that is exactly what we’re going to run it through in real life (with no plants of course). We then collect the input and output solution and run lab analysis of both of these solutions. **We can then compare the results and see how much the media is actually changing the composition of our input solution and we can then make some decision to adjust.** Such a test would proceed as follows:

1. Prepare the strongest final solution that will be used in the growing process. (for example the solution that is used at the peak of fruit generation in a tomato crop)
2. Take a sample of this starting solution to send for chemical analysis.
3. Pack a burette with a column of media as high as the containers the plants will be in.
4. Fill the burette with the nutrient solution.
5. Run as much solution as required to collect a sample of equal volume to the first one.
6. Send both samples for analysis.

The difference in nutrients between both solution will show us what we should initially be doing to maintain a consistent composition of the nutrient solution, given the interaction with the media. If the interaction is too strong it can also

tell us that we shouldn’t be using this media without previously treating it to ensure the imbalances do not happen. For example media like biochar can have an extremely high affinity for metal chelates and nitrogen compounds, if we ran our solution through the media and it turns out that it soaked up almost all of our iron and ammonium, we wouldn’t want to just add more nitrate and heavy metals but we would like to pretreat the media with a concentrated solution and then repeat the test to ensure that the media is at a level of activity that we can correct for.

**A given media source that is acceptable should not strongly affect the nutrient solution**. Any media that does this in the media exchange test requires correction so that the ability to take elements from the nutrient solution is reduced. The test will tell you exactly what the media is finding most appetizing and the treatment options will then be substantially easier to plan. A coco coir that shows it soaks up almost all the Ca will need to be treated with a Ca nitrate solution and a biochar that absorbs a lot of ammonium will need to be treated with an ammonium sulfate solution. These are some cheap pretreatments that will save a lot of heartache within a hydroponic setup and will make the ongoing growing process substantially easier to manage.

**This is one of the simplest and cheapest tests that can be done to address media effects**. However it is by no means comprehensive in that it does not show us other important media properties that might be crucial for selection. It is important to consider that this test gives us only a glimpse of the chemical properties and the interactions with the actual nutrient solution we intend to use. Other media specific analysis and more complicated media run-off tests can be necessary to address the full extent of the interactions through an entire crop cycle.

# Using biochar in hydroponics to improve yields

The media used in hydroponic crops can vary widely around the world depending on what's cheaper and more easily available in large quantities. In the United States, coco coir, peat moss and perlite tend to be favored while other regions might prefer media like rice husk, sand or vermiculite. However there is an entire type of media that is available in significant quantities almost any place where plants are grown, that is rarely used: biochars. These are produced from the controlled burning of plant materials and offer a myriad of potential benefits not commonly available with the other media types. Furthermore, biochar – combined with other media – can actually provide significantly better results in hydroponic culture. In this post I'll talk about biochars, their properties and walk you through some of the evidence showing how they can substantially improve yields.

Biochar material generated from a previous crop cycle

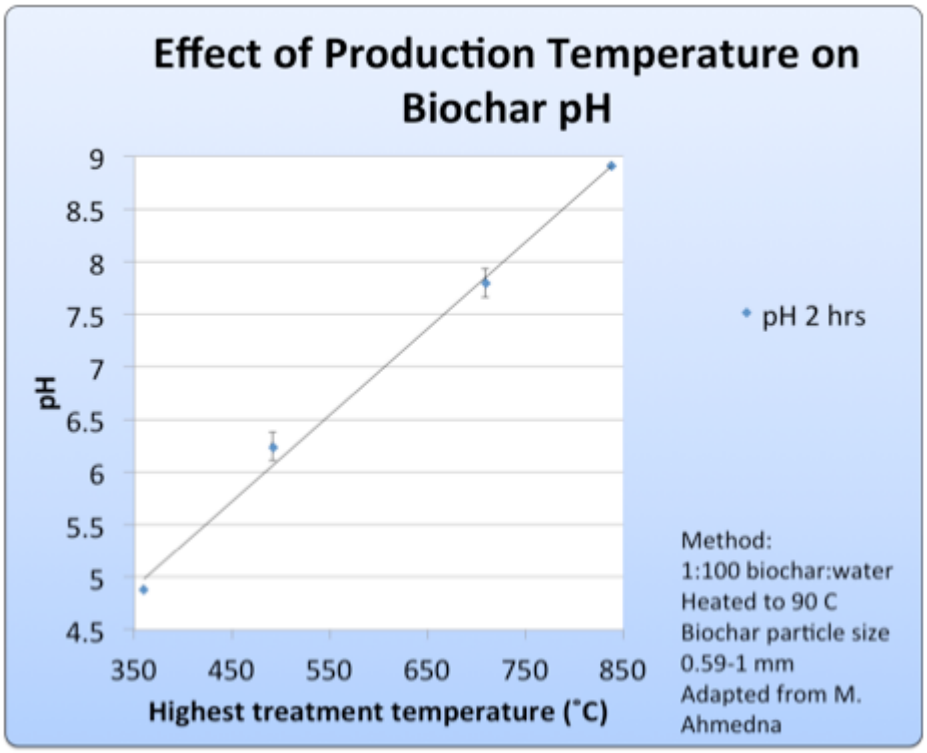
First let's talk about the properties of biochars. Since they are the result of burning plant material, their chemical and physical properties will be inherited from the parent plant

material and the nature of the burning process (temperature, speed, oxygen availability, etc). The table below shows the properties of biochars from 3 different plant sources coming from the exact same process. Although all of the biochars are basic, their cation exchance capacity (CEC) and EC values can vary very substantially. The CEC is substantially lower than that of a media like coco coir (which can be in the 40-60 range in terms of cmol/kg) but the density of the media is much higher with biochar around 80-320kg/m^3 while coir is way less dense at only 80-100 kg/m^3. This means that the volumetric exchange capacity of biochar is around the same as coir but can be much larger depending on the specific source of biochar. **Note that the initial pH of biochar can vary very widely, from around 5 to 10, depending on the temperature used to make the biochar** (see second image below). These two tables show you how the properties can vary both due to the process and the plant material used.

| Properties | CS[a] | SG | PW |
|---|---|---|---|
| Specific surface area ($m^2\ g^{-1}$) | 176 | 188 | 233 |
| pH | 10 | 10.8 | 9.3 |
| EC ($\mu S\ cm^{-1}$) | 800 | 550 | 120 |
| Ash content ($g\ kg^{-1}$) | 459 | 458 | 397 |
| CEC ($Cmol_c\ kg^{-1}$) | 24 | 19 | 9 |
| Total C ($g\ kg^{-1}$) | 480 | 495 | 550 |
| Total N ($g\ kg^{-1}$) | 4.1 | 4.5 | 3.3 |
| Total P ($g\ kg^{-1}$) | 1.9 | 2.1 | 0.4 |
| C/N | 176 | 188 | 233 |

[a] CS, corn stover biochar; PW, pinewood biochar; SG, switchgrass biochar; EC, electrical conductivity; CEC, cation exchange capacity; C, carbon; N, nitrogen; P, phosphorous. Biochar characteristics adapted from Chintala et al. (2014).

The table above was taken from this article (https://www.ncbi.nlm.nih.gov/pubmed/28618279)




This image was taken from here (https://langara.ca/departments/chemistry/biochar-project/production-and-characterization-of-biochar.html)

Biochar is not commonly used by itself but as an amendment to improve the properties of other media. Evidence across several different plant studies shows that biochar amendments systemically increase the yields in hydroponic crops. The first image below – taken from a study on cherry tomatoes – shows how a 5% amendment of biochar in coco peat was able to significantly increase the diameter of fruits produced. The second image – from a study on peppers – shows how the addition of the same 5% amendment of a "nutrient poor" biochar in coco coir produced very substantial increases in biomass over controls. There are several other studies that show improvements due to the use of biochar amendments, either under normal or stressed conditions (2, 3, 4, 5, 6, 7). From the evidence it seems to be clear that biochars can provide substantial benefits to hydroponic crop production. This is further cemented in this review about the use of biochar in container plants, which goes into additional evidence about the matter (plus some problems I'll also address later in this article).

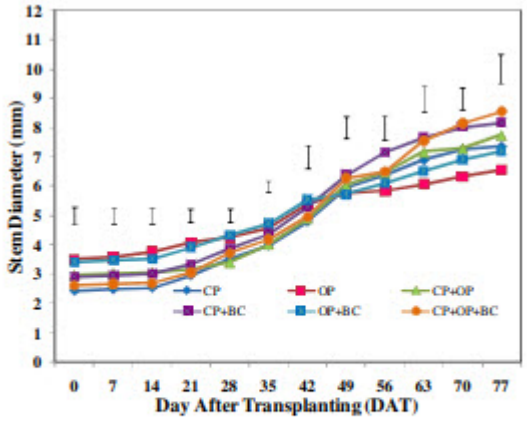



Figure 1. Effect of different soilless growing media on stem diameter of cherry tomato. Vertical bars represent LSD (P≤0.05)

Image taken from [this article]

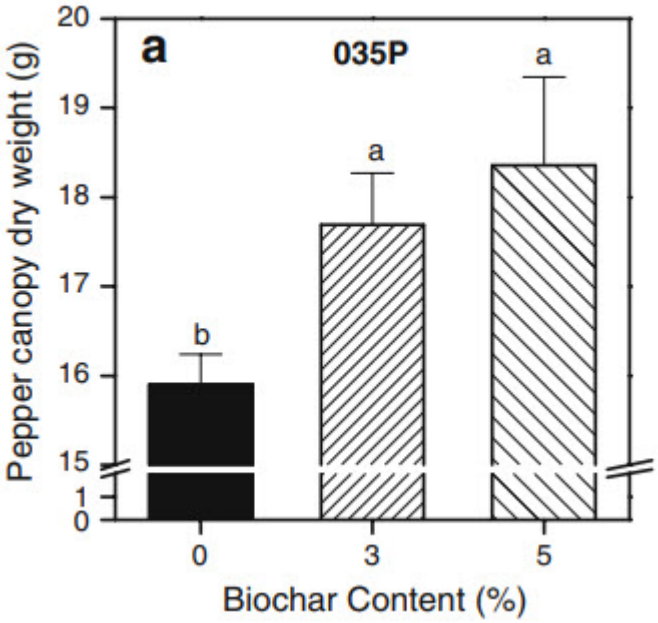



Image above taken from [this study] on peppers

But why does biochar work? There are currently three hypothesis that could explain the benefits available from biochar. The first is that it has a higher affinity for plant root exudates and other toxic substances that harm plant growth. By removing these substances, the biochar that is within the media ensures that the roots are always in a less toxic environment. The second hypothesis is that biochar provides a more welcoming environment for beneficial microbes, because of its chemical nature and pore structure, that facilitates the creation of beneficial symbioses that are harder to maintain in other media. The third is that the

biochar has higher affinity for some nutrients, particularly nitrogen, enabling the plants to maintain a steadier supply of nutrients between irrigation cycles (this chemical behavior is well documented, see here). Potentially getting these three benefits makes biochar one of the most obvious improvements to hydroponic crops. **A potential 20%+ improvement in yields could be realized in this case**, if results from the literature translate into your crop.

However there are also problems with the use of biochar in hydroponics that should not be overlooked. In particular there is the problem of consistency and quality of chemical and physical properties. Since biochar properties depend so much on the creation process and sourcing material, it is quite easy to get a biochar that is detrimental instead of beneficial to plant growth. The second problem is the potential availability of toxic substances within the biochar that might harm your plants or make your products heavily toxic. Biochar source materials can be contaminated with heavy metals and toxic organic compounds can be generated within the high temperature process. It is therefore vital to ensure that the biochar you use contains neither of these issues.

Ensuring that the EC, pH , CEC and mineral properties of the biochar are aligned with the ones that provide the most benefit in the literature is a good place to start but ongoing quality controls are also necessary to ensure that the supplier has not changed the source or chemical process in a way that’s detrimental. Producing your own biochar – since the equipment to do so is fairly simple – can also be a good possibility, given that a lot of plant material can also be wasted in crop cycles and this material could then be recycled as media for the next crop.

# What is the ideal nutrient solution temperature in hydroponics?

One of the simplest variables that can make a substantial difference in crop yields in hydroponics is the temperature of the nutrient solution. Nutrient absorption by plants is mainly controlled by chemical processes within their roots and the efficacy of these processes is determined in an important part by the temperature the roots are subjected to. Since plants don't have a mechanism for active temperature regulation they just react to changes in temperature in order to best adapt to the environment that surrounds them. Today I will be talking about the optimum solution temperature in hydroponics, what influences this value and what factors we must consider when deciding what temperature to use in our hydroponic system.

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Table 2. Fresh weight, dry weight, water content and SLA of red leaf lettuce grown at four different root zone temperatures.

| Root-zone temp. | Top fresh weight (g) | Root fresh weight (g) | Top dry weight (mg) | Root dry weight (mg) | Top water content (%) | Root water content (%) | SLA |
|---|---|---|---|---|---|---|---|
| 10°C | 3.12 ± 0.20 b | 0.61 ± 0.04 b | 211 ± 9 a | 36 ± 2 a | 93.2 ± 0.1 b | 93.2 ± 0.2 b | 0.51 ± 0.02 b |
| 20°C | 4.60 ± 0.28 a | 0.98 ± 0.14 a | 253 ± 12 a | 44 ± 6 a | 94.5 ± 0.1 a | 95.5 ± 0.1 a | 0.57 ± 0.02 a |
| 25°C | 4.51 ± 0.42 a | 0.82 ± 0.07 ab | 251 ± 20 a | 38 ± 3 a | 94.4 ± 0.1 a | 95.3 ± 0.1 a | 0.54 ± 0.01 ab |
| 30°C | 4.11 ± 0.35 ab | 0.75 ± 0.11 ab | 233 ± 19 a | 35 ± 6 a | 94.3 ± 0.1 a | 95.4 ± 0.1 a | 0.56 ± 0.02 ab |

Values are mean ± SE ($n$ = 6). Different letters in the same column indicate significant differences by Tukey's multiple comparison test ($p$ < 0.05).

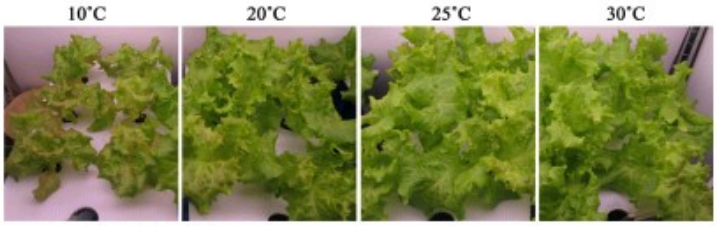


Figure 1. Effect of root-zone temperature on the morphology of red leaf lettuce.

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Solution temperature affects several important variables. Oxygen solubility changes as a function of temperature – decreasing as temperature increases – so as you increase the

temperature the availability of oxygen to plant roots starts decreasing. As you increase temperature however the speed of the chemical reactions in plant roots increases, so there is an increase in respiration rates as temperature increases. The ideal temperature is therefore always a compromise between this decrease in oxygen availability and the increase in metabolic rate that is given by higher temperatures. For almost all commercially grown plant species optimum solution temperatures will be in the 15-30°C (59-86F) range due to this reason.

However there is no rule of thumb for optimum solution temperature selection in hydroponics. It should be clear that since different plants evolved across different conditions some of them perform better at lower temperatures and some others do better at higher temperatures. We know for example that the optimum nutrient solution temperature for potatoes is in the 20-25°C range (see here) while the optimum temperature for plants like cucumbers is higher, at 28°C (see here). For some plants like onions the best solution temperature can actually be a bit higher, even in the 26-30°C range (see here). Others like lettuce and baby leaf crops actually prefer much lower temperatures, with optimum results near 20°C (see here and here).

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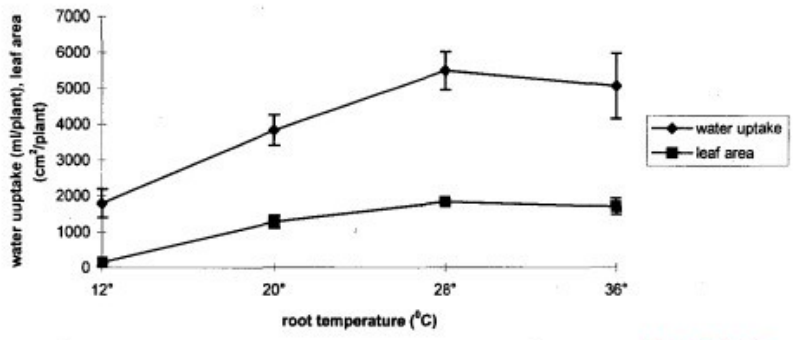


Figure 1. Water uptake and leaf area as affected by root temperature. Cucumber

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It is then clear that picking a random number between 15-30°C is not enough, a careful study of the plant specie being grown has to be carried out in order to select an adequate temperature. It is also important to note that higher temperature choices do not come without problems. We know for example that pythium and other infections are associated with increases in temperature since pathogen metabolism is also enhanced under warmer conditions (see here and here). This shows how even though the optimum temperature for tropical flowering plants is usually in the 25-30°C range, it is usually not common to see optimum results at these temperatures due to the potentially higher prevalence of diseases. This is most probably why growers usually go with a lower temperature in the 20-25°C to avoid risking diseases at a higher temperature.

If you want to try higher temperatures it is therefore better to go with sterile type hydroponic systems where microbes don't play an important role and to implement measures – such as silicate additions to the nutrient solution, UV filtration and constant oxygenation – to ensure that disease prevalence is as low as possible. Also avoid adding any source of organic carbon (like sugars) as these can play an important role in feeding incoming pathogens. Big gains can be obtained with a better solution temperature control, provided that diseases are controlled and a temperature adequate for the plant being grown is selected.

# Using coco coir in hydroponics

Side by side with peat moss, coco coir is one of the most commonly used media in hydroponic culture. Its excellent root propagation and aeration properties, coupled with its adequate water retention, make it an ideal medium for hydroponic culture. Nonetheless, there are several issues that can arise when using coco coir, particularly due to its chemistry and variability. Today we are going to talk about using coco coir in hydroponics, what the main problems with coco can be and how these problems can be avoided.

TABLE 11.7 Levels of pH and EC in Coir

| pH | EC ($mS\,cm^{-1}$) | Reference |
|---|---|---|
| 4.9–6.4 | 0.17–2.32 | Noguera et al. (2003b) |
| 5.6–6.9 | 0.13–1.26 | Evans et al. (1996) |
| 4.8–6.8 | 0.32–0.97 | Meerow (1994) |
| 5.5–5.7 | 0.80–1.90 | Handreck (1993) |
| 5.0–5.7 | 0.12–1.51 | Prasad (1997b) |
| 4.9–6.6 | 0.32–0.41 | Smith (1995) |
| 6.0–6.7 | 0.2–0.4 | Kipp et al. (2000) (coir dust) |
| 5.9–6.1 | 0.2–0.9 | Kipp et al. (2000) (coir chips) |

Values of Noguera et al. (2003b), Evans et al. (1996), Meerow (1994) are based on saturated media extract, Smith (1995) on 1:5 water extract, and the others on 1:1.5 water extract. EC values have been converted to 1:1.5 water extract (see text).

EC and pH values for different coco coir sources

Coco coir is basically ground up dried palm tree husks. Although it is organic, it is much more fibrous than peat moss and for this reason, it does not suffer from some of the pH and decomposition issues commonly found with peat. Although coco is biodegradable, its decomposition can take more than 20 years, reason why it is a suitable media for hydroponics. It can even be used several times within a hydroponic crop in order to save production costs, as long as plant material is removed and the media is properly treated between crops.

Since coco coir comes from large plants grown across a variety of different conditions, the actual chemical makeup of the coco can change very substantially. The table above shows the

pH and EC of different coco coir sources. As you can see, we have everything from an EC of 0.1 mS/cm to an EC of 0.9 msS/cm, with pH values that cover anything from 4.9 to 6.8. This is mainly due to the big variations in the ions contained within the coco and how these ions interact with the plant material.

Coco coir also has a high cation exchange capacity, meaning that it can retain large amounts of ions. These are only taken out if they are replaced by others with stronger affinity for the media or when strong interactions with chelating agents are possible. This is generally why coco is treated with calcium nitrate solutions, to remove many of these ions from the media structure and allow the media to be as neutral as possible when used in hydroponic culture. However, many coco producers do not treat the media at all – or simply wash it with plain water – leaving a lot of potassium and sodium within the coco that needs to be accounted for. A lot of micro nutrients that are tightly bonded to cation exchange sites are often also often present inside the coir.

TABLE 11.9 Chemical Properties of Coir ($CaCl_2$/DTPA Extractable Macronutrients) ($mg\,L^{-1}$)

| P | K | Ca | Mg | Na | Reference |
|---|---|---|---|---|---|
| – | 183–222 | 100–172 | 36–58 | 85–92 | Kipp et al. (2000) (coir dust) |
| – | 47–98 | 56–60 | 31–79 | 30–78 | Kipp et al. (2000) (coir chips) |
| 8–17 | 304–720 | 6–15 | 8–28 | 110–114 | Handreck (1993) |
| | 69–128 | | | | Prasad (1997b) |

TABLE 11.11 Chemical Properties of Coir ($CaCl_2$/DTPA Extractable Micronutrients) ($\mu g\,L^{-1}$)

| Fe | Mn | B | Zn | Cu | Reference |
|---|---|---|---|---|---|
| | 1100–1500 | 120–180 | 700–1300 | 170–2200 | Handreck (1993) |
| 79–157 | 814–1540 | 66–77 | 429–527 | 0–6 | Kipp et al. (2000) coir dust |
| 45–140 | 484–561 | 66–154 | 364–552 | 240–448 | Kipp et al. (2000) coir chips |
| 4100–7700 | 900–5000 | 200–400 | 500–1100 | 100–300 | Prasad and Maher* |

*Prasad and Maher unpublished data.

Some of the chemical properties of different coco coir sources

If you want to ensure your coco is as neutral as possible in terms of nutrients, you can extract it with a 1 g/L solution of calcium nitrate and then with 2g/L of tetrasodium EDTA. This will extract both macronutrients that are exchangeable

for Calcium, and micro nutrients that can be extracted when using EDTA. The EDTA step is important, as coco can hold a large amount of micro nutrients within it, that can be exchanged and used by the plant. If you want your nutrients to all come from solution you will need to remove these contributions from the media. After this, you will then want to run plain water to remove any excess Ca and EDTA and then run your full strength nutrient solution for a few days. This will strip the coco from excess ions and equilibrate the cation exchange sites with your nutrient solution's composition.

Note that these steps aren't necessary to grow successfully with coco, but they can give the grower more control over the nutrients received by the plants. You can alternatively run nutrient solution through the coco and then perform an analysis of the output, so that you can compensate for the nutrients that are given by the coco through the growth cycle. This of course means that you need to spend money doing solution analysis through the crop's life to ensure that you're adequately compensating for the coco's contributions through the entire growing period.

When properly treated, coco can be a very good media for growing hydroponic crops. The larger aeration, better chemical stability and fibrous structure makes it better for root growth than most peat moss sources. Yields for several plants are also often larger or just as good in coco when compared with peat moss. The lack of important decomposition during growth cycles is also a big advantage over peat, as important drops in pH due to media decomposition can be avoided and the media can be more readily recycled.

# 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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TABLE 11.2 The von Post Scale for Assessing Degree of Decomposition of Peat (von Post, 1922)

| Degree of decomposition (H) | Quality of water exuded | Proportion of peat exuded |
|---|---|---|
| 1 | Clear, colourless | None |
| 2 | Almost clear, yellow brown | None |
| 3 | Slightly turbid, brown | None |
| 4 | Turbid brown | None |
| 5 | Very turbid, contains a little peat in suspension | Very little |
| 6 | Muddy, much peat in suspension | One-third |
| 7 | Very muddy | One-half |
| 8 | Thick mud, little free water | Two-thirds |
| 9 | No free water | Almost all |
| 10 | No free water | All |

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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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TABLE 11.3 Cation Exchange Capacities of Different Peat Types (Puustjarvi and Robertson, 1975)

| Species or peat type | Cation exchange capacity (CEC) | |
|---|---|---|
| | cmol $kg^{-1}$ | meq $L^{-1}$ |
| Undecomposed sphagnum moss peat | 130 | 80 |
| Sphagnum sedge peat | 110 | 60 |
| Sedge peat | 80 | 40 |
| Highly decomposed black peat | 160 | 240 |

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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.