A Beginner's Guide and "What to search for" about planted tanks.

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There are a few common questions that I see online from beginners. "My plants don't look good, what is wrong with them?" or "I want to grow plants but don't know anything about them, what should I know?" The guides that I find online are outdated or incomplete and sometimes just plain silly. Over the last 15 years many things have changed in planted tanks, however the core needs of plants remain the same.

In order to help people get started, I put together a basic guide based upon keywords that can be searched for the most recent information. The objective is to dispel some common myths and start the beginner on the path for success not an algae covered atrocity. As one kind person once said about my algae filled tank when I was first starting, "It looks like the Jolly Green Giant took a dump in your tank."

Aquarium Lighting:

Terrestrial plants are commonly divided into full sun, partial shade, shade, and deep shade to indicate the amount of light they are adapted to. These are the recommendations for light levels where the plants will look their best or even survive. In aquatic plants the same concept applies but the names are different. Plants are classified as **high light**, **medium light,** and **low light**. Matching the plant species to the local light level is an important consideration when planning your tank.

Here is some basic science about light and plants.

Plants only use a small segment of the colors of the rainbow from the sun or light fixture: Blue and Red. This is scientifically referred to as **Photosynthetically Active Radiation** or **PAR** for short. When researching a lighting system it's best to research PAR. With all the variation in lighting that is available (LED, CFL, HO florescent etc…) it is difficult to guess at how much usable light any lamp will give off. The only way to really know is to take a measurement with a PAR meter. PAR meters are readily available online and have been decreasing in price. Caution: Meters that measure in Lux or Footcandle have little to no value in evaluating PAR. Some local aquatic clubs buy PAR meters to share among members.

Also remember the **Inverse-Square Law** for light. The amount of radiation on an object decreases by ¼ for every time the distance doubles from the source of the light. The important takeaway is a lamp that produces high light over a 12" tall tank would be considered low light over a 24" tank. It can be a struggle to find a powerful enough light over a tall tank to grow high light plants.

Substrate:

A.K.A. the stuff you put on the bottom of the tank. Everyone has their own preference for substrate and there has been lots of arguments over the years. For plant growth there is one property that is of concern: **Cation Exchange Capacity** or **CEC**. CEC is a measure of how well the substrate binds to and later releases positively charged ions. Most nutrients for plants (see below) are positively charged. For plants the CEC of the substrate acts like a battery. They store and then slowly release nutrients as they are needed. Just like a battery it can be charged up and then completely depleted.

There are three main types of substrate that are common.

Inert Substrate: This is material that offers very little or no CEC. Almost all the nutrients that plants need come from the water column. These include Gravel, Marbles, and all the types of sand (Pool filter, play sand, etc..). Large sized gravel and marbles have very limited species that can grow in them. Many plant species are adapted to growing in sand provided they have sufficient nutrients from the water.

Moderately rich substrates: These substrates have some CEC value but also have some inert structure to keep the plants firmly in place. This group contains most of the commercial aquarium substrates designed for planted aquariums. Examples are Eco-complete, Flourite, Fluval Stratum etc.. They are designed to be a happy medium between all the needs of a planted tank. Many popular aquatic plants do very well. There are some plants that prefer sand or richer substrates.

Rich Substrates: These have the highest CEC value but can be more difficult to work with. These are the "Dirted" tanks that use garden soil, clay, or potting soil in them. They start with the CEC completely charged and then slowly diminish over time. Using these substrates is best for short-term (6 months to 1 year) high growth tanks or longer-term minimal input tanks (Walstad method).

Layered substrates or Capped substrates: This is an attempt at getting the best of both worlds. Say you like the aesthetics of gravel bottom aquarium but want to grow a plant that requires a rich substrate. It possible layer the bottom of the tank with a rich substrate like organic potting soil and then cap it with gravel. The largest challenge with this type of substrate is in attempting to move any plants location. The substrate layers mix and can make quite a mess.

Fertilizer:

Fertilizer, such a simple word for a very complex topic. Fertilizers are the basic building blocks for all the cells of the plant. When a nutrient is not available the plant starts to suffer and show symptoms aka deficiencies. Fertilizers are grouped into classes depending upon the total volume that the plants need.

First some basic nomenclature:

Primary Macronutrients (Macros) are used in the highest quantity. In terrestrial plants they are nitrogen (N), phosphorous (P), and potassium (K) in terrestrial plants. In aquatic plants we also include Carbon (C) as it is commonly deficient.

Secondary & Tertiary Macronutrients (Micros) are used in smaller quantities but significant amounts. They are Sulfur (S), Calcium (Ca), and Magnesium(Mg). Traditionally these have been lumped in with the micronutrients and are still referred to as micros in common usage.

Micronutrients (Micros) are used in sometimes minute quantities but are still vital for the health of the plant. Some of these minerals can replace each other with some species and some species don't use some nutrients at all. These are Iron (Fe), Molybdenum (Mo), Boron (B), Copper (Cu), Manganese (Mn), Sodium (Na), Zinc (Zn), Nickel (Ni), Chlorine (Cl), & Cobalt(Co).

Carbon:

The most important element in organic life is carbon. Plants get the carbon they need from CO2. For terrestrial plants this is around 0.04% of the air. In our fishtanks the concentration of CO2 is much lower

at around 0.0002%. It doesn't take long for them to use it all. Adding in CO2 increases the speed that plants can grow in aquatic conditions. Injecting CO2 into the water can increase the concentration by 10X or more. CO2 injecting setups can be very simple or expensive and complex. DIY CO2 normally refers to using yeast metabolizing sugar or an acid/base reaction to produce CO2. Pressurized CO2 setups use tanks or paintball cartridges as their source. Tanks that are injected with CO2 are often referred to as **High Tech**. Tanks that do not have CO2 injection are referred to as **Low Tech**. Always know the CO2 needs of any plant before putting it in your tank. A plant that requires supplemental CO2 will not thrive in a low tech tank.

Nitrogen:

The most talked about nutrient in the aquarium is nitrogen. "Cycling" the tank and "Old Tank Syndrome" are all about the N in the tank. When keeping fish only tanks, it's a constant battle to keep the nitrogen levels as low as possible. In a planted tanks we need to reverse our thinking. Plants need lots of nitrogen. Nitrogen deficiency is very common in planted aquariums.

There is a common myth that is spouted by petstores and online that fish waste is all that you need to keep plants fed. This is blatantly false. The math doesn't add up.

A healthy 10 gallon planted tank will eat up over 1g of nitrate (NO3) per week depending on the species in the tank. Your average tropical fishfood is around 4% N (Based upon a 40% protein guaranteed analysis of which 16% is N). For every 1 gram of fish food you feed you are adding 0.04g of N. This works out to a maximum 0.18g of Nitrate at the end of the waste breakdown process. To keep your plants fed on their nitrogen needs would need to add over 5 grams of fishfood per week in a 10 gallon tank. You'd be going through a 150g (around 6oz or a full cup) of fish food per month. Now I don't know about you, but I've never kept fish that would eat that much food in a month that would fit into a 10 gallon tank.

Bottom line for planted tanks, YOU MUST ADD NITROGEN FOR THE PLANTS. This comes in very important below when we discuss **Choosing a Fertilizer**.

Phosphorus:

Phosphorus had a very bad name in aquariums many years ago. It was thought that excess phosphates lead to algae outbreaks. When I started many places still advocated keeping the P very low. P plays many roles in the cell but here is two you might be familiar with. It is one of the molecules in DNA. If a plant wants to grow it needs to make more cells and more DNA. Without P, well it just doesn't happen. P is also used in Adenosine triphosphate (ATP). ATP is how cells move energy around to get things done. So without P a plant doesn't grow and can't do anything.

P is supplied by fishfood to some degree but just like N it is not nearly enough.

Bottom Line for planted tanks, YOU MUST ADD PHOSPROUS FOR THE PLANTS.

Potassium:

Potassium (K) is the grease that keeps things moving in the plant. It effects almost every major part of how the plants machinery works. It's key in photosynthesis, sugar movement, nutrient transport, enzyme activation, protein synthesis and many more. Having high K has little to no negative effects. Having low K can cause everything to shut down. Being short in K is pretty easy to spot in aquatic plants.

The classic symptom is small holes in the leaves. Although fishfood does contain K it is not in sufficient quantities for a planted tank.

Bottom line for planted tanks, YOU MUST ADD POTASSIUM FOR THE PLANTS.

Calcium & Magnesium:

Ca and Mg are naturally found in water. They are the two out of three major components in "hard water". Together Ca & Mg are detected in a test call General Hardness or GH. The other component is Carbonate (H_2CO_3) and is detected in a KH test (Carbonate Hardness). The three components together effect the pH of the water. Ca & Mg are both eaten by the plants. In very soft water or minimal water change setups they may become deficient. The removal of Ca and Mg by plants in soft water can also cause pH to fluctuate dramatically depending upon the amount of carbonate in the water. Knowing the GH, pH and KH can help you better understand if you need to add in supplemental dosing.

Water softeners present a challenge to a planted aquarium. They operate by replacing Ca and Mg with Sodium (Na). Using water that has been run through a water softener can make your plants nutrient deficient. It is recommended to fill your tank directly from the source bypassing the water softener. Alternatively you'll need to dose Mg and Ca for your plants.

Bottom Line: You MIGHT need to add magnesium & calcium for the plants but you MIGHT NOT.

Iron:

Iron is an important nutrient for appearance. It makes red plants look red and green plants look greener. Most of the time a good micro blend will have more than sufficient for the plants needs. If needed chelated (pronounced "key-late-ed") iron is readily available and easy to dose.

Boron:

Out all the micronutrients boron is the one you need to be careful with. Some locations have high levels of boron in the water. If boron is overdosed it can cause toxicity to the plants. Most micro nutrient blends will list a +B at the end to indicate it contains Born.

Other Micronutrients: All the other micronutrients are needed in small quantities and are very commonly supplied by most commercial fertilizers. Plants only use a small quantity so overdosing has no added value. Some of them also have toxicity so being careful with them is highly recommended.

Choosing a Fertilizer:

If you browse through the fertilizer isle at your local hardware/garden store you'll always find a Guaranteed Analysis on the packaging. The only reason companies put this on the bag is because of government protection against fraud. They can do a lot of stretching the truth or flat out lying everywhere else but not there. If it is sold as fertilizer it must have this statement and it must be reasonably accurate. The analysis is based upon the percentage of weight of the most commonly used fertilizer. Always look at the "derived from" section. This tells you what the ingredients in the fertilizer is.

Aquarium fertilizers are also bound by the same law. They have to label the product with a guaranteed analysis. All of the liquid fertilizers that are sold in the petstore are derived from common fertilizer salts.

The analysis is normally less than 1% by weight with 99% being water. They also commonly have undesirable ingredients like Urea or Ammonium Nitrate. Both of these introduce ammonia into the tank that the biological filtration needs to break down. The recommended dosing rate is also well below what is needed for a healthy planted tank. A 75 gallon tank would need most of a bottle of fertilizer per week if heavily planted.

Online retailers sell the needed dry components at a fraction of the cost as you can find in the store. If you do the math it works out to somewhere around $1/100^{th}$ of the cost to order dry ferts. You will need to read up on a dosing methodology like the Estimative Index (EI) or Perpetual Preservation System (PPS). To summarize EI relies on over-fertilizing and then resetting the balance with 50% weekly water changes. PPS relies on testing to attempt to exactly meet the needs of the plants with minimal water changes. Both work perfectly well in my opinion, it's all a matter of personal preference. I use the E.I. method because I detest testing.

Root tabs are recommended for some heavy root feeding plants. These are generally not enough to sustain an actively growing tank alone. These are for supplemental dosing for particular plants. The can be purchased premade at petstores, online retailers or even made at home with slow release fertilizers and gel caps. They can be evaluated by looking at the guaranteed analysis. Root tabs of the same price can have vastly different nutritional properties. DIY root tabs with slow release fertilizer tend to be the cheapest and have the highest nutritional rating. Wholesale agricultural supply generally have the highest quality and most expertise with fertilizer blends. If you can find one that stocks 50lb bags of fertilizer it is generally superior to anything you can find in retail stores. Only use fertilizers containing Ammonium NH4+ or Urea if they are bound with a slow release polymer.

Basic Information about plant species.

As the plants we grow in are tanks are collected from all over the world and from all sorts of environments it's important that we know something about the species we chose.

Some plants are true aquatic species. They will only grow under water and any portion of the plant that dries out will die.

Other plants can transition between fully aquatic and terrestrial plants. They are happy in either environment given a bit of transition time.

Some plants like their roots in the water but if their leaves are submerged eventually rot and die. Pet stores are notorious for selling these as (aquatic plants). If you've kept aquatic plants for any length of time it's likely that you've fallen for their shenanigans. It happens to the best of us. They got me with Mondo Grass when I was first starting out.

Some plants like their roots buried in the substrate with lots of food. Other plants use their roots to grasp onto rocks and branches, if the roots are buried the plant will die.

Some plants can grow without CO2 addition while other require it or they will slowly melt and disappear.

Some plants grow very large and fast and will quickly suck up all the nutrients. Other plants grow very slowly with putting out only one new leaf in a month or two.

Some aquatic plants are not plants at all. For example the Marimo balls are actually an algae called *Aegagropila linnaei.* This is a very important tidbit of information if you have an algae outbreak and want to dose an algaecide.

Some plants are adaptable across a broad range of conditions while others will only grow under a very narrow range of environmental conditions.

With all these differences it is important to know what the needs of the plants you are selecting and to place them in the correct environment for them grow.

Algae:

I don't know how many times I have heard people make the comment "I want to grow plants to reduce the algae in my tank". It doesn't work that way. Algae and plants have the same basic needs. If you grow plants you are also encouraging the growth of Algae. The challenge with a planted tank is to encourage the growth of plants more than the growth of algae. There is no such thing as an algae free planted tank.

The first way to control algae is to maintain a stable environment for the plants that provides for all its nutritional needs. Stable CO2 levels in high-tech tanks. Consistent amounts of fertilizer, not too much but not too little either. It needs to be "just right" and stay that way.

Another way is with stocking. Many fish, shrimp, and snails are algae eaters. Keeping a few of these in the tank as a cleanup crew is a good idea. Not all algae eaters will work however. Some of them like common plecos are also herbivores and will eat the plants. Some species are algae eaters as juveniles but then transition to other foods as they get older. Some algae eaters will only eat a few species of algae and leave others alone. No algae eater will eat all types of algae.

Glutaraldehyde/Polycycloglutaracetal (C5H8O2)

Commonly sold as a liquid carbon source for plants, this is actually a very strong and effective algaecide. The chemistry is broken down by bacteria into CO2 that may be available for plants. If it does, it is in such a small amount as to be immeasurable in the tank. The primary benefit is the elimination of the algae competition. Originally sold only by Seachem for the aquarium, several other companies now offer this under different names. The chemical is a very strong sterilant used in hospitals and other places (Metricide). In high enough concentration it kills all sorts of algae, fungus, virus, and bacteria. Overdosing the tank can kill everything in the tank.

How to setup a planted aquarium for success.

There are many options for a planted tank and many of them are not compatible with each other.

Start with what you must have and build from there. Rushing into setting up a tank without doing proper research generally ends in an algae bomb. Careful planning and compromise can make all of the components of the tank work together.

You can build the tank starting in any direction you want to. For example:

"I have a 10 gallon tank with a medium level light on top of it and a gravel substrate. What can I grow in the tank?"

Or

“I want a tank with a dwarf hairgrass carpet. What do I need to grow it?”

With either of these statements you can build by elimination of possibilities.

In the first a gravel substrate limits you to plants that don’t need much rooting. These are generally slower growing plants so the medium light is likely too much. Some floating plants can reduce the light levels.

In the second, dwarf hairgrass needs high light, rich substrate, and CO2 injection. Shorter tanks make achieving highlight easier so something less than 15” tall.

Please realize that perfect tank you dream up may be impossible to achieve. I once tried growing duckweed in a goldfish tank. The goldfish pooped green for a couple days and got every speck of it.