Plant Survival – (reprint) Part of the larger usenet "Aquatic Plant FAQ" series of articles in Tank Talk Volume 19 No. 3 1996

FAQ: PLANT SURVIVAL
(contributed by George Booth)

Plants need certain things to grow: light, CO2, nutrients and trace elements. This should be no surprise. What is generally not known is that plants need these things in fixed proportions (and unfortunately, the proportions vary with each type of plant). For example, if you have plenty of light, CO2, nutrients and most trace elements but not enough of one specific trace element for a plant, the trace element in short supply will determine how well that plant grows even though other plants do fine. This explains why some plants are "easier" than others - their needs are typically supplied by tap water or other incidental sources. If the plants aren't able to utilize all the nutrients due to a shortage of one or more specific elements, the "excess" nutrients and light energy will be wasted or be used by algae.

In general, there is no information available that says "this plant needs this much light, CO2, nutrients and trace elements". Aquarists can only determine "what works for me" by tedious trial and error. Aquarists who follow the Dupla "Optimum Aquarium" regimen try to ensure that all the requirements of all the plants are met, but this leads to expensive and complex systems.

LIGHT

Light is very important for photosynthesis since it supplies the energy required to drive the chemical reactions involved. The plants use light energy primarily in the blue and red spectrum but an aquarium will look better to people if full spectrum lighting is used.

Light intensity and spectrum are more important than duration. You can't make up for dimmer bulbs by leaving them on longer. 10-12 hours per day is usually sufficient. You need about 1.5 to 3 watts per gallon, with deeper tanks requiring more intensity.

It is important to balance light intensity with other nutrients. Intense lighting will be wasted if not enough CO2 and nutrients are available to support the needs for photosynthesis.

CO2

This is very important to plant growth. Without sufficient quantities of dissolved CO2, photosynthesis cannot take place. Most tanks will have some CO2 due to fish respiration but this is usually not enough to get "lush" growth. Some plants do not need much CO2 and some plants like Cryptocorynes actually seem to do worse with higher levels of CO2.

Typical levels of CO2 in a non-CO2-injected aquarium are in the range of 1-3 ppm. Most plants will flourish with levels of 10-20 ppm but this requires some type of CO2 injection. With lower levels of CO2, the plants will not be able to utilize high levels of light and nutrients and the extra light and nutrients will be used by algae.

NUTRIENTS

Beyond the "building blocks of life" provided by water and CO2 (oxygen, hydrogen and carbon), two other important nutrients are required: nitrogen and potassium. Nitrogen is usually available in sufficient quantities from fish waste in the form of ammonium (NH4+). Most plants will prefer ammonium but some will use the end product of the nitrification cycle, nitrate (NO3-). Ammonium is the preferred source since it takes less energy to use that form of nitrogen. A good test for ammonium levels is to monitor nitrates. If the nitrates are 0 ppm, you know that all the nitrogen is being used. This may indicate that some plants are starving for nitrogen. It also might indicate that a perfect balance has been achieved, but that is unlikely.

Potassium (K+) is also usually available from fish food. Unfortunately, potassium is difficult to measure in the water. If there are enough nitrates, there is usually enough potassium. Some fertilizers contain additional potassium and can be used to be on the safe side.

TRACE ELEMENTS

Trace elements are those things required in very small quantities yet are still vital to plant growth. These are taken in by the plant in ion form. The more important trace elements are sulfur (SO4--), calcium (Ca++), phosphorus (HPO4--/H2PO4-), magnesium (Mg++) and iron (Fe++).

Sulfur, calcium and magnesium are usually found in tap water. If the water has too little general hardness (< 3 degrees dH), calcium and/or magnesium may be in short supply. This can be remedied by adding calcium and magnesium sulfate in small quantities.

Phosphorus can be measured in the water and should be present in quantities less than 0.2 ppm of phosphate. If the nitrates are OK, phosphorus levels are usually also OK.

Iron may be present in tap water in the correct ionic state (Fe++) but will quickly oxidize to a form unusable by plants. To prevent this, chelated iron mixtures can be used. The chelator prevents the iron from oxidizing and makes it easy for the plants to assimilate. The iron concentration should be less than 0.2 ppm.

Other trace elements are needed in extremely small quantities and can usually be provided in fish food or specialized trace element formulations. Note that some of these elements are toxic in anything but trace amounts so the addition of trace elements should be done very carefully.

OTHER INFORMATION

Some plants can concentrate carbon, potassium, nitrogen, phosphorus, iron or the lesser trace elements and store it for later use. This means that plants may do well for a while, using stored nutrients, and then mysteriously wither if they can't replenish their supply. This also means that some plants may "out-compete" others for required nutrients, preventing the other plants from doing well.

Regular water changes are an important part of keeping a planted aquarium healthy since many of the nutrients and trace elements are in tap water. Changing 25 percent every two weeks is recommended.

The substrate can play a major role in the availability of nutrients. Nutrients can be put in the substrate when an aquarium is setup by mixing laterite (tropical clay), potting soil, peat moss or commercial equivalents into the lower layer of gravel. These additives will release some necessary elements and provide chelating sites so that the correct ionic states are maintained. However, if nutrients aren't replaced, the substrate will eventually be exhausted and the plants will begin to do poorly.

If laterite or peat is used in the substrate and a very slow flow of water can be forced through the substrate, water-born nutrients will be chelated by the laterite or peat. This will provide a continuous source of nutrients in the substrate. Substrate heating coils are recommended for this since they can provide slow convection currents. They are expensive, however.

The following table is based on data from the Feb, 1988 "Today's Aquarium, the International Magazine of the Optimum Aquarium", ("Aquarium Heute" in German), published by Aquadocumenta Verlag GmbH.

Average nutrient content of plants and aquarium water

Symbol	Nutrient	Plant mg/kg	Water mg/L	Absorbed as	Concen Factor	
O	Oxygen	48,000	880,000	H2O	0.02	Abundantly available in the water
C	Carbon	36,000	Varies	CO2(HCO3-)	1000	Absent if no CO2 injection
H	Hydrogen	6,000	110,000	H2O	0.02	Abundantly available in the water
K	Potassium	3,600	5	K+	1000	Sufficient with good feeding, otherwise fertilizing
N	Nitrogen	3,200	5	NH4+/NO3-	1000	Too much nitrate with good fish feeding
S	Sulphur	660	15	SO4--	50	Source: fish food and mains water
Ca	Calcium	650	90	Ca++	10	Absent in soft water
P	Phosphorus	460	0.1	HPO4--/H2PO4-	1000	Too many phosphates with good fish feeding
Mg	Magnesium	210	18	Mg++	10	Absent in soft water
Fe	Iron	15	0	Fe++/Fe+++	1000	Absent under good light, unless fertilized
Other	Trace elements	10	0	Ions	1000	Sufficient with good feeding, otherwise fertilizer

Notes: "mg/kg" and "mg/l" are roughly parts per million or "ppm"

"Concen Factor" is how much plants can store beyond their needs for growth, i.e., plants can store 1000 times more iron than they need.