Background

Aquaponics:

Aquaponics is a combination of raising fish and hydroponics (growing plants in water and without soil), together in one integrated system. In this system, fish waste provides organic food for the plants and in return the plants filter the water in which the fish live. Fish waste contains ammonia, which is harmful to fish and useless to plants. But beneficial bacteria converts this ammonia into nitrates. These nitrates are relatively harmless to fish and make great plant food. Both the plants and fish benefit from this relationship.

An aquaponics system is highly productive and conserves both water and land. If done correctly, plants will grow bigger and faster because they will not have to work as hard to obtain nutrients. Since the plant easily receives all the nutrients it needs, it will focus more on growing upstairs instead of expanding the root system downstairs. An aquaponics system will also use much less water than plants grown in soil and a typical fish tank, because water from the fish tank will not need to be constantly changed to remove waste and the plants are grown in an enclosed area, resulting in less evaporation.

To fully understand aquaponics, you first need to understand how a hydroponics system works. Hydroponics is the process of growing plants with nutrients and water, and without soil. Plants don't need soil, they simply need the nutrients, water, and stability that soil provides. In a hydroponics system you provide the nutrient solution and growing medium to anchor the roots. In an aquaponics system, fish provide the nutrients needed. This gets rid of the need for soil and with it, any chance of soil-borne pests and diseases. Since this is a pure clean method of cultivation, it is recommended to start your plants from seeds to prevent contamination.

The roots system can hang directly in the nutrient solution, be misted by it, or can be enclosed within a container or trough which is filled with a substrate. A substrate is a replacement for soil and can be many things including: perlite, sand, sawdust, woodchips, clay balls, pebbles or rock wool. The substrate must provide a good water holding capacity but be porous enough for gas exchange.

A hydroponics or aquaponics system can provide complete control over the environment in which the plants grow. Because of this, it can get somewhat expensive. Lighting and temperature control can quickly add up in price. For this reason, most hydroponic/aquaponic gardeners are limited to only grow crops that sell for a high price. Among these profitable crops are lettuce, basil, and tomatoes. Tomatoes being the most commonly grown.

Goldfish:

There are many reasons why we decided to use goldfish. They are easy to maintain, cheap, and available almost everywhere. They can also survive in the pH range required to grow tomatoes. Although goldfish do best at a pH between 7.2 and 7.6, they can easily survive anywhere between 6.0 and 8.0 pH. With gradual changes to pH, they can even adapt to pH levels outside of this range. However, any large sudden changes in pH can be bad for their health.

Water temperature is also very important for the health of the fish. There are mixed opinions on the best temperature range for goldfish, but anywhere between 60-70^{o}F is safe. Outside of this range or any sudden large changes in temperature can cause health problems for the fish. When the temperature nears 50 ^{o}F, goldfish can become almost catatonic. As water temperature nears 80^{o}F, the oxygen level of the water drops too low.

It is also important that the goldfish receive a varied and high carbohydrate diet. It is suggested to only feed them once a day to prevent overfeeding. It also helps to have only one person do the feeding, to avoid any confusion about the last time they were fed. A goldfish's stomach is about the size of its eye. This can be useful in figuring out how much food they need. However, the main problem with overfeeding is not the fish overeating. If there is too much food in the tank, the goldfish will most likely not eat it all. Any uneaten food will decay and can cause multiple problems for the fish, such as lower oxygen levels, lower pH levels, and the uneaten food will break down into large amounts of ammonia and nitrites, which are extremely toxic to fish.

It is also recommended that each fully grown goldfish receives a minimum of 6-8 gallons of space and 50-75% of this space is hiding places. Neither of these are required, but they lower the stress of the fish, which improves their immune system. Doing this does not take much effort and can improve the health of the fish.

Tomatoes:

It is recommended to grow your tomato plants from seeds if possible. Bringing plants from outdoors can introduce pests and diseases to the aquaponics system. The seeds should be planted in a nursery tray with a substrate, instead of soil. The substrate should first be soaked with pH 4.5 water, then the seed should be planted under the surface. When growing seeds, the tray should be covered in a moist, warm area (68-77^{o}F).It should be between 10-14 days before they are ready to be transported, and the roots and leaves should be showing. When placing the plants, they should be 10-12 inches apart.

There are many important factors when growing tomatoes such as pH levels, temperature, and lighting. The pH level should remain anywhere between 5.8 and 6.8. Anything outside of this range can cause nutrient lockout. Nutrient lockout is when plants are unable to absorb the nutrients they need. Lighting is also important in growing tomatoes. Seedlings should receive at least 12 hours of light a day. Once fruit has set, it is suggested to increase the amount of light it receives. At maturity, tomato plants require about 16 hours of light to ensure maximum fruit production and an eight hour respiration period of total darkness. The recommended daytime temperature is between 64-77^{o}F. And the night time temperature should be between 53-64^{o}F.

There are many common problems that can occur when growing tomatoes. Yellow leaves can indicate that the nutrient solution is not strong enough or the pH is too high causing nutrient lockout. Leaf tips curled upwards or a red stem are results of a magnesium deficiency caused by low pH. On the opposite side of the spectrum, leaf tips curling downward is caused when the nutrient level is too high. Another common problem is the flower falling off before setting fruit. This can be cause by a potassium deficiency and can be solved by adjusting the pH level or nutrient solution.