Water

Oxygen

Nutrient

pH

Environment

Environment includes; Temperature, Humidity and Light.

All Hydroponic growing requires all these basic principals to be correct, problems will occur if any are not attended to when they are not correct for the crop being grown.
If you have a problem while growing plants in Hydroponics, it will always be because one of the following Basics has been ignored, or has changed from when you started growing.

Basic requirements for Water.

Before buying equipment or even land, it is necessary to have the available water supply on any site analysed for mineral content, and for Bacterial problems, plus ensure there is sufficient quantity for the crop to be grown.
Any water that does not have the necessary purity of minerals and bacteria cannot be used without growing problems occurring.
Water treatment may be needed, and this should be discovered before any money is spent on other materials. Water treatment is not cheap, and it has to be done correctly.
When the water is analysed it can be checked against the following charts.
Crop type will determine which chart is used.

Tomato.	Limit.	Ideal.
pH	**5.0 to 8.0**	**5.8 to 7.8**
Conductivity. (CF)	**6**	**2**
Nitrate.	**50 ppm**	**<5 ppm**
Phosphorous.	**20 ppm**	**<5 ppm**
Potassium.	**50 ppm**	**<10 ppm**
Calcium.	**150 ppm**	**<30 ppm**
Magnesium.	**25 ppm**	**<10 ppm**
Sulphur.	**30 ppm**	**<10 ppm**
Sodium.	**180 ppm**	**<20 ppm**
Chloride.	**100 ppm**	**<20 ppm**
Iron.	**5 ppm**	**<0.05 ppm**
Manganese.	**2 ppm**	**<0.09 ppm**
Boron.	**1.2 ppm**	**<0.25 ppm**
Copper.	**0.3 ppm**	**<0.15 ppm**
Zinc.	**0.45 ppm**	**<0.15 ppm**
Molybdenum.	**0.025 ppm**	**NIL.**
Silicon.		**40 ppm**

Note; this list is only for Tomato, for other crops see crop data reports.

Water can be demineralised, and can be purified with Ozone or by other chemicals being added to the water, the total requirements for the plant have to be supplied as treated water, no untreated water should ever be used in the system as problems can occur.
You need sufficient quantity and quality of water to supply the Hydroponic venture, if this cannot be guaranteed, then the venture is doomed to fail before you start.

You can email your analysis report for our comments and advice on any water treatment needed.

Other things to watchout for include the following;
Acidic water (Below pH 6.9) will be prone to attacking any metal fittings or tanks it comes in contact with, so Brass, Zinc Galvanizing and Steel tanks, pipes and fittings are not suitable for use in water or nutrient storage or nutrient delivery and return supply pipes to plants, as minerals can be dissolved from them and cause a toxic level to be reached in the nutrient. All water collection and storage materials should be plastic or stainless steel.

All plastics used should be virgin plastic; no re-cycled plastic using toxic plasticisers in their manufacture should be used.

Water treated with Chlorine for water purity can cause problems to some crops, Lettuces and some herbs for example do not like residual Chlorine in the water or nutrient, it can easily be removed by passing the water through a swimming pool filter, filled with Activated Carbon, this removes residual Chlorine and makes the water safe to use.

Basic Requirements for Oxygen.

Plants require Oxygen as much as we do, no Oxygen and we die, and it's the same for plants. Oxygen is required in the root zone for plants, and is supplied dissolved in the nutrient, or if bare rooted it can be supplied by the air around the roots.

The Oxygen we are talking about is Dissolved Oxygen, dissolved in the water and nutrient we supply to the plants. There is a maximum amount of Oxygen that can be dissolved in water, and you cannot over do this. The easiest way to get Oxygen into water is to free fall it like rain through clean air, not always practical in Commercial Hydroponic systems, however we can use a very simple method to do this, a Spa Pool Venturi can bubble air into a tank of water or nutrient, dissolving Oxygen directly into the water, at the same time it can flush out any waste gasses in the tank, reducing the possibility of waste gasses getting into the nutrient.
(See section on tank size required for plant numbers, ask us what size you need for your planned crop numbers)

The following photograph shows a twin venturi setup to oxygenate nutrient on a system containing 1200 gallons of water, the large 11/2" down pipe has the surplus nutrient from the main supply pump running to the venturi, and the smaller ¾" pipe is for fresh air to be drawn down to the venturi, (clean, fresh air should be drawn in, not stale pump room waste gasses) the unit should be covered by the nutrient in the tank, but not be too deep as the increase in back pressure on the unit will stop it running efficiently, it should be at approximately 6 inches below the surface, but not deeper than 1 foot.
The 2" pipe on the right is the pump supply pipe. Note how the venturi's point across the tank, this aids mixing and swirls the water allowing any nutrient concentrate supplied by an automatic nutrient dosing system to be well mixed. The air supplied via this system keeps the tank flushed of waste gasses, blowing them out of the top, the tank room should also be ventilated, to remove these waste gasses, using an exhaust fan.

Twin venturi system.

Media used for plants has a need to allow air to pass to the roots to supply Oxygen to the roots, a very course media has no problem in doing this, but a very fine media, easily compacted like concrete will eliminate air from the roots, causing root death, and possibly plant death.

NFT (Nutrient Film Technique) systems do not suffer the same way as media systems, however there still has to be a maximum quantity of Oxygen dissolved in the nutrient.

Ventilation of the tank and pump rooms is needed to remove any waste gasses, plants while growing release waste gasses from the roots, and these are usually heavier than air, and will flow back to the holding tank if using a recycling system, and gravity fall back to the tank.

Tank size has a large bearing on the quantity of dissolved Oxygen in nutrient pumped to the plant, a small tank with very little water per plant will always struggle to have sufficient dissolved Oxygen in the nutrient, because the plants will take most of the Oxygen out quickly and even with a good Oxygenation system will not have it all replaced before it's pumped out to the plants again, leading to a lowering of Oxygen in the nutrient. This results in a deficiency of Oxygen in the root zone, root death and finally plant death. Lettuces for example should have at least 250mls of water per plant in the system, so a system with 10000 plants needs 4000 litres of water. Tomatoes should have at least 500mls per plant.

Basic requirements for Nutrient;

NUTRIENT SOLUTION.
This is the very basis of hydroponics, and IT HAS TO BE CORRECT. There are thirteen mineral elements in the nutrient solution required for satisfactory growth. If just one is missing the plant will not grow satisfactory. The thirteen elements are divided into "major" and "minor" elements. ALL are essential.

MAJOR ELEMENTS;
Nitrogen
Phosphorous
Potassium
Calcium
Magnesium
Sulphur

MINOR ELEMENTS;
Iron
Boron
Manganese
Copper
Zinc
Molybdenum
Chloride

Note; Sodium has not been included here as this is usually present in sufficient quantity as either a contaminant in the base water, or in the raw materials used to make up the nutrient solution, and Silicon is often present in base water at a suitable level (see Silicon treatment data sheet).

Nitrogen is usually supplied in the form of Nitrates such as Potassium Nitrate. Phosphates are supplied as Potassium Phosphate and Phosphoric acid. (used for pH control) Magnesium as Epsom salts (Magnesium Sulphate) Iron as Iron Chelate (FeEDTA- expensive but essential) Boron as Boric acid, Manganese as Manganese Sulphate, Copper and Zinc as the Sulphate, and Molybdenum as Ammonium Molybdate, Molybdic Acid or Sodium Molybdate. Chloride is usually found in water supplies, or as a contaminant in the other materials used in sufficient amounts.

Experience has shown that it is often better to purchase ready-blended Hydroponic dry mixes and simply dissolve them yourself. Liquid nutrients are also available to growers, but make sure that they are complete in all the thirteen minerals required. However it is still cheaper to purchase in powder form and just add your own water.

See the section on nutrient mineral make up.

Elements Required in Nutrient Solutions

ELEMENTS	Typical Range in ppm	Optimum Tomatoes	Optimum Lettuce
pH	5.5-6.7	6.3	6.2-6.6
CONDUCTIVITY (CF)	2.5-60	30	7
NITRATE (NO3-N)	50-300	200	50
PHOSPHATE (PO4)	20-200	50	12
POTASSIUM (K)	50-600	300	70
CALCIUM (Ca)	125-400	250	60
MAGNESIUM (Mg)	25-150	50	12
SULFER (S)	30-200	80	20
SODIUM (Na)	less than 250	<180	<33
CHLORIDE (CL)	less than 175	<125	<35
IRON (Fe)	1.25-6.0	3	1.9
MANGANESE (Mn)	.25-5.0	1	0.35
BORON (Bo)	.01-2.0	0.2	0.1
COPPER (Cu)	.01-1.0	0.1	0.05
ZINC (Zn)	.05-5.0	0.1	0.05
MOLYBDENUM (Mo)	.025-0.1	0.05	0.01

Notes: 1ppm = 1 mg/l = 1 ugm/ml

ppm is one of the units of measurement used to determine the strength of the nutrient solution, it is a means of stating the concentration of a mineral in solution, 1 ppm is 1 gram of nutrient in 1 million grams of water (1 million grams of water is 1000 liters); however for automatic nutrient control it’s more usual to use the Electrical conductivity (CF or EC) of the

solution.
The CF test is a measurement of the electrical conductivity of water. Pure water does not conduct electricity so the CF is 0 (EC 0.0), but as we dissolve mineral salts into the water, the electrical conductivity increases. We can use this to our advantage when growing plants, if the plants remove minerals from the nutrient; the CF reading falls, so we add more salts. If the plants remove only water from the system, on a hot day for example, we only have to add water, as the CF reading will rising.
We measure the CF level of nutrient solution with a simple conductivity meter; they are manufactured for hydroponics with an automatic temperature correction built into the meter. This is because when the temperature of the water changes, the CF reading also changes, so all equipment should have automatic temperature correction to give a temperature corrected CF reading.
CF is important to plants, because a solution that is too strong can burn the roots, and causes reverse osmosis. (Osmosis is the natural process whereby water including dissolved minerals, but not solids, is moved through a semi-permeable membrane, such as the cells in plant roots, the weaker solution flows to the stronger to try and reach equilibrium, this is how plants take in minerals). However reverse osmosis is when the minerals are drawn out of the plant because the solution on the outside of the plant is stronger than that on the inside, this can lead to plant death).

A CF level too low will cause weak, thin and leggy plants, and the plant will not produce its potential yield.

CF levels are different for many crops, even at different stages of growth of the same plant. i.e. Lettuces grow at a CF range of 6 to 16, levels are generally at the higher levels for the hearting types in the cool conditions of winter, or cool low light conditions , and lower in hot, high light or tropical conditions, and for the loose leaf type lettuces. Tomatoes are normally grown at CF levels of 26 to 46, depending on variety and stage of crop. Starting at levels as low as 18 at planting and building up the CF level until full fruiting occurs at the higher levels. Home growers with hobby systems will grow good tomatoes at CF levels of 18 to 30, harvesting the fruit vine ripe, while the commercial grower will grow his commercial varieties of tomatoes at the higher CF levels to get better keeping quality into the fruit, as they are often picked before being fully ripe.

Grower experience will teach a grower what the CF level should be, the plants will tell the observant grower, if the plants are thin and leggy, then providing there is sufficient light, the CF level is too low. If the plants are short, thick and stunted, then the CF level is too high. We can learn from the plants, they will tell us what they want in the type of growth we see.

See CF (EC) charts for specific crops. (Note 10 CF is 1.0 EC the EC range is 1 tenth of the CF range).

Typical CF Values for Crops

Artichoke	**10 to 18**	**Asparagus**	**12 to 18**
Banana	**18 to 24**	**Basil**	**18 to 24**
Beetroot	**16 to 22**	**Blueberries**	**18 to 20**
Broad Beans	**16 to 22**	**Broccoli**	**16 to 24**
Brussels Sprouts	**18 to 26**	**Cabbage**	**16 to 24**
Capsicum	**20 to 30**	**Carnations**	**14 to 20**
Carrot	**16 to 22**	**Cauliflower**	**16 to 24**
Celeriac	**16 to 22**	**Celery**	**16 to 22**
Chinese Cabbage	**16 to 22**	**Chives**	**12 to 20**
Cress	**2 to 10**	**Cucumber**	**16 to 26**
Egg Plant	**18 to 30**	**Endive (Escarole)**	**6 to 12**
Fennel	**8 to 14**	**Garlic**	**10 to 18**
Gherkins	**16 to 20**	**Herb's (general)**	**8 to 20**
Kohl Rabi	**16 to 24**	**Kumara**	**12 to 24**
Leek	**16 to 22**	**Lettuce Hearting**	**12 to 16**
Lettuce Fancy	**6 to 14**	**Marrow**	**10 to 20**
Melon	**10 to 20**	**Mint**	**10 to 14**
Onion	**16 to 22**	**Parsley**	**10 to 18**
Parsnip	**14 to 24**	**Passion fruit**	**16 to 26**
Pea	**14 to 18**	**Pole Bean**	**16 to 22**
Potato	**12 to 24**	**Pumpkin (Squash)**	**16 to 24**
Radish	**12 to 20**	**Rhubarb**	**16 to 22**
Roses	**18 to 22**	**Sage**	**10 to 16**
Salsify	**12 to 20**	**Shallot**	**16 to 22**
Silver Beet (Chard)	**16 to 24**	**Spinach**	**16 to 22**
Strawberry	**16 to 24**	**Sweet corn**	**16 to 22**
Thyme	**12 to 18**	**Tomato**	**26 to 46**
Turnip	**14 to 24**	**Witloof (Chicory)**	**14 to 18**
Watercress	**2 to 10**	**Yam**	**12 to 24**

All of these examples should be adjusted during growing to produce the type of growth required, local climatic conditions and light factors will result in adjustments being made by the grower from visual symptoms seen in the crop.
Raising CF levels hardens the crop, lowering softens and produces more vegetative growth.

pH Basics in growing;

pH is the acidity or alkalinity of the nutrient. The most important test of a nutrient solution is pH.

The pH scale is from 0 to 14. At 0 it’s the most acidic, and at 14 it’s the most alkaline, and at 7 it’s neither acid or alkaline, it’s neutral.

Plants can survive in the pH range 4.0 to 8.0 below 4 there is a danger of the roots being burnt and some minerals are not available to plants, and above 8.0 some of the minerals can be precipitated or are not available to the plants. The ideal range for most plants is from 5.8 to 6.5. So we try to maintain this pH at all times.

If the pH is outside the range where plants can take up minerals, then it does not matter how good or bad the nutrient is in terms of dissolved minerals, the plants will starve to death, as some minerals cannot be taken up by the plant. Deficiencies are often seen in crops grown at the wrong pH even when the mineral balance of the nutrient is perfect. See section on deficiencies.

We measure the pH of a solution with either a pH meter, or a pH tape. The pH meter is calibrated using buffer solutions, and from the pH test reading we either have to raise the pH or lower the pH.
When plants are growing in good light and warm conditions the normal trend is for the pH to rise, and we have to add a pH lower (acid solution).
In cool, dark, short day conditions, it can be normal for the pH level to fall and we have to raise the pH. Add pH raise (alkali solution)

To lower the pH we use an acid.
To raise the pH we use an alkali.

Never add any adjuster at full strength. Always dilute any pH adjuster with water by at least 100 to 1 and ideally 1000 to 1. Add small quantities of pH adjusters to the nutrient solution, re-measure the pH and adjust again if necessary. Very small quantities of adjusters are required to mover the pH, so do not put in large quantities at one dose.

pH adjustments to nutrient solutions.

WARNING THESE PRODUCTS ARE CORROSIVE, HANDLE WITH CARE, WEAR SAFETY GLASSES AND USE GLOVES TO PROTECT YOURSELF. ALWAYS ADD ACID/ALKALI TO WATER, DO NOT ADD WATER TO ACIDS.
1/. ACID. Use Phosphoric Acid and/or Nitric Acid,
Often blends of the two are used to control the Phosphorous and Nitrogen levels in the final nutrient solution.
This is a good tool to adjust for climatic and seasonal needs, in winter or low light and less Nitrogen needed, reduce the Nitric Acid content, and use more Phosphoric Acid, the reverse applies in summer, high light and warm conditions add extra Nitric Acid to the mix.

Dilute the acid 500/1 with water to make a working solution (maximum strength 100/1).
To 5 Liters of water add 10 mls of concentrated acid.
NEVER USE CONCENTRATED ACID TO CORRECT pH.

2/. ALKALI. Use Potassium Hydroxide. [Common name Caustic Potash]

Make up a concentrate by adding 300gms of Caustic Potash to 1 Liter of water.
Beware this solution will be hot, cool and use at the following rate.
Use 10mls of concentrate to 1 liter of water for a working solution.

Environment Basics.

It is sufficient at this stage to say that if all the previous Basics are correct, then plants will grow providing the environment is suitable for the crop being grown.
If the environment is not correct, no light results in no growth, too hot or too cold produces dead plants.
High Humidity, leads to plant diseases that will have a good chance of spoiling the crop.
Low humidity also leads to poor plants and fruits.
It is easy to find the information needed for the correct environmental factors for most crops being commercially grown; there are many books and data sheets on the subject, see Data sheets section for information on many common crops. Seed and plant suppliers can supply the information for the environmental requirements of their plants.

Get the basics right, and the results will come