



Part 01 - Starting Out

Hydroponics Gardening - An Introduction To Hydroponics Gardening For Beginners (Part 1) Starting Out

By John R. Haughton

What is hydroponics gardening?

PhotoDerived from the Latin Hydro, meaning water and Geoponics, meaning the study of agriculture, hydroponics is the science of growing plants using a solution of suitable nutrients instead of soil. Most types of plants can be grown very successfully using hydroponics.

In conventional gardening the plants are grown in soil and take their nourishment from the chemical compounds contained within that soil. The hydroponic gardener replaces the soil with a balanced, nutrient rich, solution that the plant can absorb with ease. Because the plant does not have to work so hard to absorb the available nutrients it saves energy which can then be utilised for stronger growth.

Because of this energy saving, plants grown using hydroponic methods outperform conventionally produced plants in both growth and fruit production. Due to the consistent results and good profit margins, more and more commercial growers are turning to hydroponic production. Totally organic production is possible using specially designed organic nutrients, giving excellent, inexpensive, vegetables and herbs.

There are several different types of hydroponic system, but all share the same basic principle of supplying the plants with nutrients and water. The most common systems are: Water Culture, Aquaculture, or Nutriculture.

This is a Hydroponics system in which the plant roots are immersed in water containing a complex mixture of dissolved nutrients. A simple example of water culture is the Hyacinth bulb growing in a wine goblet shaped glass, its roots growing down into the hollow goblet stem. Aggregate Culture.

In this system a material such as sand, gravel, or marbles supports the plant roots. It is important to note that the support material, unlike soil, does not absorb nutrient. It merely traps it in the spaces between the grains or stones allowing the plant roots to freely take up the liquid. Continuous Flow Hydroponics Systems.

In these types of system the nutrient solution flows constantly over the plant roots. This is the most commonly used system for commercial production. Aeroponics.

This system is one in which the plant roots hang in the air and are misted regularly with a nutrient solution. There are a number of pre-packaged hydroponics systems available for both the commercial grower and hobbyist. Individuals, who lack building skills, or are inexperienced plant growers, should consider one of these kits as an introduction to hydroponics, a fascinating and challenging hobby. Similar systems can be built at lower cost, however, by those of you who have the expertise.

The requirements for healthy, strong, disease-free plants are covered in my next article entitled - - What do your plants need?

Part 02 - Plant Needs

The Basics of Hydroponics Gardening - An Introduction To Hydroponics Gardening For Beginners (Part 2) Plant Needs

By John R. Haughton

What Do Your Plants Need?

All plants need the correct conditions in order to grow to their full potential. Plants grown using hydroponics systems are no exception to this basic rule. Like their soil grown cousins they need sufficient light of the correct wavelengths, a suitable temperature, an adequate water supply, enough oxygen, mineral nutrients and support for their structures.

* Sufficient light of the correct wavelengths, used by the plant at the growth stage it has reached, is essential for its survival. Plants use lots of light, at least 8 to 12 hours each day, in order to make carbohydrates from CO₂ and water. Chlorophyll, the green colour in plants, absorbs the sunlight and uses its energy to synthesise these carbohydrates. This process is known as photosynthesis and is the basis for sustaining life in all plants. Because animals and humans get their food by eating plants, it can also be said to be the source of our life. Artificial lighting is generally a poor substitute for sunshine, because most indoor lights provide insufficient intensity to produce a mature crop. High intensity lamps such as high-pressure sodium lamps can provide more than 1,000 foot-candles of light. The hydroponic gardener can use these lamps very successfully in areas where sunlight is inadequate. The fixtures and lamps, however, are usually too expensive to be viable for a small commercial operation.

* It is important to allow adequate spacing between plants as this will ensure that each plant receives sufficient light in the grow-room. For example, tomato plants, pruned to a single stem, should be planted so as to give 4 square feet per plant, while European seedless cucumbers should be allowed 7 to 9 square feet and seeded cucumbers about 7 square feet. Lettuce plants need to be spaced 7 to 9 inches apart within the row and 9 inches between rows. Most other vegetables and flowers should be grown at the same spacing as recommended for a conventional garden.

* A suitable temperature is required for the plant to grow normally. Temperatures that are too high or too low will give rise to abnormal development and reduced production. Summer vegetables and most flowers grow best between 60° and 80° F, while winter vegetables like spinach and lettuce prefer temperatures of between 50° and 70° F.

* An adequate water supply is not normally a problem when using a hydroponics system, since the basis of hydroponics is the supply of water containing nutrients in solution. Having said this however, there are some systems which can give rise to inadequate watering, with the consequent detrimental results to your plants. Ebb and flow systems which are not checked on a regular enough basis, can run short of nutrient in their supply tanks, as can continuous flow systems. Most, if not all, automated hydroponics systems can have disasters if they are not monitored closely. A blocked or burst pipe, or a pump failing can result in lack of nutrient flow, which, coupled with the intense lighting and the correct ambient temperature in the grow-room, will result in dry roots and severe damage to, or even the death of, your plants.

* Oxygen is a basic requirement of most living things. Plants need oxygen for respiration, so that they can take up water and nutrient. In soil systems enough oxygen is usually available, but plant roots growing in water will quickly use up the supply of dissolved oxygen. This can damage or even kill the plant unless additional air is provided. A common method of aerating the nutrient is to bubble air through the solution. Continuous flow and aeroponic systems do not usually need supplementary oxygen.

* Mineral Nutrients are needed by most green plants. They must absorb certain minerals through their roots in order to survive. In conventional horticulture these minerals are supplied by the soil and by the addition of fertilizers such as manure and compost. Nitrogen, phosphorus, potassium, calcium, magnesium, and sulphur are needed in large quantities, whilst the micro-nutrients, iron, manganese, boron, zinc, copper, molybdenum, and chlorine are also needed, but only in very small amounts.

* Support is normally provided by the soil that surrounds the growing plant. A plant grown using hydroponics however needs to be artificially supported. This is usually done with string or stakes. It is possible to buy inexpensive automatic string reels to support your plants as they grow. This cuts out the tedious task of having to keep re-adjusting the strings on fast growing plants.

Part 03 - Lighting

The Basics of Hydroponics

Hydroponics Gardening - An Introduction To Hydroponics Gardening For Beginners (Part 3) Lighting

By John R. Haughton

An Introduction To Indoor Plant Grow Lights.

There are basically three types of grow lights used in horticulture. These are:

High Intensity Discharge Lights (HID)

These come in two types, the Metal Halide Grow Light (MH) and the High Pressure Sodium Grow Light (HPS)Metal Halide. Metal halide bulbs are designed for plants during their growing cycle. That is, for non-fruiting or non-blooming plants. Metal halide lighting is therefore the best HID choice for the plant's growing phase.

High Pressure Sodium Lights

The HPS grow light is used primarily for plants that are in their blooming or fruiting phase. Modern high pressure sodium lighting can, however, be bought, which is enhanced for blue spectrum (for vegetative growth) and for red spectrum (for flowering growth). This means that they can be used throughout the entire growing process for most types of plant.

Dual light Systems

For optimal performance, switchable systems (400 watt and 1000 watt) and dual light systems (250 watt MH + 250 watt HPS giving 500 watt output, 400 watt MH + 400 watt HPS giving 800 watt output and 400 watt MH + 600 watt HPS giving 1000 watt output) are available. This type of grow light system gives the best all round lighting choice.

Mercury Vapour Lamps

Phosphorous coated to promote both blue and red spectrums these lamps are suitable for both the growing and blooming stages of plant growth. They give off more blue light than red and are a cheap way to get started, however the lamp wants replacing every nine months as it can become volatile. Mercury vapour lights cost more to run and maintain compared to HPS, MH or fluorescents.

Fluorescent Grow Lights

These lights emit less light than high intensity discharge lights and although they can be used throughout the plant cycle their lack of brightness will produce small yields. The light produced tends to be softer and less damaging to tender young plants. For this reason, the fluorescent grow light is popular for seedlings and cuttings, an excellent way to establish young plants.

Ballasts

All of the above types of lights use some kind of a ballast system. The one most people are familiar with is the fluorescent light. This has, a small, built in, ballast. It allows the fluorescent tube to build up enough energy to strike, and excite the molecules within the tube, causing light to be given off. Metal Halide and HPS grow lights are usually run from remote ballasts. These are external boxes containing the electronics to pre-heat and run the lamp. The ballast is connected to the lamp holder and to the mains power supply. Each ballast used is rated for the lamp wattage and so it is necessary to have different ballasts available for each of the different values of lamp to be used. HID bulbs should be replaced after 12 to 18 months of use. Although HID lamps will continue to light beyond 18 months of use, they will have lost up to 30 percent or more of their lumen output while consuming the same amount of electricity. Mercury Vapour Lights. Most of these lamps, up to a value of 500 watts, require no additional ballast. You just screw them into the lamp holder supplied with your equipment. N.B. Here is a word of warning about lighting. There are an awful lot of companies out there selling lights for the hydroponics enthusiast. As in all walks of life, there are good and bad suppliers and manufacturers of lighting equipment. Always look for equipment made by a reputable company and backed by an official testing scheme. (For example the C E mark in Europe means that the article is up to European standards of safety and quality).

Cheap, nasty, home made, dangerous lights have dogged the hydroponics market for some years. There are these kinds of light and there are well built, professional grade, horticultural lights on today's market. The first are often death traps, being cobbled together from the cheapest, obsolete, end of the line components that are usually mismatched and wrongly configured.

To think that these poorly built, badly wired, misconfigured lights are being fitted in damp, humid and sometimes even wet, grow rooms is a very scary thought indeed. The installation of these poor quality, dangerous, lights in your home, where your family lives and plays, is always a very grave risk. All this in the name of a bargain!

So don't risk your own life or the lives of those who live with you. Buy from a reputable source! Lighting is possibly the most important decision for indoor horticulture, cheap normally represents a health risk. For the sake of saving a relatively small amount of money, is it really worth it?

You have been warned!

Part 04 - Environment

The Basics of Hydroponics

Hydroponics Gardening - An Introduction To Hydroponics Gardening For Beginners (part 4) Environment By John R. Haughton The Success or Failure of Your Plants Depends On Their Environment

The environment, or climate, in which your plants are grown is one of the most important factors affecting your end results. The temperature and humidity have to be right for the type of crop you are raising, the lighting has to be of sufficient intensity and duration for the stage your crop has reached. These and many other factors have to be considered before you can hope to grow a healthy and productive crop.

Let's look briefly at the various factors involved. Growing plants indoors means that you have to create similar conditions to those outside. This may seem obvious at first glance, but is it true? Ask yourself what the advantages of Hydroponics gardening are. The outside climate is very varied and does not always work to the plant's advantage. For example a bad storm or a late frost can damage or kill tender young plants.

One of the major advantages of hydroponics gardening is that you can control the climate within the grow room. This means that you can supply your plants with the ideal conditions for their healthy growth, throughout their lives. This ensures a good healthy yeild and a bigger profit margin.

So what do you need?

Having decided upon which type of hydroponics system to use, you now need to promote the right growing conditions. All healthy plants require a good supply of water and balanced nutrients. They need the right kind of light, for the right period of time, each day. Your plants will need some kind of support for their structure, especially as they mature and grow heavy with harvestable produce. Like outdoor plants they also need the temperature to be within a certain range. Too cold and your plants will not thrive, but remain poor stunted things. Too hot and they may well dry out, then their leaves will wither and the plants die.

The addition of Carbon Dioxide gas (CO₂) may be advisable to promote Photosynthesis within the green leaves of your plants. Finally some form of clean fresh air circulation is needed to ensure that your crop can breathe. Like you, your plants need Oxygen for life. They breathe it in through their tissues and like you, can become sick if it is dirty or contaminated. So, taking these factors one at a time, how can we create the optimum conditions for our plants?

Firstly water and a good supply of balanced nutrients are essential. Which nutrient to buy and how to use it? This again is a major question to some people. My advice to you would be to go with a nutrient that you can understand and are comfortable using. As you gain experience and confidence you can experiment with other methods and suppliers at will.

Lighting is another key area that seems to cause newcomers a problem. The type of light and the number of daylight hours are determined by the species of plants you are cultivating and their stage of development. Young seedlings and cuttings, for example, need much softer light than do plants about to flower. Equitorial plants will generally need a higher light intensity for a longer period than will plants from the regions where days and growing seasons are short. Ask your hydroponics supplier for help in any of the areas you are unsure of. He will be pleased to assist you.

When looking at lighting you also need to take into account the area to be covered and whether the lights are to be static or moving.

A Brief Word Of Warning.

Poor quality lighting systems can be very dangerous and accidents are more likely to occur if the person who sets up the equipment is not particular about safety. Always buy quality assured electrical equipment that carries the safety mark for your country. Do not risk your life or the lives of those you love just to save a few pounds or dollars.

IF IN DOUBT CONSULT A PROFESSIONAL ELECTRICIAN

Plants can be supported in a variety of ways, by using frames and tying the plant stems to them at regular intervals using plastic ties. Automatic reels can be bought which makes the job a lot easier. They consist of a spring loaded reel of cord with a hook arrangement that fixes to the ceiling, or a top runner, and a hook or loop to tie to the top area of the plant stem. As the plant grows so the slack in the cord is taken up by the reel. Depending on your growing system the roots will either be supported or not. If no support is used, for example in a water culture system, then the plant should be supported at or near the base of the stem, to stop it lifting if reel supports are used.

And so to the temperature control in your artificial climate. The optimum temperature for your plants will again vary with both genus and species. Ask your supplier what this should be. Now you will need devise a system to maintain the temperature within the optimum top and bottom limits. This can be achieved by either a series of fans and/or heaters together with various other pieces of equipment such as timers, controllers, monitors and CO2 dosers, or by a commercially produced environmental control system. These ready made systems come in a variety of price options designed to suit almost every pocket. In general, the more you are prepared to spend, the more sophisticated the systems that are available to you.

Fresh air requirements for your grow room are normally provided using a fan assisted ducting system. This introduces clean air from the outside, via a filter to remove impurities. An ozone generator is often used to improve the supply of oxygen and neutralize any noxious odours. Another similar ducting system then extracts the dirty air back to the outside, again via a filter to remove impurities and cut down on unwelcome odours. Humidifiers can be used, if needed, to increase the amount of airborne water vapour.

Part 05 - Plant Growth

The Basics of Hydroponics

Hydroponics Gardening - An Introduction To Hydroponics Gardening For Beginners (part 5) Plant Growth By John R. Haughton Plant Growth and Physiology

There are three classes of plants. Each of these classes metabolize in a different way. The first class are succulent plants called CAM. These plants like low light and high humidity levels and so thrive indoors, in bathrooms and kitchen areas.

The second class of plants is called C4. These plants grow in hot arid regions and are very efficient at using both Carbon Dioxide (CO2) and Sunlight. Most C4 plants are grasses.

The third and last class of plants are called C3. These plants join two 3-Carbon atoms together to produce sugar. The chemical formula for sugar is C₆H₁₂O₆ which is 6 Carbon, 12 Hydrogen and 6 Oxygen atoms stuck together. Most of our favourite plants are to be found in this class. How Does A Plant Work?

Like all living things, plants breathe 24 hours a day. In order to make energy each plant cell respire (converts plant sugar to energy). The plant uses Oxygen (O₂) and expires, or breathes out, Carbon Dioxide (CO₂). (Growers' Products Editors Note... I believe that Mr. Haughton means the reverse. Plants absorb carbon dioxide during the process of photosynthesis although they do use oxygen to help produce sugars. Ref: 1 CO₂ Cycle Ref: 2 Plants Use Oxygen Too)

In the same way that energy moves around the human body, so water, nutrients and plant sugars are continually being transported around the plant body. The leaves create a circular flow with the roots. This circulation occurs when the leaves draw up, water from the roots, through their xylem.

These are straw like cells found in the plant stem. The water continually evaporating from the leaves sucks up more water from the roots and creates the internal water pressure that keeps the plant rigid. Thus if the plant is deprived of water, as in a drought, it loses its rigidity and begins to wilt when the internal pressure drops.

The leaves return energy to the roots in the form of sugar solutions. These are transported from the leaves via the plants Phloem. These are also straw like cells found in the plant stem. In this way the leaves exchange sugars for water and nutrients, while the roots exchange water and nutrients for sugar solutions. This liquid circulation is constant and continuous throughout the life of the plant.

The Main Plant Parts:

The 3 main parts of a plant are the Roots, the Stems and the Leaves. Each of these parts is of great importance and any problem that arises in any of them will be a major one. The most sensitive part is the roots, as well as being the most difficult to see should a problem occur.

The Roots:

The miracle of growth starts at the roots. As already mentioned, roots transport nutrients up to their leaves and plant sugars are returned by the leaves. The roots also act as storerooms for the excess sugars that are produced by the leaves. These sugars are stored in the form of starch. The size of the root ball and therefore the amount of starch that can be stored, determines the success of the plant in terms of growth and productivity.

The size of the root system is directly affected by the amount of moisture, the temperature, the available Oxygen and the supply of plant sugars being transported down from the leaves. According to Graham Reinders, in his book "How to Supercharge Your Garden", a research Rye plant in a 12 inch pot was said to have had 14 billion root hairs. These hairs would have stretched 6200 miles (nearly 10,000 km) if placed end to end and covered an area of 180ft by 180ft (about 55m by 55m). The greater the root system is the more energy (starch) it will be able to store and so, the more nutrients it will be able to send up to nourish the leaves. The plant will then have the capability to grow stronger. The end result of this is that the leaves will be able to pass more plant sugars back down to the roots and so the cycle continues.

Another factor to be taken into account is the root medium. Plants take their nourishment from the medium surrounding their roots. It stands to reason that the less energy the plant has to expend in order to get that nourishment the more energy it will have available to use for growth and nutrient exchange with its leaves. Because a plant takes most of its water in via its roots, (the root hairs trapping the water molecules surrounding it) and

transpires about 99% of that water out via its leaves, it will wilt and fall over if its roots cannot extract enough water out of its surrounding medium.

A plant growing in the ground will take its moisture from the surrounding soil. This moisture normally gets into the soil as rain and the plant absorbs that rain and the nutrients that have dissolved in it, via its root hairs. After the rain has stopped the topsoil quickly dries out as the water filters into the ground. Because of this drying out the plant has developed a means of absorbing Oxygen via its upper roots. The top third of the roots become specialized as “Air Roots” while the bottom third becomes specialized as “Water Roots”.

It is vital to ensure that the Air Roots are not kept constantly wet as this will result in the plant drowning. The Water Roots however, may be kept wet all the time, providing that the water has sufficient Oxygen dissolved in it. Insufficient Oxygen will result in roots with brown, discoloured root tips and subsequent infections. Healthy roots are a crisp, white looking structure.

The plant is quite capable of healthy living with the roots exposed to light as long as they remain moist. However, light will encourage the growth of Algae which will cause odours. The Algae will also compete with the plant for Oxygen during the dark periods and nutrients in the light ones. This, of course will mean the plant has to work harder in order to produce sufficient sugars for its needs. The Oxygen produced during the dark periods is used to help the roots convert these sugars, from the leaves, into energy (Starch).

Part 06 - The Autopot

The Basics of Hydroponics

Hydroponics Gardening - An Introduction To Hydroponics Gardening For Beginners (Part 6) The Autopot By John R. Haughton

The Advantages of The Autopot System

The basic Autopot System consists of a plant pot on a membrane in a container. This container has a SmartValve built into it which is fed from a nutrient tank. As the plant in the pot uses nutrient the level of nutrient in the Autopot container is maintained by the SmartValve. This means that the plant always has the optimum level of nutrient at its disposal. As the plant grows and needs more nourishment, the SmartValve opens more frequently to replenish the nutrient supply from the tank. Because the plant pot is sat on a membrane, it will only take up what it needs in the way of moisture. This system ensures that the plant does not become too wet and drown or rot, neither can it dry out provided that the tank is kept topped up.

In our climate in the United Kingdom, where rainfall is often quite high and sunshine limited, I have found that the results obtained with the Autopot system have far outstripped those of a conventional system of soil and a growbag. These results have only been studied using tomatoes, however I have no doubt that the same benefits would apply to virtually any type of plant.

I have grown a crop of tomatoes from seed this year and for the first time tried the Autopot system against a growbag and against pots hand watered with nutrient solution. The substrate used was washed coco. The seedlings were grown on to about 4? in height using rockwool cubes and a small propagation tray. They were transplanted into 8? pots (3 plants per pot.) and the pots placed in either Autopot systems or into containers about 2?

deep. Some were planted in soil in Growbags.

The Autopots were connected to a nutrient tank and the trayed pots were watered twice daily using nutrient from the same tank. The plants in the Growbags were watered daily and had plant food added to the water as directed on the container. It was found that the Grobag plants did not grow as well as the others and fruited less abundantly. The plants in pots and container trays fruited well, but during hot spells needed more frequent watering as the coco does not retain moisture. By far the best results were obtained from the Autopots. The plants grew quickly and were soon very well established. The root balls soon became dense and well formed. Within a short time the plants became sturdier than their less fortunate siblings and started to flower.

I had deliberately done no maintenance with any of the plants. They were planted, fed and left to grow without interference. This meant that the crops would be smaller than if I had pinched out the shoots, but there could be no discrepancy due to better maintenance. The results were quite staggering. The trayed plants produced some 250% - 300% more fruit than the Growbags and the Autopot had at least double the crop produced by the trayed plants.

The only drawback with the Autopot was that when it rained the water ran back into the nutrient container causing it to overflow. This problem did not seem to be detrimental to the plant's growth or yield.

Part 07 - Hard Water

The Basics of Hydroponics

Hydroponics Gardening - An Introduction To Hydroponics Gardening For Beginners (Part 7) Hard Water

By John R. Haughton Your Water Hardness is a Critical Factor for Success.

What Is Water Hardness And Why Does It Matter?

Water Hardness refers to the alkaline mineral ion count, usually from Calcium Carbonate and bicarbonate. Water with a high count is called Hard Water. You can usually tell if you are in one of the many hard water areas of Europe (Editor's Note... Or North America) because your kettle will get a build up of 'Lime scale' on the inside.

Hardness of water can be measured in parts per million by using a total alkalinity test kit. These cheap simple test kits are available from your local hydroponics retailer and are quite accurate enough for the purpose. If your water tests at anything over 150ppm it should be considered to be hard. Do not be alarmed if your water is hard, it does not mean you cannot grow things using hydroponic methods. Why Does It Matter If My Water Is Hard?

For many years growers in some areas have had unacceptable results, with low yields and poor plant performance. The reasons for this have been unclear until it was realised that the plants were suffering from a chemical imbalance. Hydroponics growers were particularly badly affected in these areas.

Growing hydroponically using normal nutrients means adding a balanced solution of chemicals to the hard water. The hard water already contains an excess of some of the essential minerals that the plant needs and so the solution quickly becomes imbalanced in the nutrient tank.

In order to reduce the pH of the standard nutrient solution the bicarbonate ions have to be neutralised. Because these alkaline ions buffer the solution it is necessary to add large amounts of phosphoric acid to the nutrient in order to reduce the pH. This in turn increases the phosphate ion content of the solution causing an imbalance. This imbalance can have serious consequences for your plants in a very short period of time.

What can I do about it?

The simplest way around the problem is to use a nutrient formulated specifically for hard water areas. A hard water nutrient has been produced with the correct balance of nutrients to compensate for the excess alkaline mineral ions in the water. These nutrients are also much more acidic to combat the buffering action of the bicarbonates.

The benefit of using this formulation is that you will not have to add large amounts of adjusting chemicals to your nutrient in order to achieve the correct pH. Also your plants will have a balanced nutrient solution containing all the ingredients they require to thrive. This means that your crop will grow up healthy with better growth and a superior yield.

Part 08- History

The History and Potential Uses of Hydroponics

Hydroponics Gardening - An Introduction To Hydroponics Gardening For Beginners (Part 8) By John R. Haughton Hydroponics is the science of growing plants without soil.

History shows us that this is by no means a new concept. In ancient times the hanging gardens of Babylon, the floating gardens of the Aztecs of Mexico and those of the Chinese were all early examples of 'Hydroponic' culture. Egyptian writings dating back to several hundred years before Christ have descriptions of the growing of plants in water.

During the 1930s, scientists experimenting with the growing of plants without soil, using nutrients dissolved in water, discovered that the soil was needed only as an anchor for the plant's root system. Since that time more and more research has resulted in the development of commercial nutrients and purpose built systems of differing types. Hydroponics is now popular in Western Europe, Australia, Canada and many other areas of the world.

As technology advances more and more of the world's food is produced using hydroponic methods. Although rooted in history, it is still a relatively young science, Hydroponics has progressed rapidly over the past half century, it has been adapted to suit many and varied situations from outdoor farming to greenhouse production and now also indoor home cultivation. The military use it for growing fresh vegetables in submarines and the space programmes are even experimenting with Hydroponics to feed the crews on board manned space stations

Hydroponics Growing Has Enormous Potential

The potential use of Hydroponics for future cultivation is enormous. It is already being looked at for increasing the food production in underdeveloped countries where space can be a factor. Because it is feasible to grow in areas of poor and even barren soil, arid regions of the world such as deserts could be utilised to grow crops hydroponically. The desert sand could be used as an ideal growing media and the nutrients even mixed with sea water, once the salts have been removed.

Even in countries with a more temperate climate Hydroponics can be used for food production, the temperature being maintained with the use of modern grow lights.

In Holland and other European countries the production of vegetables, such as Lettuce and fruits, like Tomatoes is showing that Hydroponic methods can be very effective and cost efficient. A large proportion of this produce is now being grown that way.

Some 20 plus years ago racehorse stables in the U K were looking at production of highly nutritious barley and wheat 'grass' as a feed. It was then very expensive and in its infancy, however today a large number of horse owners feed their animals in this way. It is also not unheard of for farmers to use the same methods to feed their cattle during the winter periods when the fields are too wet to graze.

With the advent of more efficient methods of production the uses of soil-less culture will advance and multiply as more people experiment with the systems available.

Part 09 - Experiment

My Autopot Tomatoes

Hydroponics Gardening - An Introduction To Hydroponics Gardening For Beginners (Part 9)

By John R. Houghton An Experiment In Hydroponics Container Gardening

The basic Autopot System consists of a plant pot on a membrane in a container. This container has a SmartValve built into it which is fed from a nutrient tank. As the plant in the pot uses nutrient the level of nutrient in the Autopot container is maintained by the SmartValve. This means that the plant always has the optimum level of nutrient at its disposal. As the plant grows and needs more nourishment, the SmartValve opens more frequently to replenish the nutrient supply from the tank. Because the plant pot is sat on a membrane, it will only take up what it needs in the way of moisture. This system ensures that the plant does not become too wet and drown or rot; neither can it dry out, provided that the tank is kept topped up.

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The Autopots were connected to a nutrient tank and the trayed pots were watered twice daily using nutrient from the same tank. The plants in the Growbags were watered daily and had plant food added to the water as directed on the container. It was found that the Growbag plants did not grow as well as the others and fruited less abundantly. The plants in pots and containers on trays fruited well, but during hot spells needed more frequent

watering as the coco coir does not retain moisture as well as soil.

By far the best results were obtained from the Autopots. The plants grew quickly and were soon very well established. The root balls soon became dense and well formed. Within a short time the plants became sturdier than their less fortunate siblings and started to flower.

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The only drawback I found with the Autopot was that when it rained the water falling onto the surface of the substrate ran back into the nutrient container causing it to overflow. This problem did not seem to be detrimental to the plant's growth or yield.

Part 10 - Nutrients

How well do you know your nutrients?

Hydroponics Gardening - An Introduction To Hydroponics Gardening For Beginners (Part 10) Nutrients By John R. Haughton An Experiment In Hydroponics Container Gardening

There are many different plant nutrients on the hydroponics market today. Their function is to provide the optimum mix of Nitrogen, Phosphorous, Potassium, Calcium and various other trace elements, in order to sustain growth, improve yields and allow the plant to achieve its potential. The plants requirements will vary to some extent as it develops. Concentrations and plant food components may also vary with differing growing mediums. The food is absorbed through the plants roots and transported to the leaves, where it is converted into the sugars that the plant needs for energy.

The most important thing to remember about plant nutrition is that the NPK, (Nitrogen, Phosphorous, Potassium) Calcium and trace element ratios are correct. There can be a wide variation of ingredients in the various mixes for sale.

Because the plant will take whatever it requires from the elements available and leave the rest, the balance will alter as unused elements build up in the solution. If left unchecked this will result in a toxic build up of salts and a subsequent drop off in growth followed eventually by the death of your, well loved and nurtured, plants. This same result will occur if the water content is not replaced and the mixture strength increases. If the plant transpires 50% of the water from the supply tank, the concentration of elements within the solution will become dangerously high.

The concentration of salts in the feeding solution is measured using an Electrical Conductivity (EC) meter. The EC meter measures the strength of the solution in parts per million. This means that in a 1000 PPM solution there are 1,000 units of dissolved salts to every 1,000,000 units of water. The meter measures the total salt concentration in solution and does not discriminate between Potassium salts say and Calcium salts. It cannot tell the difference between a good and a bad mix, only their relative strengths.

The EC meter works by measuring the speed at which electrons travel between probes immersed in a solution.

In distilled water, the electrons cannot find any impurities to use as footholds to cross the water and so the meter returns a 0 reading in mMho or mS (these are units used to measure electrical conductivity). As food is added to the water, the concentration of impurities in the form of salts increases and the electrons can find more footholds, and so cross the water faster. Thus the meter reading rises. Of course this is a very simplified explanation, but it should serve to give you an idea of the basics. One other important thing to remember is that as in all things chemical temperature plays an important part. The higher the temperature, the faster the electrons move and the higher the EC reading. This means that in order to accurately assess your mixture's EC you must record the PPM as mMho (mS) at a specific temperature.

As the PPM reading is a conversion from an electrical reading and as each addition of a different salt will alter the electrical properties, in order to obtain an accurate EC reading you will have to use a reference solution of a known value. Because the EC meter you are using will not necessarily have been calibrated for the mix used by the people who prepared your reference solution, these values can be quite inaccurate. In view of this, any reference solution that does not show the EC value in mS, or give you the conversion ratio that was used, is of no use for nutrient evaluation purposes. Don't Make the Plant Roots Work Hard

It is important to note that if the nutrient EC reaches 3,000 PPM (or the meter reads over 4.0mS) your plants will begin to show signs of nutrient deficiency even though they will have an excess. The reasons for this are quite complex, but basically it is because the chemicals dissolved in the solution are competing for the available water and the stronger ones are blocking out some of the weaker ones. This leads to the roots having to work harder to absorb the nutrients. By working harder they have to expend more energy at the expense of growth. If at this time the temperature rises and the water level drops, due to evaporation, your plants will, very probably, die.

Probably the most important factor that will affect your plant growth in relation to nutrient uptake is pH. Different types of plant prefer different pH values and it is important to ascertain which the optimum for the species you are growing is. The medium in which you are growing will affect the cation exchange capacity of the plant. This is the ability of the medium to hold nutrients on call for the plant roots to use. Normal soil has a high cation exchange rate (CEC) of between 100 and 200 equivalent units. A number of growing mediums and of course water cultures have a CEC of 0. This means that once a nutrient has passed the roots it cannot be taken up by the plant, and neither will it have any buffering effect. The nutrients, the gasses, the trace elements, the water and the growing medium all have differing electrical charges and are all exchanging positive and negative charges around the roots of the plant. This ionic battle enables the roots to absorb the nutrients it needs to sustain the plant. If the pH is incorrect it stops the particle exchange. This is because the shapes and sizes of the charged particles will be different from the spaces available within the plant root tissue. The pH can be looked at a bit like a Yale lock and key. If all is correct the lock opens if the plant pH and the surrounding pH differ then the lock cannot open.

Different plants need different nutrients at differing stages of their growth. These nutrients have different charges and so in order to get the greatest nutrient uptake the pH must be closely monitored. If in doubt about the requirements of your plant try asking the manufacturer of your nutrients for help. After all he made the mix in the first place and so should know all there is to know about it.

If your plants are not thriving look at the pH as the primary cause and try to work out which of the nutrients is not being absorbed and why.

Part 11 - What Is pH?

pH Is The Most Important Factor In Aquaculture.

What Is pH?

pH is the term used to assess the acidity or alkalinity of a solution. This acidity or alkalinity is determined by measuring the concentration of Hydrogen ions in the solution. This normally falls between 10⁻¹⁰ and 10⁻¹⁴ gram-equivalents per litre. In order to simplify this, a scale of values between 0 and 14 has been adopted.

This pH scale is a measurement of how strongly the electrical charges hold the atoms and molecules of substances within the solution together. The higher the concentration of positively charged ions, the lower the value is on the scale and the higher the concentration of negatively charged ions the greater the pH value.

Hydrogen (H⁺) has a positive charge while the hydroxides (OH⁻) have a negative charge. Pure water has a value of 7.0 so it is easy to see that water must be H-OH or more commonly H₂O.

The decimal points on the scale are very important because each whole number is approximately 10 times greater (or less) than the next whole number. So pH 2.0 is 1000 times stronger than pH 5. The greater the concentration of Hydrogen ions in the solution the more acidic it is said to be and the lower its pH on the scale. The greater the number of hydroxide ions the greater the alkalinity (or basicity) it is said to have and the higher its pH.

If we look at the structure of the pH scale, we can see that it goes from 0 (very strong acid) to 7 (neutral) and then to 14.0 (very strong Base or Alkali). If we mix an acidic solution with an alkaline one, providing that the positions on the scale are equidistant from the neutral value of 7.0, we will end up with a neutral solution. This is because the positive charges will be cancelled out by the negative ones. If however we use differing positions on the scale, then the resulting imbalance will give us a solution with either acidic or basic properties depending on which side had the greater distance from the neutral value.

But Why Is This So Important?

All of the chemicals in the solution have differing electrical charges because each of them is made up of different combinations of elements and ionic values. As they are all competing for the exchange of charged particles, a huge electrical battle is constantly raging within the solution. This constant exchange of positive and negative charges surrounds the plant's root system and it is this that allows it to absorb the vital nutrients needed for its growth.

You can think about the chemical battle being a bit like a moving 3D jigsaw puzzle, with the positive and negative charges all having to combine in the correct shape and order. The plant can only absorb those bits that fit into its own bits, like a lock and key. As the levels of pH change, so the jigsaw bits alter and no longer open the lock. In fact the plant itself will, at times, alter its own internal cellular pH in order to either slow down or speed up certain enzyme reactions.

It is vitally important that the pH of the nutrient used in the hydroponic system matches the plant's own internal pH as closely as possible, otherwise this chemical exchange cannot take place. The main chemicals within the solution, Sodium (Na⁺), Phosphorous (P⁺), Calcium (Ca⁺) and Potassium (K⁺), together with all the other ele-

ments will affect the efficiency of each nutrient's absorption through the root walls.

Different species of plant prefer different pH values. The three main things that affect the pH that a plant prefers are: 1. The pH of the water used.

Your water will not be pure and so will contain charged ions either from deliberately introduced contaminants or from environmentally absorbed ones like Calcium Carbonate from passing through limestone and Sulphurs from acid rain.

2. The growing medium that you are using.

Rockwool is over pH 7.0, Peat Moss below 6.0 and hardened expanded clay is 7.59.

3. The nutrient you are using.

Nutrients can be mixed in lots of different ways, forming various combinations of elements and so giving a wide variation in pH. Because these chemical combinations behave in different ways they give up their elements to the plant at differing pH values. Therefore the nutrient preferred by the plant determines which the best pH value for that species is.

Part 12 - Oxygen

How Oxygen Keeps Your Plants Thriving!

Oxygen is used in large quantities by plants. If you were to analyse a dried plant you would find that about 45% consisted of Oxygen atoms. Just like humans, plants need fresh air and their cells use Oxygen in the same kind of quantities that ours do. In air conditions with a low concentration of Oxygen, or where the air is poor, plants do not thrive. Those that do manage to eke out an existence remain poor stunted specimens.

The leaves of a plant have easy access to Oxygen. They make it as a natural bi-product of the process of producing plant sugars and breathe it out as waste during the process of photosynthesis.

The roots of the plant do not have the same amount of Oxygen available to them. They have to work a lot harder to find enough for their needs. Insufficient Oxygen at the roots will reduce the plants root respiration and result in the shutting down of photosynthesis.

A plant's growth and its yield are governed by the size and health of its root system. It can only grow to its full potential if the roots have enough Oxygen for their needs. In plants grown hydroponically this essential ingredient is supplied dissolved in the nutrient solution.

Dissolved Oxygen in the nutrient solution can be measured by a DO meter. These are available from all good hydroponics equipment suppliers.

The amount of Oxygen dissolved in the solution will vary depending on both temperature and pressure. The warmer the water the lower the gaseous content will be. Really cold fresh water has a DO reading of up to 14 ppm or 14mg/litre, while water at 30 degrees centigrade can only hold about 5ppm or 5 mg/l DO.

This DO only amounts to a very small percentage of the roots needs. All water culture systems have to utilise

some other form of oxygenation for the roots as well as DO in the nutrient. Root systems that have insufficient Oxygen available will soon turn brown and become very sick.

We aerate the nutrient in our systems in order to get the best saturation that we can, (from 5ppm to 8ppm) but the main function of this aeration is to kill off the anaerobic bacteria around the roots. Anaerobic bacteria are pathogens that cannot survive in an oxygenated environment; (Anaerobic meaning without air).

Because the dissolved Oxygen in the nutrient can only supply about 1% of the roots requirements, the balance must be made up by breathing air. This air is trapped within the soil in conventional gardening and in the growing medium in normal hydroponics systems. This Oxygen search uses up energy that the plant could better use to produce root growth.

The only type of system where this does not happen is the aeroponics system. The aerated water being sprayed directly onto the roots, allows the plant to take in free Oxygen from the surrounding air, while still keeping the roots moist and supplied with nutrient.

One of the functions of Oxygen is to facilitate the exchange of nutrients and gasses between the plant roots and the surrounding solution. It does this by changing the electrical charges within the water, so allowing the roots to absorb the available nutrients with the least expenditure of energy. For this reason, if no other, the roots need all the Oxygen they can get.

Part 13 - Hydrogen Peroxide

The Importance of Hydrogen Peroxide (H₂O₂)

Hydrogen Peroxide (H₂O₂) is a water molecule with an extra atom of Oxygen attached ((H₂O) + O₂ = 2(H₂O₂)). This extra Oxygen atom is quite easily detached from the water molecule and eagerly combines with any suitable substance that has the room for it. For example it will attack organic blood cells.

Any chemist's shop will sell you some concentrated 35% Hydrogen Peroxide, which may be diluted with water to give a 3% solution for human use. This diluted solution is good for treating minor cuts and scrapes etc. It is also used for softening ear wax. It works by oxidising the chemical parts that are presenting as having a free space for the Oxygen atom.

When (H₂O₂) comes in contact with these "impurities" it will give a reaction which causes it to fizz. This fizzing is the Oxygen atoms coming out of their bond with the water molecules and bubbling out of the solution. As gardeners, we can use this eagerness to break its bond to help keep our plants free from everyday pests.

In the same way as old organic blood cells are attacked and consumed by the fizzing action of the peroxide, so will any bacteria and small insects be destroyed by a solution of up to 5% (H₂O₂). At this strength it is safe for human skin but lethal to most bugs.

Mix up the following for a weekly preventative spray:

Add to 1 Litre of Water:

- * 30ml of 35% Hydrogen Peroxide
- * 20 ml of Alcohol (Old style mouth wash works well)

* 2ml of wetting agent (Washing up liquid [detergent] will do)

Use this mixture as a foliar spray to keep your plants healthy and free from bugs.

Another advantage of the Peroxide breaking down is that it releases free Oxygen into the area. So, if you were to add some to your nutrient tank, the dissolved Oxygen being released around the root system not only kills any bad root material and bacteria, but also oxygenates the roots with the excess Oxygen produced.

Plants can easily cope with a 5% H₂O₂ solution and because the mixture reduces to water in a short space of time, the dilutions are not that critical. For this reason, it also makes a great disinfectant for plant pots, greenhouses, and grow-rooms.

It may be used at 10% for these jobs, but make sure to only use it if the area is plant free. A really great advantage is that you do not have to rinse it away after use because it will revert to water on its own.

Click the link to see how NASA is planning to use this sanitizing Hydrogen Peroxide system. <http://www.primidi.com/2005/08/29.html>

Part 14 - Carbon Dioxide

How Carbon Dioxide (CO₂) Can Keep Your Plants Growing!

Carbon, Hydrogen and Oxygen make up about 90% of the dry matter in a plant. CO₂ (Carbon Dioxide) in the air supplies all of the Carbon in the plant. Like animals, plants breathe in Oxygen and breathe out Carbon Dioxide all the time. The plant needs Carbon Dioxide during the hours of daylight and uses this to produce sugars. During the hours of darkness it will breathe out Carbon Dioxide, which is a waste product.

The plant uses light and Carbon Dioxide for photosynthesis. The more light there is available the greater the plant's requirement for Carbon Dioxide. It has been found that it takes about 10 photons, (quantum units of light) during photosynthesis, to create enough energy to split one Carbon Dioxide molecule into its basic components of Carbon and Oxygen and form a sugar.

Because there are trillions of photons hitting the plant's leaves, sufficient Carbon Dioxide is needed to convert their energy into sugars. If enough CO₂ is not available, then the unused photons will bounce off the plant's leaves and be lost. So the more light the plant is given the more Carbon Dioxide it will need to produce its maximum yield of sugars from photosynthesis.

Plants absorb different spectrums of light in differing amounts. This light is affected in different ways by a range of factors, such as distance and percentage of reflection etc. Because any unusable light is wasted, the calculation of how much useable light the plant is getting is quite complicated. It can be measured using a special PAR meter (PAR = Photosynthetically Active Radiation).

This machine takes into account the lumen level of the light striking the leaves and discounts the unusable fractions of the available light.

Plants outside, in full sunlight, will get about 5000 lumens per square foot. This means that the plant could process about 2000 ppm of CO₂. It is unfortunate that the Carbon Dioxide levels outside are nowhere near this level.

Indoors, using a light level of 3000 lumens, the plant will need approximately 1500 ppm of CO₂. If the light level was at 1000 lumens this would drop to around 300 ppm CO₂ (city air is about 400 ppm) which is within the normal range. The lower the concentration of Carbon Dioxide the more the air has to be moved across the plant's leaves in order for it to get sufficient exchange.

It is known that if the plant has enough CO₂ and enough light it will perform to its optimum, so if we increase the light levels and up the CO₂ available then we can expect a good increase in growth and subsequent yield.

Part 15 - Ozone

The Uses And Dangers Of Ozone (O₃) In The Grow Room

Ozone or Trivalent Oxygen (O₃) is an unstable gas made up of three Oxygen atoms. It is formed when a single Oxygen atom attaches itself to an Oxygen molecule (O₂). Ozone is very unstable and will revert back to Oxygen very easily, (2O₃ = 3O₂). Because this third atom is so easily dislodged from the molecule, it will freely combine with any other molecule that has a spare space for it.

This process of is called Oxidation and is the reason why Ozone is an excellent killer of bacteria, moulds and viruses. It is also an effective means of removing odours, which it does by attaching to the scent molecule and altering its chemical makeup. This does not mask the smell, it destroys it at source.

Ozone is produced naturally in two ways; Firstly by the chemical reaction with the sun's Ultra Violet rays in the upper atmosphere and secondly by Corona-Discharge. For most practical applications Ozone is generated using the Corona-Discharge method.

In nature, when there is a thunderstorm, massive voltages are passed through the air as the lightning jumps from cloud to Earth. This electrical discharge with its accompanying blue/white corona causes some of the Oxygen Molecules to break down from O₂ to 2O which in turn immediately attaches to another 2 Oxygen molecules giving the equation $2O_2 + 2O = 2O_3$. This also happens when the energy produced by very heavy rain and waterfalls causes the natural production of Ozone.

Because any impurities in the air around us, for example exhaust fumes, will have been cleansed by the Ozone molecule combining with them and then reverting to pure Oxygen and oxidised pollutants, which are virtually odourless, the air will smell clean and fresh. So the advantages of using O₃ as a means of providing your plants with extra Oxygen are several: The increased Oxygen levels, the odour control, and the anti-microbial and spore controlling properties. Use Only Certified Ozone Generators!

Ozone generators can be purchased from most reputable Hydroponics suppliers. These work by passing Oxygen through a strong UV light or, more commonly, by using a high voltage discharge to break down the Oxygen molecules. In practice the UV system produces considerably less O₃, per unit of energy used, than does the Corona-Discharge method.

There has been a lot of discussion about the dangers associated with Ozone in confined spaces. Ozone has a strong recognizable odour, so very low concentrations soon become apparent. This makes it generally safe to work with. The use of Ozone is thought to be safe in low levels (0.05ppm); however in higher concentrations it can be very dangerous. Because it oxidises materials readily it can cause severe irritation to lung tissue and mucous membranes. Other symptoms include headache and a feeling of tightness in the chest, coughing and

dryness in the mouth and throat.

Recommended safe levels of maximum acceptable concentration (MAC) for humans are: 0.06 ppm for 8 hours per day 5 days per week (ppm = parts per million). For a maximum of 15 minutes a MAC value of 0.3 ppm may be applied. These levels far exceed that where the gas is noticeable by smell.

While it is quite possible and fairly easy to make an Ozone generator at home please bear in mind that a good working knowledge of high voltage electricity and its associated safety procedures is essential to avoid injury or even death.

It is always better to spend a little extra money on an article and know that it is safe for you and your family to be around, rather than risk a less safe alternative which could end in a tragedy.

Part 16 - Temperature

Take Control Of Your Grow Room Temperature

It is vital to maintain a temperature within the specified upper and lower limits for the species of plant being grown. This temperature may need to vary between dark and light periods, again dependant upon species. The desired results are usually obtained by either fans, to lower the ambient room temperature, or heat sources to raise it.

Reducing the room temperature can be done in various ways. For example, if your grow room is quite small and the air input via say a 4 inch diameter ducting system, then you might decide to use another slightly larger duct with an in-line fan to extract the warm air and send it to the outside atmosphere. This can be supplemented by the use of free standing oscillating fans circulating the grow room air. Should more cooling be needed, in some hot climates for example, then an air cooler can be used. This can be easily made by passing the air over a refrigerated surface like a car radiator with ice cold water running through it.

It goes without saying that when the lights are turned off the temperature will reduce quite rapidly. If your grow room is not very well insulated, this is when you may need to turn on your heaters. Most growers find that it is more efficient to increase the insulation to a point where the heat loss is minimal, rather than spend money on raising the ambient temperature too much.

It is important to remember that any heat source used must not be placed so close to the plants as to burn them. Oil filled radiators and similar systems can be used with good effect.

In order to monitor the system some kind of sensor and switching device will be needed. These control systems are readily available at most suppliers. You will need a sensor for temperature linked to a switch for powering the cooling systems. Do not however rely upon them to never fail. I know of growers who have left their plants unattended for several days, only to return to a dead crop of nearly mature plants. The culprit being a defunct control unit that allowed the lights to stay on and did not turn on the fans when the temperature climbed.

It is always wise to monitor your plants on a regular daily basis.

Part 17 - Germination

Seed Germination in the Hydroponics Garden

Many advantages are to be gained over conventional, soil based, seed germination, by using hydroponics. The growing mediums are clean and in a lot of cases sterile, which reduces the instances of disease and infection, as well as insect attack. Soil may contain all kinds of harmful bacteria, fungal spores and insects that might harm vulnerable young plants. Root rot should also be easily avoided, using a high quality growing medium.

Because the hydroponics gardener has complete control over the plant's environment, it is possible to ensure that each and every aspect of the plant's growth is catered for to its optimum effect. This, of course, rules out the inconsistencies in the weather and avoids problems such as late frosts and storms etc. The subsequent advantage to the plants is an ideal climate in which to grow strong and healthy. This leads, eventually, to greater and better quality yields.

A lot of seeds contain their own nutrients and require only water and Oxygen in order to sprout. It is important to realize that using a nutrient solution can and often will either retard or block the seed's ability to germinate. Once it has sprouted and has reached a point where it has viable leaves, then it can be fed using a weak nutrient solution. One species of plant that has very little nutrient within the seed is the Orchid, so, as you can see, it is important to research your plants prior to germination in order to minimize any stress to the plant.

The choice of growing medium is important when dealing with seedlings and young clones. It must provide the young plant with water and Oxygen in adequate quantities, while not allowing it to become waterlogged. Drainage is very important at this time and the porous growing mediums have excellent properties in this area.

Perlite, Vermiculite and Rockwool all offer great drainage properties together with the major advantage, in the case of Rockwool, of coming in nice little cubes with holes in for your seeds. The beauty of these cubes is that they can be transplanted straight into larger Rockwool cubes or other mediums as the seedling grows, thus cutting down on the plant's stress and on the transplanter's time.

It is better to plant the germinated seeds in a medium with a built in weak nutrient and to add water only. When the seedlings are established you can then start them in a weaker version of your normal nutrient and gradually increase the strength until you are running at normal strength nutrient. This system can be ongoing, with germinating seeds being brought on at regular intervals to replace plants that have reached their fruiting stage and been cropped.

It is always wise to monitor your plants on a regular daily basis.

Part 18 - Plant Disease

Disease Control In Plants

Is Disease Going To Destroy Your Crop?

Plants, like animals are vulnerable to disease. All living things are made up of a collection of cells. Plant and animal cell structure is similar in make up, having a cell wall containing the cell's internal components, such as

the nucleus and the protoplast: the 'hollow' part of the cell where the cell conducts activities. There are many different types of plant cell, but all cells, be they plant or animal, share some basic characteristics.

Because they are cellular structures, plants are subject to disruption of their cells by invading organisms. Thus at the microbial level the plant may be invaded by pathogens. These are organisms which do harm or cause the death of the plant by extracting its nutrients, damaging the cell structure, or producing toxic by-products. These pathogens can come in the form of either viruses or bacteria. Both of these types of infection will do major harm to your carefully nurtured plant.

Bacteria attack the plant cells in the same way that they attack our own cells. Think back to the last time you had a cold or flu, remember how unwell you felt and how your energy was depleted. The plant also has to use a lot of energy in order to stop infection from spreading. One way in which it can fight back is by sealing off the diseased area and so blocking the pathways available to the intruding pathogen.

It has been found that plants also use Salicylic Acid (the active ingredient in aspirin) as a trigger to mobilize their defences against attack. To find out more about this mechanism visit <http://www.sciencedaily.com/releases/2003/12/031209080025.htm>

Unfortunately, as there are no antibiotics that can be used on plants, the pathogenic bacteria are very difficult, if not impossible, to kill. They normally enter the plant via the site of some type of injury. For this reason, if no other, it is very important to check your plants daily for signs of damage from insects and other predation, as well as physical cuts and scratches.

Virus attack is usually caused in a similar manner, but these organisms are very much smaller than bacteria and can enter via the tiniest mark. Once inside the plant they live within the cells and are unable to be killed without destroying the plant.

Plants are also susceptible to fungal infections. Fungi, unlike the microbial pathogens, attack using spores. These can lie dormant for long periods of time and then be triggered to come to life. They are mainly an essential and welcome addition to the garden because they break down dead and decaying material and improve the humus content of the soil. Some, however, are bad news for the grower and cause disease within the growing area.

Fungi in general tend to attach to the outside of the plant and use root like structures to penetrate the plant and steal its nutrients. For this reason they are vulnerable to chemical attack and destruction. There are various preparations available for eradicating fungal attack.

The best form of defence against plant disease is vigilance and meticulous hygiene. Here are a few ways in which you can help to prevent attack within your grow room or greenhouse.

1. Always wash your hands in hot soapy water before entering the growing area.
2. Always destroy diseased plants and all their dead leaves and debris.
3. Always use new, or well washed and sterilized, pots when planting new plants and cuttings.
4. Always sterilize your secateurs and equipment before use. This can be done by dipping the blades in Methylated Spirit, shaking off any excess and then lighting it. Care must be taken not to either ignite the alcohol bottle

or burn the user or equipment. If you wish, you can just dip them in the spirit and allow it to dry. The use of a naked flame on knife blades etc is recommended when taking cuttings.

5. Allow as much free air between your plants as possible. This cuts down on the transmission of fungal infections.

6. Ban all smokers from your growing area. Tobacco is one of the biggest causes of the spread of Tobacco Mosaic Virus which attacks various plants. It is carried on the skin of people who use tobacco products.

7. Finally always be on the look out for changes in your plant's appearance. This can be the early sign of a disease.

Part 19 - Gray Mould

Is Your Mould Under Control?

Gray Mould (Botrytis blight)

This common fungus infects leaves, rhizomes, stems, flowers, and seedlings of many plants. The disease thrives on mild, moist conditions and often survives on infected plant debris. The fungus which causes the disease is *Botrytis cinerea* and it is known to infect large numbers of differing plant species, but is a serious problem in only a small number of them.

Botrytis blight can be a problem in greenhouses where the humidity is high and the temperature moderate. It attacks tomatoes, as well as cucumbers and other fleshy plants, and fruits such as strawberries and raspberries.

Botrytis blight can affect plants in various of ways. It may cause collapse of seedlings, blossom blight, fruit rot, stem and crown rot, or shoot blight. The first symptom is usually the appearance of water-soaked lesions. This is followed by tissues becoming soft and watery. The affected parts of the plant then wilt and collapse.

If the humidity remains high, the infected area quickly becomes covered with a gray-brown mass of fungus and spores. Lots of spores are produced and these are easily blown or splashed onto healthy foliage. If there is moisture present and other conditions are favorable, germination and infection can take place in as little as a few hours.

Varying in size up to 1/4 inch, flattened, black, Sclerotia may be produced on fleshy parts of stems and fruits. These structures allow the fungus to survive when conditions are not favorable for growth. The Sclerotia are not always easy to see as they may be embedded in decayed tissue or coated with soil and other debris.

The spores need a film of moisture in order to germinate and infect plants. This is why gray mold thrives in humid and moderate conditions. In greenhouses, good ventilation will help to control gray mold. The use of a small fan to improve air circulation will also help to keep this problem at bay.

The fungus thrives on plant debris and detritus, so cleanliness and sanitation is an essential part of gray mold control. Fallen leaves and dead plants, as well as any extraneous plant material, should be removed from the greenhouse and burned. This will greatly reduce the amount of infectious material available, and so limit the fungal spread.

In the event of a bad outbreak of Gray Mould it may be necessary to resort to some form of chemical treatment. There are a lot of suitable fungicides available through your local garden center, so ask for advice as to the best one for the particular crop you are growing.

Part 20 - Soil Based

Conventional Gardening or Hydroponics, the Advantages and Disadvantages

Why choose hydroponics over the conventional gardening methods using soil and composts etc.? There are several reasons for considering hydroponics or Aquaculture and these are listed below.

Time

The most obvious benefit of Hydroponics is the saving in time and effort. You do not have to spend as much time attending to the preparation and maintenance of your garden on a regular basis, so a simple Aquaculture system can be much more time efficient than a conventional soil based one.

Weeds

Growing in soil involves keeping your planting area weed free. In order to give your plants the best possible chance of thriving, they must be able to absorb their optimum nutrition from the surrounding soil. If the area has lots of weeds then your plants have to fight for their place, their roots competing with those of all the weeds.

In the Hydroponics Garden, because the growing medium is sterile, there should not be any weeds appearing. This means that your plants can devote all their energy to production and not have the stresses of competition.

Health

No soil and sterile growing media coupled with the correct nutrients means healthier plants. The absence of parasites and pathogenic bacteria in the growing media ensures that your plant roots stay healthy and disease free. Any infections or pests above ground can be monitored and treated quickly and efficiently because the growing area is more compact.

Light

Outside, in the conventional garden, the sunlight is never predictable in either intensity or duration. Inside, under lights you have complete control and can supply your plants with a constant unchanging environment.

Growth

Optimum nutrition and water requirements having been satisfied, your hydroponically grown plants will develop a massive but compact root system. This means that your plant will not have to use extra energy either searching for sustenance or transporting nutrients and sugars long distances. The net result of this is quicker growing, faster maturing and greater yielding plants.

Stress

Your plants will not be stressed through changes in conditions of light, temperature or water as is the case with plants grown by the conventional gardening methods. This in turn will lead to stronger more resistant plants.

Yield

Your plants will yield considerably greater crops than conventionally grown ones because of all of the above factors. The greater storage capacity within the root system and the shorter stems give rise to an increase in plant efficiency of up to %30, with a corresponding increase in crop.

Cleanliness

Hydroponics Gardening is in essence a clean occupation. There is no soil, so very little dirt. For this reason it is ideal for indoor gardening, utilising the spare room, or perhaps a conservatory. On top of this there are no more grime encrusted fingernails!

Part 21 - Auxins

Auxins Start Your Plant's Growth, Top And Bottom

Auxins drive the plant's shoots and roots to thrive, they are primarily concentrated in the root and shoot endings. Produced mainly in the buds and leaves of the plant, they promote the elongation of plant cells. The greatest concentrations are found in the root and shoot tips because the greater the concentration of Auxins, the better the growth of the root and shoot will be.

New roots need Auxins to get started and the shoots tips need them to sustain continued growth. In cuttings this hormone must be redeployed from the shoots to the root beginnings so that the roots can start to grow. Artificial rooting and shooting powders and gels are often used to boost the hormone levels during this process.

It is essential to always use the weakest possible rooting powder or gel. The reason for this is that too great a concentration of Auxins will actually stop the roots from developing. The rooting compound must all be gone within a few days, so this is a definite case of less being more.

One strange thing, which is, as yet, unexplained is the gravitation of the Auxins to the underside of a horizontal branch or stem. This causes the cells on the underside to elongate faster than those on the upper surface, resulting in the stem or branch curving upwards until the vertical is almost achieved and the greatest light is accessed.

On occasions a cutting taken from a horizontal branch will not grow upwards even as it gets older. It is thought that in this instance the cutting of the donor stem has disrupted the message sent by the growth hormone.

Another unexplained anomaly is the action of the Auxins on the shaded side of the plant's shoots. This accumulation of hormone causes the shady side to elongate more than the lighted side and so making the shoot curve towards the light.

The Auxins also accumulate in the top section of the growing shoots, causing the plant to grow upwards towards the light. The main shoots will grow at a quicker rate than their companions. This is because they have the abil-

ity to slow the growth of the other shoots by altering the Auxin concentrations. As the dominant shoot grows away from its less dominant companions so its ability to affect them decreases and they can then start to catch up. Should the dominant main shoot be broken or pinched out the Auxins within will be redistributed amongst the other shoots. These shoots will then start to grow stronger.

Part 22 - Gibberellins

Gibberellins Awaken the Plant's Seeds and Control Internodal Length.

Gibberellins primarily develop in the plant's shoots, buds and seeds. They are involved in breaking the cycle of dormancy in the seeds and in the process of seed growth signals. They promote extra length and fast growth of cells between the plant's nodes and in the leaves. It is these hormones that are responsible for driving the plant rapidly upwards, making it long and spindly, in low light conditions.

The shorter the distance between the nodes of a plant, (the point from which each leaf shoots) the more efficient the plant will be in relation to its root size. This is because the taller it is the more energy it will need to use for growing the thicker, longer, stems needed to hold the extra weight. Also it will use more energy to transport its water and plant sugars over the greater distances from roots to leaves.

Another reason in indoor plants is that the taller the plant is the steeper the angle of shade becomes making a greater space necessary for its neighbouring plants.

Artificial light halves in intensity for each foot from the source, meaning the leaves at the bottom of the plant are getting weaker light than those at the top. The taller the plant grows the further away the lamp must be placed and so the weaker still the light intensity impinging on the bottom layers.

A final drawback with tall plants is that the CO₂ needed by the plant will tend to collect at the lower levels because it is heavier than air. This will make getting it to the upper levels more difficult and of course, ultimately, more costly.

It is obviously better to limit the height growth and increase the potential yield gained by this action. The Gibberellins within the plant will slow the growth of the stem cells under good light levels. Increase the light intensity and the growth will be transferred from height to root ball and plant density. Remember, the more root and leaves, the more flowers, fruit and seeds.

The complicated interaction of Auxins and Gibberellins is responsible for the way in which the plant reacts to the available light. The Auxins make it turn towards the brighter light while the Gibberellins slow its growth when the optimum light intensity is reached. Outside, in the sunshine, this is a very delicate and complex interaction as the light varies from day to day and month to month.

There are in excess of 70 different types of Gibberellins that assist in the germination of seeds, the elongation of stems and leaves and also affect the development of fruit.

Auxin-Gibberellin sprays are used by commercial growers to promote the growth of some fruits such as apples, currants and eggplants without fertilization. An example of one interesting use for Gibberellins is in the production of the Thompson variety of seedless grapes.

Part 23 - Cytokinins

Cytokinins Influence How Fast And How Often Your Plant's Cells Divide

Cytokinins are organic chemical compounds containing Carbon, Hydrogen and Nitrogen, whose structure resembles that of Adenine. They promote cell division and have other similar functions to Kinetin, which was the first cytokinin discovered and named because of its ability to promote cytokinesis (cell division).

Despite being a natural compound, Kinetin is not made by plants, which leads to it being thought of as a "synthetic" Cytokinin. (A hormone synthesized somewhere other than in the plant.)

In today's plants the most common form of naturally occurring cytokinin is called Zeatin which was isolated from corn (*Zea mays*).

Cytokinins have been found in almost all higher plants as well as mosses, fungi, bacteria, and also in the RNA (definition) of many prokaryotes and eukaryotes. Today there are more than 200 natural and synthetic Cytokinins combined. Cytokinin concentrations are highest in meristematic regions.

Meristemic tissue is a type of cellular plant tissue containing non-specialised embryonic cells. It is found in areas of the plant where growth may take place, such as the shoots, buds and roots. Specialised plant cells have a precise set of rules that they follow in order to produce cells of the correct shape, size and structure. Because the plant needs to be adaptable as it grows it uses the meristemic cells in order to alter the shape and structure of the plant body as it grows.

Thus the meristem provides new cells which the plant uses to expand its basic body and form. This allows the plant to maintain its shape and type of structure according to its rules, while still giving leeway for growth. Each of the roots and shoots being able to grow and expand as needed throughout their lifetime.

Because this primary growth is not predetermined by the plant's blueprint, the overall shape of the plant is also indeterminate in advance. This gives each meristem the latent ability to develop into a complete plant. As a consequence of this new plants can be grown from cuttings where cells in the broken or cut end change to become specialised root cells. This method of reproduction is called Asexual or Vegetative Reproduction.

A partner in a thriving retail hydroponics supply business, Rickie Haughton is the owner of <http://www.hydroponics-gardening-information.com> Your First Choice For Hydroponics Gardening Information, the Hydroponics-Gardening-Information website is packed with good content about all aspects of hydroponics gardening and offers a free Hydroponics Gardening Information Club membership to all subscribers.

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