HYDROPONICS, THE BASICS

The most important thing for you is to realise is that Hydroponics should be easy. It is easier for the home grower to grow Hydroponically than in soil and that's a fact! This is the reason for this booklet. In this booklet I hope to show you how easy, how inexpensive, and how satisfying Hydroponics is. Simply there is no easier way to grow, house plants, ornamental plants, vegetables such as tomatoes, lettuce, beans, fruit, root crops such as potatoes, carrots, onions, flowers such as roses and carnations, bulbs, vines, trees, orchids, herbs, anything in Hydroponics. To my knowledge, there is nothing that is grown that cannot be grown using hydroponic techniques. In Europe they call Hydroponics, "soil-less culture". This is in fact, the best possible way to describe what we do. We take away the nutritional control of soil, by using a balanced liquid containing 99.9% water, and 0.1% of the Minerals found in soil. Instead of soil giving out some nutrient whenever it can, Hydroponics gives the right amount all the time. Hydroponic nutrient is totally organic (in terms of not artificial or synthetic compounds), except the minerals are mined from the ground and are then balanced to exact proportions, so your plant will get exactly what they need, nothing more, and certainly nothing less! In fact if we could take the perfect soil and dissolve it, we would have exactly what a nutrient solution is, totally natural, but under your control.

Apart from nutrients, the most important thing we do in a Hydroponic growing design is make sure the plants have access to Oxygen. Basically, this means that they are not growing in water so they drown, but have a supply of air around their roots. I will explain more about this shortly.

The burning question in your mind should be:-
How do I get started in Hydroponics?
This is the question I most want to answer in this book. I will discuss the major systems and hopefully lead you to the conclusion that Hydroponics is EASY.

To get started in Hydroponics is as simple as deciding what system will best suit the plants I wish to grow? This question determines the type of system.

The systems described further on explain whether they suit small plants like lettuce and herbs with smaller root systems or larger plants like tomatoes and cucumbers with larger root systems, short term crops like lettuce or long term crops that will be in the system for more than 3-4 months. Remember, plants such as tomatoes can be harvested and removed, from short-term systems, before they clog up the system with roots, but some crops will be harvested for long periods. E.g. flower and herb crops may cut without the actual plant being removed. These can be an extreme example, of a long-term crop, but their roots could be trimmed, or plants replaced with young seedlings instead of re-cropping.

We'll discuss more with each system.

THE FIVE BASICS

1. LIGHT

Light is the energy that creates life. Life cannot exist without it, and cannot thrive without enough of it. Plants process up to 5,000 foot-candles of light intensity to get the energy to grow. The sun is around 1,000,000 foot-candles. Shade can be lower than 1,000 foot-candles.

Plants will enjoy much light, but some do not like all the heat put out by sunlight. Shade cloth is ideal for hot conditions, also to keep plants from, insects, wind, rain and other damage, but rarely is the requirement for low light levels.

Sunlight is an ideal source of light for plants. It is bright and contains the Reds and Blues necessary to produce good healthy growth. However it also has infrared, Green and Ultra-Violet light.

The infrared light or heat is absolutely necessary or we would all freeze to death, but it can be too little or too much heat. Too little heat is best combated by using a recirculating hydroponic system. By heating the nutrient in the tank, and pumping the 20 to 25C nutrient around we can keep the plants warm. Excess heat in summer, can be alleviated by cooling the tank, usually by aerating the tank

heavily. By using a venturi, a water jet, or having the nutrient rising and falling into the tank like a waterfall will cool the nutrient as it passes through the air.

It is not necessary to worry about green light as it is usually reflected off the leaves, making them look green. There is some evidence that shows that a reduction in Ultra Violet (or UV) light can improve growth. If you are growing under glass or plastic this may interest you.

We generally grow outdoors, so just use common sense. If you'd feel hot or cold in the sunlight, then the plants would feel that too. Plants tend to grow well in the same climate as humans feel comfortable. A great way to grow is under artificial horticultural lights that will allow more control, and less damage from the elements, but that is a decision you can make. What I can tell you is that, a 400-Watt plant light, costs very little to run, but the benefits are, faster growth (from up to 18 hours of light per day), more control of the seasons through day length, less pest problems, no wind, rain and less cold problems. But you may need an exhaust fan to ensure good air circulation and no heat build up in warm climates. (See Appendix on Artificial Light)

RULE: A PLANT GETS ALL ITS ENERGY FROM THE LIGHT IT ABSORBS THROUGH ITS LEAVES. LOWER THE LIGHT LEVELS AND YOU REDUCE THE GROWTH RATE.

2. OXYGEN TO NUTRIENT RATIO

Oxygen keeps a plant's roots healthy and allows the plant to take up nutrient. Oxygen is the key to growth rate. Without oxygen around the roots, the roots will rot and die. You cannot grow in water, unless you dissolve oxygen in it. The recommendation is that you do not grow in water, just feed enough nutrients to keep the roots moist, with access to oxygen. The 5 systems I have described in this book will have varying degrees of oxygen according to their design. The oxygen level or the oxygen to nutrient ratio is the key to success.

RULE: PLANTS CANNOT TAKE UP THEIR NUTRIENTS UNLESS OXYGEN IS PRESENT. THE MORE OXYGEN, THE FASTER THE UPTAKE OF NUTRIENT.

3. NUTRIENT STRENGTH

Assuming you have a commercial brand of nutrient made by a good Australian company such as Accent Hydroponics, Growth Technology or the like, you will get excellent consistency in the nutrient. Always use a 2 part A&B style nutrient where possible. Nutrients must be solely designed for Hydroponics. Soil fertilisers require bacteria to break down more complex elements into useful ones. They are likely to be less soluble, not pH adjusted, and are usually too slow to release the necessary elements to be suitable for Hydroponic systems. Plants may grow for a little while in Hydroponics using soil fertilisers but they generally exhibit minor mineral deficiencies, then develop major deficiencies, until even changing to a Hydroponic nutrient can not correct the disorders. Soil fertilisers normally kill hydroponically grown plants, but not overnight. Certainly they will never produce as nature intended them to if you do not supply the right amount of minerals in a soluble form.

There are a range of companies offering a grow (High Nitrate) nutrient and a bloom (high Potash) nutrient. Neither will MAKE a plant do anything. You can use these formulas to approximate the nutritional requirements of your plants. When growing, a plant generally takes more nitrates, and during flower production and/or fruit production, plants generally increase their potash and phosphate uptake, but lessen their need for nitrates. However, in cloudy, overcast or short days of the year, the plants will take up more potash and phosphorus due to lower light levels, and on sunny, long, cloudless days the plants nitrate uptake is greater. Sounds confusing? It isn't really. Most manufacturers put an excess of everything into their general-purpose nutrients. But when in doubt, ask a store. Also, when people tell you an imported nutrient is better, don't believe them, unless they've tested a good Australian nutrient with a growth additive like Superthrive, Budwiser or Organic Growth Promotant (OGP). They will find out smartly, that these nutrients only grow a bit better because of the Americans and other countries put small amounts of hormones or vitamins into their nutrients - and imported nutrients cost more! Use Australian nutrients, and to boost growth, add a good plant hormone and Plant Vitamin treatment to the nutrient. You will be amazed!

Once you have a good brand of nutrients, mix exactly to directions. Less is better than too much. Less will make a plant grow faster, but more stretched, and leafy than normal. More will create a compact plant that hardly grows upward but is extremely bushy, woody, but can be a heavy bearing

fruiter/flowerer. If nutrient strength is strong or weak to the extreme, this will lead to deficiencies or death. E.g., too strong, and calcium is deficient because the plant is not taking up nutrient fast enough. If the nutrient is too weak, it is the same deficiency, but due to insufficient calcium in the nutrient. Follow directions and ask a store what to do. Nutrient strength can be read and adjusted by electronic conductivity meters. Ask your store what a conductivity meter will cost. (See also Appendix on advanced nutrient control through CF adjustment)

RULE: THE NUTRIENT CONTENT AND STRENGTH GOVERNS HEALTH, HEIGHT, LEAF AND FLOWER PRODUCTION, AND ALL GROWTH ASPECTS.

4. NUTRIENT pH (ACIDITY AND ALKALINITY)

pH is the level of acidity or alkalinity of the nutrient solution. Think of it as sweet and sour. Most nutrients in town water will be within the range of 6 to 6.5 pH. ALL PLANTS GROW IN THIS RANGE IN HYDROPONICS. Anyone who tells you otherwise, is either horticulturally trained in soil only or is reading materials drawn from soil based research and is therefore untrained for plant nutrition in Hydroponics. I extend my apologies to Horticulturists. Some of you do understand the nutritional simplicities of Hydroponics, but 4 years of soil training is hard to overcome, research into Hydroponics is still new, and soil nutrition is not suitable for the simple Hydroponic plant. If recycling nutrient, pH and Nutrient strength can change as certain elements are taken in by the plant. All you have to do is change the nutrient for fresh nutrient as often as possible, or adjust to the correct reading with a set of meters. If the nutrient is too sweet or too sour, the plants will develop deficiencies. I will discuss manual care, electronic adjustment, and computer control later. As discussed in water purity - pH must be checked if you are using rain, dam, bore water or any other source than town supply.

RULE: pH IS THE KEY TO KEEPING PLANTS FEEDING ON THE CORRECT ELEMENTS, AND KEEPS THEM FROM DEFICIENCIES.

5. TEMPERATURE AND FRESH AIR

Optimum temperature depends on the plants. Generally, Phosphorus up-take is severely impeded below 15 degrees Celsius, so that's our bottom temperature. It is recommended to heat the nutrient if it is below 15 degrees Celsius for more than 4 hours per day. Maximum temperatures are, (as a guide) around 30 degrees Celsius but as long as it is well below the temperature where humans start to sweat the plants should be all right.
Use common sense. If the plants are in 20-25 degree temperatures and 40-60% humidity, then it is likely that you would feel comfortable where the plants are. By coincidence, plants tend to grow best in climates approximate to human comfort. So if you visit your plants and it feels like a blast furnace, or a freezer, it is likely they would benefit from some attention on the matter. Fresh air is absolutely essential in shade-house, tunnel-houses, glasshouses and grow-rooms, as the Carbon Dioxide the plants breathe is essential for every plant process. Poor ventilation will kill plants, as surely as poison. You will notice ventilation problems by the better growth near vents, doors, or fans. If plant growth is more sluggish away from these areas, then you should improve your fresh air, or use Carbon Dioxide enrichment systems to add CO2.

RULE: PLANTS NEED CARBON DIOXIDE IN EVERY PLANT PROCESS. THEY NEED FRESH AIR, NOT TOO MUCH HEAT OR THEY CANNOT PROCESS DUE TO WATER LOSS AND NOT TOO COLD OR THEY CAN'T GET THEIR FOOD.

Plus one other basic:

WATER PURITY

Town water is generally suitable for Hydroponics, but if you are using bore water, spring water, dam water or rain water, you may have to check to see if this is suitable.

What problems could occur, is the salt content of the water, may be too high, the zinc content from metal (zincalume) tanks, could make it toxic for plants (even though it may be still safe for us to drink), as well as any number of chemicals, poisons or fertilisers, could be contaminating the water supply. Please speak to a Hydroponic Company about the water supply if you are unsure.

In all the above cases, pH control of nutrients is required.

However town water is generally fine.
Now we have looked at common sense approaches to growing conditions, we can identify 90% of problems and correct them. Let's have a look at the five systems!

SYSTEM ONE:

Perlite and Vermiculite.

SETUP COSTS LOW.

RUNNING COSTS AVERAGE.

EASY TO BUILD VERY EASY.

EASY TO RUN VERY EASY.

MAINTENANCE FREE AVERAGE.

RESULTS GOOD.

THE INGREDIENTS ARE:

GOOD LIGHT LEVELS.

PERLITE AND VERMICULITE.

WATER WITH HYDROPONIC NUTRIENTS.

CONTAINERS, POTS WITH SAUCERS OR RESERVOIRS.

Variations could be Polystyrene Boxes, Planter Bags, Channels, Plastic Tubs, and Buckets.

Concept:

Perlite is a white porous substance that is Very light and made from volcanic glass. It is an excellent soil substitute and will hold moisture for short lengths of time. Vermiculite is made from mineral ore and appears as a brown flake that can hold 100-300 times it's own weight in water. By adding two parts of Perlite, and one part Vermiculite in a well draining container, the nutrient solution that will be absorbed and held by the Perlite and Vermiculite mix is the right amount to keep the roots moist (a good ratio of oxygen to nutrient). This Mix will enable you to feed a plant and still keep the roots healthy. Perlite and Vermiculite are both Sterile and contain no disease or bacteria due to the heating in their manufacture.

Design:

Garden Pots are the easiest containers to use. By keeping the Perlite and Vermiculite Mix moist, the plants can draw upon the nutrients and grow. System variations. If using Polystyrene Box or Plastic container drill a hole in the side about 5 to 10% up from the base of the box, so that you will have a reservoir of nutrient in the bottom. (e.g., in a 10-cm high container, make a hole about 0.5 to 1 cm from the bottom.) The other benefit is that if you over-water, or rain fills the box the hole will provide drainage. Plastic sheeting inside a wooden frame can make a good garden bed. Make sure there is a slope on the bed and a point to drain off rain or over-watering of nutrient. If using PVC pipes or channels filled with the Perlite and Vermiculite Mix, ensure a slope and drainage point. Remember, in all designs, look for a system that will drain if saturated.

Set-up:

1. If potting an established plant first wash roots thoroughly in tepid water to remove soil and place in pot or container. If starting from seed go to step 2.

2. Empty perlite into container (around roots if potting established plant) and wet with fresh water. If starting from seed, sow seeds so that the Perlite and Vermiculite mix just covers the seeds and keep the seeds moist with fresh water.

3. Feed plants with nutrient when seeds have fully germinated . The seeds should be seedlings after the first seed leaves or cotyledons have appeared and the first true leaves have opened. This indicates that the seedlings have developed roots and can now feed on nutrients.

Maintenance: (or how to keep the plants growing)

All you need to do, is check the saucer or reservoir, to see if it is dry and see that the Perlite and Vermiculite is still moist. Ensure that the Perlite is moist; do not worry if the top is a little dry. Test by pushing your finger down into the mix. The lower parts where the roots are should be moistened by capillary action from the bottom saucer or reservoir. The top area may be dryer due to evaporation.

Problems:

If your plant does not look as healthy as it should, you should flush the Perlite and Vermiculite with half strength nutrient until it drains freely out the bottom of the pot. This will wash any nutrient inconsistencies out and replace with a good supply of nutrient. If the plant is not draining freely, then something is wrong; i.e. the plants are water logged and are drowning. Check drainage holes are not blocked. If problem persists, please contact your nearest store.

Growth rate (oxygen : nutrient ratios)

Because Perlite and Vermiculite are lightweight the oxygen levels are good. Because the nutrient is not recycling, the dissolved oxygen levels are low. Growth will be better than soil, but less than recirculating systems.

Heat and Cold Control:

Generally heating and cooling methods are not available because this system does not generally recalculate. Placing pots on a heated bed can work in cold climates.

Suitable crops:

All Crops.

Short-term crops only need a small container.

Root crops need depth, Carrots and Onions about 20 cm. For Potatoes, cover seed Potatoes and water till moist. As the shoots appear, cover with more Perlite and Vermiculite. The higher the container the better, (best in a Plastic Garbage bin with drainage holes). Try and let root crops like Carrots and Onions dry out a little before re-watering. For example, after a saucer has been empty a day,

then water....

Tall plants and heavy feeding plants need large pots or containers to draw nutrient from. The Larger the pot, the more Perlite Mix and therefore, the more nutrient held in reserve. Use large pots if you water infrequently.

Good system for permanent and root crops.

Great system for houseplants too!

Set-up Costs:

Enough Perlite and Vermiculite to do Five 200 mm (8") pots costs around $10-$15 Perlite and Vermiculite breaks down into a fine powder in 2 to 5 years. However, if the Perlite Mix becomes contaminated by soil, bacteria or disease, then you should discard and restart.

Pots/Boxes:

Pots or Boxes at cost according to size and shape. Polystyrene Foam

Boxes are easy to break.

Plastic lined beds:

Plastic film is usually around $7 for 3m x 1m of black heavy-duty plastic panda film. Replace plastic if torn, but don't repair as some glues used for patching holes can be really toxic to plants. Timber Framing costs can be high. Try Bricks or other frames. I recommend for drainage, pest control and sterility, that you do not line a channel dug in the ground or use earth walls.

PVC Channel:

Use ONLY UV stabilised channels or they will crack in sunlight. Storm-water pipe is designed to be underground, away from UV light!

Running Costs:

Nutrients should start at about $7-$8 (about 50 litres of watering solution) and a standard hobby pack at $20 (200 to 400 litres of watering solution) Running costs should be quite low, unless plants are in hot areas that create evaporation.

Options:

Auto pot valves, feed plants automatically. Cost around $22 to $25. Connect to a drum and the valve will fill a container to 20-30 mm of nutrient, then wait until dry before filling to 20-30 mm again. Ideal to use for maintenance free growing by using large drums for reservoirs, especially for growers that travel away for many days or weeks.

Wick Systems:

By filling a tube with Perlite, you create a wick. This Perlite wick can draw nutrients from a bottom tray, up as much as 10 cm to moisten an upper tray. Many basic kits sold by Hydroponic stores use this design. If designing a wick system, steal their design first! Then grow for it. In fact tell the store what you're doing. They'll probably help you do it!

Expansion:

Expanding your system is not difficult. Generally you just add more systems. Perhaps you could connect all trays with hoses, so that any nutrient in the base of one pot can be equally used by pots with more thirsty plants. If doing so, be careful to check for leaks. If the nutrient leaks away the plants can just seem unnaturally thirsty!

Variations of materials used:

DO NOT use metal containers near hydroponic solution unless a very good layer of plastic has been coated onto it. Generally, plastic is the best container for all Hydroponics. Some plastics can be toxic to plants, and some pots are made of this reground plastic, usually recycled plastic with Lead in it. This type of plastic is not high quality and is usually black, so if you have cheap and nasty looking containers; try this test. Put some of the plastic in boiling water. SNIFF THE WATER; if you can smell the plastic, it probably is toxic. SECOND, TASTE THE WATER when it's cooled enough. If you can taste plastic, then it's probably toxic. Ask a good store if in doubt.

Pre-built systems are available in most stores. Asking for a starter kit usually means a Perlite and Vermiculite growing system. Check your stores out. Steal their designs if you want but don't forget to buy some of the ingredients from that store.

This system is good for beginners, and is the best system for the hobbyist to grow Carrots, Onions, Potatoes, and other "root" vegetables and bulb crops. It is highly unlikely to cause problems unless the Perlite mix is saturated and the roots are drowning.

For a basic system, I think it is ideal for everyone.

SYSTEM TWO:

NFT or Nutrient Film Technique.

SETUP COSTS AVERAGE.

RUNNING COSTS LOW.

EASY TO BUILD SMALL AMOUNT OF SKILLS.

EASY TO RUN VERY EASY.

MAINTENANCE FREE VARIES BETWEEN TWICE A WEEK AND AUTOMATIC.

RESULTS EXCELLENT.

Ingredients.

The ingredients for NFT are - flat bottomed channels/gullies.

As an option they would be preferably in one piece only (not lid and base).

Irrigation lines.

Pump and tap to draw excess pump pressure away from main feed line.

Plastic or fibreglass tank.

Filter system such as header box.

Stand for channels if necessary.

50 mm pots for seed raising if starting from seed.

Sterile (& fertiliser free) seed raising mix (Perlite and Vermiculite Mix).

Nutrients.

Concept.

Dr. Allan Cooper in England invented this technique, during the 1970's to save the British Glasshouse industry from cheaper European imported vegetables. It had to be inexpensive to produce crops, and inexpensive to set-up. Therefore, the nutrient should be the only cost for running (except minimal pump power), and there should be minimal need for cleaning and other labour. NFT has proven to be one of the top performance systems, as well as being the lowest maintenance system in terms of cost.

The Concept of NFT is simple. The plant roots grow on a surface that has no more than 1 mm of nutrient moving slowly across it. This is called Nutrient Film Technique, as the nutrients are a film on the base of a flat surface (like a damp surface). The plants roots are not submerged, and have access to the air, yet can draw up as much nutrient as they require from the damp surface. We usually use channels for this as channels or gullies keep the light out of the root zone. Light on the roots generally slows the growth rate. By having a running Solution of 750 ml to 1 litre per minute down a flat surface at 1:40 slope (1:40 = 25 mm drop every meter) we can achieve the nutrient film.

Design.

Remember our basics. We must have good light levels. Tiered systems can cut down light because of the plants above shading the lower plants. The standard system is a table of parallel channels with a fall of 1:40 built into the stand that holds the channels. We must have good Oxygen levels; therefore we must control the flow rate exactly. We must control both nutrient strength and nutrient pH, and as this is a recirculating system, we can optimise the nutrient readings easily by testing and adjusting, or by dumping and restarting the nutrient. We must have good ventilation, therefore plants must be spaced for airflow, and the channels should be off the ground, to provide additional ventilation. The stands also keep soil pathogens away from the system and a number of pests as well. The Stands make it easier to plant and harvest plants as there is minimal bending and stretching for the grower.

We will feed each gully through two small dripper lines to ensure that each channel receives the same amount of nutrient. (You will note that we also use two drippers instead of one, so that in the event of one blocking up, there will still be some flow of nutrient into the channel). We see in figure 2.1 how the channel has a nutrient film of 1 mm running down a 1:40 slope, and the plant holes that will take either a seeding or a small pot. These small pots give the seed the minimum amount of moist seed raising mix to start the seed off.

The roots of the seedling will quickly grow out of the bottom of the pot, and lift the pot to keep the seed raising mix dryer from this point on. This will eliminate stem rot problems caused by high moisture and low oxygen within the pot.

We see in figure 2.2 how the roots are exposed to the air in the channels, and kept moist by the roots drawing up the nutrients by capillary action (like laying a sponge on a damp surface.)

We see in Figure 2.3 a table set-up, noting stand fall, tank and pump placement (do not use gravity feed as it complicates the whole idea of simplicity. Besides, a small 10 Watt Submersible pump only costs about Aust $8.75 per year to run flat out)

We see in Figure 2.4 the irrigation lines. Note the use of 15 mm PVC pressure pipe to balance the pressure to each dripper and the optional unscrewing end cap to flush the pressure line in the event of contaminants or grime that might block drippers. The drippers are 4 mm micro-tube and are placed into the pressure line by drilling a hole that is slightly smaller (usually 7/32nd drill bit) and placed into the pressure line by soaking the dripper in hot water first. By placing the dripper in this way, without glues, solvents, or silicon, we can easily replace them if they become brittle, split or block. However for any basic blockages, you can clear the dripperline by just tapping or blowing down the dripper.

We see in Figure 2.5 the pump and the tank. The tap shown here controls the flow rate by taking some of the pump pressure away and sending it back into the tank. This also provides agitation and some additional aeration of the nutrient. We see in Figure 2.6 the wrong way to recover nutrient. By putting a hose in the end, we will cause a pool of nutrient to back up in the gully, causing root problems because of deep water. The right way is to have the gully bent a little using a heat gun, steam from a kettle or a good hairdryer. Try using a header box, or a 2 litre milk bottle to catch the nutrient and then drain this box or container.

Set-up.

Pick a place that has plenty of light. Using shade-cloth is usually necessary for hot conditions and what is considered hot would relate to individual crop techniques rather than Hydroponics.

Try to set up the system on a reasonably level surface so the legs of the stand can be made to basic lengths to give the whole stand a uniform 25-mm drop per meter. By measuring the stand length and making the legs 25-mm shorter for every meter, you will achieve an overall slope of 1:40. The Channels will bend if insufficient supports are used. As a guide, 2 part channels (Base and Lid type) require a support every 1 metre, 4 sided down pipe every 1.3 to 1.5 meters and 6 sided channels every 1.5 to 1.8 meters. For long systems, such as commercial benches, it is best to pick a gully with the least supports required because the costs can skyrocket when nearly twice the number of stands are needed. If possible, set up in a position that is not exposed to gusting winds and heavy rains.

You can set up a float valve on your tank to replenish nutrient levels with fresh water as the level drops. If you can pick a place near a tap this may be an advantage.

For a system with up to 30 holes, we would use about 20 Litres in our tank. (I calculate usually about 650 ml to 700 ml per plant for a home system). Mix 20 litres of nutrient according to pack directions. Adjust nutrient strength (CF or EC) and nutrient pH if necessary. Turn the pump on and keep the adjustment tap closed. Then take the two drippers from one of the gullies and allow to run into a 1-litre container. Time the rate of flow, and adjust the tap until ¾ litre to 1 Litre per minute is obtained. Then check that all the gullies have a 1mm nutrient film.

Plant your seeds into a 50-mm Hydroponic pot filled with Perlite and Vermiculite mix. The seeds only need to be just below the surface, around 1mm deep. Moisten the pot with fresh water to start germination. If starting from seedling, then wash the roots in tepid water till free of soil. Do not damage the roots. Place in a hydroponic pot with Perlite and Vermiculite Mix. You can keep the seedlings in a warm spot until roots appear at the bottom of the pot, or just place the pot with the newly planted seed into the gully. Maintain the nutrients by changing it every 7-10 days or adjust with electronic testing equipment. (See Appendix on Nutrient Control) The nutrients and the flow rate need to be maintained until Harvest.

Maintenance.

The only maintenance is to see that the nutrients are changed every 7 to 10 days or adjusted with the electronic testers, and that the nutrients continue to flow without any blockages. Normal crop techniques such as tomatoes trellised to a wire, stake, or lattice will apply as usual.

Problem solving.

Root rot occurs when the flow rate or slope is incorrect. The effect is that the roots are waterlogged by excess nutrient. The lack of oxygen makes the roots susceptible to rot. Regular checks of the flow rate will eliminate this problem. To identify Root rot, there may be the following symptoms: slow growth, wilting, or yellowing of the older leaves - but always accompanied with discoloured roots, either brown or black and a mild to strong odour of rotting. Sometimes the roots are covered in a slimy coating. Call your local Hydroponic Store. Fungal rots are rare but can occur, when the water supply is contaminated by Phythium or similar Fungi. This is true of Hydroponics and soil production, so please do not panic.

Regular changing of the solution usually eliminates the fungal build up, or Ultra Violet sterilisation of the water supply would be needed to kill Phythium etc. Generally dam water can suffer this problem as the fungus comes from soil runoff.

Remember whenever in doubt check the basics. Light oxygen to nutrient ratio, (In this case, check that the flow rate is between ¾ to 1 litre every minute). Nutrient strength is not too high or too low, nutrient pH is between 6 and 6.5 (if the nutrient is only 7 to 10 days old it should not vary too much) and check the temperature of the nutrient and the air.

If all else fails - call a Hydroponic Store. They are there to help YOU!

Growth Rate.

The growth rate in NFT is generally very fast. This is due to very high oxygen levels, the ability to aerate, heat, adjust the strength and adjust the pH of the nutrient. Even without adjusting the nutrient or heating the NFT is easy to achieve much better plants, faster.

The NFT idea has a flaw. When the roots get very large they can choke the gully. This happens when plants such as fast growing herbs and large plants like tomatoes grow unattended for more than 6 months in a 100-mm wide channel. Growth rate is inhibited by the choking effect. To fix the problem, use 150-mm wide gully wherever in doubt. 150-mm gully has more than just one and half times the base area, it has an air supply that is greater. A 150x75-mm gully has more than double the air space of a 100x50 gully. Even if the root mat becomes thick in a 150x75 gully, no problems develop unless plants are grown to extremely advanced ages.

Heat and Cold Control.

Heating the nutrient becomes advantageous when the temperature of the nutrient drops below 15 degrees Celsius. The optimum for growth is 20-25 degrees Celsius. If a small 20 to 80 litre reservoir needs heat, a 150-Watt aquarium heater with a thermostat is ideal. Set the temperature in-between 20 and 25 degrees for best results. For tanks up to 160 litres use a 300-Watt aquarium heater, and for larger tanks, there are some excellent custom made heaters from 1500-Watt to 2400-Watt. The element is designed specifically for your tank. These are the most efficient way of heating up to 5,000 litres without getting a heat pump. If cooling is required, refrigeration, ice, and other methods are generally inefficient or ineffective. Try setting up a fountain or jet of water (venturi system) off your pump pressure. This will cool the nutrient as it falls through the air (as well as adding oxygen to the nutrient). It only takes a little imagination to increase the cooling effect, with a fan (If you have your tank in a tank room this is easy) or more ventilation over the tank on hot days. When in trouble, call a Store.

Suitable Crops.

In the 100x 50 Channels you can grow leafy vegetables such as lettuce, beans, broccoli, Brussels sprouts, cauliflower, celery, cress, mustard, endive, most herbs if short term (because of smaller root systems), okra, peas, schallots, silver-beet, spinach, squash, and many other medium sized plants. In a 150x 75 mm channel, you can grow all the above plus, tomatoes, cucumbers, strawberries, beans, cabbage, capsicum, eggplant, longer term herbs, marrow and melons, pumpkin, and anything that grows above ground (i.e. not carrots), and will be grown for up to 18 months. (Use common Sense. If the root system is getting too large, you should remove the plant. Some success is reported when trimming the root systems of herbs, as many varieties do not exhibit large amounts of stress when this is done carefully.) Ensure all the plants have good ventilation and light. This is determined by hole spacing. Fancy lettuce can be spaced 200 or 250 mm apart, head lettuce and most vegetables at 250 mm, but a tomato, climbing bean, cucumber or similar large plants really needs 350 to 450 mm spacing as their leaves take up too much area. Don't forget how much root area will be taken up as well.

Set-up Costs.

A parts list for NFT is usually very simple. You will need a stand, Hydroponic channels, end caps, a catchment box/ header box and drain system (preferably with a filter system of a simple design), tank, pump, feed-lines, seed raising pots and seed raising mix, and nutrients. A pre-built system of about 30 plants should cost around $400.00. To do a proper system add $90 for a nutrient strength meter and

about $20 to $90 for pH test equipment. These are optional extras that will get you extra growth. (See Appendix on pH and CF)

Running Costs.

If growing around 30 plants, with a 20-litre tank, you could change the tank every 7 days and work out how much nutrient will cost. E.g. Optimum Grow 2L approx. $20 per pack would make up about 200 Litres, or about 10 weeks of nutrient changing. Accent Culture 'S' 1 kg (a powder, you mix up liquid concentrate yourself) approx. $20 per pack would make up 400 litres and give you about 20 weeks worth of changing.

For real budgeting, a $40 pack of culture 'S' would give you 110 weeks worth of nutrient changes, or about 36 cents per week.

A pump is the only other real cost. For this system a little 600 Litre per hour pump draws about 10 Watts. Running 24 hours per day, 7 Days a week would cost you about 18 to 19 cents per week to run. THE RUNNING COSTS are the real advantage of a NFT System!

Options.

Trellising the channels or arranging them on an A-frame is very difficult in soil. It is a great way to grow in Hydroponics once you realise the difficulties and cost of these systems. First of all is light (remember the BASICS) If you have your channels above one another you will have great plants on top, but plants that look sick beneath. Make sure the front of the trellis faces north (i.e. runs east to west). You need to allow more space in a trellis than in a table, because the sun may reach all the plants except during the morning and afternoon, when it is at right angles to the kit (i.e. from the east and west). A-Frames are best-set facing north south, so one side gets the morning sun and the other gets the afternoon sun. You will note less response this way. Trellising and A-frames naturally require much greater pump pressure, as the nutrient must be pumped to a greater height. In all cases, it will cost more to set up and run. Also, if you intend to link the gullies together, ensure the total run does not exceed 12 meters or the oxygen levels in the nutrient will drop beyond healthy levels, and plants will not grow very well. Adding extra oxygen to add growth is always an advantage. You can use three methods. Either use a larger capacity pump and have a jet of water into the tank (like adding a venturi or a waterfall effect), use an aquarium air pump and bubble air into the tank through an air stone, or buy a pump with a built-in air tube that will suck air into the feed line.

Heating is always advantageous if your nutrient is going to be cooler than 15 degrees Celsius. This will happen usually if the air temperature drops below 18 degrees Celsius. See heating and cooling control above for the advantages. Float valves, like a toilet cistern; help keep the volume of water at a set level in the tank. Ideal for maintenance free systems, it makes it more secure if you go for travels.

Removable lids are an advantage if you have to clean the system and you have no plants growing in it at that time. Apart from this, mostly, plants are in the system most of the time, so you can't remove the lid without flipping your plants out. The channels rarely require cleaning inside except for a wash out from the top with fresh nutrient if there are plants in it or fresh water if there are no plants in the system. The drawback of the removable lid design is that the lid can flip off if plants are top heavy, leaving your plants on the ground, and that extra supports are required, (every meter at least) or the gully will sag and cause ponding and root rot. They are never cheaper in terms of cost, because they cost more to support.

Round storm water pipe, a round pipe is not NFT, because the pipe cannot produce a Nutrient film. Roots will form in a ball, instead of a mat. There will be much less oxygen in a root ball, and some of the roots will be in air, and some under water. To use this type of pipe, use a UV stabilised plastic (most pipe is not UV stabilised because it is meant to be under the ground) and always use a flood and drain approach. (See Flood and Drain and DFT) Dosing systems will work very efficiently with NFT. These systems test the nutrient and automatically add nutrient when required. Dosing systems need a float valve to be effective, and start from around $500.

Variations on Materials.

Lead - Lead is a filler used in the recycling process with most plastics. Unless a plastic is termed food grade, it will most likely have lead in it. Leaded plastic pipe and plastic containers should be illegal to grow plants in, and moves have been made in Australia to make sure it is. However, legislation will be a few years off yet.

UV stabilisation - UV stabilised plastic will not crack in the sun. It makes sense to choose this type of material over non-stabilised plastic. Black and white co-extruded gullies - There are brands of Gully that has been made with a black interior. I have seen farms with this type of gully, and they have nearly no algae in the gullies, and tremendous root growth due to a darker interior. This type of gully is also grained to provide better nutrient flow. This seems to produce less pooling of nutrient, and better roots. Generally, this is called Panda Gully, because it is black and white. One brand even has sloping sides to provide rain runoff and extra airflow around the lower leaves of lettuce and such. It is probably the best-designed gully I have seen.

Conclusions.

NFT is easy to run, cheap to run, low maintenance, and generally problem free.
Set-up costs are reasonably low, and little media has to be used to start the plants off. A very good system for beginners, and advanced growers alike. I like the system. I recommend it.

SYSTEM THREE:

Flood And Drain

SETUP COSTS AVERAGE.

RUNNING COSTS AVERAGE.

EASY TO BUILD SOME PLUMBING.

EASY TO RUN EASY.

MAINTENANCE FREE VARIES BETWEEN TWICE OR ONCE PER WEEK.

RESULTS EXCELLENT.

Ingredients.

Container or tray to be Flooded (Food Grade Plastic or Fibreglass).

Irrigation Lines.

Upper Level Drain System.

Lower Level Feed System.

Tank.

Centrifugal Aquarium type Pump.

Filter.

Expanded Clay or Large particle (10-15 mm) Medium.

Nutrients.

Concept.

Flood and Drain uses two cycles to feed oxygen and Nutrients to the roots. These are the Flood Cycle, and the Drain Cycle.

FLOOD CYCLE: To get high oxygen into the root zone, we can flood the root zone with nutrients, and expel all "dead air" from around the roots.

DRAIN CYCLE: After the Flood Cycle (2 to 15 mins) we can drain the nutrients quickly to draw or "suck" fresh oxygen into the root zone as the nutrients drain out and at the same time, leave the roots damp with nutrient. (15 to 45 mins) Sound Complicated? It's as easy as Pump on and Pump off !

Design.

To Design a Flood and Drain System we have to pump from a reservoir into the growing container or tray. We usually do this by pumping in at the lowest point. See Figure 3.1 (The Flood Cycle)

The overflow in Figure 3.1 is the drain point during the Flood Cycle. This ensures the Growing Container does not overflow with Nutrients. The Pump is on and the Pump power keeps the nutrient "up" in the container. The Nutrients Flow in and fill all the spaces between the Expanded Clay and Soak the Roots with Nutrient. Note that the Nutrients are never Still during this Cycle. They are flowing up and out, through the over flow. Dissolved Oxygen levels in the nutrient are high because the nutrients cannot stagnate. During the Drain Cycle (Figure 3.2), the pump switches off, and gravity forces the nutrients back through the pump into the reservoir. There is a filter to stop any damaging particles getting into the pump. As gravity drains the nutrient, the spaces between the Expanded clay are left empty, and air rushes into the spaces left by the receding nutrient. The Flood Cycle should only be as long as it takes to fill the growing container or tray, and the Drain Cycle should be at least twice what it takes to drain the container. Usually 15 minutes on and 45 minutes off is enough. If any root problems occur, lengthen the drain cycle. During the night hours only have one flood cycle in the night, and one just before dawn. If heat is necessary, flood as normal during the night, but have one longer drain cycle during the morning and one in the afternoon to add extra oxygen.

Set-up.

The Growing Area should be set up with a pump connected to the inlet, and an overflow as shown in figure 3.1 and 3.2.

The pump should be a submersible, and although you might think a larger pump than usual is necessary, it doesn't usually hold true. If the pump has to pump high, measure the distance between the height from where the pump will be in the reservoir, to the height where the overflow will be. We are only interested in height vertically, not distance horizontally even if the tank and growing area is several meters away(horizontally) from each other. (The following is an approximation of pump pressure only. It can vary in practice).

If the height of the system was 1 meter,

and you have a 600 litre per hour pump

with a 1.4 meter "head" of pressure,

then you will have 0.4 meters of pressure to fill the flood area 0.4 x 600L ph = 240 Lph.

240Lph =60 Litres per 15 mins, so you can flood a chamber of approximately 60 Litres if you flood for 15 mins. Tank size in Flood Systems should be at least 1 and a half times the growing area. (Expanded Clay takes up a lot of the volume, so the nutrients required to flood the area is not even ¼ of the growing area size) Inlet: The Inlet should be at the lowest possible point to drain the growing area. Wherever possible, complete drainage will give you the best results. Some sort of Screen should be placed over the inlet so that it does not become blocked with expanded clay during the drain cycle. If the screen is fine (like stockings), it will block with the fine particles and the system will remain flooded. Use a wide mesh made of plastic like a ¾ inch Phimac Foot Valve Screen. This is large enough to not block, and small enough to block expanded clay from falling into the inlet. (Never use metal in Hydroponics. Use plastic parts, or stainless steel, because metals will react with the nutrient) Overflow: See dig 3.1 and 3.2. Set the overflow at least 1 cm below the top of the media, or the plants can be dislodged from the expanded clay when it over-floods the media. Again, use a screen so that the expanded clay will not fall into the overflow.

Use an "in-line" filter between the inlet and the pump to collect any fine particles. Clean it regularly if you notice it is picking up any expanded clay particles.

If you have any problems, discuss it with your local hydroponic store.

Propagating.

Propagating in Rockwool cubes, or perlite mix is required to give the seeds a chance to germinate and develop a root system. Flood systems usually don't give a good result for propagation because the medium has very little water holding ability. For striking cuttings, inset cutting into expanded clay, and put some liquid rooting hormone into the reservoir. Cuttings strike very well this way, but you should shield them from very hot or dry conditions or bright sun. Misting them should stop them drying out before the roots have developed.

Maintenance and Problem Solving.

I usually would advise people to keep an eye on their plants. If the stem and leaves wilt, then increase the number of floods. If the leaves wilt with yellowing of the leaves; you may have too many floods and the roots are drowning or rotting. Immediately increase the amount of time between flooding. As a guide, try flooding 15 minutes out of every hour, by setting a household timer such as a Kambrook KD84 (15min increments) to that period. I miss out 3 to 4 floods a day, during the night, or during the morning or afternoon. The reason I do this is to give the roots a chance to get a bit more oxygen. But if the plants are cold at night, and I am heating the solution, I would not give them any breaks during the night, using the morning or afternoon to give the system a break. If I have a choice, then breaking the flood times during the day is always my second choice.

Nutrient Changes should be performed regularly, if you have no electronic test equipment. For a 20 to 40 litre tank, feeding around 2 to 10 plants, I would change every 7 to 10 days. If more plants are using the solution, then change more often, and use common sense. If your plants start looking less than perfect, try changing more often. Take a sample of your nutrient into a hydroponic store and ask them to test it for you. take a fresh sample from when it was first mixed up, and a sample before dumping. This will give you reference to how the nutrients are going. Flush the expanded clay every 4-8 weeks with a weak nutrient, just in case any nutrients build up on the expanded clay. This can occur if the plants use a lot of water, and leave the nutrient behind. This is called salt build up. Some people get this problem, some don't. Clean the filter if the system is not draining quickly.

Growth Rate.

This system is known for unbelievable growth rates when it is really well run. Even without nutrient management, and control, the high oxygen ensures good growth rates at all times.

Heat and Cold Control.

Since this system uses intermittent pumping cycles, the only time we have complete control of the nutrient is when the nutrient is flowing in the growing container. When the Growing container is drained of nutrient, the temperature is affected more by the air temperature. If heat or cold is extreme, consider using more flood cycles during that period of the day and less at other times. An example might be, very cold at night, and medium hot in the day around noon. Then you could flood more at night and miss a flood in the morning and one in the afternoon. Don't flood for longer, but have less of a period for draining. Heating the Solution is an effective way of controlling the temperature. If the weather is hot, you will find that nutrient will cool enough generally because the nutrient flowing into the growing chamber is falling back into the tank through the overflow, and the aeration is cooling the nutrient enough. Further Aeration should cool the nutrient further if required.

Suitable Crops.

Flood and Drain is excellent for permanent crops, Herbs, Flowers, and all crops. Harvesting plants usually means taking some of the media with the roots, so I do not usually grow short-term crops in flood and drain, but it works very well. If root crops are grown, make the expanded clay a fine grade, and keep flood cycles far enough apart so that rotting does not occur. Root Crops will do better in a Pot with Perlite really, but you can give it a try. Striking cuttings with a Flood and Drain System is excellent, just add some rooting hormone to the nutrient solution. Too many floods could lead to stem rot in this case so halve your flood cycles, or keep a good eye on your cuttings.

Set-up Costs.

Pump, Expanded Clay and Growing trays make this a medium cost system to set up. Some trays can cost a lot. For Price, if you are setting up the system yourself, use plastic tubs and more of them, than trays. Trays are cheaper when buying a complete kit, because stores find the labour time shorter and less framework to build more inexpensive, and generally discount the pump and media. A small tub system should cost less than $200 and full Trays up to 1 square meter in size should only cost $350 to $400. They are excellent when pre-built, but check they have included a filter for the pump, (unless they are the top feed type).

Running Costs.

Running costs are medium because the larger tank holds more nutrient and should still be adjusted or dumped regularly. Also the replacement of media adds cost because when plants are removed, as they

can take some expanded clay away with their roots. Offset against running costs is the excellent growth rate. I would rate this system a top performer. So yields can offset the cost.

Options.

Flood and Drain Systems have a disadvantage in that normal automatic filling systems using float valves are more difficult to set up as the reservoir will be lower during the flood cycle and higher after the system has drained. We should set up the float at the minimum level, and ensure no leakage around the float valve fitting. Fig # 3.3 The different reservoir quantities at flood time and drained time can make nutrient dosing computers difficult to organise as it may adjust the tank and find that during a different cycle the nutrients need a radical readjustment because the total volume of the tank changes.

However, using diagram #3.4 we can see a timing system for dosing equipment that should optimise the computerised flood system.

Variation on Feed System -.

A flood and drain system using a top feed. Nutrient pours into the top at a faster rate than the smaller holes at the bottom can drain. The overflow is still present, but when the pump switches off the system drains slowly. The bottom holes can block with small media particles, so ensure there is a drain coil (not a foam or cloth filter) around the drain point to keep them clear and allow you to check them for blockage. This system has the advantage of saving your pump from grit and cleaning, but is less responsive if the system does not drain quickly enough.

Variations on Materials.

There are purpose built flood trays, which drain completely with no pooling at the base of the growing tray. These are better than normal buckets, boxes or other containers. For DFT or Deep Flow Technique, we can use channels, or even round pipe, but flat bottoms make it easier to plumb fittings, and round pipe can only be fitted at the end caps. See DFT later in this book. For efficient draining, ask for a ¾ inch Foot Valve (Screen Only), made by Philmac. They are a drain cover with openings too small for expanded clay, but big enough to drain quickly. They are also, very easy to plumb.

Conclusions.

Flood and Drain is a very high powered system, and will give you much higher yields than similar systems. It is too tricky and expensive to consider on a large scale, and running costs versus yield is lower than NFT. You will have fun with Flood and Drain, because there is more experimentation for the grower than with normal systems, and root size doesn't matter as much as NFT as the roots don't usually choke up when large like they can in small NFT channels. One of my favourite systems for those who like to tinker around, and "play" with their plants.

SYSTEM FOUR:

DRIP SYSTEMS

SETUP COSTS AVERAGE TO LOW.

RUNNING COSTS AVERAGE.

EASY TO BUILD LITTLE EFFORT.

EASY TO RUN EASY.

MAINTENANCE FREE VARIES BETWEEN TWICE AND ONCE A WEEK.

RESULTS VERY GOOD.

Ingredients.

Media, such as Expanded Clay, well draining.

A Container for the Media - Plastic lined containers, Fibreglass trays, Plastic or Polystyrene Boxes, Pots, Buckets, Planter Bags etc.

Feed lines and Drippers

Drain/Returns

Pump

Reservoir

Nutrient

Concept.

The Plant is grown in a media that is has low water-holding capacity, and large particles, so air can move around the roots. The Plant is fed by pumping the nutrient through dripper lines. By altering the amount that is feeding the plants or by using a timer, the oxygen to nutrient ratio can be adjusted. The ideal situation is to keep the roots reasonably moist, but not wet. Results are also good if excess nutrient is used to feed the plants roots, followed by a break for them to drain off a little. The plant roots are never immersed in nutrient at any time.

Design.

Drip Systems give the greatest latitude to the designer. Almost any container can work as long as it is a food grade Plastic, Fibreglass, Polystyrene, Stainless Steel or other non-phytotoxic container. All you have to achieve is moisture at the plant roots, and have the container drain well to provide good oxygen levels around the roots. As the plant grows, the amount of nutrient required may increase slightly as the plants consumption rate goes up, but oxygen levels must never be compromised.

Drip either onto the surface of the media or just below if you wish to avoid algae on the top of your media. Ordinary garden type drip irrigation fittings seem to work very well. Ensure that drain fittings do in fact drain, and will not get clogged up by media or roots. Any nutrient pooling in the bottom of the container due to incomplete drainage can lead to root problems, as this nutrient can become stagnant, and rot the roots that grow into it. Do not use brass or other metal fittings in your design.

Set-up.

Gravity is the best drainage system, so set up your system with the tank at the lowest point, and feed from that tank directly to the plants. Use the pressure of a pump to feed the dripper as a pump is easily controlled, and the pressure keeps blockages to a minimum. Remember, Gravity is not the best-feed system, as Gravity is plagued with blocked feeders. This is because any small particle (like bits from a plants old roots) that may be in the nutrient will be moving slower in a gravity fed system, and if the particle finds a place to settle it can create a problem, because as more particles build up the end result is a blocked up feeder or dripper. And besides, I can't see the need for an upper tank and a lower tank. Pump running costs are generally very low and using a larger pump, less often, just to fill an upper tank, never saves you money.

Propagating.

Propagating in Rockwool cubes, or perlite mix is required to give the seeds a chance to germinate and develop a root system. Drip systems usually don't give a good result for propagation because the medium has very little water holding ability.

Maintenance and Problem Solving.

Generally, 15 minutes out of every hour works best. I have seen incredible variation, from adjustable drippers running with a very slow drip continuously, to gushing flow for a minute every hour. COMMON SENSE APPLIES. The roots need to be moist (and never wet and never dried out). They need oxygen. Try to give good drainage, and good amounts of nutrient, but always watch the plants for changes. It will help to get individual advice from a store, because of climate, system design, and crops grown.

Change the nutrient regularly, if you have no test equipment. For a 20 to 40 litre tank, feeding around 2 to 10 plants, I would change every 7 to 10 days. If more plants are using the solution, then change more often, and use common sense. If your plants start looking less than perfect, try changing more often. Take a sample of your nutrient into a hydroponic store and ask them to test it for you. Take two samples

to the store. The first sample from when the nutrient was first mixed up (start-up sample), and a sample before dumping (end sample). This will give you a reference to how the nutrients are going. Flush the expanded clay every 4-8 weeks with a weak nutrient, just in case any nutrients build up on the expanded clay. This can occur if the plants use a lot of water, and leave the nutrient behind. This is called salt build up. Some people get this problem, some don't.

Too much feeding will usually cause root rot, and the older leaves will yellow, and the roots will go brown or black and start to smell. Plants may wilt. Be careful that you do not interpret wilt as under-watering. Under watering causes wilting at more specific times, such as the hottest periods of the day, and during the periods before their next watering. Generally stems wilt with under-watering, and the stems are less likely to wilt with root rot.

Growth Rate.

Drip systems are generally very good for getting results, without too much design problems. If Oxygen is high in a fast draining medium, there is no reason that this may not produce very fast healthy plants.

Heat and Cold Control.

Heating and Cooling Techniques are applicable to Drip Systems, and are especially effective if the nutrient is continuously dripping, but this is difficult as roots may become too wet and Oxygen levels could be too low. Perhaps night feeding can be stepped up if the temperature is particularly low, or a greenhouse arrangement would be required. Cooling can be effective, but again, it will require the nutrients to circulating as much as possible Suitable Crops Drip Systems excel because you can build your system to suit the size of the plants' root system. As a rule, the longer the plant is to grow, the larger the growing space required. Herbs and Flowers are good in Drip Systems, and Lettuce or Tomatoes would merely need smaller root areas. I like using 20-30 Litre Crates for drip systems generally, but ensure that the plastic is not reground recycled plastic, which is usually toxic to plants.

Set-up Costs.

The set-up costs are inexpensive, except when using growing containers, which are very large. In these cases, the amount of expanded clay per plant makes the cost rise. Don't go over board on the size of containers, as hobbyists usually pick the largest container available. Even Food Grade Plastic Buckets work well for drip systems. About $40 will get you a 40 to 60 Litre sized bag of expanded clay, and you can always ask the store for $20 worth and so on. Apart from containers, expanded clay and three or Four Dollars of Polypipe irrigation, the only concern is the pump. Pumps will work for years if you buy a good one. Cheap ones usually work for a few months and give up. What you are interested in is not necessarily the flow rate but the Pump Head. This is the measurement of pressure, and the maximum height a pump will lift nutrient to. So ask a store what the pump head is, and wherever possible, keep your system low, or keep your tank up off the ground, and this will save you money in pump size.

Running Costs.

Nutrients are inexpensive. About the same nutrient consumption as for the NFT system mentioned previously. For 2 to 20 plants, a $40 pack of Accent Nutrients (makes 2200 Litres) will last about 1 to 2 years. Pumps consume about 1 cent of electricity for every 10 hours running, so running costs overall will be very low indeed.

Conclusions.

Drip Systems make a very versatile system for both long term and short-term crops. It is also the best recirculating system for the do it 'yourselfer' to make, and usually can be made from inexpensive materials, and can be expanded easily. I recommend this system for those of you who want to grow large plants quickly, with no troubles either with design or maintenance. As always, draw up your system as a sketch first and ask an experienced grower or a Hydroponic Store before purchasing materials or making the first hole. This will be like insurance, that the whole system will be designed to grow well year after year.

SYSTEM FIVE:

ROCKWOOL

SETUP COSTS LOW TO AVERAGE

RUNNING COSTS AVERAGE IF ROCKWOOL REUSED

EASY TO BUILD CAN BE VERY SIMPLE

EASY TO RUN AVERAGE

MAINTENANCE FREE ABOUT TWICE TO THREE TIMES PER WEEK

RESULTS GOOD TO EXCELLENT

Ingredients.

Types of Rockwool

Rockwool comes in different sizes and shapes, as determined by each individual manufacturer. This can often become a headache for the grower if his design incorporates certain sizes. I can explain that Rockwool comes in slabs, thick, thin, wide and narrow, wrapped slabs so growers can grow directly into the slab, and unwrapped so the slab can be put into pre-designed troughs and channels. Also available are small propagation blocks, for germinating seeds, and medium sized cubes for propagating cuttings or for growing seedlings previously grown in the small blocks.

Concept.

Rockwool is a fibrous product that appears a little like insulation slabs. It is made by spinning liquid rock and collecting the strands like fairy floss at a carnival. The fibres of rock in the slab hold large amounts of water, without depriving the roots of oxygen, and will drain well because of its density. It comes in two grades and the two grades are vastly different, although the manufacturing process is the same. Horticultural Rockwool is made from basalt rock, a combination of rock, limestone and coke. The best Rockwools are made from Volcanic Basalt. The insulation grade and cheap grades of Horticultural Rockwool are made from the slag from a blast furnace, often containing a lot of metals such as steel, iron, or copper, occasionally minute contaminants, and can affect nutrient solutions, as well as having a distinct problem with wetting down due to oils in the fibre. You can pick these grades by the requirements to wash or rinse the impurities from the Rockwool first, and this Rockwool will often foam from the wetting agents that are mixed into them. (Do note that Rockwool should be rinsed no matter what grade, as uniform moisture levels are harder to achieve if this is not done first)

In Horticultural grade Rockwool, such as Grodan, Pargro, Esplan and others, the Rockwool fibre can be placed in bags, containers, troughs or other well draining types of systems. Rockwool is best if over irrigated with nutrient and then allowed to drain as the slabs will shed excess moisture till an optimum moisture level is reached. Small Rockwool cubes are great for propagating seeds and cuttings as the moisture retention levels are high.

Design.

Rockwool is best if fed by drippers until uniformly moist. However, because Rockwool will maintain an optimum moisture level if overfed and allowed to drain, we must ensure good drainage. Rockwool Slabs can be placed in plastic troughs or plastic lined troughs, and inclined so that they drain well. Nutrients can be recycled if pH testing is done regularly. The Slabs can come wrapped in plastic as shown in figure 5.5 and the plastic wrapping acts as the growing container. A sheet of plastic is used to collect the nutrient and send it back for recycling.

Other designs also make use of the drip system by cutting the slabs into blocks and slipping them into pots or buckets (again ensuring adequate drainage). You should use a pump. Set up a drip system similar to Drip systems I described earlier. By switching on the pump for 30mins and checking when the Rockwool begins to dry out you can locate the best irrigation cycle for your system. Remember, Rockwool holds a lot of moisture, but is difficult to saturate with too much nutrient as it drains away.

The other advantage is that Oxygen is still trapped in the Rockwool fibres so plants can be over-watered if desired. Be careful not to let the Rockwool dry out too much as it can be a little bit harder to rewet evenly, and the roots will die back if they encounter dry spots. If re-wetting is required, flushing the Rockwool with a soil wetting agent can work, but good results have been obtained, (but only second hand knowledge to myself) using an organic liquid detergent such as L.O.C. or similar as these organic detergents don't seem to hurt plants. Commercial brands of detergent can contain a lot of other compounds, but the organic ones are simple phosphorus compounds with organic bases, (and keep your pH down too.) Some people have good results with Flood and Drain Systems and Rockwool. Unfortunately, I have never done this myself, so although it can work according to those who do so, I cannot comment on it. I would be very concerned with the amount of water being forced into the Rockwool, and it may take a longer time to drain than a drip system. I can imagine that the Rockwool would certainly be more evenly moistened by flood and drain systems than in drip systems.

Maintenance.

Rockwool can build up unused nutrients in the form of salts. By regularly flushing the Rockwool with half to full strength nutrient, these salts will dissolve and be washed away. Plain water flushing is not recommended as it can stress the root system and even cause damage, especially at the sensitive root "hairs" that can explode with the sudden change in osmotic pressure. pH is critical in Rockwool Systems. If recycling nutrient pH should be checked every day if possible, but at least twice a week. (Run To Waste Systems:

Rockwool can be watered till 5 to 10% runs to waste without recycling. Ensure a sample is taken from the root zone by inserting a syringe into the Rockwool and drawing out some nutrient. Syringes can be arranged through a Hydroponic Store, and sometimes they'll do a test for you.)

Growth Rate.

Growth rates in Rockwool vary between good and unbelievable, as long as pH adjustment and regular flushings take place.

Heat and Cold Control.

Heating and cooling usually applies to nutrient heating or aeration as we discussed before. Sometimes slabs can be placed on heated pads, or heating coils or hot water pipes that are in a bed of sand. This can provide the bottom heat between irrigation, but only really applies in a commercial situation. If using heated blankets under a bed of sand, ensure a "shocksafe" is installed in case of a shorted wire. In one case of the use of electric blankets I know of, the only thing that saved the growers life was that his dog touched his plants first, and was electrocuted in front of him. Be careful with cheap electrical solutions. Sometimes they treat you like a cheap parachute!

Suitable Crops.

Most common crops are Tomatoes, Herbs, Flowers, Cucumbers, strawberries (Be Careful with strawberries. They hate salt build-up and are susceptible to crown rot in continuously flowing media systems). You can also grow most medium to long term crops including good results with root vegetables. Short term crops like lettuce will grow, but you will go through more Rockwool slabs, and it will cost more than a simple Perlite and Vermiculite mix without any advantages.

Set-up Costs.

Rockwool Prices vary from town to town, and brand to brand. Check with a Hydroponic Store, however, costs are similar to a drip system to set up.

Running Costs.

Rockwool should be reused only if the root systems have not destroyed the fibrous nature of Rockwool, or if disease or salt build-up has been a problem. If so, you must factor about 1 to 3 crops before replacement in imported Rockwool, or just the one crop in Australian Growool (could be two if you are on a budget).

Options.

Granulated Rockwool is often available. This is like a shredded or flock of Rockwool and many orchid growers use it in pots, because it is not in a slab/block form so it fills the pots easily.

The Rockwool cubes or blocks suit both propagation of seedlings, cuttings and cloning procedures. The cube protects the roots, so when the cube is transferred into a Rockwool, Expanded clay, Perlite System, or even soil growing there is little transplant shock. This is because the roots are not disturbed during transplanting. Soil Growers like them because they are a better economic choice than Peat pots.

Warning to NFT growers

Rockwool cubes are not compatible with a standard NFT system. Sometimes a cyclic NFT (timed on and off) can give good results. Always ask your Hydroponic Store for Advice.

Conclusions.

Rockwool requires pH monitoring. Apart from that, a hobbyist can use Rockwool with surprising results. The Rockwool acts like a buffer to any changes such as pump failure (very rare with good quality pumps), and holds excess moisture without depriving the plants of trapped oxygen in the fibres of the Rockwool. A good system, with too many variations in ideas to list. Great for the experimenter.

Other Systems:

Aeroponics

Aeroponics is growing plants in Air. The Roots are suspended in the air, in the dark and MISTED with nutrients. The roots have maximum oxygen and a damp atmosphere in which to grow. I emphasise Misted, because I have seen systems do considerably worse than a simple drip system, because the spray was sharp and damaging to the roots. Aeroponics requires specific misting emitters to softly apply nutrient to the exposed roots, and a high-pressure pump to do it. If you can't deal with the cost of this system, don't bother trying to use lower pressure, build a drip, flood, or NFT instead. The results from Aeroponics show that this is the ultimate in all systems. There are some aeropots that are built for Aeroponics, that have overcome the problems with Aeroponics plant support. Use Expanded Clay in these pots and the roots will come out of the sides very quickly, develop to be huge. A humble lettuce can grow roots to 5 foot long, so ensure you have some depth for the roots to grow in the aero-chamber.

Drip Aeroponics.

is a new term, and is a fantastic development. Drip Aeroponics uses the common small submersible pump, and drips nutrients through an aeroponic or garden pot of any size. The pots are filled with expanded clay. By suspending these pots the roots grow out the base and hang in the air. The Nutrients exit the pot the same way, and dribble down the roots. If the drip system uses sufficient breaks to let the roots "air" of any excess nutrient, the results are Aeroponic, or at least resemble Aeroponics. Try it out! I nearly made it one of the 5 Systems. I will be writing more on this system if we can try a large trial kit to test it out on a mini-commercial level.

DFT.

DFT stands for Deep Flow Technique. The best way to explain DFT is that it is a Flood and Drain system with no media. Usually a DFT system is a trough much like a NFT system, except the roots are submerged by about 40% of the gully height with nutrient for about 15 minutes and allowed to drain down to 1mm deep for the next 15 minutes. The Flow of Nutrient is designed so that the plant never begins to float, the nutrient at any point does not have a chance to stagnate, the roots are not flooded (drowning) for too long, the roots never dry out, and the system is heavily aerated. Designing a system to do this is similar to flood and drain and has given fantastic results to some people, and not so terrific results to others. The trick is to obey the rules of Hydroponics. LIGHT, OXYGEN TO NUTRIENT RATIO, NUTRIENT STRENGTH, NUTRIENT pH, AND TEMPERATURE. I have included below a design of a system I have used. It works very well. Figure 6.2 DFT Gully, Feed and Drain System, showing the gully to be level, not sloped, and that there is a minimum level of 1mm in the system.

Bag Culture.

Basically a drip system, used by commercial growers. Planter Bags filled with Media such as Broken up or loose Rockwool, Perlite (no Vermiculite), Sand, Gravel's, Expanded Clay etc., are suitable. Use a roll of heavy-duty plastic on the ground and have a slope on the ground so that excess nutrient flows to

a point that you can run the nutrient into a plastic gutter or pipe to recycle. Drippers are run to each Bag. Use a dripper that can be adjusted for each plant. Can be effective, but prone to disease, pest and nutrient problems as all sorts of things can end up in the tank, even the enemy of Hydroponics, the dreaded dirt!

Soilless Culture-Plant Nurseries.

A combination of Disease free river sand, bark or chip, and other non-soil materials, with a trace element mix, slow release fertilisers have worked a treat for nurseries. These nurseries plants are always in demand and are usually better quality. It takes more time to set up a mix, but the pH is easy to keep consistent, and results pay dividends. If you are a Horticulturist, you can read a mere page or two of your textbooks to get a mix planned. If you have problems, give one of the large Hydroponic Companies a call. They may be able to help with a mix. Other types of systems have not been used enough to give certainties. Bag culture is too expensive for common plants, but super advanced, or mature trees can get a boost from nutrients and an additive called Superthrive. Superthrive can get two years growth into one! One way is the sand bed. Sand beds fed with nutrient provide capillary nutrient feeding when pots are placed on the sand, but algae can grow, and diseases if Sand is very wet on top. Clean up for Sand beds is messy. Otherwise consider overhead sprinklers, with recycling via the plastic sheeting or under gravel drain coils. These could work well.

Soilless Culture-Landscaping.

Landscaping, without dirt??? Yes it is possible, and even practical. If you consider how well plant growth can be controlled in Hydroponics, as well as computerisation from around $500 to $600, why not? For Landscaping, the design is critical if nutrient is to be recycled. Plastic containers and fibreglass enclosures can be sunk into the ground, and will work well. These can be connected to PVC pipe to drain to a main reservoir. For large Landscaping projects, plastic coated concrete troughs can be laid and a drip system used with gravel as the medium (decorative gravel at the top). A concrete mould can be poured in such a way that the nutrient runs all around a building like a huge pipe channel, and drains at only one point. If it were flat on the bottom of the concrete, a secondary Hydroponic System like NFT would be effective to supplement growth. Use Groundcovers to cover the gravel, to reduce overheating of the gravel in hot climates, and to lower evaporation and keep heat in for colder climates. For Indoor Landscaping, with the use of Sky-lighting and Artificial Lighting, the effects can create a centre-point to an entire building. Imagine your own rainforest bathed in the glow of Son T Agro lighting even at night or at your command. (Son T Agros are very much like a sunset in colour, and rainforest effects as well as excellent growth have been used by Hydroponic Landscapers before.) See Artificial lighting below.

Fodder Production.

Commercial Hydroponic Fodder Production is quite common in Race horses and High grade or unusual Livestock. Seed is placed in large trays, either barley, oat varieties, or other fodder seed, and misted from above until moist. No Medium is used for growing (although sometimes a blotting type paper suitable for ingestion is used). The seeds are lit with fluorescent lighting 24 hours per day and heated to a suitable temperature, usually 25 degrees Celsius. High humidity is maintained by intermittent misting of nutrients whenever the seed begins to dry out. Some varieties of fodder can mature in days, and the fodder is lifted off the trays, root mat and all. The animal will eat the root mat as well as the green fodder. Hydroponic Fodder is fast, easy (once the system has been set-up), and highly nutritious. I am not an expert in livestock nor do I have any knowledge of livestock nutrition, but I believe the animals will still require secondary sources of food to achieve total nutrition as is the case with most fodder, however, this feed is generally very high quality and very fresh. Fodder Machines can be installed into trailers, caravans, or vans, and brought to the racetrack/livestock show/etc. with your animals. When a site has been found at the show, you simply hook up into electricity and water and switch the fodder factory back on.

Commercial Aspects of Hydroponic Vegetable and Flower Production.

Primary Considerations: Market and Water Supply.

Before entering into a Business of any sort, you must thoroughly research what it is you are going to produce, how much it will cost and how much you can expect to be paid for it. If you have a significant demand for the product then you can consider the profitability of such an enterprise. Many Growers in Soil and yes, in Hydroponics as well, have gone to the wall by growing something that was over supplied or under valued by the consumer. Always research your crop and see what highs and lows there have been in the past, consider that unless there is sufficient under-supply, you may end up with a crisis where the crop is not worth selling because market price is too low to meet the cost of producing it. For instance, Strawberries can go from 80 cents per punnet to $4.00 per punnet; less market costs, transport costs, labour to pick and plant, nutrient and runner costs, electricity and so on. At 80 cents many growers tell me it's not worth it. If you can secure a buyer such as a restaurant direct it is safer, but still no guarantee that you'll get a good price, or that they'll take your produce on the days you harvest. If you are growing an UNUSUAL or NICHE product consider that there must be some demand or you may have no buyer at all. Commercial Growers can make a fortune if they are good at business first, and good at growing second. First contact your Department of Agriculture or Primary Industries. Get some information. Contact your nearest market. Get some information. Talk to Hydroponic Suppliers. Get some information. Check your water supply is suitable for Hydroponics. Start planning your first year profit and loss. Show it to a grower - ask a store if you don't know any.

An Accountant might be a good idea, if you haven't done a profit and loss before. Once this all has happened, you can see what your moneymaking abilities are. If you will be borrowing money from banks, you will need to consider how this will eat into your profitability. If it is your own capital, consider the returns on your money. There can be many tax breaks when you are a grower (ask an accountant) which can make it extremely profitable as a negatively geared enterprise to recover taxes you already pay. Then get some growers to recommend your next step. Always talk to someone who has done the job. Look at different systems. If you have to travel around, the cost is a good investment. Don't forget your business sense when chasing your dreams! Hydroponics is very commercially viable, because of cleanliness, low labour costs due to less weed control, spraying etc., usually lower transport costs as farms can be closer to town, the farms require little land (1 to 5 acres of flat available land), much lower running costs, but higher set up costs (can be offset due to the cost of tractors and heavy machinery that are generally not required). The best farms have been run by good business people and the most profitable growers are on main roads (roadside stalls increase profitability), on islands, in deserts or remote locations where normal agriculture is too unproductive and produce is freighted in. (Prices higher) Consider also, if you have a farm in a tourist location, that people may pay for a tour, if a cup of coffee and a Hydroponic starters kit is thrown into the deal. Use your imagination.

Propagation.

Starting from Seed.

Seeds require only moisture and warmth to germinate. God's design placed every nutrient required by an embryonic plant in the husk of the seed. Besides, nutrients cannot be absorbed until the plant has roots, so why waste your nutrient. Better results are obtained in media that have no nutrient, than in potting mixes, because the availability of nutrient can actually draw goodness from the seed husk. Optimum germinating temperatures can vary from seed to seed, but as a guide, 20 to 25 degrees should give you a very good strike rate. The most critical time for a plant is the first two weeks (generally), because the plant will develop into an ideal plant if it comes from a good strike and a good environment. Both the top of your hot water service and on the top near the back of the fridge near the condenser are two locations in the home that should have excellent warmth for low cost propagation. Desk lamps can also provide some warmth for a tray of seeds, however, the light is not really an issue until the seeds have leaves to use it.

Using Perlite and Vermiculite mixes has been a professional method for many years, sometimes with a small amount of Peat to turn it to the colour of dirt. (I think that's why the Horticulturists add peat. Peat is dark, but Perlite looks unnatural to them, it is white and doesn't look dirty enough. Just to digress for a second....I pride myself in the fact that my garden doesn't get my hands dirty. I can now avoid the "Dreaded Dirt") Rockwool cubes are an excellent way to start seeds as they hold their moisture for long

periods. My only concern is that if the Rockwool seedling is placed into a continuous flow system, the Rockwool can get too waterlogged and cause stem rot. Remember that Rockwool cubes are impossible to remove from the plant roots without pulling most of the roots off too! Seeds germinate when moist, not when wet, or after being allowed to dry out too much. The seed swells with moisture then some miracle happens and a bit of dead plant (the seed) actual begins the life process again. The first to emerge is the seed leaves or cotyledons, and the first root has not fully developed yet.

Nutrients could be applied now but half to a quarter strength at this stage. Be careful not to over-water or allow them to dry out at this point. When the next set of leaves emerge there will be a root system in place. Continue with half strength nutrients for a week or until the next set of leaves is formed. The whole process can be a long period, but as a guide, 3-10 days to emergence in summer, up to 3 weeks in winter if at all, and 2 to 5 days if optimum heat is applied.

Taking Cuttings or Cloning.

Cuttings are to be selected from healthy parent stock only take a cutting from non-woody stems if possible take at least 25mm or 1 inch more than required immerse the cutting in water make a cut with a sterile razor or scateurs whilst underwater just below a branch By cutting underwater you eliminate air bubbles forming at the incision and blocking the rooting process. make this cut diagonally (about 45 degrees) to the stem (still underwater) cut off the branch just above the first cut to provide another surface for roots to strike (still underwater) Gently scrape the stem for 25mm above the cut to disrupt the cells on the stem (still underwater).

Use the sip of life technique for hard to propagate cuttings by using an extremely sharp razor blade to puncture the stem about 25mm from the base of the cutting. This puts a small amount of water into the stem and must be a very thin cut, as the incision must close itself up when you withdraw the blade. The cutting will now suffer less dehydration whilst rooting.(still underwater) remove the cutting from the water (Optional) dip cutting in a root rot treatment to avoid stem rot during rooting dip the cutting in a rooting hormone, preferably a Gel, or a Liquid and stir around for 15 seconds. Powders can rub off. Place in Perlite and Vermiculite Mix or a Rockwool cube, and keep the medium moist. Dehydration is the major cause of cutting failure because there are no roots to replace lost moisture. Best strikes above 20 degrees Celsius. Up to 30 degrees Celsius.

Mist the cuttings with water to stop dehydration (and a vitamin B solution such as Superthrive if available) Using an aquarium as a mini-greenhouse keeps dehydration down to a minimum. Small clear Propagation shells are available with vents designed for this purpose at Hydroponic Stores.

A Cutting will usually live or die within the first 3 days (72 hours) Use up to 24 hours of low light intensity (such as Fluorescent light) to ensure photosynthesis is still occurring, but not so bright as to cause dehydration. After the cuttings appear to be rooting, vent the propagator to avoid stem rot or root rot from the high humidity. Remove the propagator after 1 week if all is well. When in doubt, ventilate the mini-greenhouse but use warmth and keep some humidity in the propagator for as long as you require to confirm they have survived.

Transplant cutting if required when rooted.

Tissue Culture and Microponics.

Tissue Culture is the process of taking a small slice of a plant, and by using extremely sterile conditions, propagating the slice in a test tube or petri-dish into thousands of tiny "plantlets" This is achieved by a series of dividing and then a short period of growing or nurturing, followed by further division of the plant material. This can go on and on until one plant can be cloned millions of times. Due to the lack of popularity, this form of propagation is still the mainstay of bigger commercial propagators that have the skill and knowledge to blend different strains of plants together. The advantages are that the offspring from these test tube cultivators can be designed to incorporate disease resistance, new or better colours, and shapes or be faster or greater yielding plants. At home, we are faced with lack of materials to achieve good tissue cultures, but home kits are becoming available and soon this will be another avenue for the home gardener.

A new term called Microponics is a technique involving simpler techniques, larger plant sections, but is still being researched. Hopefully, a future revision of this text will eradicate the need to take cuttings, and you will read of methods to produce perfect clones every time, just by finding a suitable parent plant that you wish to duplicate. Microponics may prove to be an ideal method.

CF and pH.

The basics of Nutrient Control.

pH and Nutrient Strength will change as plants use the nutrients you feed them. The Nutrient solution will eventually become depleted, and your plants will have nothing to continue growing with. There are two ways to treat this situation. Empty your tank and fill with fresh nutrient every 7 to 14 days; or test and adjust your solution and dump every 7 to 28 days. The latter will ensure problem free Hydroponic Gardening. The former will cost you more in Nutrients.

Nutrient strength is either read in conductivity factor , or in parts per million. If conversion is needed, a multiplier of 65 to get parts per million is approximate enough. By keeping the nutrients at an optimum level, your plants will do much better. The range of nutrient strength is 8 to 30 CF, depending on the plant.

Some guidelines would be:-

8 to 12 will apply to lettuce,

10- 18 for ferns, herbs,

16 to 22 for most vegetables and plants generally,

22 to 30 for Tomatoes or heavy feeding plants.

We try not to grow plants that have much different nutrient strength requirements in the same system (such as lettuce and tomatoes) but if you did, these would be best grown at or just above the lesser of the two plants If I was growing Tomatoes (22 to 30CF) and Lettuce (8 to 12 CF), I would set up the system at 12 to 14 CF.

Another option could be that if you are growing a mixture, using 16 to 22 and keeping your lettuce in another simple system, such as Perlite mix, then hand watering the lettuce or arranging a drip system could allow you to optimise the other plants in the system. I say this but remember, good results have been obtained with Lettuce mixed in with plants at this strength (16-20CF). We must emphasise that Lettuce is the difficult crop to mix with others (except for some herbs), due to its abnormally low Nutrient requirements. Otherwise for a mixture of plant varieties outside of Tomatoes and Lettuce, 16-22 CF seems to work well in most situations.

The pH of a solution is the acidity or alkalinity of the nutrient. When a Solution is too acid, plants have difficulty taking up most elements. When a Solution is too alkaline, similar problems develop. pH is read on a scale of 0 to 14. In soil pH can vary and can be difficult to adjust. However, in Hydroponics, adjusting the solution with pH raise or pH lower to read between 6.0 to 6.5 (optimum 6.3 pH) will allow all the minerals and micronutrients to be more available to the plant. Figure 6.3 pH Chart showing availability of minerals in pH ranges always top up your tank with water and test your nutrient strength first. Then adjust the strength if necessary. Then you should test pH and adjust if required. If testing both Nutrient Strength and pH, the nutrients need only to be changed on a fortnightly to four weekly basis. (The more often you change your nutrients, the more 'balanced' your solution will be. But as you will be adding nutrient as you go, the nutrient balance does not become as critical as it does without.) For pH control, you will need pH test tape or a Handheld pH meter, pH Raise and pH Lower. For Nutrient Strength a CF meter is best. Don't forget a calibration solution to check that your electronic meters are reading accurately.

Advanced Plant Control through CF control.

Osmosis is the theory behind nutrient uptake from the roots. If we take a nutrient strength of say 22CF, the concentration would be roughly 99.86% water and 0.14% minerals. However, in a plant root system, there may be a concentration of up to 70CF. Because there is a higher concentration of minerals and therefore a lower content of water in the roots, the water from the solution moves through the membrane-covering that the roots have, taking the minerals in our nutrient solution with it. It doesn't actually happen that way. Experts tell us there are specialised receptacles for certain minerals, but even the experts are not sure how the roots really work. This is a convenient way to explain how nutrient

strength works. If the concentration of nutrient is increased, the water content decreases, but by minute amounts. The difference between concentrations in the roots and in the solution is now closer, and nutrient solution is absorbed through the membrane more slowly. The effect on growth is exactly as you might assume.

1. The higher the CF strength the slower the new growth of the plant.

2. The Lower the CF the faster the new growth of the plant

This would be, in the case of Tomatoes, a change from 24CF to 30CF or 0.156% to 0.195% nutrients. You cannot adjust a solution that accurately without a CF meter.

Also, due to the concentration then changing inside the plant, the emphasis on the type of growth changes.

1. Stem growth is more woody and usually thicker, the higher the concentration.

2. Leaf growth has more emphasis when the nutrient strength is low

3. Flower/Fruit Production has more emphasis when the nutrient strength is high

4. Height is determined in plants by the internodal length, or the distance before another branch or leaf occurs. The Internodal length is closer (plants are shorter and bushier) when the strength is high.

5. Calcium is a difficult element in terms of nutrient strength. While Nitrogen and other elements can be moved by the plant from the older leaves to newer leaves if required, calcium cannot be stored or moved. It must be available to the new growth at all times or calcium deficiency, characterised by tip burn of the leaves and blossom end rot on fruit, will occur. If the nutrients are not being taken up at a fast enough rate, the leaves will begin to brown at the tips. This occurs because the nutrient strength is too high and the nutrient uptake has been slowed by the high strength. If nutrient salts are building up

in a Perlite, Expanded Clay, Rockwool or other media System, the plant roots are in the same situation of high nutrient strength. When adjusting CF levels with a crop, immediately check your strength if tip burn occurs.

By using CF control, we can control the stages of growth. The only more effective way is to use day length control with artificial lighting as discussed below.

Indoor Lighting

I can't explain in just a small book what goes into lighting and the indoor environment. In all cases, I suggest you ask a Hydroponic Store for Advice, but I can give you a few guidelines as to what to expect.

Spectrum:

Spectrum is the colours that the plants use. Plants use Oranges to Reds more than any other colour. They give the plant the highest energy levels. But without enough Blues they will become unhealthy and spindly. Blues cause a plant to grow bushy and leafy, but reds encourage the upward growth. Ultra Violet doesn't help much, in fact outdoor growers have seen improvements in plant growth when grown under a sheet of UV protectant glass. Infra Red Light is Heat, and doesn't help unless heat is required.

Light Intensity:

Light Intensity is important as well as colour spectrum. You can't stare at the sun without damaging your eyes, so you can imagine the brightness that plants require to grow to maturity. The more the total leaf area, the greater the light required to keep the plant healthy. Therefore, the low light intensity of fluorescents work best for cuttings, and seedlings, or for supplemental light, where indoor type plants are not getting enough sunlight.

Fluorescent:

Fluorescent tubes have been used for seedlings, tissue culture and cuttings for a great number of years. The most commonly used is GROLUX and Activa 172 tubes, but also Powertwists and other speciality

Fluroscents, as well as Cool White tubes (as used in plant terrariums e.g. Phototron). By using Fluorescent tubes, to achieve mature growth, plants must be grown as close to the tube as possible, without touching the tube, as this may cause burning of plant tissues. The closeness of the tubes is required as each tube only outputs the minimum light required for plant growth (about 1000 foot-candles) and if further away from the tube, the output of the light diminishes. Always use a horticultural reflector. Because a fluorescent tube is round, light is travelling in all directions from the tube, and any light travelling upward, or sideways will miss the plants below. Reflectors redirect this light in a favourable manner and generally increase the light to the plants by 50% to 95% with any standard lamp..

The benefits of Fluorescents are smaller internodal lengths, smaller leaves and smaller flowers but more numerous. Plant growth may be slower than expected.

Incandescent:

The filament design of household incandescent lights reduce the average life span of each bulb well below that of Fluorescent. Incandescent output too much of their light in the red band of the spectrum making these unsuitable for plant growth. Colour corrected bulbs are available such as CROMPTON, and these output around 5000 foot-candles, and are suitable for plant growth, however they are more suitable for supplemental lighting, where plants already receive some light from the sun, e.g. most indoor plants, and seeds and cuttings can benefit from the small amount of heat they produce. Incandescents are frequently used to confuse a plant in greenhouses and tunnel-houses by extending the day length. The plants are exposed to a longer day than usual, and when this additional day length is removed, flowering and fruiting plants can be induced to produce their fruit or flowers out of season.

Contact a store or your Department of Agriculture/Primary Industries for more information.

HIGH INTENSITY DISCHARGE LAMPS

Metal Halide:

Metal Halides are available in 400 Watt (60,000 foot-candles) and 1000 Watt (100,000 foot-candles), and sometimes in other sizes. They emit a blue/white light and are used for increasing plant growth rates, controlling the seasons (Photoperiodic control) and for indoor growth, away from pests, disease, wind, rain, heat or cold extremes, as well as the healthy growth characterised by these plants. Hobbyists use these lights for these reasons and for limited growing areas where indoor gardens may be either more viable or decorative. Metal Halides are very suitable for healthy vegetative growth, flower growth and produce excellent large, bushy plants. These lamps require Metal Halide control equipment, which is sort of like a transformer and starter put together.

High Pressure Sodium:

High Pressure Sodium's are available in 400 Watt and 1000 Watt sizes, as well as other sizes. They emit a spectrum of red/orange/yellow and have been compared to the autumn or harvest sun. There has been in the past, considerable debate over whether Halides or Sodium's are more suitable for plant growth. The High Pressure Sodium lights are best known for their longer life, higher light output and flowering capabilities, but with less blue light than Halides, some plants may not produce the healthy vegetative growth when used alone. High Pressure Sodium are ideally used in conjunction with Metal Halides to produce a brilliant plant growth environment, and an excellent spectrum full of high energy reds, and blues that keep the plant compact and healthy. Sometimes Halides are used up to the flowering stage and High Pressure Sodium is used from this point for increasing the flower/fruit size and weight. Son T Agro Lamps (see below) are an example of a lamp designed to incorporate these two spectrums. High Pressure Sodium's require High Pressure Sodium Control Gear.

Because of the requirement for different Halide and high-pressure Sodium control gear (also known as ballast) the retrofit bulb was created.

Retrofit Bulbs:

There are High Pressure Sodium retrofit bulbs available for running in Metal Halide ballasts. They are available in a 350-Watt and 360-Watt lamp sizes for running in 400watt Metal Halide ballast's. High Pressure Sodium retrofit bulbs do not have the longer life and higher light intensity of Standard High

Pressure Sodium's, but Metal Halide systems are cheaper and run at a slightly lower amperage than High Pressure Sodium ballast's. Ideally, both a High Pressure Sodium and a Metal Halide should be used throughout the flowering cycle, however, Retrofits provide an economical alternative for the hobbyist when a distinct lighting source is required for flowering as opposed to another light source for flowering.

Son T Agro Bulbs:

Son T Agro Bulbs are a new development from Phillips. They run in 400 Watt High Pressure Sodium Control Gear, and they are basically a modified High Pressure Sodium Lamp with 30% more Blue light in it's spectrum, making it the best lighting system for plant growth, with high energy reds to speed growth, and enough blue light to keep plants compact and healthy. With No Lamp change required when plants begin to flower, Son Agros are now the most popular growing system on the market. Son Agro Lighting sources are only 400 Watt, but are brighter than 400-Watt Metal Halides. PL90E fittings are used in Holland extensively, with Son T Agro Lamps. Holland's use of Son T Agros represent the largest usage of lighting for commercial purposes in the world. (Consider growing plants in winter there. Sometimes the 4 hours they call daylight is not overcast, but not often. Without lighting, growing vegetables or flowers is quite difficult.)

Used in the European PL 90 E Fixtures the coverage of the light is more than that of a 1000-Watt Metal Halide lamp in a normal Australian fitting. Mathematics tells you that Son T Agros at 400 Watts use only 40% of the power of the 1000-watt!

Planta -T Lamps:

To produce a lamp that matches the plant sensitivity curve, the Son T Agro was not quite high enough in the blue spectrum. This Osram Lamp is designed to match the plants requirements for an ideal light source, without reducing efficiency per watt. They are as bright as Son Agros, and High Pressure Sodium's, but have more blue. Results under these lamps are excellent leaf production as well as good flower production.

Ensure you have a good High Pressure Sodium Ballast, that is a high performance ballast. (Short or Long Stage Ignitors will not ignite a Planta T.) High Performance ballast's, incidentally, will ignite lamps that will no longer ignite in normal ballast's.

Running costs:

The running cost of anything running at 400 Watts is around 4 cents for every hour running (assuming a Kilowatt-hour is 10-11cents). If you examine your fan heater (usually 2400watts), Hairdryer (1200Watts), Air-conditioning (1500Watts), Pool Pumps (up to 1500watts) and other appliance wattages, you may be very surprised! With lighting, if a 12 hour day is used this is roughly three dollars a week. High Intensity discharge lights are therefore regarded to be more efficient (light intensity vs. wattage) than Fluorescent. (Considering Fluorescents are advertised for their energy efficiency) For a 1000-Watt light the costs are around 11 cents per lamp. (Figures based upon 11cents per kilowatt-hour)

Greenhouse / Growroom sizes:

I'd recommend placing lights two to three feet above the plants for optimum growth rates . At this height, a minimum of one 400 Watt per 1.5m x 1.5m or a minimum of one 1000 Watt per 2.5m x 2.5m to maintain the optimum growth rate. If a light is raised the growth rates slows. At four feet above the plants you should maintain a reasonable but slower growth rate, and the useful area should about double. When attempting to stretch the light source, it is difficult to say what the average would be as reflector type and plant types can affect the outcome. Use of a light meter would help your growroom design.

I have used a PL90 E to light areas up to 3 meters by 2 Meters effectively with the running cost of only 400-Watts.

Lighting Accessories:

Light Rails move lights over the plants slowly to improve growth. These cost around the price of a lamp, but are very effective in making plants bushy, without growing straight up toward the light source. Reflective plastic (white and Black) is excellent for doing the same thing. You hang this plastic like a curtain to reflect the light back into the plant growth. NEVER use aluminium foil, or insulation foils, as these are designed to reflect heat, not light. These foils tend to affect the spectrum, and reflect

less visible light, and keep your growroom too hot. Some mirror films and Mylar are okay, but only purchase it as is recommended by a Hydroponic Store.

Ventilation:

Ventilation is the key to a good growroom. If you do not have enough fresh air, and a suitable temperature, plants can suffocate. An exhaust fan, especially the steel ball bearing types are quiet and much more efficient than 10 of the budget ceiling fans. Ideally you should have a fan with an air exchange of 10 to 15 times the growroom size per hour. Remember, the more fresh air the better. Carbon Dioxide Enrichment systems are fine when a grower is experienced, but to a beginner they represent more problems than they are worth. Ask a Store for advice.

The results of using lighting in an indoor environment are at least remarkable.

The benefits of controlling a plants environment are numerous, and you should speak to your local Hydroponic Store about the results obtainable.

NOTE FOR THOSE "ACQUIRING" LIGHTS FROM OTHER SOURCES THAN THOSE OF HYDROPONIC STORES..... The above is a GUIDE ONLY! When considering a Lighting System for plant growth it is important to ensure every consideration is taken into account, for example reflectors, burning position of bulbs, ballast's etc. Many systems designed for lighting large areas have NO PLACE IN HORTICULTURE! They can BURN the leaves, reflectors may destroy the spectrum and cause unhealthy growth. If you come across other systems, describe them to a Hydroponic Store who will tell you if the system is suitable, or can be modified! PLEASE SPEAK TO THE EXPERTS FIRST!

Controlling stages of growth under artificial lighting.

This should only be used as a general guide. Ask your store if they have anything further to add. For the following, I have assumed that no sunlight will be used to supplement growth.

1. Seeds and Seedlings.

All a seed needs to germinate is warmth and moisture. A seed has all the nutrients it needs in the husk of the seed. Generally, the medium used to germinate a seed must be well draining, but remain moist to the touch. Although moisture levels may vary for different varieties, the medium must not be too wet. The media is best described as not dry and never very wet. (Other descriptions of moisture levels could be described as like a sponge used to wipe a counter. Not so wet as to leave water on the counter, but not so dry that it does not clean.)

Once a seed has sprouted it is a good idea to give it some indirect light in preparation for its first leaves. (Lighting should be Fluorescent close to the tops of the seedling or a Metal Halide / Son Agro about 1 meter from the seedlings) The Seedling will sprout with small "false" leaves (cotyledons or seed leaves), but when the first true leaves appear it is a good indication that the seedling now has roots and you should apply nutrient from now on. For the first week, half strength nutrient can be applied. It should be noted that the first two weeks of life are critical. If a plant does not have a good start, then you can say generally that the plant will not grow to be an excellent plant.

2. The Vegetative Cycle.

Once a seedling becomes a young plant, full strength nutrient should be used (On average 2 to 4 sets of true leaves is a young plant). Using a CF meter, adjust your nutrient to the correct strength for your crop. If you do not own a meter yet, mix nutrients according to pack directions. Your store should be able to provide you with specific crop directions. Metal Halide Lighting is the best light source to use at this point. Lamps should be 2 to 3 Feet from the tops of the plants. The Photoperiod or length of artificial daylight is best set at 18 Hours with a normal household timer. Other "day" lengths are discussed below. The rate of growth will gradually become faster; Young plants usually grow slower than they do when they become maturer. A Vegetable or flower that has been grown at 18 hours per day of HID lighting can be induced to flower/fruit as early as five weeks (approx) but better end results occur when the plants are eight weeks old or more before reducing the light hours. The plants are growing at such a rate that they give better results if their metabolic age and chronological ages have a

chance to catch up on each other. It is during the vegetative stage that growers should take their cuttings or clones. For more detailed information on cloning, please consult our staff.

3. The Reproductive Cycle.

The Light hours can be reduced to induce Flowering or Fruiting. Once the light hours are reduced to 12 Hours, ensure that the plants receive NO LIGHT at all during their dark 12 Hour "night". Should you open a door to your growroom and allow light from a hallway light to enter the room during their 12 hour sleep, this will stress the plants by "waking" the plants up and putting them back to "sleep". Stress is to be avoided at all stages of growth. This stress will slow the flowering process. Plants require less nitrogen during this cycle, and will consume more Phosphorus. There are two ways to combat this. Either increase the strength of your starter nutrient with a CF meter, or purchase one of the range of Bloom solutions/additives available. No one really understands why the red spectrum of light stimulates and increases the floral hormones of a plant, but the effect of an autumn sun is more in the red band of the light spectrum. What we do know is that during flowering, a High Pressure Sodium Lamp will add to your total flowers/fruit if used with a Metal Halide during this Cycle. Many Growers will run High Pressure Sodium during flowering alone, and this can still increase the crop significantly. It could be noted however; Metal Halides will be enough during the flowering and fruiting stage to produce good results. It is worthwhile to have High Pressure Sodium for the results are usually larger flowers and/or fruit and more numerous flowers/fruit, as well as significantly shorter flowering time. Son Agros are suitable during both growth and flowering stages.

Flowers generally will be visible in one to four weeks. (If not, it is likely that the plants were stressed by poor ventilation, heat, cold, produced from poor cuttings or seedlings, were an offspring of a sickly variety of that plant type or were too young to be "flowered".) From then it is only a matter of time for your plant to produce ripe fruit or fully form their flowers. Plants can be harvested and an 18 Hour Vegetative Cycle begun again. Whether your plant is better off started from seed, cutting, clone or re-cropped at this point cannot be generalised. Ask your store for advice.

Other Options.

A plant requires a minimum of 8 Hours lighting out of every 24 hours. But the light hours must be long enough to enable you to reduce them and create an artificial autumn. If 18 Hours is used, then a reduction to 12 hours will induce flowering and fruiting in most plants. This is done in order to induce flowering and/or fruiting with most plants where required. Obviously, you are not interested in flowering or fruiting Lettuce, because you are more interested in the leaves. With Chrysanthemums, or fruiting crops, you will require a shorter day length to induce the plant into its reproductive cycle. If you use 12 Hours for your initial cycle, then reduction to 8 Hours will result in Flowering. However, that the plants would take longer to grow to a point where flowering could take place, and flowering may take longer to come on. Should you have any problems, please do not hesitate to contact your local Hydroponic Store. It is through talking with them that they can help you get the most out of your garden. Besides, the advice is free.

TIPS.

1. When assembling your light for the first time, screw the bulb in until it is finger tight, and then give it a little more of a twist to ensure a firm contact. After a week to two weeks, the contacts will have worn in, and could need a little more of a turn.

2. Many people use nylon rope to hang their lights. Ensure they do not contact the bulb and melt. I would recommend welded link chain. Unfortunately, these do not go through pulleys very well, but it can be easier to unhook the light and move it up a couple of links at a time.

3. Make sure your plants are well ventilated. A plant is 90% water and carbon. The only way a plant can take in Carbon is through the Carbon Dioxide in the air. If the Carbon Dioxide content in the garden is not replenished, plants will grow more slowly and could develop problems.

4. The optimum temperature of the growroom is between 22 and 25C and the optimum Humidity levels lie between 40% and 60% Relative Humidity. Generally, it may be difficult to obtain this range of temperature and humidity, however as a general rule, try to keep the room as close to the optimums and most plants will adapt themselves to their environment. Try to avoid sudden leaps of humidity or

temperature as this may shock your plants. If you maintain the environment within the optimum ranges, you will see a much better growth rate.

5. Remember that Light is one of the most essential ingredients in plant growth. If poor growth occurs in any environment, 90% of problems relate to LIGHT, OXYGEN IN THE ROOT ZONE, pH (Acidity/Alkalinity), NUTRIENT STRENGTH, TEMPERATURE AND VENTILATION. Think about these factors as discussed at the start of this book.

Guidelines for the Media used in Hydroponics.

Media should be disease free.

Media should not have any nutrient quality of its own, or the whole point of a balanced nutrient solution is lost. If the Media adds Calcium for example, how much, and does it change, and is it soluble? It's best if we determine the nutritional balances for the plant not the media.

Media must be pH stable, and reasonably inert.

Media should be high in oxygen.

Media should not have overheating problems, such as gravel does in the Northern Queensland sun.