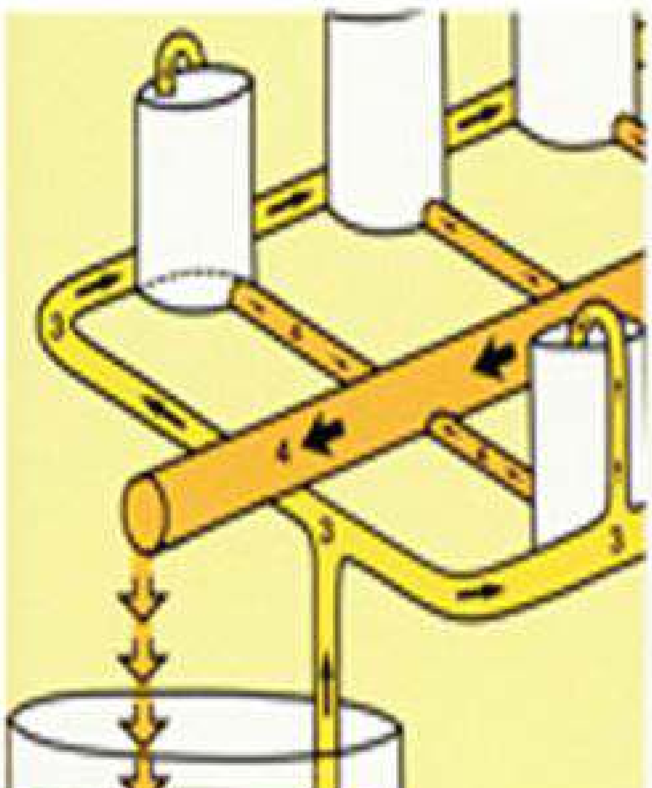
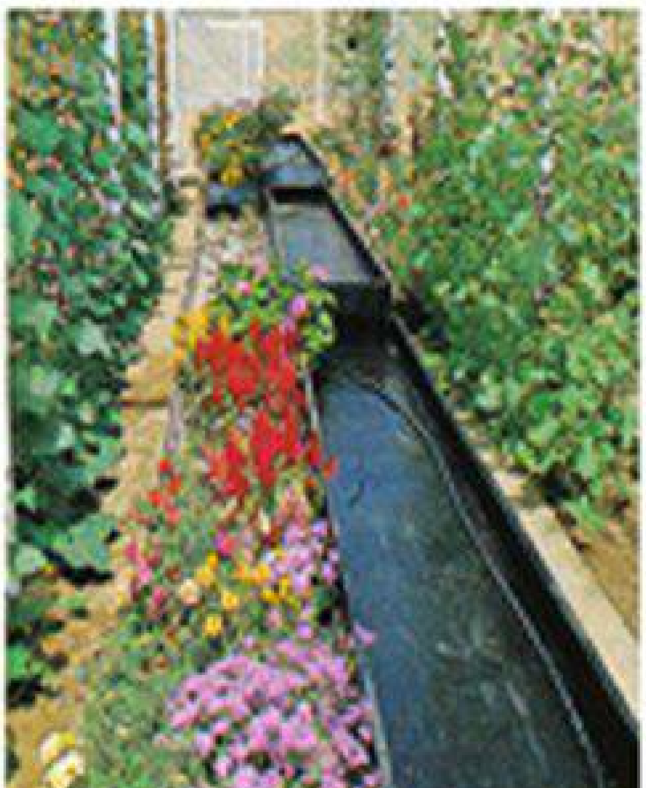
HYDROPONIC GARDENING

A practical guide to growing plants without soil





Lon Dalton/Rob Smith

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A Practical guide to growing plants without soil

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Rob Smith

Rob commenced his apprenticeship in the Electrical Industry in 1956 and worked his way up in that industry, until he gained the highest Qualification of Technician/Inspector in l97l. He has been involved with major Industrial Electrical Installations such as Export Cool Stores, and meat works, and in the position of Consultant Electrical Engineer to Toyota (N.Z.) Ltd. being responsible for assembly Plant Automation Design. Early in I977 he was requested by a Fertilizer Company to design and build a commercial Hydroponic Controller, since none was available World Wide.

After four months of intensive research of the subject he set to and constructed the very first purpose made Hydroponic Controller, which was installed at the largest New Zealand Tomato Growers property at South Auckland NZ.

Since I977 Rob has continued to develop sophisticated Electronic controls for all types of Industry. Hydroponics remains a strong love and their old company, now renamed and badged as 'BlueLab Corporation' continues to produce a wide range of Controllers, meters and systems with the emphasis being upon reliability and simplicity of operation. The world renowned CF Truncheon, 'Dipstick' and 'Quickdip' are good examples of the technology Rob presented to the industry.

Now in the new millennium and also in semi retirement, Rob concentrates upon his love of performing Jazz on his Tenor Saxophone, however still continues to write, including having been a regular contributor to the prestigious print version of 'The Growing Edge' magazine and consulting to the industry.

The author 'Rob Smith' in hydroponic glasshouse - courtesy Rosemary Wallace Rotorua NZ.

Lon Dalton (1926 - I999)

Lon was one of life's positive thinkers, he had always held an interest in the possibilities of "hydroponic gardening".

A man of many and varied pursuits in the game of life, Lon had been a director of several successful companies both in New Zealand and in the islands of the Pacific.

Many years ago Lon decided to have a go at the subject that for so long had fascinated him, like so many others, he studied the information which had been published on the subject, and proceeded to build his first hydroponic garden. His home was one big hydroponic garden, with every conceivable type of system, growing the widest possible variety of plants, from grapes, limes and roses to potatoes, pumpkin and watercress. Lon became involved with Rob Smith and between the two, NZ. Hydroponics was formed, a company which would fill all the gaps that Lon had found to his cost, faced anyone who wanted to get into the world of hydroponics. This book continues to reflect much of Lon's enthusiasm and knowledge of the wonderful world of Hydroponics.

Preface

This is the book that will get you started in hydroponics. More than just a discussion of the topic, 'HYDROPONIC GARDENING' provides the reader with complete background information on hydroponics, explains the different systems and how they work, then shows the reader in a step by step guide, how to set those systems up. A growing guide is included showing you what to grow and how to grow it hydroponically.

This book is an invaluable guide to understanding, setting up and running hydroponic systems for both the home gardener and the commercial grower.

The product of the knowledge of two of New Zealand's leading advocates of hydroponics, Lon Dalton the director of a number of companies in both New Zealand and the Pacific, Lon's experience in hydroponic growing is coupled with Rob Smith's technical expertise in the design of electronic control equipment. As Lon and Rob kept track of the latest developments in hydroponics this book is a must for would be hydroponic gardeners anywhere in the world

These Kumara (sweet potato) plants are growing in a fiberglass container filled with a mixture of vermiculite and gravel through which a hydroponic solution is flowing. You can grow virtually anything hydroponically. Conventional vegetables including the root crops, shrubs and even trees will thrive in a hydroponic system.

The wonder of hydroponics

What motivates a Gardener to explore new methods of growing plants?

From our point of view this was a very important question, which we researched, in order to target the potential grower with the right information, to assist the Grower to make the most appropriate decisions regarding equipment and system needs. Also to provide sufficient operating information in an easily digestible form, to allow the grower to gain the very best performance out of their Hydroponic growing system.

Successful, sustained hydroponic gardening is still a relatively new Industry and, there is still a tremendous amount of Hydroponic misinformation circulating. This inevitably leads to misconceptions, couple this with those, who through fear, and/or ignorance, continue to dogmatically rubbish the whole concept of Hydroponics, and it is obvious that a considerable amount of education is still required.

We produced this book in 1983 and after significant fine tuning had it published in 1984, as our effort to increase the general knowledge of the subject to our fellow countrymen. The result has been a book which has now sold thousands of copies, in many countries and, continuing sales had encouraged us to update various aspects of the book. In editing this revised ePub edition of the book (2013) it was obvious to me that the passage of time, manifested in improvements to both materials and construction methods played an important part in making some of the necessary changes.

It was always our desire to retain the 'down to earth ’ style of the presentation and, I feel confident that the new photographs and text amendments which describe updated systems and methods will further assist the reader in a better understanding of the subject.

Rob & on behalf of the late Lon Dalton

You will be smiling too when you have your hydroponic system running and producing top quality plants which *have never lacked any of the requirements necessary for quick, strong and healthy growth.*

Chapter One: Introduction

History

The term hydroponics was coined in the U.S.A. in the early 1930's to describe the growing of plants with their roots suspended in water containing mineral nutrients. Derived from the Greek words for 'water' - hydro and 'to work' - ponos, hydroponics literally means 'working with water'. The definition has gradually become broadened to describe all forms of gardening without soil.

Hydroponic gardens in history date back to the Hanging Gardens of Babylon. The Aztec Indians had a system of growing crops on rafts in shallow lakes, you can still see some of these floating gardens near Mexico city.

Developments did not start taking place in Europe until 1699 when Woodward found that he could grow plants in a solution of water to which soil had been added. Liebig, a German scientist, started using nutrient solutions to study the nutritional requirements of plants in the 1850's and was followed by Sachs in 1860 and Knop in 1861 who made studies of nutrient elements in water solutions. They were able to grow plants in nutrient solutions made up from mineral salts eliminating the need for soil.

Research on the nutritional requirements of plants continued through into the 1870's. By 1925 practical applications of hydroponics were being made in the greenhouse industry. The next decade was to see extensive development as researchers became aware of the potential of growing hydroponically. In 1930 Gericke produced the first commercial hydroponic unit in the U.S.A.

Later during World War II the American forces in the Pacific grew vegetable crops hydroponically. Developments continued and the commercial use of hydroponics spread throughout the world but it was the development of a system known as NFT (Nutrient Film Technique) by Dr Alan Cooper in the 1970's, along with improved nutritional formulations that made the hydroponic growing of a wide range of plants commercially viable. Since then automatic control systems have become available as well as digital testing equipment which has opened up the field of hydroponics to the home gardener.

How Hydroponics can work for you

Hydroponics is no longer a subject of science fiction or a mysterious form of growing plants in a laboratory. It is a well established and fast growing part of modern commercial agriculture. Anyone willing to familiarize themselves with the principles of hydroponic culture and the basic requirements of planting and caring for a home garden can successfully establish and operate a highly productive and rewarding hydroponics unit. Hydroponics is still a developing field so you will find plenty of range for experimenting with plants and trees

Hydroponic gardening can alter your lifestyle by providing you with fresh fruit, vegetables and flowers all year round. Even the banana plants are being grown hydroponically

There are two main methods of growing hydroponically. The NFT system developed by Dr Alan Cooper involves a system of covered plastic channels, the plants growing through holes in the covers with their roots in the nutrient solution. The other method involves using containers filled with an inert substance such as sand, pumice or gravel. The nutrient solution is pumped into the containers through a system of pipes or tubes, the excess being cycled back around, more water, air (oxygen) and nutrients being added when needed as with the NFT system. You will discover the numerous advantages that growing hydroponically offers over conventional growing practices when you set up your first system.

The Advantages of Hydroponic Growing

Hydroponic systems can drastically reduce the amount of time needed to produce good plants, crops and fruit. Any vegetable, flower, shrub and even trees can be grown without the need to cultivate, weed, and mulch, while watering and fertilizing can be taken care of by automatic systems. The time saved by using a hydroponic system will allow you to concentrate on pruning and training plants, as well as providing you with more time to spend outside on other gardening activities. No longer will the quality of your soil dictate the results you will get from your crops. Hydroponic gardens can be established anywhere, irrespective of the soil or climate. You will find that vegetables and fruit produced hydroponically have a superb flavour and texture. The plants have no need to waste energy developing large root systems as all the nutrients they require are brought to them. Because the plants will not be lacking in any nutrients you will find that they develop faster, and are healthier with more resistance to disease than plants grown in the soil. You can also speed growth up by using techniques such as heating the nutrient solution to the optimum temperature for the plants' roots. You will be able to grow a large number of plants in a small area producing a far higher yield than normally possible. When plants are removed from a hydroponic system, new seedlings can replace them immediately. There is no time lag as there is no soil to be sterilised making it possible for you to have continuous production.

You will find that only a small number of seedlings are required to produce what you need, as losses from pests and disease are greatly reduced when you grow hydroponically, especially if the plants are in a greenhouse or some other structure. Without dirt in the system it is easy to keep everything clean enabling you to eliminate problems caused by many soil borne diseases.

For the commercial grower hydroponic systems are ideal, they are highly efficient, requiring a low capital cost while producing high yields with less labour input. These same advantages apply to the home grower who can cheaply and easily produce quality vegetables and fruit almost all year round. Whatever your preferences are, Hydroponics will provide you with a challenging and exciting hobby or vocation. This book will explain to you in practical terms how to get started in this fascinating field.

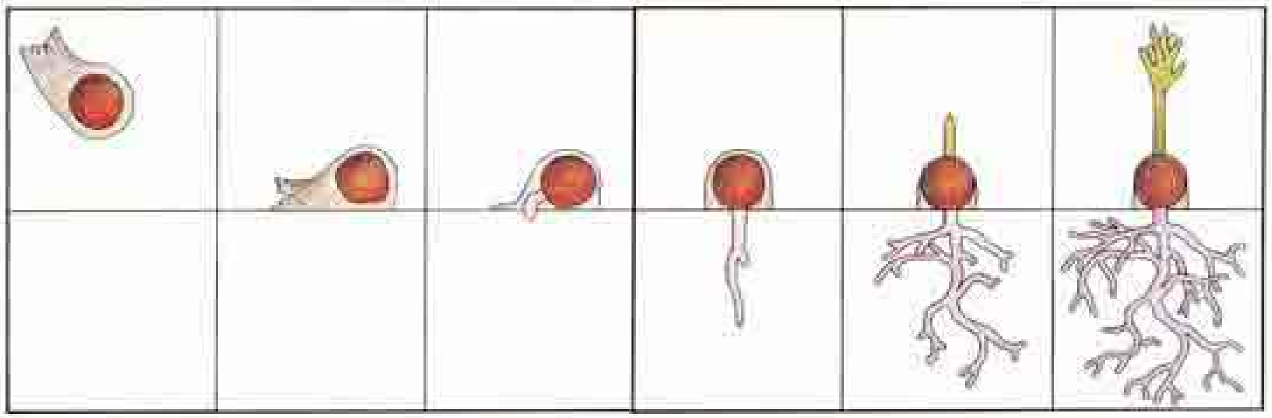
Hydroponic systems are extremely versatile You can adapt a system to almost any situation. A hydroponic garden is ideal for the home owner with limited space as fresh lettuce tomatoes and perhaps a herb garden could be kept growing in a small area such as a window box You can produce enough vegetables for a family all year round by setting up an outdoor growing area coupled with an additional area in a greenhouse or enclosed well lit porch.

Chapter Two : How plants work

Probably the most important prerequisite to successfully running any Hydroponic system is to have a clear understanding of how plants work. With this knowledge you will be able to see why the component parts of a hydroponic system are included and why some actions will produce better growth in the plants whereas others may prove detrimental to their health.

Hydroponic systems can be as unobtrusive as the gardener desires. This greenhouse has a nutrient holding tank hidden beneath the floor which feeds plants through small microtubes. The plants are growing so quickly that they will soon cover the greenhouse.

How Plants Grow



A young root tip develops from a seed pushing its way down into the soil.

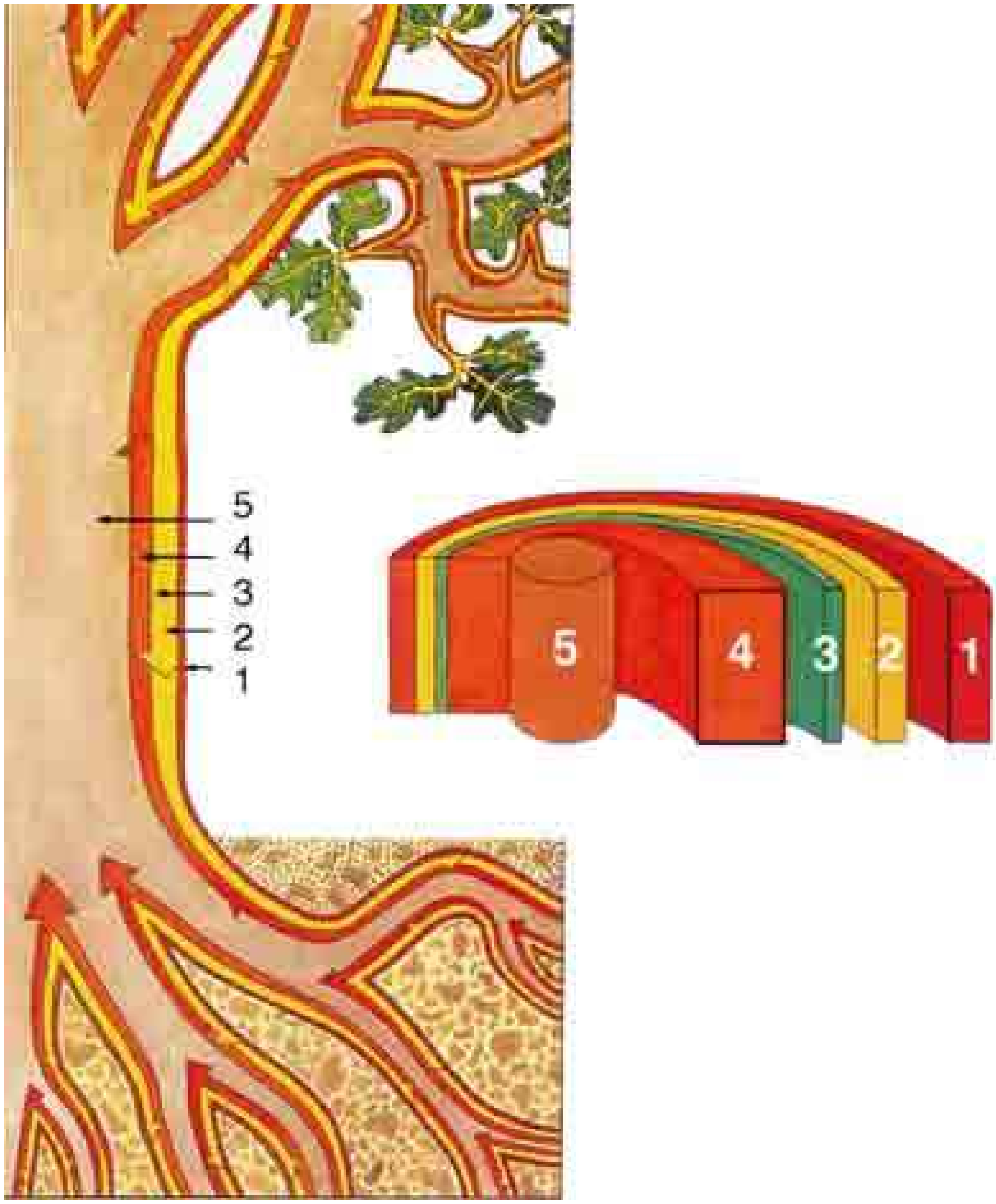
By looking at how trees develop you will soon gain an understanding of how most plants work. The story begins with the seed which is the dispersal unit in the life cycle of a tree. Thousands of seeds will be spread across the forest floor each autumn by their parent trees, sprouting later in spring.

Germination begins when the dry seed draws in water from the soil and the seed softens and swells. A few days later a tiny root will grow by cell division, developing into a visible root that emerges through the seed coat, bends downward and enters the soil. The root then develops tiny root-hairs, through which the new tree absorbs the water it needs for growth. Dissolved in the water are the minerals the developing tree requires. Within a few weeks branch roots begin to develop which, as they grow stouter, will in turn throw off more branch roots.

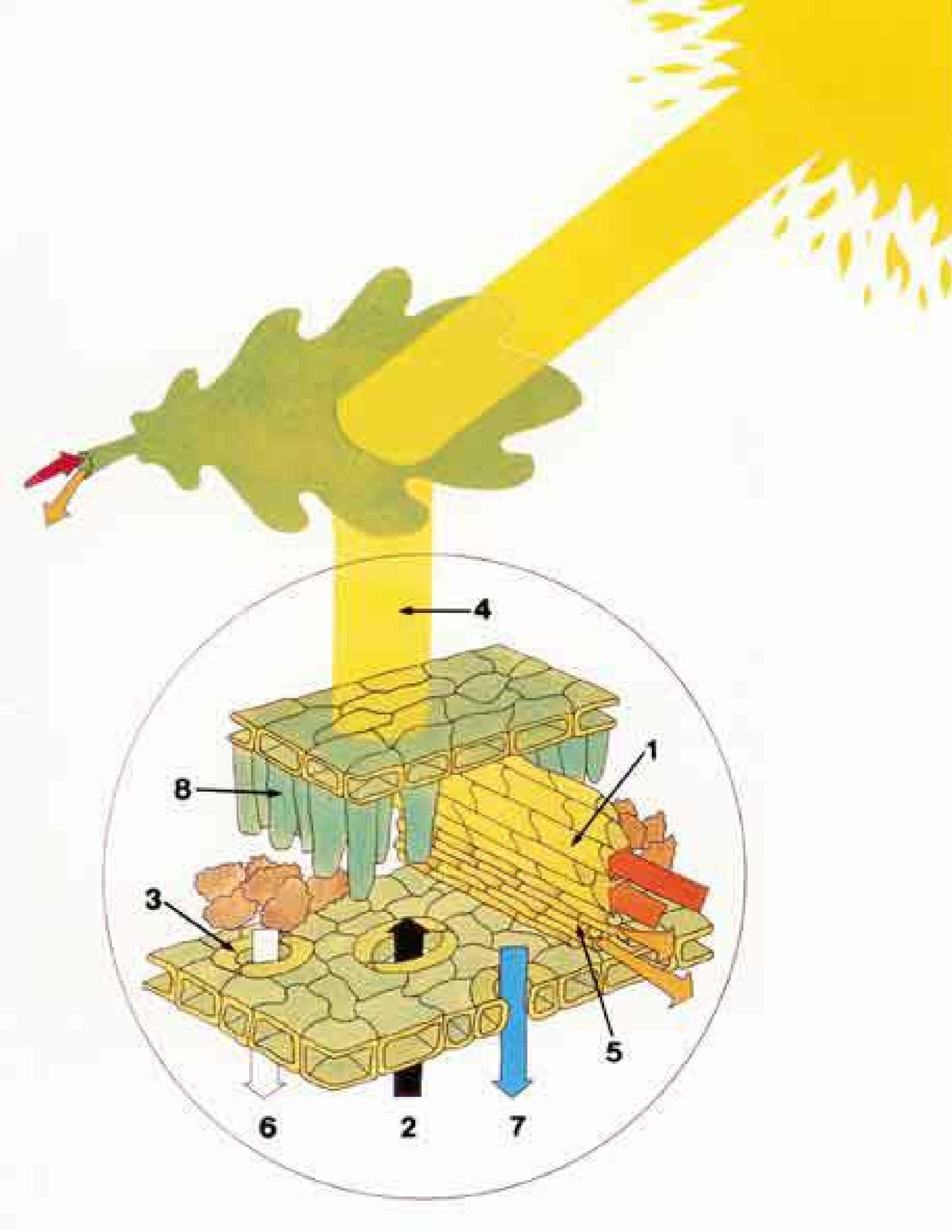
The root system remains surprisingly shallow. Deep tap roots are rare, for roots fulfill their functions best in the soil's surface layers. The increase in size and substance of a tree's roots is maintained through the nourishing function of the tree's green leaves.

Photosynthesis

A few days after the first roots emerged from the seed and made their way underground the seed would have also produced its first small shoot. All tree seeds contain one or more seed leaves, known as cotyledons. The upward growth of the tree's first small shoot continues for the rest of its life. The aerial shoots like the trees roots are nourished by the leaves that develop on the shoots. The key process is called Photosynthesis. Translated from its Greek form it literally means 'building up with the aid of light'. Photosynthesis is essentially the process whereby plants trap and use light energy. Green plants appear green because they reflect green light and absorb the other colours that make up 'white' light. The pigment which gives plants this green colour is called chlorophyll and it is mainly this substance which is used to trap light. Chlorophyll is contained in special cells in the leaves called chloroplasts which control the photosynthetic reaction. Plants need to absorb sunlight as it provides them with the energy required to produce the food they require for growth



Beneath the protective layer of bark [1] the phloem cells [2] carry food made in the leaves throughout the tree. The cambium layer [3] is the growing layer with new phloem cells being produced on its outer edge and xylem cells on its inner edge. The xylem [4] carries water dissolved nutrients upwards for use in food production. Dead xylem cells [5] form the core of the tree.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Water containing dissolved nutrients [1] is drawn up through the xylem into the leaves, from the roots Carbon dioxide [2] also enters the leaves through special guard cells [3] which open and close holes in the leaves known as stomata. The carbon dioxide and nutrient laden water moves through the loosely packed spongy mesophyll cells in the leaves. The chloroplasts in these cells will act on the carbon dioxide and nutrient laden water when sunlight [4] reaches the leaves providing the chloroplasts with energy. This is the process known as photosynthesis which results in the production of carbohydrates, mainly in the form of sugars, which are then transported through the phloem [5] to the roots and other parts of trees and plants to produce growth. Oxygen [6] is also produced and is released through the stomata into the atmosphere for animals to breath.

Another process occurring in the leaves is transpiration. The air passing through the loosely packed cells in the leaves evaporates some of the water in the leaves and carries it out through the stomata [7]. The leaves also have special cells for support These are the palisade cells [8] which also contain some of the chloroplasts involved in photosynthesis.

The Production of Food in a Plant's Leaves

The leaves on a plant are constantly filtering a stream of air through their tissues, which are open-textured with many air passages. Air consists of about four parts of nitrogen to one of oxygen, plus a tiny but significant amount of carbon dioxide. The plant needs carbon to create new tissues producing what we see as growth. The chlorophyll in the leaves, using energy from sunlight, extracts the carbon dioxide from the air and combines it with water to make chemicals called carbohydrates. A familiar type of carbohydrate is sugar. Glucose sugar is a soluble type of carbohydrate produced by photosynthesis that is able to flow freely throughout the plant providing the food necessary to nourish every kind of growth and also supply the energy for every vital process. The leaves, shoots, roots, the woody stem, flowers and finally the fruit and seeds are all built up from it. Plants use the energy stored in carbohydrates through a process called respiration.

You can see that photosynthesis is an important process for plants for without it the carbohydrates or sugars needed by the plant for growth, would not be produced. It is also an important process for humans because during the process of trapping light energy, oxygen is separated from water and released into the atmosphere. Green plants therefore remove the carbon dioxide that humans and other animals breathe into the air and release the oxygen we depend on to survive

Keep plants in outdoor hydroponic systems sheltered from strong winds. This will reduce the amount of water lost from the plants through transpiration.

You will be able to grow the plants you have always wanted to grow, hydroponically in a greenhouse. Greenhouses are good because they provide all weather protection for your plants.

Transpiration

Between 80 and 95 percent of a plant's weight is made up of water. Plants take in supplies of water through their roots losing up to 98 percent of their water intake through a process called transpiration. This occurs when the air passing through the passages in the plant's leaves carries away large quantities of water. The flow of air is necessary so that the plant can obtain the carbon needed to produce carbohydrates. The plant also needs to maintain its water supply. It is not surprising therefore that the root systems of plants are extremely efficient at extracting water from the soil while other structures within the plant can efficiently transport it against the force of gravity, up to 100 metres high in some trees.

There are a number of materials available which can be used to break the wind as well as a number of designs for fences and other structures. It is important to dissipate the wind or deflect it away from your plants rather than presenting a solid wall over which the air will flow creating turbulence on the other side. Photograph courtesy of Accent Hydroponics, Australia.

Transport Systems within a Plant

There are two main types of vessels enabling water and nutrients in the form of sap to flow upwards from the roots and the carbohydrate solution to flow throughout the plant. The xylem vessels contain the sap flowing from the roots upward to the leaves while the phloem vessels contain the carbohydrates made in the leaves which are flowing around the plant and down to the roots where they may be converted to starches and stored. In most plants these two way channels, the xylem and phloem are grouped in vascular bundles running up inside the plant's stem. When they reach the plant's leaves they take the form of veins.

The xylem and phloem are arranged in a different pattern in the branches and trunks of trees. They are grouped on either side of a layer of cells beneath the bark, called the cambium. The root sap rises on the inner side of the cambium layer while the carbohydrates or sugar sap, descends through the Phloem tissues called Bast on the outer side of the cambium layer. The carbohydrate solution produces new growth on this side of the cambium layer which, when combined with a shrinking of these cells in summer, forms the growth rings visible when you cut through a tree. Each spring the cells open up again allowing the sap to flow and a new ring of cambium growth to form beneath the bark.

Plant Nutrients

The xylem in plants carries not only water but also minerals which have dissolved into the water. Plants need most if not all of at least sixteen different elements to produce healthy growth. Nine of these elements; carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, sulphur, calcium, and magnesium are needed in large amounts and are called the macro nutrients.

The first three; carbon, hydrogen and oxygen are obtained from carbon dioxide and water, the rest come from the soil.

The remaining seven nutrients known as micro nutrients or trace elements are required in smaller quantities but are still important in producing healthy plant growth. These are iron, manganese, boron, zinc, molybdenum, chlorine and copper. If any of these mineral nutrients are not available to the plant then the plant's growth will in some way suffer.

Some soils are lacking in certain elements so that plants grown in them display the deficiency symptoms of the elements they are lacking. The element may even be present in the soil but not in a soluble form that will allow the plant to absorb it. This is one of the reasons why hydroponically grown plants produce rapid, healthy growth. All the nutrients they require are always available to them in the right proportions as is the all important water supply which the nutrients are dissolved into.

Conserve space in your greenhouse by training plants up garden cords or a trellis. Hanging plants can drop over the edges of their growing containers. Tomatoes are easily grown this way.
You will be able to grow some magnificent flowers hydroponically. They should be healthier and will flower longer as the plants will be receiving all the nutrients they require, just like this next photo of a beautiful rose.

A Rose by any other name!

Large plants such as the pawpaw are easily grown hydroponically. These pawpaw are growing in a container filled with a mixture of gravel and other cleansed media through which the nutrient solution flows. The media gives the plants roots something to anchor themselves into enabling them to support the heavier top growth. Pawpaw grown from cuttings can be producing fruit within sixty days when kept in a hydroponic system.

Osmosis

The process by which mineral nutrients dissolved in water are absorbed into plants is called osmosis. Osmosis is the tendency of fluids to pass through a semi permeable membrane and mix with one another. A semi permeable membrane is something that will allow some things to pass through it but not others. In plants the small hairs on the roots allow nutrients dissolved in water to enter the root system but do not allow particles of dirt, for example, to enter the plant. Osmosis is an important process operating in both plants and animals. Digested food enters the bloodstream in animals by osmosis.

The cells in a plant's root hairs contain a dense solution of salts and organic acids. Because this solution is stronger than the weak solution of nutrients dissolved in water in the soil, there is a strong osmotic pressure driving the weak solution in through the cell walls to mix with the dense solution. This process of osmosis continues from cell to cell so that the nutrients dissolved in water in the soil enter the plant's roots, eventually moving through the whole plant.

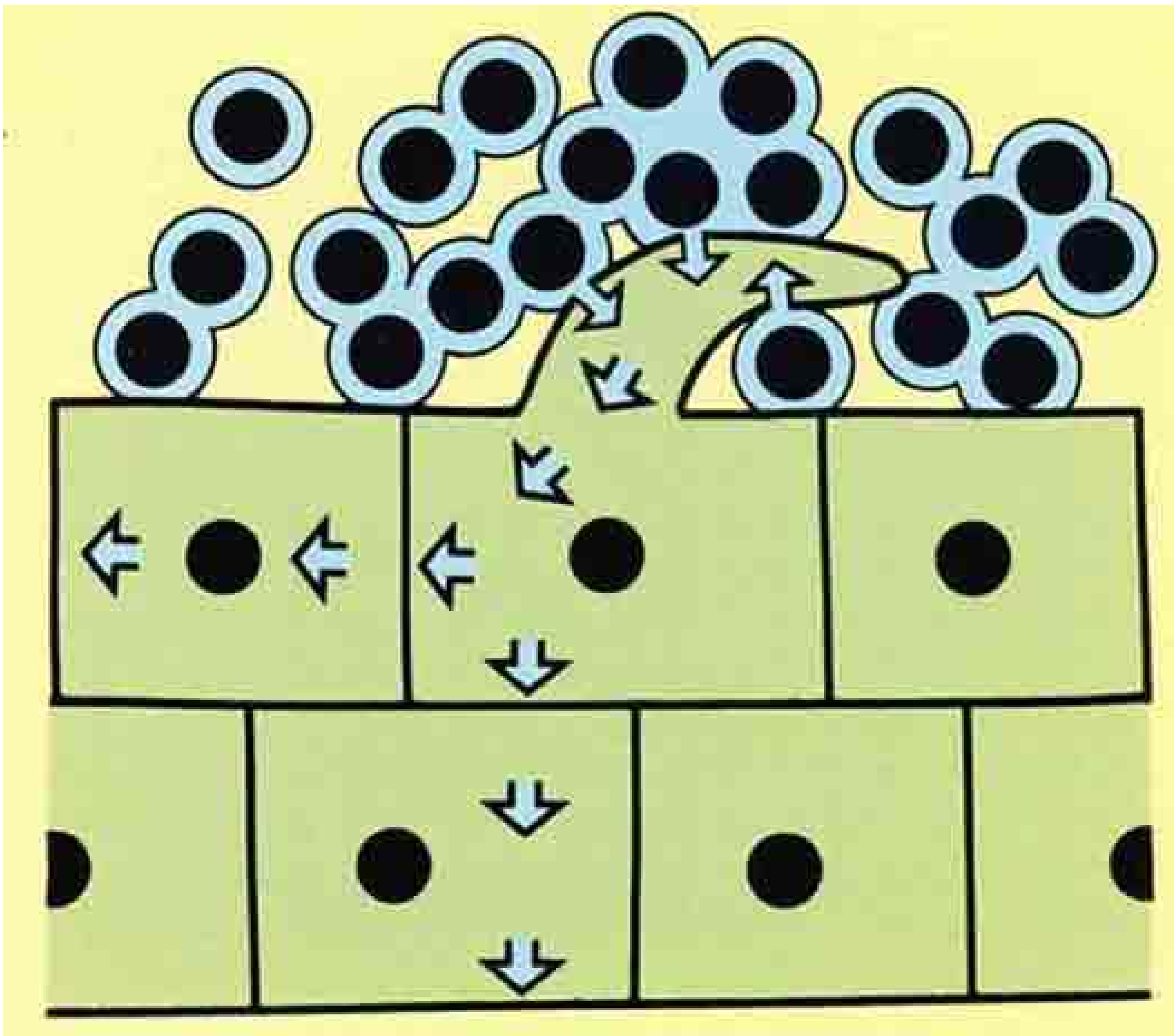
Osmosis can also work in reverse and kill a plant. Some gardeners when they apply a heavy dosing of soluble fertiliser around a plant create a situation where the solution in the soil is stronger than in the plant. As a result the plant loses its moisture, wilts and often dies. Because the nutrient solution being fed to hydroponically grown plants can be metered, this situation is easily avoided. Plants grown hydroponically, receiving the nutrients they require, may even develop to a degree not normally reached by plants grown in the soil. Their roots become extremely well nourished, accumulating large quantities of mineral salts. Because the solution of salts in the plants root cells is so strong the ability of these cells to take up water is increased. So instead of water and nutrients moving up through the plants xylem by osmosis, so much water may be taken in by the roots that the water is forced up the Xylem. The roots actually act as a pump. This condition has been termed 'root pressure' and accelerates the development of the rest of the plant.

Unlike soil grown plants, the roots of hydroponically grown plants do not need to travel far to find all the nutrients they need.

Growth Hormones

Further research into the way plants grow has made it possible for the rate of plant growth to be even further accelerated. Generally growth in a plant occurs at different rates in different parts of the plant. Some parts of the plant will grow at similar rates, the roots and shoots do not outgrow each other because they are interdependent. They both need each other, the shoots need minerals obtained by the roots and the roots need the photosynthetic products of the leaves on the shoots. There are special messenger molecules in plants known as hormones which control the rates of growth in plants.

Hormones are generated in various parts of a plant and are transported in minute amounts around the plant affecting the type of growth taking place in the cells that plants are made up of. Synthetic hormones are now available which can be included in a hydroponic growers nutrient solution to produce the increased growth attributable to some of these hormones. Flowering and fruiting are two important developments in a plant's growth in which hormones are involved. Hormones respond to changes in the environment stimulating flowering and fruiting. Flowering for example is often controlled by the day length, a response known as photoperiodism. Flower growers can now induce flowering at almost any time of the year with equipment regulating the amount of light to their plants, and growth hormones.



Nutrients contained in the water surrounding the roots, move into the plant through the root cells. They enter through the fine root hairs which are an extension of the root.

Chapter Three: How to grow hydroponically

Having discussed the essential elements of plant growth through to some of the more advanced developments we will now return to the basics with a step by step description of how to set up your own hydroponic garden.

Simple Hydroponic Systems

Most children at some stage have probably already experimented with a simple hydroponic system, raising seedlings on some water soaked blotting paper in a saucer. If fast germinating seeds from plants such as beans, radishes or cress for example are used, the seeds soon produce a basic root and leaf system using the food supply contained within the seed. The seedlings will continue to grow on any nutrients present in the water or dissolved out of the blotting paper. They will keep growing until a deficiency in one or more of the required nutrients ends the plant's life.

The Essential Nutrients

Nitrogen

Nitrogen is one of the main elements contributing to the growth of a plant. Plants convert nitrogen to produce amino acids and proteins which are used to produce new cell growth. Nitrogen moves easily throughout the plant servicing new growth at the expense of the older foliage. Any deficiency will cause the new growth to become weak and spindly resulting in a stunted plant. The shortage is usually first visible in a plant's older leaves which lose their green colour and gradually become yellow. This is because nitrogen is important for the green oxygen producing chlorophyll pigment in the leaves.

As the shortage continues the younger leaves will also become yellow and the veins on the underside of the leaves turn a red or purple colour. Vegetable plants are liable to run to seed. An excess of nitrogen will also affect the fruiting or seed development of most plants

A small microtube feeds nutrients onto the gravel surface layer of a hydroponic growing container. These microtubes are easily hidden just below the surface of the gravel if your plants are to be arranged decoratively indoors.

Phosphorus

Another important element for plant growth, phosphorus, is also vital for photosynthesis and cell formation in plants. It acts as a catalyst making it easier for the plant, in this case, to transfer energy. Phosphorus is important in developing good root systems and is also needed for the formation of a plant's flowers and seeds. Because phosphorus is very mobile within the plant, like nitrogen, any deficiency is usually visible in the colour of the plant's leaves. Phosphorus deficiency produces a deep green leaf colouring.

Potassium

Potassium, like phosphorus, acts as a catalyst within plants activating or triggering a number of plant functions. It is a catalyst for enzymes within plants that ward off disease and plays an important part in cell growth.

A deficiency in potassium can be evidenced by the mottling of older leaves on plants and a yellowing of leaves between their veins. It is another element that is mobile in the plant so the older leaves will show up any deficiency first. Plants lacking in this nutrient are liable to lose their fruit before it ripens.

Calcium

Calcium is the element which supports the cell walls in plants as they form. It helps to buffer the excesses of other elements and is an important part of a plant's root structure. Calcium is not very mobile in plants so it is present in greater concentration in older growth. As a result it is the new growth that suffers first when there is a calcium deficiency. The older growth retains its calcium but the new growth will be short of this important element. The new leaf tips and growing points tend to die back with a deficiency of calcium and the leaves show a brown to black scorching, also low calcium is the cause of blossom end rot, often seen as a black scab on the bottom of tomato fruit.

Magnesium

Magnesium is another element that is important for photosynthesis in plants. It is vital to the chlorophyll molecule and is also used extensively in the production of seeds. A deficiency will produce a yellowing in a plant's leaves spreading from the centre to the outer edges of the leaf. Eventually the leaves will turn an orange colour. A shortage of magnesium produces further problems if you want to propagate further plants from the seeds being produced as they will be malformed and will have a low rate of germination. Magnesium acts as a carrier of phosphorus within the plant and promotes the formation of oils, fats and juice.

Sulphur

Sulphur is important in a plant's tissue structure, as is calcium. It is one of the components of plant proteins and plays an important part in producing the flavours and odours in most plants. A lack of sulphur shows up when the younger leaves on a plant become pale. Although growth will continue, it tends to be hard and woody with very little increase in radial growth. Sulphur does not move around much within a plant.

A mass of lush growth typifies plants grown hydroponically. Get in, prune, thin and train your plants in the time you would normally spend weeding a conventional garden.

Iron

Iron is necessary for the production of chlorophyll in plants and is used in photosynthesis. A deficiency of iron will affect the plants new growth, the leaves will become almost white and the leaf veins show a definite yellowing.

Iron is not very mobile within plants or easily absorbed by them, making it a difficult element to replace once lost. Iron is an essential micro nutrient required by all plants and animals.

Manganese

Manganese is involved with many enzymes in plants, especially those that reduce nitrates prior to the production of proteins. Generally a shortage of manganese will be characterised by the mottled yellowing of younger leaves. On citrus trees especially, only small yellow leaves form and do not develop any further. The formation of new bloom buds is also affected.

Zinc

Zinc is an element involved in the growth hormones and is also important for most plant enzymes. Zinc is another element that is not easily replaced once lost. The new leaves of plants deficient in zinc are extremely undersized. Zinc increases the source of energy for the production of chlorophyll and also promotes the absorption of water. This is partly why plants lacking in zinc are liable to be stunted. The formation of auxins, hormones which promote growth in plant cells, is also partly dependent on the presence of zinc.

Perfectly formed fruit with a superb flavour and texture are the product of plants which do not need to compete for nutrients. An added advantage is that the food and water used in a hydroponic system is only the food and water used by the plants. There is no loss of nutrients through leeching or any waste from over watering or by applying too much fertiliser.

Copper

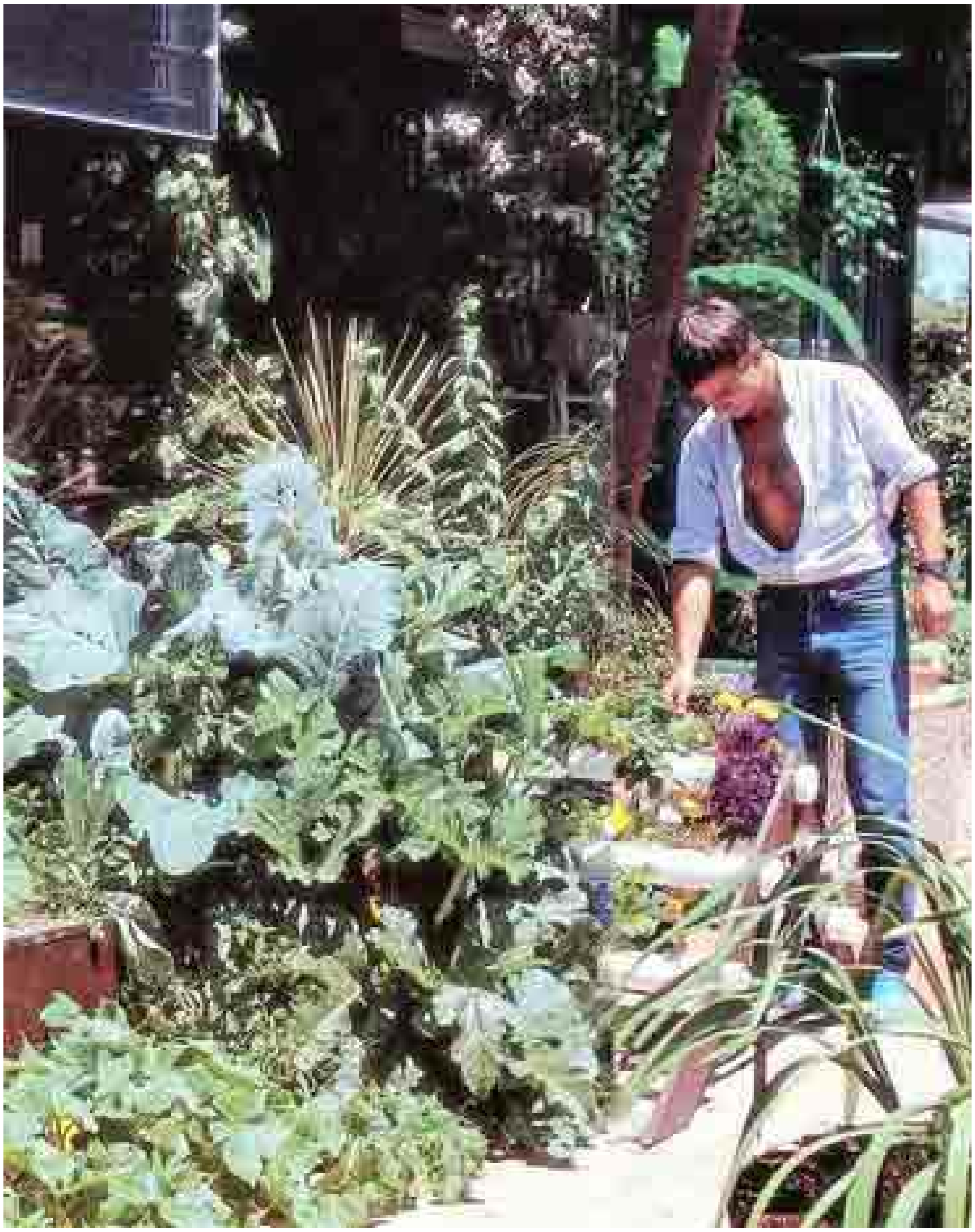
Copper is used by plants as an activator or catalyst for several important enzymes. A lack of copper will result in the wilting of new growth or sometimes irregular growth, often with new shoots dying back. Fruit will often split while it is ripening, especially in warm temperatures. Copper increases the sugar content of citrus fruit and intensifies the colour of crops such as carrots, spinach and apples. Copper is important in the utilisation of iron when haemoglobin is formed in the blood of animals.

Boron

Deficiency in this element is generally shown by the slow death of plant tissue especially around the main growing point and the apex or centre point of the roots. Cracks varying from small to quite large in size appear on the fruit of plants lacking in boron. Quite often the stems deteriorate and become hollow. Boron is necessary for normal cell division and protein formation as well as being important for pollination and seed production.

Molybdenum

Molybdenum is used in the formation of proteins by plants and affects the plant’s ability to fix atmospheric nitrogen. A deficiency may be indicated by pale leaves which appear burnt towards the edges. The foliage may also become distorted. Broccoli, Brussels sprouts, cabbage, cauliflower's, and other brassicas will not develop leaves properly when there is a shortage of molybdenum. Molybdenum is also essential for plants such as peas which have nodules on their roots for nitrogen fixing bacteria. Having detailed the functions of these nutrient elements it can only be concluded that they are all vital in producing healthy plants. You may wonder how plants can survive in the soil where any one or more of these essential elements may be deficient in varying degrees. In the wild, unaffected by humans, plants grow extremely well. Only plants suited to extremely poor soils will grow on those soils. Plants also gradually modify the soil breaking it up with their root systems, some even help to replace nutrients in the soil, peas for example have nitrogen fixing bacteria in the legumes on their roots



Weeding and cultivating become a thing of the past in a hydroponic garden. You can spend your time trimming pruning and harvesting the produce from your plants. The plants will be healthier and less prone to diseases and insect pests, however you will still need to keep an eye open for any of these problems and treat them promptly, as you would in a conventional garden.

Decaying plant matter by adding humus to soil also improves its condition . Even in the most deficient soils some plant species are bound to become established paving the way for other species which may succeed them later.

Complex plant communities often develop, the New Zealand native forests for example, feeding large amounts of humus into the soil as old growth breaks down making way for new growth. The complex root systems of the native trees hold this enriched soil in place while the dense cover provided by their leaves keeps it moist and damp providing the ideal conditions for ferns and other undergrowth.

Plants when left alone adapt to, and modify, their environment very efficiently, the problems arise when humans trying to support large numbers of people, set up specialised monocultures. Single crop types are grown over large areas, requiring the use of large scale pesticide applications to eliminate competitors and other chemicals to reduce disease. The humus remaining in the soil from bygone native forests is soon expended requiring continued large scale applications of fertilisers which may provide plants with the nutrients they require but do not replace the function of humus in keeping the soil in a light, aerated, workable condition.

The home gardener is placed in a similar position on a new section which has had all but the minimum amount of topsoil, required to grow a layer of grass, removed during the subdivision process. Topsoil (and compost) has to be brought back to establish a vegetable garden or fruit trees. Fertilisers are needed as well as compost to bring up the humic content in the soil. The home gardener is further disadvantaged in not having technical advice available from the specialists who are often employed to analyse the soil conditions where large scale cropping is being undertaken and prescribe the fertiliser applications required. For the home gardener wanting to grow a range of crops, prevention is better than cure, the solution being to keep feeding a steady supply of fertiliser and compost into the vegetable garden soil rather than waiting for the deficiency symptoms described earlier to appear.

Hydroponic growing eliminates the problems associated with poor soil and it’s nutrient deficiencies for both the commercial and home grower. Rather than having to expend large quantities of fertilisers on a large area of soil where crops are to be grown, the commercial grower can instead cycle the required amounts within a compact hydroponic system adding more nutrients only as required.

Hydroponic systems eliminate the problems home gardeners come across when a fertiliser applied to one group of plants counteracts another fertiliser applied to different plants growing nearby. It is also easy to apply a nutrient to your plants in too large a quantity. Some of the important elements only need to be present in small amounts as they become toxic to plants if they are present in too high a concentration. A good hydroponic nutrient food, tailor made to the crop being grown, contains the right nutrients in the right proportions for optimum growth and is easily measured and adjusted with cheap, efficient and readily available equipment.

Plants growing outdoors and in their wild state will produce flowers and seeds efficiently to ensure that new generations of plants follow them. In a greenhouse you may have to pollinate plants yourself as the wind and bees, two of the natural agents aiding pollination, may not be present.

These tomatoes are being grown in plastic (polythene) lined wooden gullies which have a thin film of nutrient flowing through them (NFT).

Chapter Four : The nutrient formula

Now that you have an appreciation of the role the different nutrient elements play in plants, and an idea of the poor plant health brought about by deficiencies of these vital elements, I can describe a typical nutrient formula to you, so that you can get some insight into the way these elements are made available to your plants in a hydroponic growing system. The essential elements comprising the nutrient mixtures are Nitrogen, Calcium, Potassium, Phosphorus, Boron, Copper, Iron, Manganese, Magnesium, Zinc, Sulphur and Molybdenum.

There are a number of other elements known to science which also play a part in the growth of plants. Among these are Sodium, Selenium, Chlorine, Vanadium and Cobalt. These elements are not normally included in the nutrient mix, since they are required in extremely small amounts, so small in fact that sufficient quantities are almost certainly present in the mixture by way of impurities. There may well be other elements which are also required, again in microscopic amounts, however, the presence of these elements as impurities is so small as to be extremely difficult to detect. Some elements are also derived from sources other than the nutrient mix. The air supplies some of these, as also does the water supply.

There are two approaches to obtaining your nutrient mixture, you can buy it in ready mixed powder form from a number of suppliers or you can mix your own. If you are a commercial grower with a large operation you will probably want to at least mix your own major components. Some home growers who enjoy experimenting may also want to make up their own, however you will find it easier just to buy a ready made product. Unless you are using more than 100 kilograms of dry salts per year the cost savings of mixing your own will be minimal. It's like owning a car, you may enjoy driving it but there is little point in trying to save a few cents by mixing your own petrol. Anyway, here are some formulas for those who wish to use them or would like to know what the different mixtures are made up of. You will notice that the mixtures come in two parts. This is for storage purposes to prevent precipitation between the different elements making up the mixture.

The plants do not need to compete for nutrients so a row of any crop will look like a hedge with each of the plants being the same size and shape. Photo courtesy of Spring Water Hydroponic Farm, Queensland, Australia.

Formula Number One for 'To Waste' systems
Grams per 100 litre

Bag A- Calcium Nitrate______80.9

Bag B-Potassium Sulphate_____55.4

Potassium Phosphate_________17.7

Ammonium Phosphate_________9.9

Magnesium Sulphate__________46.2

Iron EDTA___________________3.27

Manganese Sulphate__________0.02

Boric Acid___________________0.172

Zinc Sulphate_________________0.044

Ammonium Molybdate________0.005

You use this formula by volume and should dissolve the elements in the quantities shown into 100 litres of water. Note: Do not attempt to dissolve the above quantities in a smaller volume of water since chemical precipitation will take place essentially destroying the nutrient)

Formula Number Two

The following ingredient to be dissolved into two separate containers of 25 litres of clean water to make two 'stock solution' concentrates for use in recirculating systems (can also be used in 'To Waste' systems if desired)

Bag A Calcium Nitrate__________2.5 Kg

The following ingredients to be dissolved into 25 litres of clean water

Bag b-Potassium Nitrate__________1.5 Kg

Mono Potassium Phosphate_______0.5 Kg

Magnesium Sulphate_____________1.3 Kg

T.E. (Trace Element) MIX________0.1 Kg (100 grams)

To make the TE (Trace Element mix) it pays to work in larger quantities to avoid problems of weighing small portions so this makes approximately 10Kgs of TE mix:

Iron Chelate__________7.5 Kgs

Manganese Sulphate____1.4Kgs

Boric Acid____________350 grams

Copper Sulphate_______120 grams

Zinc Sulphate (Mono)___85 gram

Ammonium Molybdate__20 grams

This mixture now allows you to mix your own nutrients avoiding having to measure small quantities of micro nutrients.

Besides simplifying the mixing of the nutrient solution the use, as the iron shown above, of a complex chemical compound, known as a chelate, also has other advantages. A trace element when in the form of a chelate is held tightly with a molecule, which prevents it from reacting with other substances. Yet when the chelate is taken up by the plant the nutrient is still fully available for use. This avoids the situation which sometimes occurs when sulphates are used where the sulphate becomes insoluble and unavailable to the crop. Similarly a reaction may occur with soluble phosphates which will result in a 'lock up' of both the trace elements and the phosphates. Iron especially should be introduced to the nutrient mixture in chelate form. Although it is more expensive than iron salts only small amounts are required.

The use of iron salts such as ferrous sulphate in your mixture creates problems with precipitation of iron in the system requiring regular flushing out with water and regular replacement of the nutrient solution. Most of the trace elements can be introduced into the nutrient solution in chelate form with the exception of boron and molybdenum which are inorganic so they are unable to be chelated.

So these are the main nutrient mixture formulas which I would recommend. They will provide your hydroponically grown plants with a balanced diet for fast and above all healthy growth. Now that you have the formulas you can try mixing the one you think will suit your needs or buy a ready mixed product. If you buy your mix, all you will have to do is weigh part A and B so that you get the right ratio as described on the packet, and then add it to the prescribed amount of water.

As long as it is a reputable "two part” mix nutrient, then results will be produced on demand. Beware of single mix plant foods, with labels claiming suitability for hydroponic growing. There are a lot on the market which are useless for hydroponic use, despite claims to the contrary.

Lon Daltons prize hydroponically grown tomatoes growing from a hanging basket. Just keep on picking them and your plants will keep growing them!

Chapter Five: Important aspects of hydroponic growing

Oxygen

Having introduced you to the nutrient solutions used when growing plants hydroponically, we can now return to our simple example of seedlings growing on blotting paper in a saucer of water. This will introduce some new concepts. Normally the new plants would die once the small quantities of nutrients in the water and those dissolved from the blotting paper had been used up. By adding a suitably small quantity of one of the nutrient mixtures available we could prolong the life of these plants.

You can get a variety of plants growing once you dissolve some nutrients into the water you want to grow them in. For example the top of a carrot can be made to produce new green shoots and flower cuttings will often develop new root growth. However eventually all of these plants will die. This time the cause will not be the deficiency of one or more of the nutrient elements, but the lack of an equally important ingredient, oxygen!

The root structure of a plant needs oxygen if it is to remain in a healthy growing condition. The water in the saucer would have had some oxygen in it, enough to allow the plant to grow for a while, however, the water would have become depleted of oxygen quickly turning stagnant. Plants in the soil would also die if the oxygen which permeates through the soil to their root structures, were not available.

Worms are valuable in the garden because while dragging decaying organic matter underground they form small tunnels which allow more oxygen into the soil. That is why plants will grow well in a light, well cultivated soil. Plants will often die if the soil is over watered, making it heavy and cutting off the oxygen supply to the plant’s roots.

All hydroponic systems therefore, have to include some way of introducing oxygen to the plant’s root structure. Keep this in mind, it is very important. A number of different methods for bringing oxygen into hydroponic systems are described later in the book. One simple way is to use a small air pump of the type used in goldfish tanks. The air pump is plugged into a normal power point and the plastic hose running from the pump is placed into your solution of water and nutrient elements. Air is bubbled into your nutrient mixture for the benefit of the plant’s roots in the same way as it is bubbled into an aquarium for the benefit of the goldfish.

This strawberry runner is growing in a mixture of gravel and vermiculite in a fibreglass growing container. Oxygen could be introduced into the nutrient solution by spraying it onto the aggregate around the plant however the nutrient when exposed to light encourages algae growth.

Light

An important consideration before setting up a hydroponic system is the effect that light will have on the nutrient solution. It would be easy to expand the system already described so that instead of growing plants in a saucer, they were grown in a larger container filled with water and nutrients while an aquarium pump could be used to provide the oxygen.

However if light is able to reach the nutrient mix, either because it is in a transparent container or if the top of the container is uncovered, then algae will soon start growing. It grows rapidly on the inside walls of the container and on the roots of the plant. This is undesirable as the algae is an unwanted organic substance which will upset your carefully balanced nutrient mixture. This is why the nutrient mixture used in hydroponic systems should not be exposed to the light. Light proof covers and materials are used in most systems.

Although plants grown hydroponically will not be competing for nutrients, they may still have to compete for light. Space your plants making an allowance for the size they will reach at maturity. Light is the main source of energy for plants so optimum light conditions will play an important part in achieving optimum growth. A greenhouse enables you to provide your plants with plenty of light all year round without having to subject them to winter frosts or any of the other unfavourable conditions they are liable to be exposed to outdoors.

Peppers and tomatoes in NFT - Photo courtesy of the BOP Polytechnic.

Most plants will grow larger and faster in a hydroponic system. Keep a log or handbook in which you can note how fast the plants are growing. This will help when you want to start seedlings off to replace mature plants.

Take a note of the sizes they are reaching so that you can space the plants more efficiently, especially when growing flowers. An enthusiast will eventually start experimenting with different growing media's and also try altering the strength of the nutrient solution charges, which if recorded will enable you to judge how successful they were.

Growing Media

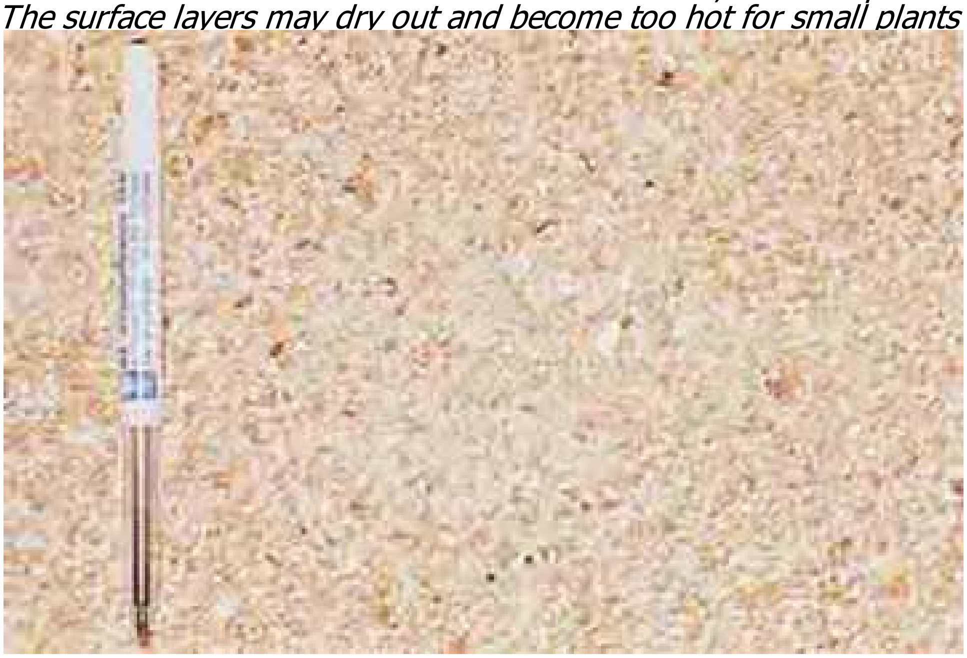
One of a plant's requirements is for support which is usually provided by its roots anchored in the soil. Soil is not used in hydroponic systems but there are other types of mediums which are suitable. Sand, gravel, scoria, pumice, Vermiculite, Coir, Expanded clay etc, or a mixture of these mediums can be used. Virtually any inert material can be used provided that the material is clean, will not add any extra chemical constituents to the nutrient mix, and that it will provide good drainage. Always wash the medium well before use, and if you are in any doubt, use a weak solution of household bleach to sterilize the medium. Coarse, washed, river sand is a good medium when used with a drainage base of gravel. Gravel alone is also suitable. The best sizes to use are between 3mm and l0mm. Gravel lasts well which is why it is used by many commercial installations. It is also easy to remove plants from gravel without leaving quantities of root material broken off in the medium where they will rot.

Scoria can cause problems because small roots will grow into the scoria so it is better used for growing indoor plants which will not need frequent repotting. Pumice, like scoria, is a very porous medium but you will have to make sure that the pumice is free from chemical contamination. It often contains sulphur. Vermiculite is a lightweight and very porous medium, ideal for starting off seeds and exceptional for raising cuttings in. Vermiculite is quite expensive when compared with other products so it pays to reduce the amount you need by mixing it with other substances.

Perlite is another medium which retains moisture well. I would recommend that you try gravel as your medium with a layer of perlite or vermiculite worked into the top 40cm. You can easily combine any of the mediums mentioned, to a degree it depends on what you have available locally.

Remember your medium should provide a place where the plant's roots can support the plant while still allowing air and the nutrient mixture through without adding any extra substances.

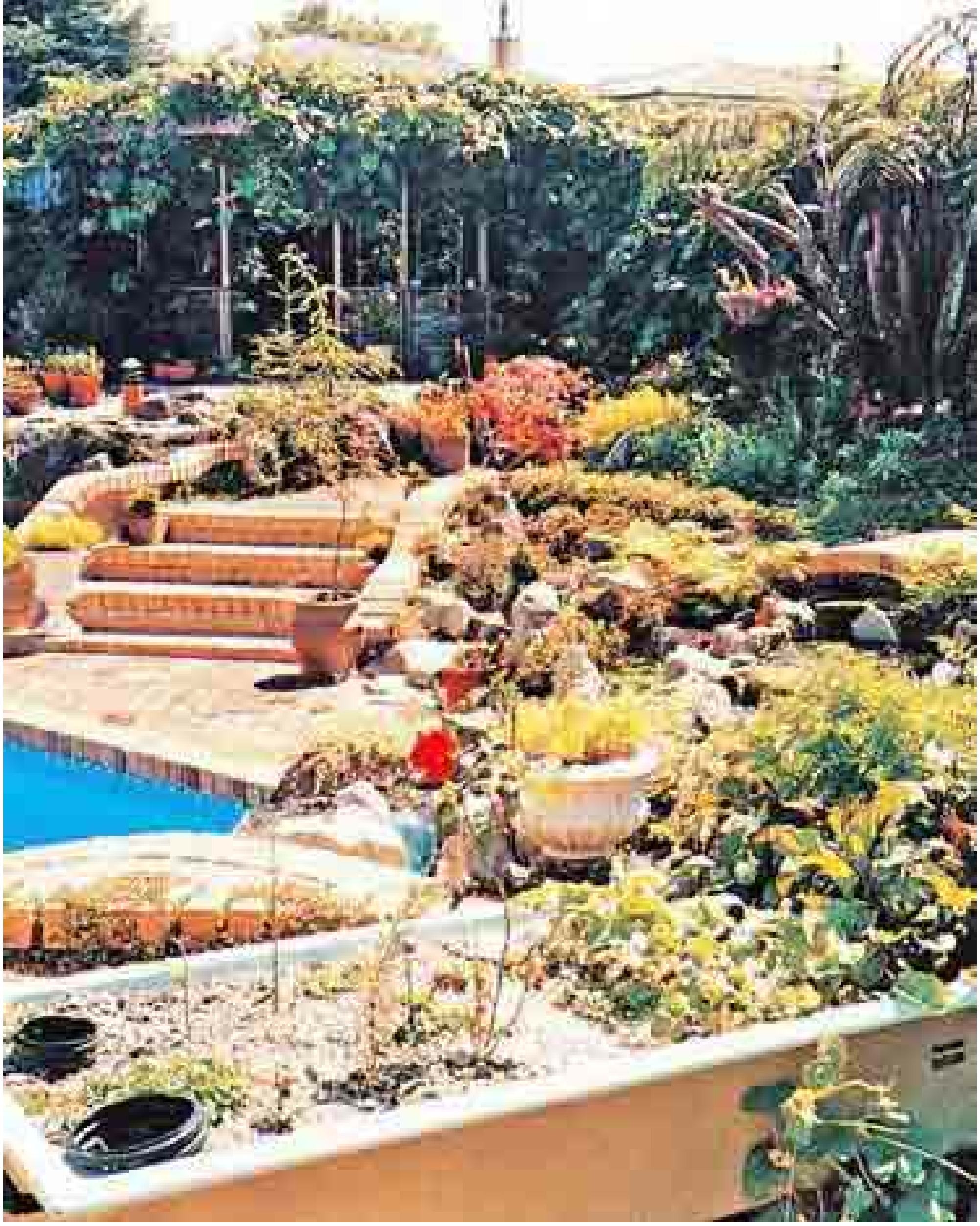
1 - Gravel is an excellent medium. It drains well and does not break down, however problems may arise in extremely hot weather. The surface layers may dry out and become too hot for small plants and seedlings.



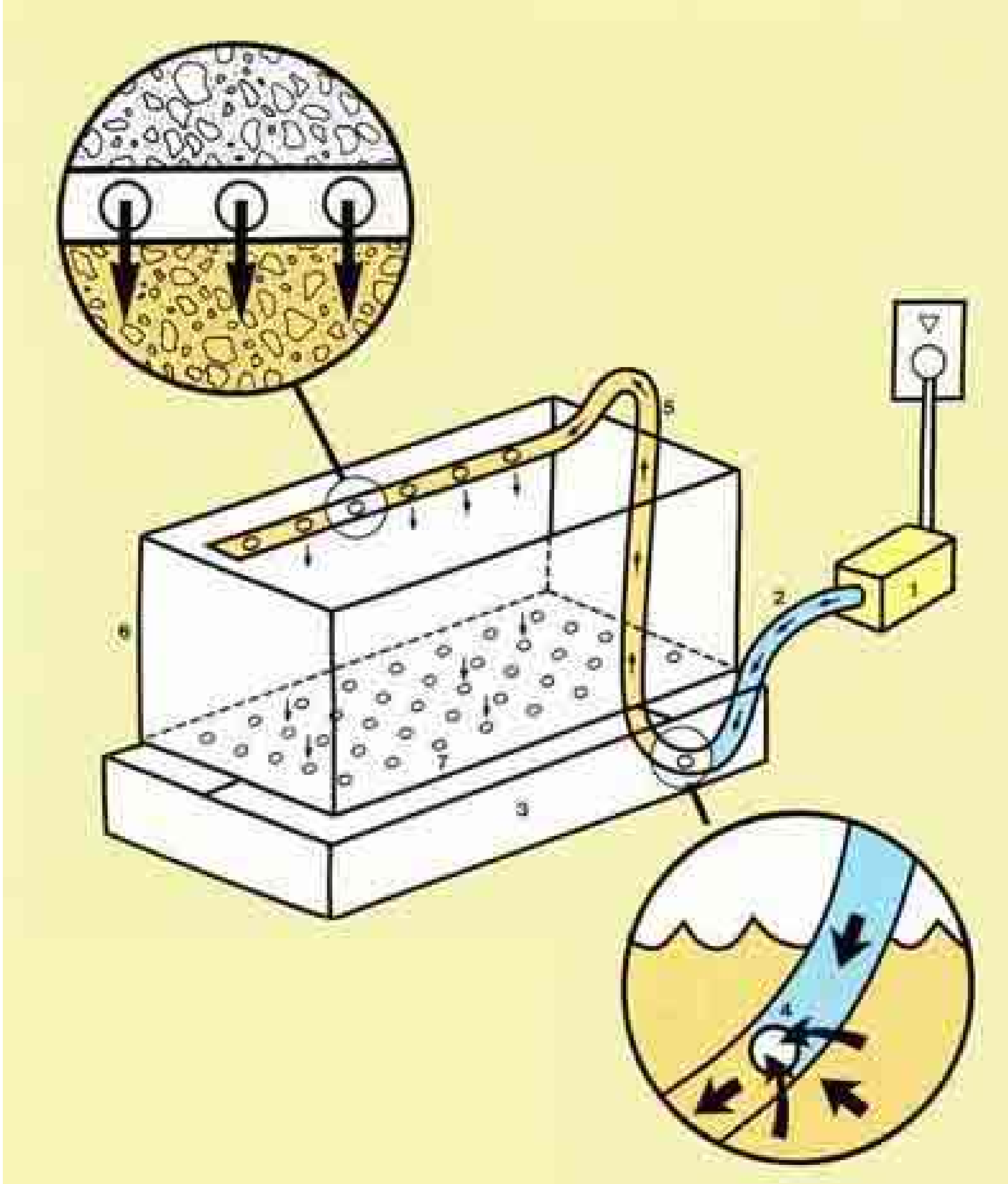
2 - Vermiculite is a porous substance which will hold water well keeping the medium cooler and moisture available to the plants. The only drawback is that vermiculite will break down over a period of three or four years.

3 - Heat treated, screened pumice is a very good base material for a soilless seeding and propagating mix.

4 - Perlite is a heat expanded material which, when mixed with about 25% vermiculite, makes an excellent soilless seeding mix.



The purpose of the growing media is to provide a substance in which the plant's roots can grow to support the plant. The media should be friable enough to enable oxygen to reach the plant's roots. Light sand, for example, is too dense when it has water flowing through it and needs other substances added to give it more bulk to open it up for adequate drainage. The media should provide a balance of good drainage and moisture retention, while local availability and price will also be important considerations.



A small air pump [1] pumps air down a plastic tube [2] which runs into a holding tank [3] filled with nutrient solution. The nutrient solution flows into the tube through a hole [4] and a mixture of air and the nutrient solution [5] is lifted up the tube to the top of the growing container [6]. The nutrients drain down through an aggregate mixture in the growing container back into the holding tank through drainage holes in its base [7].

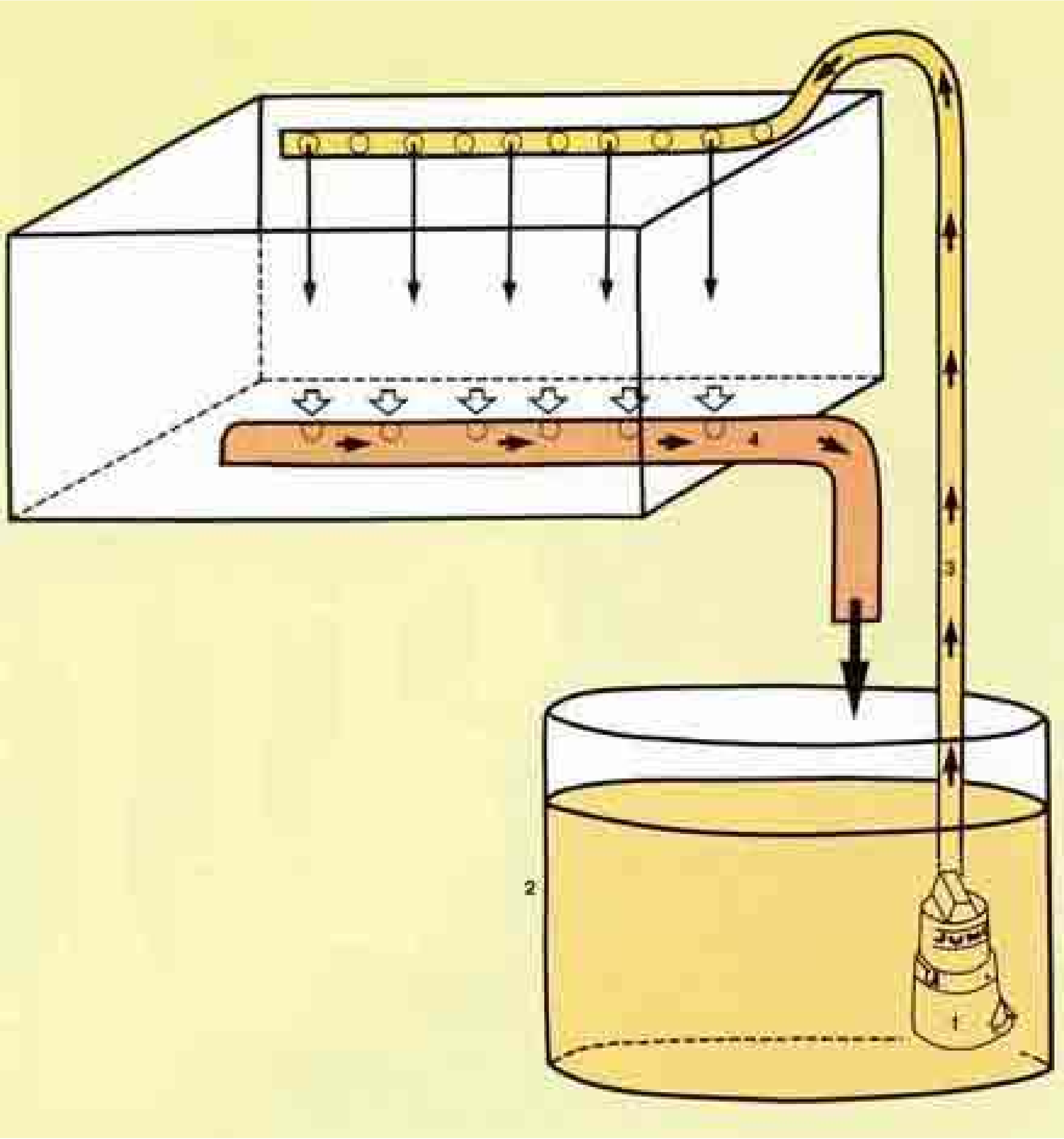
Chapter Six: The basic hydroponic systems

Aggregate Filled Systems

With the knowledge you will have gained so far, you should be ready to start with a simple yet highly effective system. We start off with a shallow tank made out of a light-proof material. This will be the holding tank for the nutrient mixture. Another deeper container but with the same size base sits on top of this holding tank and is filled with aggregate. Aggregate is the term used to describe any of the inert substances such as sand, gravel or perlite which make suitable growing mediums. Remember that the aggregate must be clean. There should be no soil or vegetative material, which could alter the gardens nutrient mixture. Small garden containers can work on a passive capillary action method by making a simple wick, such as polyester rope, or a piece of pipe filled with vermiculite, this is placed between the two containers so that water and nutrients are drawn up by capillary action into the top growing container. Larger garden containers will require some form of pump. The next step is to connect an aquarium air pump. The tube from the pump should pass down through the container filled with aggregate and enter the holding tank filled with the nutrient mixture. The tube should then rise back out of the holding tank and run back up to the top surface of the aggregate filled container. It can be laid along the top of the aggregate and small holes made in the tube along the length on the surface. This section of tube can then be covered with about another lcm of aggregate. Another hole should be made in the tube where it curves and starts to rise out of the nutrient holding tank. Make a hole about 1 to 2 mm across in this part of the tube. This will allow nutrient mixture to enter the tube so that when the aquarium pump is on, the air pumped through the tube will also push the nutrient mixture up the tube. The nutrient mixture will flow out of the holes in the top of the tube where it runs just under the surface of the aggregate. What you will have created is an air powered Venturi water pump to cycle your nutrient mixture. It works especially well because the aquarium pump will also be introducing oxygen to the nutrient mixture. You will be able to grow plants hydroponically in the aggregate because the nutrient mixture will be draining down through the aggregate back into the holding tank before being pumped back up to the top again. No algae will form in the nutrient as long as you use a holding tank container for the aggregate made from light-proof materials. This is also why the tube releases the nutrient mixture 1 cm below the surface of the aggregate. If it was released on the surface then algae would grow on top of the aggregate

There is no built in obsolescence in hydroponic equipment. Everything used to put your first manually controlled system together can be retained if you automate and will still be running in twenty years if you want it to.

Drainage is the most important aspect of a media bed, to ensure that adequate oxygen from the air is available to the root zone.



A submersible pump [1] is used to pump the nutrient mixture from the holding tank [2] through a feed pipe [3] up to the surface of a growing container [4] The nutrient solution drains through the aggregate in the growing container into a drainage pipe [5] which returns it to the holding tank. Oxygen is introduced into the nutrient mixture by the waterfall effect achieved when the concentrated flow of draining nutrients drops back into the holding tank. One enterprising grower who built a holding tank into a concrete floor but did not allow a high enough drop to effectively introduce oxygen into the nutrient solution, overcame the problem using spa pool venturi's. Instead of digging out the holding tank and lowering it, the spa pool venturi's were used to blow air (oxygen) into the mixture.

You will find that you can successfully grow a wide range of plants in a simple hydroponic system. You can experiment with different plants, growing mediums, and try running the pump for different lengths of time. Vermiculite holds up to five to eight times its own weight in water so if used with gravel or pumice to ensure good drainage you will have an aggregate that retains the nutrient mixture well, even when the pump has been switched off. You should only find it necessary to run the pump for a few hours during the day and probably not at all during the darkness hours. The general concept of this hydroponic system can be modified and expanded into a large number of designs for systems providing that the basic principles are adhered to. Oxygen must be able to reach the plant's roots, light must be kept away from the nutrient mixture and the aggregate must provide good drainage. With the system just described, the size of the growing area and the number of plants that can be supported is dependent on the ability of the air pump to push enough nutrient mixture to the top of the aggregate. If you wanted to cover a larger area you could use more air pumps, however a proper water pump will prove to be more efficient. Even a very small submersible pump is capable of servicing quite large areas of aggregate. A submersible pump will efficiently move water from a holding tank up to near the surface of the aggregate mixture, however it will not pump oxygen into the water. The air pump worked well on a smaller scale and could still be coupled to a submersible pump for larger systems. However there is little point in running two pumps when there are other methods of introducing available oxygen .

Tumble aeration is a more effective technique for handling larger volumes of water. Natural examples of tumble aeration include the waterfalls and rapids in streams and rivers. The water is agitated vigourously so that oxygen is dissolved into the water from the air. This movement puts the life giving oxygen into our streams and rivers. They become threatened by pollution when the level of oxygen available in the water is thrown out of balance by the introduction of high levels of waste products. Large quantities of fertilisers which are often washed from our farmlands into lakes also produce a problem as algae thrives on the excess of minerals, while other life forms do not. To introduce oxygen into our nutrient mix without the use of an air pump, we incorporate a waterfall in our hydroponic system. Instead of allowing the nutrient mix to return to the holding tank through a series of holes in the base of the aggregate-filled container, the nutrient can be channelled so that it will flow back through one hole. The water falls into the holding tank with greater force when it is concentrated, putting oxygen back into the water. You will notice the same thing happening when you turn on a tap into a sinkful of water. You can see the bubbles of air in the area around the point at which the tap water is entering the water in the sink. So by introducing a more efficient pump and by using the natural waterfall effect to introduce oxygen you can build up even larger aggregate-filled hydroponic systems.

The Flood and Drain System

The systems described so far involve the nutrient being supplied at the top of the system before draining down into a holding tank. This works well as there are no demands for complicated equipment or large amounts of power to move the nutrient mix upwards, while gravity ensures that it returns to its starting point.

The flood and drain system (also known as the ebb and flow system) works in a slightly different manner to the systems just described. In a flood and drain system you still have a growing container filled with an aggregate that has good drainage qualities. However, the nutrient mix is pumped in at the base of the container so that it completely fills up the growing container.

When the nutrient mix has risen to just below the surface of the aggregate and the container has been thoroughly flooded, the pump is switched off. The nutrient mix is then allowed to drain back into a holding tank.

When the solution of water and nutrients is pumped into the growing container it forces out the stale air from around the plants roots and from the passages in the aggregate. Then as the water level drops during draining, fresh air is sucked in replenishing the supply of air available to the root mass. This aspect of the system works well. Problems however, arise in that salts may build up in the aggregate.

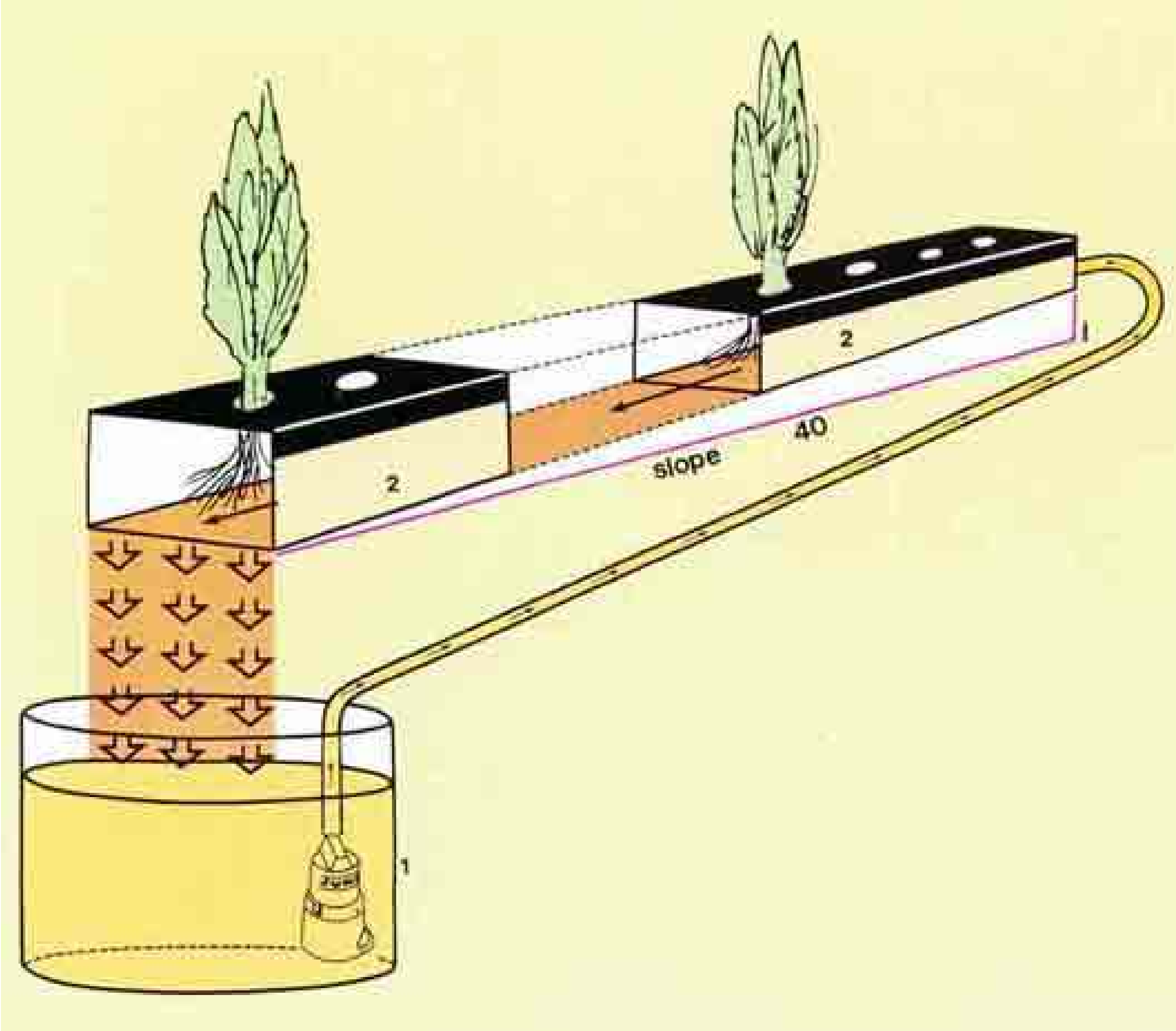
Remember back to the section on 'How Plants Work' explaining that nutrients need to be dissolved in water for plants to be able to absorb them. In a flood and drain system, these mineral salts are liable to build up in a non-soluble form. You can create a similar effect by mixing some common salt from the kitchen with water then pouring some into a saucer. If you leave the saucer for a day or two the water will evaporate leaving small salt crystals. If you add more of your salt solution and allow the water to evaporate again you will see that the crystals have developed further. If the process is continued these crystals will continue to build up unless they are thoroughly agitated and dissolved into the new solution.

This is a problem with flood and drain systems. There is a build up of residual salts and the plants are unable to absorb these salts unless they are completely dissolved in water. Many of the elements become toxic to the plants if they are present in too great a strength.

This could result in the loss of plants growing in the system, so the build-up of these residues must be prevented. Therefore flood and drain systems require regular flushing with clean, fresh water to remove the residual salts.

Outdoor gardens that receive regular rain fall are usually not bothered with this problem There are also other complications involved in flood and drain systems. The holding tank has to accommodate enough nutrient mixture to fill the whole growing area. This is acceptable for small hydroponic gardens but for a large scale commercial garden the holding tank would have to be disproportionately large and costly compared with those required by other systems. Further complications arise in that some form of cyclic controller is needed to control the flood, drain and standby cycles. These gardens are usually flooded every 2 to 4 hours depending on the type of plants and aggregate being used. A simple time switch on the pump can handle this task for single bed systems, while multi bed systems using the same holding tank would require a multi station irrigation type controller. Although it has problems, I have described the flood and drain system as it was one of the most popular and widely used hydroponic systems until recent years, especially in the U.S.A. If the idea of a flood and drain system appeals to you and you are keen on experimenting then I doubt if you will be deterred by a few complications. Generally though, I would recommend the continuous flow aggregate systems described previously for those who want to start off and expand a hydroponic garden or, the N.F.T. system which I will describe next.

This is an empty growing container in a flood and drain system. The flood cycle has been started and the nutrient solution is filling the container before draining back into the holding tank. The drainage cycle is quick to ensure that air is sucked efficiently into the media around the plants' roots.



Nutrient solution is pumped from the holding tank [1] up into a gully [2] through which a thin film of nutrient flows, in an NFT system. The gully is raised to a slope of a minimum of one in forty to allow the nutrient solution to flow down the gully and drop back into the holding tank. Again it is the force of the water failing back into the holding tank that introduces oxygen into the nutrient mixture.

Tiered NFT gullies allow for a wall of colour

The NFT System

Developed by the British scientist Dr Cooper in the 1970's the NFT system does not use aggregate. Nutrient mixture is pumped from a holding tank up into a covered gully so that the gully will have a thin film of nutrient solution flowing through it. NFT stands for Nutrient, Film Technique. A simple gully may be made from the plastic gutter material used on many homes which is covered to prevent algae growing in the nutrient mixture. The gully runs on a slight downward slope to the holding tank where a waterfall effect is used again, to put oxygen back into the nutrient mixture. The plants are grown through holes in the covering over the gully with their roots in the nutrient mixture film, which is ideally 1mm thick.

This is an extremely simple but highly effective system which is being used world wide to grow thousands of tonnes of produce of all types each year. A small submersible pump can be used to pump the water which flows down the gully at a depth of only lmm. The gully should be on a minimum slope of one in forty, so for every 40cm of length in your gully, the far end will have to be raised lcm. In the aggregate filled systems the plants had the aggregate in which their roots could become anchored for support. There is only nutrient mixture flowing through the gullies of an NFT system. As a result the plants may fall over when you put them in as seedlings through holes in the gully covers but within days they are standing upright. The continuous supply of water and nutrients to the seedlings promotes rapid root development so that the roots are soon able to support the plants. You will find the system extremely versatile. You could try growing tomatoes, cabbages, peppers, beans, cucumbers, melons, strawberries and a number of other plants in NFT gullies together with carrots, lettuce and beetroot for example in aggregate filled containers with both systems using a common holding tank and pump. The possibilities are almost endless. Now that you have an understanding of how the basic hydroponic systems work, we can move on and look at how to keep these systems producing at an optimum level

The root system of this silverbeet or Swiss chard plant are small by normal standards since the roots do not have to spread over a large area to obtain all the nutrients the plant requires, this is not always the case since some hydroponic plants grow larger than normal roots due to factors such as heating the root zone which stimulates root growth and also the fact that many of these hydroponic plants grow for a much longer period than normally expected.

Chapter Seven: Testing nutrient solutions

The secret behind obtaining consistently good results from a hydroponic system lies in two simple tests of the nutrient solution. I will explain these two types of test carefully because once you have an understanding of them, you will have a complete basic knowledge of how to grow hydroponically. The first test is a simple measurement of the strength of the nutrient solution. The strength of the solution is measured by its conductivity factor, and we refer to this as the CF (Conductivity factor) or EC (Electrical conductivity) measurement.

The principles behind taking a CF measurement of your nutrient solution are quite straightforward. Water conducts electricity in the same way that the copper wires running through a house conduct electricity to supply lights and power outlets. This is why it is unwise to operate electrical appliances in damp or wet situations. The water may conduct the electrical current so that you receive an electric shock. Water conducts electricity, because it is full of impurities. There are a number of common elements which are readily dissolved in water producing salts as well as the microscopic particles of all sorts of compounds that we generally call 'dirt', which are easily suspended in water. Totally pure water itself, will not conduct electricity. How well water will conduct electricity can be measured by an inexpensive and readily available device, the CF meter. This meter basically consists of two electrodes which are placed in the water to be measured.

When switched on, an electronic current tries to pass from one electrode, through the water to the other electrode. The meter has a digital display which will tell you how much electric current is flowing between the electrodes, resulting in the CF measurement. So if a CF meter probe is placed in pure water and switched on, little or no electricity will flow so the meter will produce a readout of zero. Now remember back to the jug of water and common salt we used earlier to produce salt crystals. If a very small amount of this salt solution is added to a container of pure water and the CF meter is used to test it, you will get a reading. The more of the salt solution that is added to the water the higher the CF reading will become.

The nutrient mixture used for hydroponic growing is not very different from a mixture of common salts for the purposes of a CF reading. It is derived from many different elements, but, when you mix them with water they have the same electrical response as common salt mixed with water. The stronger the solution, the more electricity will flow and the higher the reading you will get on a CF meter. The CF scale on hydroponic CF meters is designed to show the strengths required for hydroponic growing. The scale ranges from 0 CF which is pure water, to 100 CF which is generally the maximum strength required. The scale, therefore, is divided into 100 parts, each part is a CF. unit.

Rob Smith testing a sample of the nutrient solution in his hydroponic system. Regular testing is the key to successful hydroponic growing. By dipping the probe of a pH meter into a sample of your nutrient solution the pH meter will give you accurate readings enabling you to keep the pH of the nutrient solution within the range required.

Different crops will grow better in a hydroponic garden at different CF values. Lettuce for example, grows better in the range between 3 and 12 CF units. Tomatoes on the other hand, generally require from 22 to 28 CF units. When you are starting off with a hydroponic garden for your home you will find it easy enough to get an average CF level that will suit the variety of crops that you will probably want to grow. Commercial growers however, wanting optimum growth and performance from their systems can grow separate crops, making sure that each type of plant receives a nutrient mixture in the strength that it will perform best on.

Altering the strength of your nutrient mixture is easily achieved. When you mix up the A and B parts of your dry nutrient powder with the amount of water prescribed you will have mixed it to a certain strength. A quick test with a CF meter will tell you how strong the mixture is so that if you want it weaker all you have to do is add more water. Adding more dry nutrients will strengthen the mixture raising the CF reading. You can keep altering the mixture until you have the desired CF reading on your meter.

If you are starting off with a hydroponic garden for a range of vegetables for the home you will find that the powdered nutrients available give you mixing instructions on the packet giving you a strength suitable for general growing. If you are intent on making up your own combination of nutrients I would advise you to use the formulas provided earlier as most plants will grow well in them, including all of the vegetables that are commonly available.

Ph

The second type of test you should make of your nutrient solution is a pH test. The pH scale indicates how acidic or alkaline, water or any other liquid is. The scale ranges from 0 through to 14. Pure water is neutral, it is not acidic or alkaline. On the pH scale pure water is rated as 7. Anything above 7 pH is increasingly alkaline up to 14 pH which is the strongest alkaline reading you can get. Below 7 pH down to zero the scale indicates acidity. The most acidic reading is 0 pH.

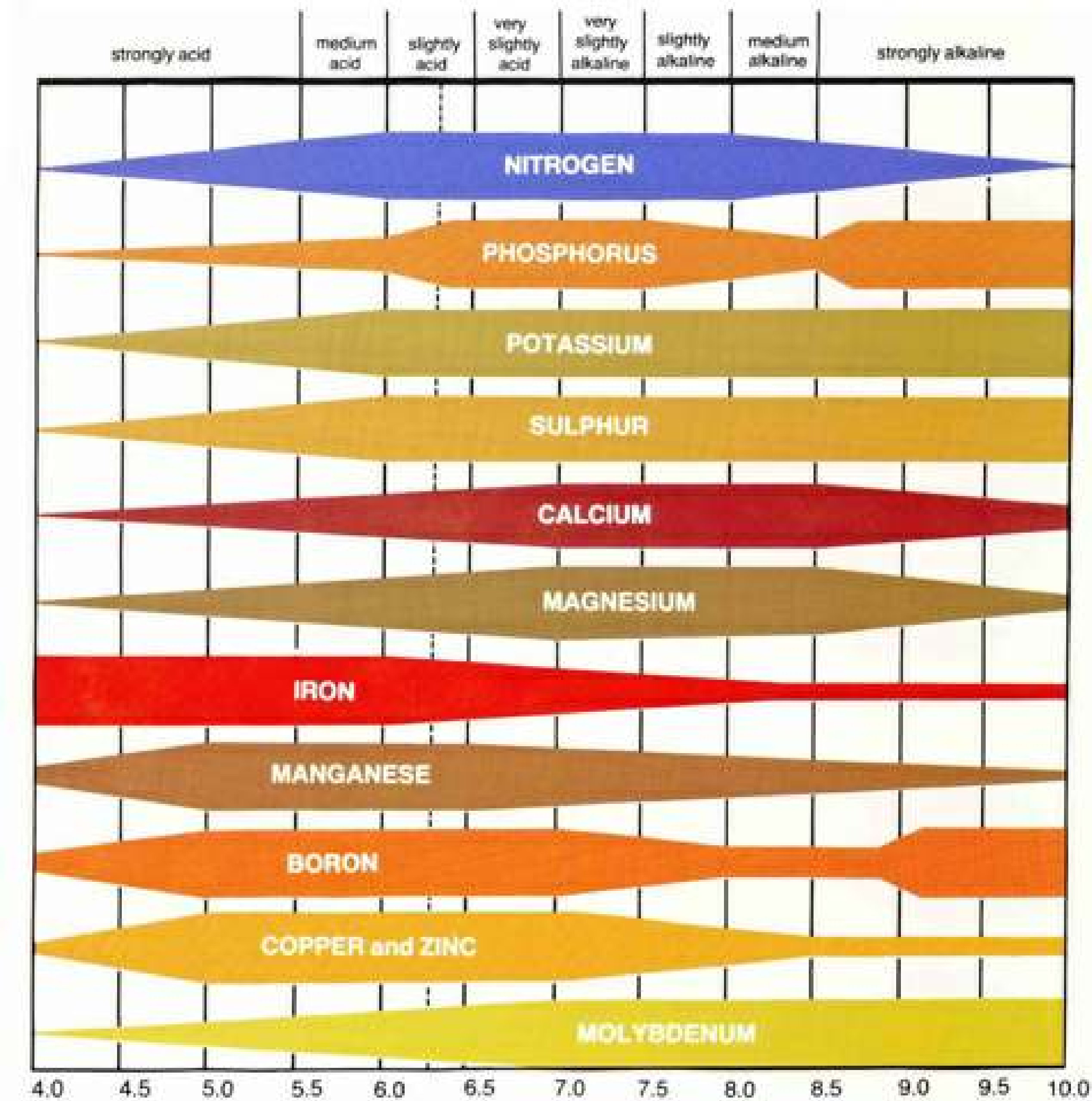
You can test pH by using colourmetric test paper, however this form of testing does not give a very accurate measurement. Digital pH meters are available which give you an instant and accurate measurement. Plants can survive in the pH range of 5 pH through to 7.5 pH. Below 5 pH there is a danger of burning and destroying the root tissue of the plant. Above 7.5 pH some of the nutrients may precipitate out of solution and become unavailable to the plants.

The reason pH is important when growing both hydroponically and in the soil is that certain elements or salts in our case, are only available to the plant within certain pH values. A pH value should be selected that will provide the best feeding conditions for the plants. This value is between 5.8 pH and 6.5 pH for most plants, 6.3 pH being the preferred value.

You will find it easy to hold the pH of your nutrient solution at the value of 6.3 pH with automatic pH dosing equipment which you will find described in the chapter on equipment. If you are controlling the pH level manually you should test and correct the pH of the nutrient solution daily. In most situations the pH will rise becoming alkaline as the plants use up the nutrients in the nutrient solution.

If you are testing your nutrient solution manually you will find that a small portable combination CF and pH testing unit (Combo Meter) will be a valuable aid. The pH meter should be buffered every week to make sure the readings are accurate.You can see the relative proportions of the different pH levels in the chart. Compare the thickness of nitrogen, calcium, magnesium, iron, manganese, copper and zinc at pH 6.3 and pH 10. For example there is a high level of nitrogen available at a pH of 6.3 dwindling to almost nothing at a pH of 10. To correct the pH of your nutrient solution, add a very weak solution (less than 10%) of either phosphoric acid to lower the value, or potassium Hydroxide (caustic potash) to raise the value. Be very careful that the additions are made in small quantities until experience is gained. Photo courtesy of BlueLab Corporation.

HOW NUTRIENT pH AFFECTS AVAILABILITY OF PLANT NUTRIENTS



The width of the bands indicates the relative availability of each plant food element at various pH levels. Having mastered the techniques of controlling your nutrient mixture you should now be ready to obtain the equipment you will need to make up a hydroponic garden.

This white bucket is the holding tank for a home hydroponic system. The black float operates the water make up valve allowing extra water to flow into the tank when the level becomes too low. This float arm needs covering to stop the nutrient on metal contaminating the nutrient (See the obvious corrosion on the arm)

Chapter Eight: Equipment

There are two important things to keep in mind when selecting equipment for a hydroponic system. The first is that any material which will contain the nutrient solution will have to be light-proof. The second thing to remember is that the materials coming in contact with the nutrient solution must not give off any substances which will upset the balance of the nutrient solution.(such as the brass arm on the float valve shown) Cost will obviously be important but it must not be allowed to override these first two considerations.

Holding Tanks

Plastic drums with their tops cut off and plastic rubbish bins are two types of inexpensive and readily available holding tanks which should meet all the necessary requirements. Stainless steel is a suitable material as it is not affected by the nutrient solution. Concrete tanks can also be used but should be aged to make sure that all of the limes and other substances are leached from the surfaces of the concrete. A coat of sealer is one way of overcoming that problem.

This installation shows an early 'Dosetronic' hydroponic controller mounted inside a building while controlling a hydroponic installation in the glasshouse outside.
Note the two small PVC drums which hold the 'A and 'B' nutrient stock solutions.

Feeder lines run from the main nutrient flow pipe running along this wall to a number of aggregate filled containers. The plastic drainage return pipe can be seen at the base of the wall.

Nutrient Lines

Food grade, PVC pipes are the most suitable material for conveying the nutrient solution. There are a variety of plastic materials which can be adapted for use as nutrient lines, just remember to make sure that they are light-proof. Black or dark coloured pipes work well in keeping out light and also assist in picking up solar heat.

Pumps

The vibrator type, aquarium pumps work well in the venturi type, aggregate-filled systems. They can also be used in the larger systems to pressurise a tube which can then be used to feed acid into the system. This is fully described in the chapter on setting up a system. Submersible pumps are suitable but you will have to check that they do not have any metallic components which could contaminate the nutrient mixture. These pumps are available in low voltage types from around 20 watts up to types producing several horsepower running off the mains. The average home system could be run successfully on a 40 to 60 watt pump. There are a number of pumps available for larger systems.

Valves

Shutoff valves placed at strategic points can be extremely useful especially in larger hydroponic systems. They will allow you to work on sections of the system without having to shut everything down. Again these valves should be made of PVC or stainless steel. Another aspect of larger systems which you will find described in the chapter on setting up is the need for a float valve or ballcock to control the replenishment of water. It is surprising how much water plants use, so with this in mind virtually any system larger than a window box or patio type garden will need to have a water supply flowing into the nutrient solution to replace the water used. This is easily controlled by a float valve or ballcock which will stop the flow when it reaches a selected level. If the valve does not come into contact with the nutrient solution it could be made of brass or some other alloy, however I think you will find that plastic valves are generally cheaper and work better.

Growing Containers

There is an almost limitless range of containers that you can use in a hydroponic system. If the container is not light-proof or if it is likely to contaminate the nutrient solution you can line it with plastic film. Black polythene is the cheapest and has a long useable life. Plastic drums with their tops cut off are an economical way to set up a large growing area. The drums can be placed in a row and filled with aggregate. The nutrient mixture is pumped from the holding tank through feeder pipes to each drum. The main feeder pipe runs down the middle of the line of drums with smaller tubes branching off to each drum. When operating the nutrient will flow in near the top of the aggregate and drain down to the base of each drum. From there, the nutrient solution is channelled through drain pipes back to the holding tank. A 15mm (1/2”) polythene pipe should be large enough to drain the nutrient solution from each drum back to a main drainage pipe running to the holding tank. This is an extremely simple yet effective way to build up a large system with inexpensive growing containers.

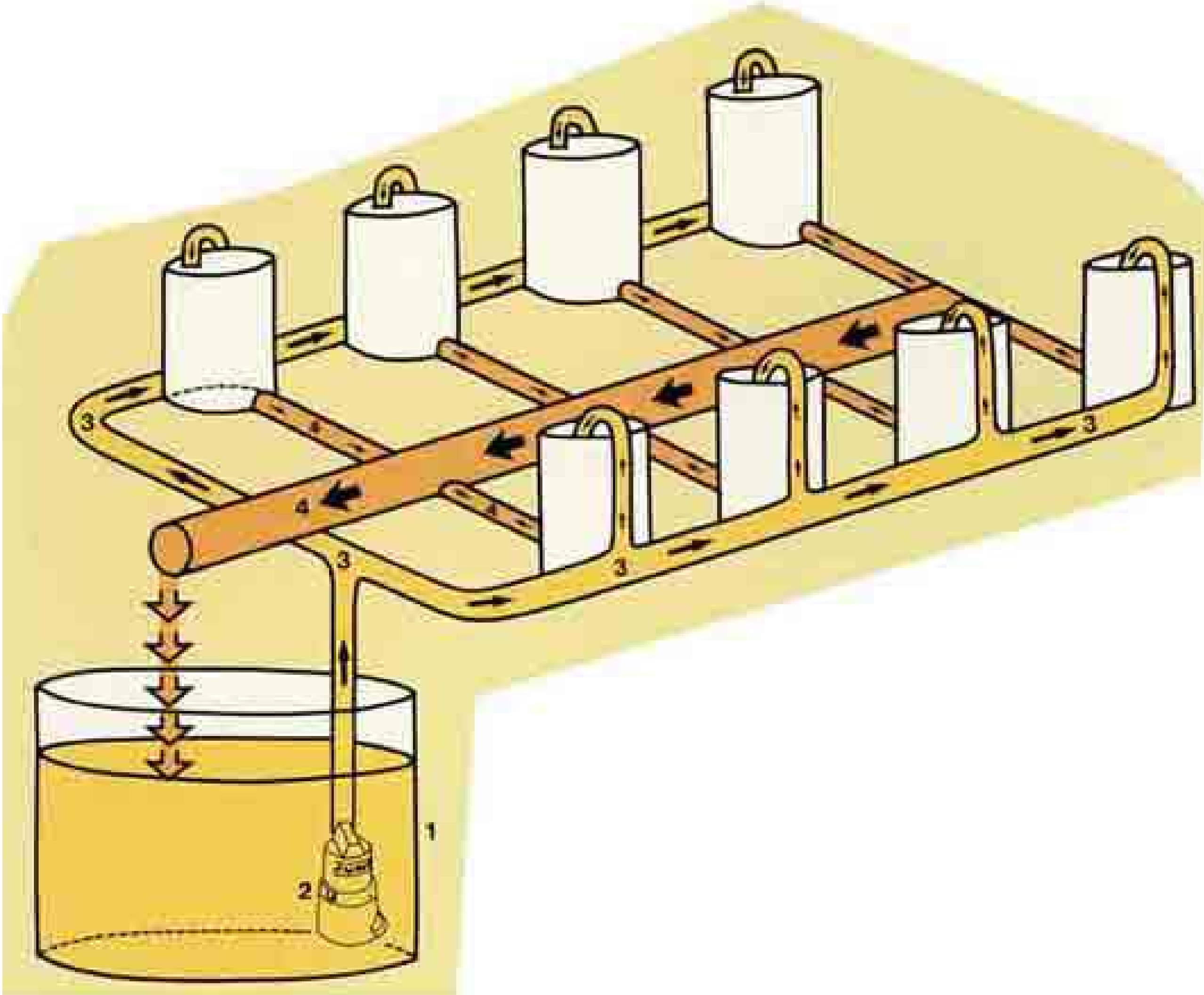
You can acquire all sorts of disused containers at scrap value and adapt them for use in a hydroponic system. Old concrete wash tubs for example, are ideal for use in aggregate filled systems.

There is also a wide range of pipes and other materials which can be used as gullies in NFT hydroponic systems. Storm water products are ideal, plastic spouting, plastic downpipes and even long run roofing products can be used successfully. You can drill holes in plastic for the plants to grow through.

When using guttering and other materials which provide you with an open gully, use white polythene or panda film (co-extruded black and white plastic film) to cover the gullies and keep light off the nutrient solution. Holes are easily made in the polythene for the plants. You can even make up your own wooden gullies and line them with polythene. Polythene can also be used by itself by folding it up and clipping the edges together at the top with clothes pegs. The pegs when clipped either side of a plant will also help to support the plant.

Make sure that the growing containers you start your seedlings off in are large enough to hold the stem of the plant when it reaches maturity. Small plastic pots with seedlings in them can be placed into aggregate filled systems or slotted into holes in NFT gullies. It will not matter that the seedlings pot contains aggregate providing it is clean. Any material washed into an NFT system can be collected by a strainer located at the return into the main holding tank.

Typical Gro pot for use in NFT systems



A larger system using a number of aggregate filled growing containers can still be fed from one holding tank [1] by one submersible pump [2] The feed lines [3] run to each growing container which drain the nutrient solution back into a main drainage pipe [4] The combined flow of draining nutrients then returns to the holding tank.

If you are experimenting with irrigation cycles in an aggregate filled system, make sure that the media does not dry out. The cuttings on the edge of this bed are receiving a steady supply of nutrients.

These hydroponic gardens use a number of different growing containers and gullies. Fibreglass trays can be seen in the foreground with plastic gullies behind them. Note the use of plastic coated wire frames to support plants in the background. We do not recommend the use of round pipes since true NFT is impossible to achieve without a flat gully base. The round pipes lead to ponding of nutrient which ultimately leads to root death.

C F (Conductivity) Testing Equipment

The value of equipment which will analyse the nutrient solution should be quite clear now. Before the advent of testing equipment, growers had to add a set amount of nutrients to a set volume of water which would then produce a nutrient solution of the desired strength. This could then be used for a specified period before it had to be dumped and replaced with a new, fresh mixture. This is a wasteful practice as it assumes that the plants have used up all of the nutrients in the solution during the time it was being used. In fact probably only a proportion of the nutrient elements may have been used and aside from any deficiency symptoms displayed by the plants, the grower would have had no idea when the various nutrient constituents had run out. Now there are registered laboratories where growers can have their nutrient mixtures analysed. They may use an atomic absorption spectrometer which is capable of analysing the nutrient mixture and giving a readout in parts per million of the various elements in the mixture. This sort of equipment is far too complicated, expensive and unnecessarily accurate for regular use by hydroponic growers. The CF meter already described, which measures the strength of the nutrient solution is more appropriate. They are easy to use and readily available to both commercial growers and home enthusiasts.

There are several types of CF meter. Older, Manual CF meters usually consist of two dials and a zeroing or nulling meter. To test the nutrient solution the operator first measures the solution's temperature and then sets this on the temperature dial which usually has settings from 15°C to 40°C. The sample cup in the meter is then filled with some of the nutrient solution. The second dial is rotated until the meter needle falls to zero. The CF value will be indicated by the position of this second dial. The meter includes an adjustment for temperature because this has a considerable effect on the CF reading. Generally CF values are given at a standard temperature of 20°C. For every one degree Celsius the temperature of the nutrient solution changes, the CF value will alter by around two percent. This can make a significant difference so the meters have to be able to make an allowance for temperature variations. Modern automatic conductivity (CF) meters, automatically compensate for differences in temperature from the 20°C standard measuring temperature. These meters simplify testing to a minimum. There are no controls, all you have to do is dip the probe section of the meter into the nutrient solution. The meter then registers the CF value, adjusted for temperature on a digital display for you. The only thing the operator has to remember is to leave it dipped in the solution long enough for the temperature detector to correctly assess the temperature. These meters are available in both hand held and in line models. The in line units have fittings on either end so that they can be fitted into the nutrient feed pipe supplying the growing area. The meter will then be constantly giving CF readings on the state of the nutrient mixture. An added advantage offered by some manufacturers is the ability to read the values in other conductivity scales such as the 'EC' scale and the TDS (Total dissolved solids - not a recommended) scale

A wide range of plants can be grown in the same hydroponic unit by adjusting the nutrient solution to an average strength which can be suitable for a wide range of plants. Here a CF Truncheon is used to measure a sample. Photo courtesy BlueLab Corporation

An automatic CF meter will provide you with accurate temperature adjusted readings of the strength of your nutrient solution Shown is the 2012 automatic 'pen' type - Courtesy of BlueLab Corporation..

Hydroponic Controllers

Automatic hydroponic controllers can be used to control the nutrient solution of almost any system from home systems to large commercial systems. The 'Dosetronic' employs a number of logical functions to prevent accidental overdosing. Photo courtesy BlueLab Corporation

The two plastic containers hold the topping up solutions for a home system. The automatic controller above them will open small solenoid valves in the feed lines from the containers to the holding tank when the nutrient solution becomes too weak.

The hydroponic grower with the help of a CF meter can easily assess the strength of the nutrient mixture and add more nutrients to the tank as required. This may seem like a lot of work but consider that plants growing in soil are using up nutrients as well. The difference is that you only detect nutrient deficiencies in soil grown plants when the deficiency symptoms appear and it is then, almost too late. As a result you have to apply fertilisers regularly in quantities that are quite wasteful. Only the nutrients actually used by the plants have to be replaced in a hydroponic system. The plants may be using large quantities of nutrients but in doing so they will be producing phenomenal growth. The efficiency of your hydroponic system can be taken a step further by incorporating automatic control equipment.

With an automatic CF controller you can pre set the CF level you want your system to be maintained at. When the plants use up enough nutrients to make the CF value of the nutrient mixture fall below the set level, the controller automatically activates a pump or solenoid valve, this allows more nutrient concentrate to flow into the holding tank until the strength of the nutrient solution rises above the set level and the dosing process is automatically shut off. Most CF controllers also have high and low value alarms. They will sound, warning you if your topping up tank is empty for example, or if a valve or pump is faulty. A commercial grower with a large system should seriously consider an automatic controller. Once installed the only tasks left for the grower are pruning, harvesting and replacing the plants as well as occasionally refilling the topping up tanks. CF controllers are also ideal for the home gardener. It means you can go away on holiday while the controller automatically adjusts your nutrient solution as necessary. The control units now produced in New Zealand are capable of controlling both CF and the other important measure of your nutrient solution, pH. The control units are based on the CF and pH meters with additional controls allowing you to pre set the levels of each required and to which the controller will keep the nutrient solution adjusted.

This growing system is fully automatic and is shown here growing Babaco a variety of South American Paw Paw.

pH Meters

If you are happy to adjust the nutrient solution yourself manually, then a pH meter will be just as valuable as a CF meter in allowing you to assess the nutrient solution status.

Very small hydroponic units could be run without a pH meter. You could use a colour indicator tape or solution of the type provided in kit form for swimming pools. This method works as long as the colour indicator is in good condition. The only way to check that the indicator is showing the right value is to try it out in a solution which you already know the pH value of to see if you get the correct result. This solution is called a 'buffer solution. ' Generally it is not worth trying to do without a proper pH meter, the outlay for a meter is minimal and the results are more accurate, especially if you have any form of colour-blindness.

The pH meter is basically an extremely sensitive volt meter which measures the pressure of electricity. Pure water has no voltage at all but in both acidic and alkaline solutions there is a minute amount of electricity produced. It is too small to be measured by an ordinary volt meter. The pH meter has a special amplifier which increases the output of the pH probe placed in the solution to be measured. The voltage signal produced in the probe, once it has been amplified, is then conditioned by special circuits to allow for temperature differences because pH readings are affected by temperature in the same way as the CF readings, but to a much smaller degree. The meter then produces a digital readout giving you the pH value of the solution you have measured.

The pH meter works by taking a very small signal, multiplying it, adjusting it and then converting it to a pH level, so care must be taken when using the meter to ensure that the readings will be accurate. The probe should always be washed in distilled or deionized water with a neutral pH value of 7 The probe can then be checked by placing it into a buffer solution. The probe is first placed in a buffer solution that you know has a pH value of 7 The meter may not read 7 so you have to adjust the buffer adjusting system until the meter shows a pH reading of 7 The next step is to place the probe in a buffer solution with a pH value of 4 (or 10 it just needs to be offset from the neutral value of 7) a different reading is now produced so the second adjustment, known as 'slope', is adjusted until the meter displays a pH reading of 4 (or 10). The meter is now ready to give an accurate reading when dipped into your nutrient solution.

The very latest meters have micro processors in their circuits that provide for very much easier automatic calibration, so be sure to read the instructions provided with the meter to get the very best performance from it. Always remember to wash the probe on your pH meter in fresh water after taking a reading. You will also need to keep the probe moist when it is not in use as the probe should never be allowed to dry out. This procedure may seem complicated but you will find that it only takes a few minutes of your time, once you have your hydroponic garden established. Regularly testing and adjusting your nutrient mixture will provide you with good crops and will take you much less time than weeding a conventional garden. Remember too that unlike a garden in the soil, a hydroponic garden can have its pH and CF levels tested and adjusted by automatic dosing equipment of which New Zealand produces some of the leading designs

Make sure that you rinse clean the probe attached to your pH meter after each use to keep it in good condition. To adjust the pH value of the nutrient solution when it is too high, add a weak solution of phosphoric acid. Be careful as a surprisingly small amount is needed. Allow at least 30 minutes mixing time through the system before making further small adjustments. It is rare for the pH to be too low, however in the event of falling pH then correcting with a very weak solution of Potassium Hydroxide (Caustic Potash) can be used to raise the value. Photo courtesy BlueLab Corporation

These small plants and their containers can be placed directly into either an NFT or aggregate filled systems.

The small Black tubes running from the floor of this greenhouse into the NFT gullies are carrying the inflow of nutrient solution. The gullies are raised at this end so the nutrient will flow down to the drainage pipe at the other end. Two feed pipes are used per gully in case of a blockage in one of the micro tubes

Chapter Nine: Setting up a system

The basic steps involved when setting up a small growing area with an air pump have already been described. This system can be expanded although there are some points to be aware of as the size of your system increases. In an aggregate filled garden for example, you should check the drain and feeder pipes now and then to make sure that the plants' root systems have not blocked them up.

The larger system that you will be ready to set up now will also bring up a number of points that will be relevant to most large hydroponic systems. This can still be a simple system designed to supply several people and to run on a manual test system, however the step by step installation plan also includes the information needed to automate the system.

Step One: Checking the Water Supply

The first and one of the most important steps to setting up any hydroponic system is to check the quality of your water supply. Water is the basis of the nutrient mixture, the central part of your whole hydroponic system. If your water is supplied by a local authority from a water treatment station then there will probably be no problems. You can check with your city engineers department who can usually supply you with a water analysis. If your water comes from a well or bore you should have a sample analysed to make sure that the water is not overloaded with any element.

The maximum values of each element that plants can tolerate in parts per million are:

Sodium________180 ppm

(if only growing lettuce this value should only be 20ppm)

Calcium________100 ppm

Chloride________70 ppm

Boron__________0.2 ppm

Sulphate________80 ppm

Magnesium______45 ppm

Carbonates______60 ppm

The elements such as sodium, iron and zinc, for example, become toxic to plants if they are present in too high a concentration. Generally your water will be acceptable if the following values are not exceeded.

A water supply overloaded with one of the elements may be quite acceptable for human consumption yet prove to be unusable in a hydroponic system. If your water is one of the few cases where there is an impurity that cannot be filtered out, then you may have to consider an alternative water supply. Rainwater is often a good alternative.

NOTE: If levels are outside the values shown, then expert opinion should be sought to confirm both the formulae required and crops which would grow acceptably under such conditions.

If you wanted to grow plants hydroponically at a CF value of 25 for example and you were using water with an excess of sodium in it, you may find that the CF value of your nutrient solution is much higher than the 25 CF units you required.

This is because the water may have had a CF value of about 22 before you even added any nutrient mixture to it. The excess of sodium in your water supply would be responsible for this figure. This is just an example of one of the things that can happen if you fail to check your water supply before you start. Most hydroponic growers never experience this problem but it still pays to check.

Nutrient flows below the surface of the aggregate in this plastic lined wooden trough. The plastic pots are filled with perlite or a similar material which will support capillary action and the pots are screwed down into the aggregate to come into contact with the nutrient flow.
This is a great system for the easy rotation of flowering varieties to allow for a continual display, while those pots not currently in flower can continue growing in a less conspicuous area of the garden.

Any containers that may not be inert should be painted with two coats of bituminous paint to make sure that they do not release any harmful substances into the nutrient solution.

Step Two: Planning the Layout of the Growing Area

The next step in setting up a hydroponic garden is to plan the layout of your gullies or growing areas. Keep the growing surface well above ground level. This will help you keep the produce clean and provides for good air circulation which is especially important if you are growing in a greenhouse. Always leave plenty of room between the growing areas so that you can get in to harvest your crops and put new plants in with ease. You can increase or decrease the size of the growing areas and alter their arrangement to suit your own situation so long as you adhere to some basic principles. The first is that the minimum fall for NFT gullies must be at least one in forty. Remember that this equals 1 cm of elevation at one end of the gully for every 40 cm of length. The flow to each gully should be around one litre per minute although experience will show you by how much you can reduce this figure. Pumping nutrient solution through your system at a faster rate than necessary would be a waste of electricity and could lead to undesirable ponding and root death..

The size and length of the NFT gullies will depend totally on the type of crop being grown. Lettuce for example, is not a big feeder, so gullies measuring 100 mm across, 50 mm high and anything up to 18 metres long can be used successfully. Tomatoes, on the other hand, are very heavy feeders and also have a vigourous root structure which demands a good supply of oxygen and nutrients, so the length of the gully needs to be reduced. The use of excessively long gullies would result in the plants at the end of the gullies suffering poor root health. A good length of gully for tomatoes is 10 metres, although this can be extended up to 15 metres providing the gully is of sufficient size, is installed correctly to avoid any ponding of nutrient, has a minimum 1:40 slope and is provided with control of the flow rate to limit the volume of nutrient entering the gully.

Some growers use extra feeder pipes placed at intervals along extremely long gullies. This is not a recommended way to go about using longer gullies. You should always introduce all of your nutrient mixture at the head of the gully as the stale nutrient solution is expelled from the gully by the inflow of the replenished incoming nutrient solution. This may not happen as effectively when the inflow of nutrient solution is divided among a number of entry points. It would be better to use a larger number of gullies in short lengths with adequate flows. Remember how important oxygen is to the plants, the stale nutrient must be cycled back through to the holding tank effectively so that waste gases can be expelled and that the plants will receive fresh oxygen and nutrients

You can combine a variety of different growing containers which will enable you to grow a range of plants, all run on the same system. These NFT gullies and aggregate filled containers are all being fed from and are draining back into, one common holding tank with a single submersible pump. This grower has used various shapes of gully to compare the relative growing performance. Rectangular gully, is the recommended gully type for true NFT performance. Note the range of growing containers being used in this greenhouse including a number of household baths filled with aggregate. Greenhouses provide excellent all weather protection for a hydroponic garden system. Besides enabling the grower to extend his growing season, as with conventionally grown crops in greenhouses, there is the added advantage that the whole operation can be run in clean and hygienic conditions.

Note the range of growing containers being used in this greenhouse including a number of household baths filled with aggregate. Greenhouses are a suitable form of cover you can provide for a hydroponic system. Besides enabling the grower to extend his growing season, as with conventionally grown crops in greenhouses, there is the added advantage that the whole operation can be run in clean and hygienic conditions. A hydroponic grower can go as far as concreting the floor of a greenhouse so that only the hydroponic systems components and the plants are contained inside. Soil borne diseases and pests can be kept completely away from the growing area.

A recent practice with NFT gullies has been to use a capillary mat to line the gully. This material acts like blotting paper, ensuring that the nutrient solution spreads over the whole floor of the gully. The permanent capillary mat is excellent in commercial situations where all of the plants and their root material are able to be removed at one time along with the mat. However with a hydroponic garden in the home, it can prove to be a nuisance when you only want to remove one plant, as the plant's roots will have grown right through the capillary mat. In most cases the mat is unnecessary except when the plants are extremely small. At this stage there is a chance that the plant's root system will not be in the path of the nutrient flow.

This problem is easily solved by placing either small pieces of paper towel underneath the roots of very small plants or a piece of the disposable capillary mat which dissolves after approximately ten days after first being wetted. These will act like blotting paper until the roots develop and the material gradually breaks up. The pieces of material are caught by a strainer which also removes any small particles of vegetation before they are flushed into the holding tank. This helps to keep the system clean.

Setting up aggregate filled containers is quite simple. The arrangement described in the section on growing containers using drums can be expanded until you reach the growing area you require or you can use large trays similar to those illustrated for the dual system in this chapter. The size of the aggregate filled containers can vary depending on the size of the holding tank you have room for. How you determine the size you need is fully explained in the section on holding tanks. Something you should remember to do when filling containers with aggregate is to use coarser material on the bottom which becomes finer as you fill the container up. Finish off with a layer of slightly coarser material on the surface. A layer lcm deep of 4mm or 5mm chip works well, allowing the surface layer to remain dry and free from algae growth

The drain tubes shown in the top right of the picture, in this system return the nutrient solution to the holding tank through a strainer to remove any unwanted material.

Step Three: The Holding Tank

The materials suitable for use as a holding tank have already been discussed, however the size of the tank still has to be assessed. The size of the holding tanks will depend on the size of the growing area to be supplied and on the type of system. Manual test and dose systems have different requirements from automatic dosing systems.

Manual Systems

There is virtually no maximum size limit for holding tanks in manual test and dose systems, only a minimum size. The minimum size of the holding tank can be accurately established once you have your gullies, growing containers, feed and drain pipes and your pump set up and ready to operate. Select a container which you think will hold enough water to fill the system with an allowance for some extra water. You can then fill the container with water and start pumping it around the system while continuing to fill the container.

When all the gullies and growing containers have water flowing through them and back into the temporary holding tank you can stop filling it with water but keep the pump running so that water is still circulating through the system. Now you can start slowly draining water out of the container until you reach the minimum amount needed to adequately service the pump.

When you have reached this level stop draining and turn off the pump. Allow the water in the gullies and growing containers to drain back into your temporary holding tank. This will probably take from five minutes to half an hour after which time you will have the minimum quantity of water required to run the system in your tank. Having discovered the minimum amount of liquid required to run your system you can obtain a holding tank of the appropriate size. You will be surprised how much water is in the system. If you fail to allow for the amount of water in the system when you decide on a size for the holding tank it will flood as soon as there is a power cut or if the pump fails.

The tank may still have to be able to hold considerably more liquid than the minimum amount you discovered in your trial run. Because when the system is operating complete with plants, the amount of nutrient solution in the system will have to be able to supply the nutritional requirements of all the plants for the time that passes in between tests and dosing.

The minimum amount of nutrient solution needed to keep liquid flowing through the system and to keep the pump operating could provide enough nutrients for the plants if you test and dose more regularly, say twice a day. In other words if you test and dose the mixture before breakfast and after your evening meal the minimum amount of nutrient mixture used will only have to keep the plants adequately nutritionally supplied for periods of about 10 hours.

If you decide that you only want to test and dose the mixture once a day it is going to have to last twice as long so a larger holding tank could/will be required. By using a larger tank than technically needed you will ensure that the plants will be kept adequately supplied especially during times of heavy feeding. Obviously considerations such as the effective use of the space you have available as well as finance will place some limit on the size of your holding tank although theoretically for manual systems this is a case of the bigger the better.

The same flood and drain system shown earlier, now during the drainage cycle. This is a manually operated system. The tap on the black plastic pipe in the foreground floods the containers when turned on. The growing containers are set at different levels and are on an angle so that the nutrient solution flows down from one container to the next then into a drain pipe.

Automatic Systems

The automatically tested and dosed system is the most efficient of all hydroponic systems. The simpler systems all work well but they sacrifice some aspect of performance to retain their simplicity. You can grow hydroponically without any testing equipment at all. Instead a larger than actually required volume of nutrient solution is completely replaced every two or three weeks. Besides being wasteful you have to accept that you will have no idea if there is enough food available for the plants during the whole time period, when you use this system. This dump and replace period can be vastly extended by using automatic test equipment, however there will still be times when the nutrient is not providing the best growth possible, because after time its formula may have gone well out of balance.

You will have noticed how humans get irritable when they miss a regular meal. What makes you think that plants are any different. The ultimate system therefore, will dose on demand 24 hours a day. This will ensure that plants such as tomatoes for example, which can be found absorbing nutrients at 1 am in the mornings, will have the nutrients they require at all times. To obtain the maximum efficiency possible from an automatic testing and dosing controller, the size of the nutrient solution holding tank must be carefully matched to the minimum liquid requirements of the hydroponic system. There is no room for going to excessively large holding tanks as with manually tested and adjusted systems. This is because the automatic controller will have a more rapid control over a smaller amount of nutrient solution. If you were running a system automatically set to be kept at a level of 25 C F units for example, you may find that the temperature of the nutrient solution rises by up to 10°C during the day.

The heat from the sun would be largely responsible for this rise, and every degree celsius that the temperature rises, changes the CF value of the nutrient mixture by two percent. Remember, temperature affects the apparent CF value. Automatic CF controllers have a temperature sensing circuit which compensates for any temperature change and effectively maintains the CF at the desired value, however problems occur with large capacity holding tanks which are dosed up to the desired CF Value. If the temperature changes too often the controller will be unable to keep pace with the changes. The controller can increase the dosage if necessary but it is unable to reduce it. Automatic systems rely on the plants to reduce the CF value of the nutrient solution by using up the nutrients. In a system with a small holding tank the plants would soon use up enough nutrients to lower the CF value, however in a large capacity tank this could take a long time. In some cases the temperature may have changed again before this has been achieved. The temperature variations between night and day can often be extreme enough to produce this problem. The solution is to size the holding-tank on the same basis used for the manual system. This minimum size should not be exceeded to ensure that the nutrient solutions CF and pH values are kept as consistent as possible. The system will only be using enough water to keep the growing areas supplied and the pump in the holding tank submerged so you will have to make sure that this level does not drop any further. You can do this by setting the water make up valve so that new water flows in as soon as the level drops below the required level. Remember that if you allow the water to be used up without being replaced in time, the CF value could also rise to a dangerous level. If the nutrient solution is too strong reverse osmosis will occur, the plants will lose their moisture, wilt and die. Plants use large quantities of water for transpiration as was explained in the chapter on 'How Plants Work’

Carefully plan the layout of your growing areas when setting up any hydroponic system. You will find it easier to work around your plants if the unit is raised as shown here. Remember that aggregate filled growing containers are very heavy so any support tables will have to be sturdy enough to hold them.

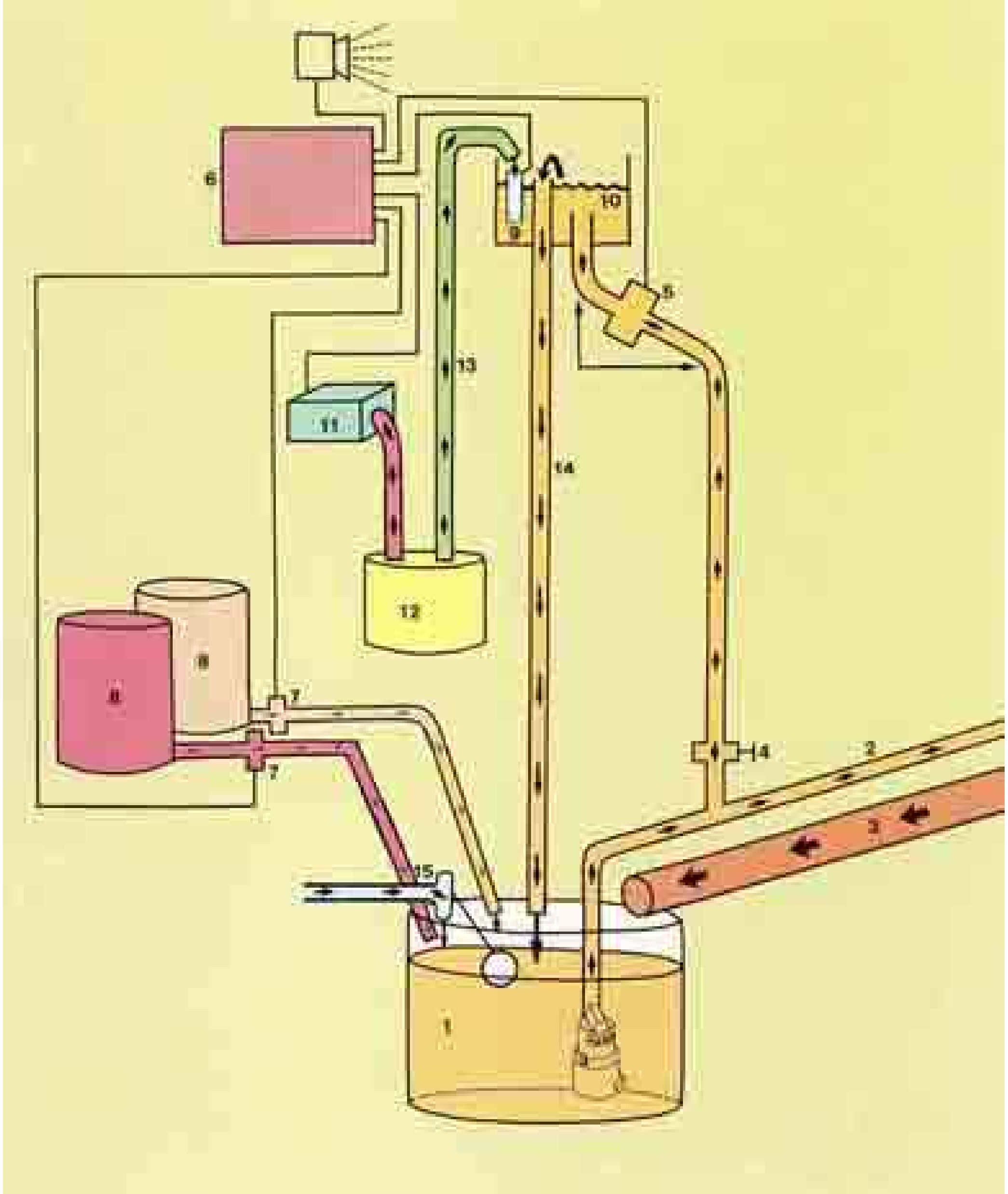
Step Four: Installing an Automatic Controller

The first and, one of the most important points to remember about installing an automatic controller is to locate it away from water, dirt or any other elements that are liable to affect the operation of the unit. Humid conditions should be avoided so a well ventilated structure should be built to house the controller away from the holding tanks and growing area. You could still house it in the same room as the holding tanks, if the conditions were favourable with the controller mounted on a wall away from any splashes or drips. You can start installing the controller by fitting a pipe into the main nutrient supply pipe just as it leaves the holding tank. A tap should be fitted at this point so that the control system can be shut off and worked on without having to close the whole system down. The pipe runs from the main nutrient pipe to a small sample container next to the automatic controller, wherever it has been located.

A l6mm PVC pipe will be large enough to take a sample of some of the nutrient solution up to this container. A CF inline cell can be fitted into this pipe and connected to the automatic controller. To ensure that the CF cell produces accurate readings install the cell inclined on a 45° angle with a non return valve on the supply side, use secure fittings on either side to prevent air leaks. Any pockets of air that form in the cell will produce inaccurate readings. The automatic controller will also have a connection for a temperature compensating probe for the CF reading. This probe can be placed either in the main holding tank or the sample container. Some controllers do away with inline cells and simply use a 'dip' type probe complete with its own temperature thermistor placed into the sample container.

The next item to install is the pH probe which is installed in the sample container. This container should have an inlet fitting at the bottom and an outlet drain back to the holding tank at the top. The pH dosing line will also feed into the sample container. You will remember from the chapter on equipment, it was stressed that pH probes should never be allowed to dry out once they have been put into operation. The glass measuring bulb has to be kept wet and clean. Both of these requirements can be easily satisfied by connecting the pH dosing line to the sample container so that it pours acid onto the pH probe. Nitric and phosphoric acid are usually used to alter the pH of the nutrient solution. Acid is also the best substance for cleaning the pH probe. This arrangement allows a fine control of the overall nutrient pH value because as soon as acid is pumped into the sample container it hits the pH probe connected to the automatic controller. The probe will send a signal to the controller which immediately shuts off the supply of acid avoiding overdosing.

The second requirement is achieved by setting the input pipe to the sample container above the height of the bulb end of the pH probe so that even if the sample container was to drain out, a residual amount would still be enough to keep the probe wet



See the following description of this schematic.

Nutrients flow from the holding tank [1] to the growing containers through feed pipes [2] and drain back [3] in an automatically controlled system in the same way as in a manual system. A line is run from the main feed pipe, taking a sample of the nutrient solution to be tested. A shut off tap is included in this line [4] to enable you to close the automatic system off if required. The feed line is connected to an inline CF measuring cell [5] connected on a 45° angle to prevent air bubbles giving false readings. The CF cell tells the automatic controller [6] when the nutrient solution is too weak and the controller activates solenoid valves (or pumps) [7] which operate, allowing extra nutrients to flow from the topping up tanks [8] into the main holding tank. The pH of the nutrient mixture is measured by a pH probe [9] located in the nutrient solution sample container [10] located after the CF cell. When the pH is too high the controller activates an air pump [11] which pressurises the tank holding acid [12] used to adjust the pH level of the nutrient. Acid flows up the pipe [13] into the sample container mixing with the nutrient solution which is continuously flowing back down an overflow pipe [14] into the main holding tank. The system also includes a water make up valve [15] which allows more water to flow into the holding tank as the level drops too low.

The holding tank for the acid should be connected to the sample container by a pipe that will be able to resist the acid (PVC - Polythene). A small aquarium air pump can be used to force the acid up into the sample container. This pump is connected to the automatic controller and is activated by the controller when the pH probe senses a rise in the pH level of the nutrient solution. The pump works by pressurising the acid in the container forcing acid up the pipe into the container altering the pH of the nutrient solution. The automatic controller activates a pump or solenoid valves to feed nutrients into the main holding tank in a similar manner. The pump is activated by the controller when it receives a signal from the CF cell indicating that the strength of the nutrient solution has dropped. The pump is shut off when the CF cell detects a rise in the strength of the nutrient solution to the level, preset on the controller.

The principles and operation of an automatically controlled system are quite simple making the arrangement something that can be accomplished by both the home and commercial grower. If you start growing with a manually tested and dosed system you will become completely familiar with the CF and pH testing equipment. This will make it easier when you decide to install automatic control equipment as you will have an understanding of how the test equipment operates. The pH testing probe will have to be buffered once a week in an automatic system and the CF probe cleaned with a suitable cleanser, Jiff, Soft scrub or proprietary cleaning materials, every three or four months. Buffering pH probes was fully described in the chapter on equipment. Apart from these regular checks all the grower will have to do once an automatic system is operating is to remember to refill the nutrient topping up tanks and the tank full of acid for altering the pH of the nutrient solution. Remember that when all else fails please read the installation and operating instructions issued by the equipment manufacturer

A crop of tomatoes in a commercially operated tunnel house. With the increasing need to place water usage restrictions on the ever increasing demands of competing horticultural operations, hydroponic growing offers a solution. By growing plants hydroponically only the water actually required by the plants is used, avoiding the need to pump large quantities of water to irrigate large areas of soil, much of which leaches away to waste.

Chapter Ten: Hints on running your system

Heating

Heating has always been one of the most important aspects of running a glasshouse during cold winters. Heating the soil is complicated and expensive, while heating the air which is the usual method of heating adopted, in order to maintain soil temperatures is a major cost factor when running a large commercial greenhouse. With hydroponic systems heating is revolutionised for both the home and commercial grower.

By heating the nutrient solution to ‘say’ 25°C the hydroponic grower can create conditions for the plants that are nearly as good as those during summer. The main difference is that the light will not be as good. Under normal outdoor conditions plants experience two different temperatures. The air temperature above ground and the soil temperature which the roots are subject to. When the ground temperature drops below a certain level in winter the root and general plant growth slows down and stops. By heating the nutrient mixture the plant's root temperature can be raised to near the air temperature promoting growth. A heater element can be located in the holding tank to warm up the nutrient solution. The heater element has to be stainless steel to avoid corrosion. Similarly to avoid damaging the nutrient solution by coming in contact with the element, a large element producing a low heat has to be used. These low density stainless steel elements can be thermostatically controlled to heat the nutrient when necessary. An important point to remember about the temperature of the nutrient mixture is that it should only be altered gradually. Sudden changes in temperature will put the plants into stress. This will apply mainly when you change the nutrient solution and replace it with another ‘fresh’ (colder) solution. Similarly the temperature of the replacement solution must be compatible with the temperature of the original solution to avoid harming the plants. As an anecdote to our discussion on heating, it should be remembered that plants, as do human beings, perform best when not under stress. Therefore every effort should be made to prevent stressful situations, such as rapid temperature excursions of the nutrient, by introducing much colder water or nutrient mix into an operating system, after all we humans are not that keen on sudden changes to our environment either. Heating the nutrient mixture has a number of advantages for the hydroponic grower. By maintaining the nutrient at the minimum temperature conducive to growth, the plants in the hydroponic system will be able to start growing as soon as there is a favourable change in the ambient (available light) conditions. In other words, because the root temperatures are warm, then the plants are ready to "go" the moment the sun provides its energy, whereas when the same plants are in the soil, it may take days or weeks for the ground to be warmed up enough to provide the root temperature required for growth.

The novice often falls for the trap of ignoring the 'basics' when designing or building a system, virtually everything which could be wrong has been included in this 'doomed to failure installation'. Unacceptably, small round pipes resulting in poor NFT and subsequent root health, too closely populated, providing insufficient light to all the plants, resulting in excessive leaf growth, and poor ventilation, all factors contributing to very poor yields of small sized fruit.

By raising the nutrient temperature to the optimum level of up to 25°C the plants ability to withstand tissue death brought about by very low temperatures is enhanced. This will give your plant's the ability to resist some of the frosts experienced during winter. It is not unusual for tomato plants under glass or plastic structures supplied with a heated nutrient mixture to fully withstand mild frosts with no air heating whatsoever. From a commercial point of view, this means great savings in heating costs, and to the home grower, out of season crops can become a reality without the associated high capital and running costs of conventional out of season growing systems. The expensive air heating equipment and the energy to run it, in other words is no longer absolutely necessary for the home hydroponic grower with a greenhouse. You can even grow crops outside using a heated nutrient mixture providing that the frosts are not too severe. Heating systems for the hydroponic nutrient are many and varied. Solar heating should not be overlooked, since high nutrient temperatures are not required, 25° C being the optimum. Electricity, gas, coal, etc may all be employed, the only factor which must be observed, is that at no time should any portion of the nutrient be raised to a temperature in excess of 60°C. At temperatures above this figure, precipitation of the nutrient mix could occur. To prevent this situation it is common practice to use water as the heated storage medium and to pass the nutrient through a heat exchanger. This is not as difficult as it may sound. A heat exchanger can be as simple as a few coils of plastic pipe immersed in the nutrient tank through which the hot water is circulated. Direct heating with specially manufactured immersion elements is also used, but avoid using standard electric hot water elements, spa pool elements etc as these will produce too high a surface temperature and will destroy the nutrient mix. For the ultimate, or "blue print" growing conditions then air heating can also be used, however the nutrient heating should always take preference if energy savings are required.

Excessively high temperatures will also affect the plants during summer as they will for conventionally grown plants. Summer vegetables generally grow well in temperatures up to 35°C but begin to suffer when the temperature exceeds 40°C. Shade cloth will protect your plants both outside or in a greenhouse. In a greenhouse a thermostatically controlled fan, to provide the plants with better air circulation when the temperature becomes too high, is the best solution

Plants grown outside hydroponically will have an extended growing season compared to plants grown in the soil. As the cooler winter soil and air temperatures slow down the activity of bees, and plants in the soil, you can continue pollinating your hydroponic plants by hand. Cup the flower as shown and use a soft artists brush to gently brush the base of the staminal cone of the flower. You will find that cross pollination is essential on vine type vegetables such as zucchinis, water melons and cucumbers.

To run, or not to run?

There are a number of opinions on the subject of cycling hydroponic systems. The premise is that because the availability of oxygen to the root zone is of such importance, then turning off the pump circulation at regular intervals during the day and not running at all during the hours of darkness will aid this requirement. I certainly would not argue against this principle, particularly so in the case of media gardens, however there are other factors which should be taken into consideration.

The rate of transpiration must be taken into account, and care should be taken to ensure that there is an adequate supply of water for this purpose. Another factor is, how do you know at what time of the day the plants are requiring uptake of nutrient, and finally if you are using the nutrient as a heating agent, then obviously the nutrient must be circulating to achieve this. Again the answer lies in experimentation, trying different programs of timing, since all installations are going to be different. Some installations may gain nothing from the exercise while others will show a much improved growth factor. My own systems are controlled by an automatic daylight switch which turns off the system at dusk, and starts it up again just after dawn. In cases where you do turn off all night, it is a simple job to put in a low temperature thermostat override switch which will turn on the circulation in the event that heating is required.

Cleaning the System

By now you will have realised how important water is to the hydroponic system. The plants themselves are made up of tissues and water, the water accounting for up to 97% of their weight. The nutrients used by the plants are dissolved into the water and must be in the right concentration to be available for use by the plants. You will remember that one of the problems with flood and drain systems was that the nutrient salts tended to build up in the aggregate in a non soluble form. The solution was to flush the system out regularly with clean water. The continuous flow aggregate filled and NFT systems are not as prone to this problem, however they should still be flushed out periodically to keep the system clean. This is done by discarding the nutrient solution and running the system on clean water for up to two days. A hydroponic system can be run on water for this period of time without harming the plants. Generally by testing and dosing the nutrient solution, either manually or automatically, the nutrient solution could remain useable for several months. In a small system holding about 70 litres of nutrient I would recommend replacing the solution every six weeks followed by flushing the system with clean water. The cost of replacing the mixture will only be something in the order of 50 cents. In a larger system where valuable dollars worth of nutrient may be circulating through the system, prolonging the life of the mixture, will be more important. This is why it is still worthwhile for larger hydroponic installations to have their mixture analysed by a laboratory and to adjust it to bring it back into balance. When the system is flushed out, remember to use water that has a temperature similar to that of the nutrient solution removed. You may have to wait for the plant to adopt a cooler temperature in the evening and then use the cooler tap water to rinse the system out. Flushing removes salts, dead roots and any other unwanted substances that may have accumulated in the system.

Power & Water

What do you do if you suffer an interruption to your water supply? The easy answer to water cuts is to have a back up storage tank, however this is not always possible, and so all that can be done is to minimise the effects of the water shortage. Do your best to reduce the CF value as low as possible as quickly as possible. If you have an automatic dosing system then this should be turned off since the first problem will arise as the water content of the nutrient solution is removed by transpiration, which in turn will increase the CF value, eventually to dangerous levels.

The rate of transpiration itself should be reduced where possible, keep ambient temperatures as low as possible, and although a little contradictory, also keep air movement around the plants to a minimum. Fortunately long term water cuts do not happen that often and water can usually be supplied from an alternative source. Power cuts of short duration really do not give great cause for alarm, and in home gardens and smaller commercial systems water can be run from a garden hose into the tops of gullies or over the surface of media gardens every hour or so as conditions demand. During the mid seventies most large systems were equipped with expensive automatic start up petrol or diesel powered standby pumps. In those days all NFT systems were run 24 hrs a day.

Nowadays with experience gained, power failures, even for prolonged periods, present little problem. The answer for both large or small systems is to install a normally open mains operated electric solenoid water valve which is kept closed when the power is on, when power is interrupted the valve is de-energised and consequently opens allowing water to flow.

A metering valve is installed into the water line, this valve is opened to allow just enough water to enter the gullies or media gardens to keep them in a moist condition, of course it should be set to allow for the highest or worst condition transpiration rate.

It does not matter whether you are running NFT or aggregate filled systems, the principles remain the same. Give your system a good flush out with clean water now and then

These babaco plants are growing in old plastic chemical containers and are being supplied by flexible plastic feed pipes.

Pollination

The methods for pollination do not vary from the normal techniques used in conventional growing. All of these techniques can be learnt from a good gardening book.

There are a number of "tricks of the trade" however, which I will pass on for your interest. Strawberries can be pollinated by the use of a portable hair dryer blowing COLD air onto the flowers, or by using the blow end of a vacuum cleaner.

Tomatoes can be pollinated in a variety of ways, however when you have a large number of plants to pollinate, a simple answer is to connect a mechanical vibrator to the plants overhead support wires. This is energised for a couple of minutes each day during flowering. Another method is to spray the flowers with water, or with one of the many commercial brands of setting agents available. If in doubt about pollination methods consult your local nurseryman or seedsmen for advice on specific varieties. Commercial tomato growers liberate bumble bees into their glass houses to perform the pollination job

If you want to make sure that your plants will be pollinated successfully in a greenhouse, make sure that it has adequate ventilation since too high or too low a humidity can sometimes make pollination difficult.

A greenhouse will enable you to produce flowers and vegetables all year round. A number of plants such as beans, peas, tomatoes and peppers have both male and female parts so you can usually pollinate them by shaking their stems.

Preparing Nutrient Mixes

All good hydroponic nutrients are (as previously mentioned) packed as two separate bags of dry granulated material. The one bag (referred to as bag 'A') contains the source of both Calcium and Nitrogen in the form of Calcium Nitrate, the second bag (referred to as bag 'B') contains all the other ingredients, including all the micro, or trace elements. If the two bags were mixed together then a reaction would take place causing certain elements to "precipitate" and consequently destroy the balance of the nutrient mix. There are several ways in which the actual growing strength brew is prepared. The good proprietary nutrient mixes are already accurately weighed to exact ratios between the 'A' and the 'B' bag and normally the complete contents of each bag would be separately mixed up with water into two containers producing two separate 'stock' solutions. These solutions should still be kept separate since precipitation takes place at an even quicker rate when they are mixed as a liquid. Equal quantities of both these "stock" solutions are then added to the water in the system until the required strength is obtained. This can be monitored with the aid of a CF meter. The alternative is to ascertain the volume of water in the total system and then add measured amounts again in equal quantities between the 'A' and 'B' stock solutions. The exact proportions to be added using this method will depend upon the strength of the stock solutions, most companies will advise the dosing rates on the package label.

Because of the problems associated with thoroughly mixing all the micro elements in the dry mix, it is not uncommon for suppliers to pre-weigh the nutrients for commercial growers, and for use in packaged unit hydroponic gardens, in an unmixed state. These packages must be used in total and must not be split up into smaller amounts since the supplier is relying on the grower to do the mixing of the various components during the dissolving process. In some cases this may be done straight into the main holding tank, in other words no stock solutions are prepared first. Another point which should be explained is the terminology which is used in commercial growing. Most growers will use two basic formulations. The 'A' bag in both cases is exactly the same however, because of the high cost of some of the micro nutrients, and because the demand by the plants for some of these micro nutrients is small then the first formulation is referred to as "starter" nutrient. It is loaded with trace elements, and is used to bring the fresh water in the system up to the initial growing strength. Subsequent topping up to maintain this growing strength is by way of the second formula referred to as "replenisher" nutrient. This replenisher nutrient does not have the same content of micro elements and is consequently a little cheaper and, its purpose is simply to replace those elements that the plants in the system have removed. The cost savings to a home grower of using this system would be minimal, however in commercial installations this could amount to savings of hundreds of dollars in a growing season. Most formulas sold for general growing would be of the "starter" type, one of the effects of adding this nutrient to the system being that the pH will be reduced initially. In the case of a newly planted out system this lowered pH may exist for a couple of days. You should allow this amount of time to pass before trying to raise the pH value to the optimum 6.3pH. With older more mature plants in the system the pH value will rise quite quickly, as some of the nutrient components are quickly taken up by the plants.

The final word on nutrient formulas is one which mainly concerns commercial growers, but still has some application for extreme cases in the field of home growing. When a grower has a specific crop to grow then the formula can be modified to suit the optimum requirements of the crop.

The important aspect of producing a tailor made brew is the quality of the water supply as previously mentioned. The characteristics of the water are taken into account when the chemist designs the formula, in extreme cases special brews can be formulated for home growers, to allow them to utilise water which may not normally be acceptable for hydroponic growing.

You can take the guesswork out of growing plants by growing hydroponically using a carefully mixed combination of nutrient elements which can be fed to your plants in the strengths most suited to them. Mixing up the nutrients is extremely simple. There are two bags of dry powdered nutrients each of which is mixed with a set amount of water and then added separately into your water filled holding tank. If you can mix up a good custard you will have no trouble with hydroponic solutions. Home growers or those growing a range of mixed crop varieties should always use what is referred to in the trade as 'Starter' formulation.(also known as 'Coopers' starter formula)

This heavily laden apple tree shows the versatility of growing in hydroponics. The picture clearly shows both the drain pipe and the nutrient supply pipe to the dripper emitter

Chapter Eleven: Planting in hydroponic systems

Seedlings and Cuttings

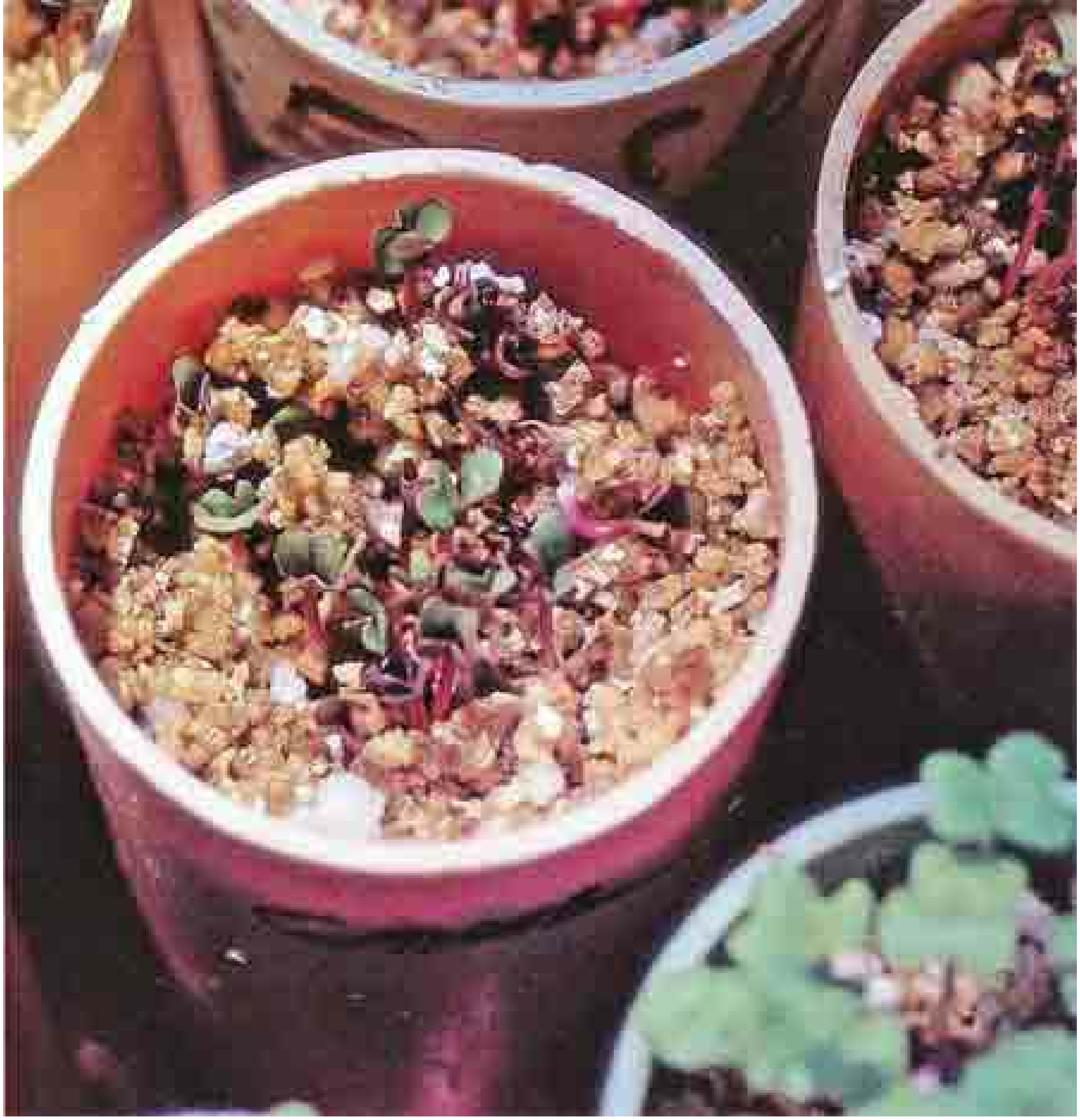
You can grow almost anything in a hydroponic system providing that you have the right seeds or a cutting from the plant you would like to grow. Seeds are easily germinated in a hot water cupboard and then transferred into an NFT or aggregate filled system. The easiest way to do this is to place your seeds in small plastic containers filled with aggregate. Once developed the seedling can be placed, still in its container, into an aggregate filled system. This will also work in an NFT system as the nutrient solution is drawn up through the aggregate in the plastic container by capillary action to the seedling's roots. The aggregate may eventually be washed into the system to be caught in the strainer located before the discharge into the holding tank. This system works well especially if you select containers the same size as the holes in your gullies so that there are no gaps for allowing light to reach the nutrient solution. Sow two seeds in each container and remove the weaker one before moving the container into a hydroponic system. If you do not have enough room to germinate your seeds separately they can still be sown together and separated later.

Any seedlings raised in soil will need to be washed thoroughly to remove any particles of soil from around their roots. You will save time by using a seed raising mixture of clean sand and vermiculite, perlite or some other water retaining substance. Any plants which are liable to develop stems larger in size than the containers you are using should also be removed and placed directly into a gully or aggregate mixture before they become too large. You will be able to sow most of the root crops directly into aggregate filled containers by using a finer layer on the surface of the aggregate into which the seeds can be placed. Generally the techniques you should use for propagating new plants and planting them out are the same as those used for conventional growing.

Make sure for example that you harden off seedlings raised indoors before they are transferred to growing areas outside. You will be able to take whatever cuttings you require and grow them quickly and efficiently in an aggregate filled growing container. As with cuttings raised conventionally you may find that cuttings taken from tropical plants need to be raised inside if you live in a frost prone area.

Plants of different cultivars can be planted in the same media bed or gully providing the nutrient strength is appropriate. Here a new strawberry plant is along side some dwarf beans.

These seedlings are being raised in a long aggregate filled growing container inside a commercially operated greenhouse. A container only a fraction of the size would be large enough to produce a stock of new plants for a home system.



Seedlings can be started off as early as possible for a hydroponic system, by raising them in the appropriate media that will allow direct placement into the main growing system, either NFT or media bed.

A brand new life awakening to a new dawn!

When the seedlings have appeared, shake them out of their container and separate them.

Holding each seedling carefully by the leaf only, place it in its own separate container. If you have raised your seedlings in soil they will have to be carefully rinsed to remove any traces of dirt.

Selecting Plants for a Hydroponic System

Select plants with a short growing period when you are starting off your first system and include the crops which take longer as you add more growing areas to your system. Hydroponic systems are easily built up to suit your requirements. You can start off with a small manually tested system and eventually build up to a stage where you may decide to automate the system.

Almost any plant can be grown in a hydroponic system if you have the right seeds or a cutting from the plant you would like to grow. Some plants will grow better in an aggregate filled system, generally the root crops and taller growing plants needing support, while others will grow better in an NFT system. Consult the growing guide included in this chapter for the systems suitable for each type of plant.

The strength of the nutrient solution, measured in CF units, is another aspect of the hydroponic system which can be varied for different plants. The growing guide includes the upper and lower CF values for each type of plant. When growing one crop in a system you will be able to optimise the growth of the plants by keeping the strength of the nutrient solution between these values. If a number of plants are being grown together a CF value can be selected by finding a value in the common range of all the plants being grown. Generally this will not be difficult to find as most plants can be grown over a broad range of CF values.

Most plants require a nutrient solution that has a strength of somewhere between 7 and 30 CF units. Some plants however may be able to use a nutrient solution measuring up to 60 or 70 CF units during various stages of their growth. As your experience with hydroponic systems develops you will be able to alter the strength of the nutrient to allow for variables such as the plant's rate of growth or changing weather conditions.

A prolonged period of bad weather for example may produce fast vegetative growth in plants because the light available to them will be poor. Fast growth can be slowed down and hardened by adjusting the CF value of the nutrient mixture upwards. The reverse can be applied if the plants are growing too slowly. There is almost unlimited scope for fine tuning a hydroponic system if you have the time and the inclination. My back yard system which grows a very wide variety of plant types runs at 16CF while my glasshouse which I have dedicated to tomatoes runs from 25 up to 35 and even up to 50CF for certain hybrid varieties

An indoor 'Solarium' garden grown completely using hydroponics. The whole system has been made as unobtrusive as possible with the small feeder pipes easily concealed among the plants and the pumping equipment located underneath a hinged seat. An indoor hydroponic system can save time with watering plants and enable you to go on holiday while an automatic controller looks after your plants nutritional requirements.

Keep an eye out for insect pests on your plants as you would in a conventional garden. Hydroponically grown plants will be more resistant to pests and diseases than conventionally grown plants, but slugs and snails for example will still eat them if baits are not laid. White flies suck sap from the under sides of leaves and breed prolifically, so check your plants regularly and spray or dust as soon as they appear. Aphids are also very numerous and destructive so eradicate them with the dusts or sprays. Safe insect sprays for home use could be one teaspoon of dishwashing detergent to 1 litre of water or 'Neem oil' at the prescribed spray rates.

Growing Guide

BEANS

Climbing beans produce a high yield in a small ground area by using air space. This makes them a good subject for a greenhouse hydroponic system. Butter beans grow especially well. You will find that only a short row is required if you are growing them for the home.

BEETROOT

Beetroot grown hydroponically has a superb flavour. Large tender roots are easily grown in an aggregate filled system taking between two and three months to reach a suitable size.

BROCCOLI

Broccoli will grow well over a long period of time enabling you to produce enough of this vegetable for the home with only a few plants. Remember to cut the main head early so that a number of smaller heads will form.

BRUSSELS SPROUTS

Brussels sprouts should be grown outside as they require a cold period to ensure that the sprouts are small and compact, when they form. Pick them early, you will find that it will take two months to grow them and that any extra growth will produce larger sprouts with less flavour.

CABBAGE

Cabbages are easily grown all year round, however they tend to use up a large amount of space. If you want to keep a supply of fresh cabbage available for use in the home keep sowing a few extra plants every two or three weeks and have a trial with some of the new dwarf varieties.

CARROTS

You should only grow carrots for home use if you have plenty of space available in your growing containers as they need to stay in position for longer than most crops. Coarse river sand is a good medium to use, thin them at an early stage then allow the rest to develop to a size your growing container can hold. You will find that even the largest carrots are juicy and delicious with no sign of woodiness.

CAULIFLOWER

Cauliflower's grown hydroponically become extremely large so unless you especially want to grow them hydroponically, do not put too many in. They will need up to 500 cm of growing space. Clip the leaves over the heart as it forms or use a covering of shade cloth to provide protection from the sun and to keep it white.

CELERY

Gravel filled aggregate systems as well as N FT systems can be used to grow celery. Generally the plants will need spraying for rust at some stage.

CUCUMBERS

The smaller varieties of cucumber are the most suitable for greenhouse systems as they can be grown upwards over a framework. Use a hybrid variety, some are resistant to mildew and you will find that others will develop to an enormous size if you let them.

LEEKS

Leeks have a lengthy growth cycle but are compact and easy to grow hydroponically.

Bolting can be a problem with plants both in the soil and in hydroponic systems. With plants like lettuce and celery bolting is invariably caused by excess heat. Grow them in a shaded position during the summer months, four hours sun is normally enough. With most plants bolting is generally caused by a weak nutrient solution. Increase the C.F. value to slow down and harden the growth.

LETTUCE

Regular sowings of lettuce are needed to keep your home supplied as with cabbages. Select the variety most suitable for the time of year and put a few new plants in every two or three weeks. You can remove leaves leaving the plants in the system if only small quantities are required. Grown in a greenhouse fresh lettuce can be available at any time. You may need to keep the plants shaded in hot areas, since they do not like too much heat.

MARROWS

Kami kamis, zucchinis, courgettes and other types of marrow grow so quickly hydroponically that it is necessary to restrict their growth. Keep picking zucchinis before they grow too large otherwise their growth cycle will stop. One or two zucchini plants are enough to keep most families supplied.

ON IONS

Onions require too much space for most systems but will grow well if you are keen to have some in your garden. Spring onions especially, are good to have growing for use in salads.

POTATOES

Potatoes grow quickly in an aggregate filled system but require large growing containers.

RADISHES

Radishes will grow extremely quickly so keep the planted area small. You can start them in water with no nutrients added for the first weeks.

SWEETCORN

Sweetcorn is not a viable commercial crop for hydroponic growing because it uses up too much room for the amount of produce the grower will be able to harvest. If you would like to try it in a home system make sure that it is carefully placed so the other plants will not be deprived of light by the rapidly developing corn.

TOMATOES

Tomatoes grow extremely well in hydroponic systems. If placed in a greenhouse with plenty of light a tomato plant will produce fruit all year round. Spray with ‘Neem’ oil for white fly and watch for unwanted lateral growth which seemingly appears overnight.

Tomatoes are always popular and grow extremely well using the NFT system.

Yum

Do not overlook plants, that for most of us are more unusual, such as the pineapple and bananas shown here, along with Lons very pretty grand daughter.

STRAWBERRIES

Perfect strawberries can be grown hydroponically with a delicious sweet taste seldom matched by conventionally grown fruit. To obtain maximum production from strawberry plants they can be removed and refrigerated for two weeks after they have produced their fruit. Refrigeration simulates the cold period the plants experience in winter so that on warming up again growth hormones in the plant are activated stimulating new growth and fruit production.

A good alternative growing arrangement for strawberries involves the use of a vertical aggregate filled tube. The plants can be inserted through holes up the sides of the tube receiving nutrients fed in from the top of the tube draining down through the aggregate to the holding tank. It is necessary to turn the growing tube regularly to afford all the plants a share of the available light This system was developed and is being used successfully in South America.

FLOWERS

Flowers are an ideal subject for hydroponic growers to develop commercially. Perfect flowers can be produced all year round in a greenhouse with a minimum of time elapsing between picking the flowers and replacing them with new plants. Flowers, like most hydroponically grown plants, can be grown much closer together than plants grown in the soil. Inter cropping can be practised successfully as well. Try growing a combination of flowers and vegetables to brighten up your greenhouse or outside growing areas.

Many products will grow equally well in various types of systems. Strawberries are normally grown in NFT gullies however thrive just as well in a media bed.

Lettuce being grown in an NFT bench constructed using RPG (Rigid panda gully) Rob Smith designed this revolutionary gully, especially for outdoor lettuce production, it is shaped to shed as much rain water as possible and the actual gully is co-extruded, being black on the inside to inhibit algae growth and white on the outside to reflect solar radiation, and has a rapid clipping system to secure it in place - Photo courtesy of NZHI Ltd and Accent Hydroponics, Australia.

A range of flowers are being grown hydroponically in this home growers greenhouse.

Note: Although there are ideal CF values for each plant type, this does not mean that a range of plants, all technically requiring different strength nutrients, cannot be grown in a home situation together, the grower simply lists the range of CF values and picks an average value, for most home systems this value will be between 12CF and 2OCF depending upon the requirements of the predominant crop types being grown.

Plant Type	Direct Sowing	Propagated Plant	Aggregate Garden	N.F.T. Gulley	CF Value Range
African Violet		x	x		10 to 12
Asparagus		x	x		14 to 18
Avocado Pear		x	x		18 to 26
Balm		x	x		10 to 14
Banana		x	x		18 to 22
Basil		x	x		10 to 14
Beans		x		x	18 to 25
Beetroot	x		x		18 to 22
Blueberry		x	x		18 to 20
Borage		x	x		10 to 14
Broccoli		x	x	x	18 to 24
Brussels Sprouts		x	x	x	18 to 24
Cabbage		x	x	x	18 to 24
Capsicum		x	x	x	20 to 27
Carnation		x	x		14 to 20
Carrot	x		x		17 to 22
Cauliflower		x	x	x	18 to 24
Celery		x		x	18 to 24
Chives	x		x		18 to 22
Cucumber	x	x	x	x	16 to 20
Dwarf Roses		x	x		16 to 22
Eggplant		x	x	x	18 to 22
Endive	x		x		8 to 15
Fennel	x	x	x		10 to 14
Kohlrabi	x		x		18 to 22
Lavender	x	x	x		10 to 14
Leek	x		x		16 to 20
Lettuce		x	x		3 to 12
Melons	x	x	x	x	10 to 22
Mint		x	x	x	10 to 14
Mustard/Cress	x	x	x	x	12 to 24
Onion	x		x		18 to 22
Parsley		x	x		8 to 18
Passionfruit		x	x	x	16 to 24
Pea	x	x	x	x	14 to 18
Pumpkin		x	x	x	18 to 24
Raddish	x		x		16 to 22
Rhubarb	x	x	x	x	16 to 20
Roses		x	x		18 to 22
Sage	x	x	x		10 to 16
Spinach		x	x	x	18 to 23
Silverbeet		x	x	x	18 to 24
Squash		x	x	x	18 to 24
Strawberry		x		x	18 to 22
Thyme		x	x		12 to 16
Tomato		x		x	22 to 28
Turnip, Parsnip	x	x	x		18 to 24
Watercress		x	x	x	4 to 18

Per cubic metre your hydroponic garden will cost less than a deep freeze. You can have fresh vegetables even out of season which considering today's vegetable prices makes a hydroponic garden an extremely attractive proposition. Everything on Lon and Fran Dalton's table, excepting the chicken, has been grown hydroponically says Lon and, we are working on the chicken by feeding them hydroponically produced stock feed from our grass machines, who knows, we may even get golden yellow yolks back into eggs.

This combination of a greenhouse with outdoor NFT gullies and aggregate filled containers would keep most families well supplied with vegetables. Hydroponic growing will provide the home gardener with a rewarding hobby and the commercial grower with an efficient and profitable operation.
Commercial cropping usually requires a one hundred percent commitment. You can`t grow in the soil part time but you can grow hydroponically part time. When you have your system set up and running smoothly you will be able to relax and start taking holidays again.

Which System?

This question is often asked, and the answer is quite simple, even although it may seem that I am evading the question. For those growing at home, then innovation is the name of the game. Providing you have got your nutrient values under control, then the way in which you grow your various plants is really up to your own imagination. There are many types of plants that do require support for their roots, particularly those plants which are normally termed root vegetables, however I have grown the likes of beetroot and potatoes in a polythene lined NFT gully.

Stress plays a big part in the success or failure of a particular variety, and there is no doubt that certain plants do like to have their feet (roots) onto or into some type of media. There has not been a lot of evidence gathered on this subject to date, so in many respects you may be researching new ground with any innovative systems you devise. As an example, tip burn in lettuce growing is often a problem. The incidence of tip burn has almost been eliminated in hydroponics by reducing the CF as low as 2CF units during high temperature conditions, and in very challenging conditions, using a 2-3cm layer of 6mm gravel or similar media on the floor of NFT gullies allowing the very fine and tender hair (feeding) roots to latch onto the media. These fine roots would otherwise be constantly moving in the flow of nutrient, slight as this may be. This in itself reduces one more area of possible stress, and I cannot over emphasise that the secret of good growing, conventional or hydroponic, is to keep your plants out of stressful situations.

When growing commercially the approach to many aspects of growing will be quite different. The reason for this is quite plain, the very word commercial says it all, commercial growers do not generally grow just for the fun of it. Economic considerations play an important part. With this in mind many commercial hydroponic installations do not necessarily grow a given crop to its ultimate potential, in many cases the crops ultimate potential is not necessarily a commercially viable product. Take lettuce as an example, as you will find once you have gained a little experience, lettuce can be grown into very large and heavy specimens, which is great for the home grower. The commercial grower on the other hand may well harvest his lettuce early in order to satisfy a market requirement for product presentation and size, with retail price considerations also being important to the grower and to the housewife. The same attitudes apply to almost any crop you wish to name, I can grow on demand tomatoes which weigh in at 1/2 to 1 kilo each, I think they are terrific, but they would not be a very marketable product since the cost each would be too great.

So the selection of a growing system, NFT gullies, media beds etc is approached very simply from a cost effectiveness point of view for the commercial grower, capital installation cost, ease of operation and associated labour costs, production capability, crop turnaround (time taken to remove spent plants and replace with new stock) and a whole host of what to you and I would be minor considerations, but which all add up on the profit and loss balance sheet

Hydroponic systems will enable you to get the most out of your plants. These tomato plants have been harvested repeatedly and the old growth (stem) has been trained around the supporting post at the end of the gully so that the new growth is actually producing fruit at the end of a stem over ten metres long.

New Developments

Commercially, hydroponics has gone through a number of evolutionary changes since its first major acceptance by growers in the mid 1970's. The NFT system was the first system which really started to offer cost effective commercially viable alternatives for the grower. The basic concepts have been taken up in a number of countries where researchers have made a number of developments towards what they feel is the ultimate system. No country has been more innovative than the growers and industry of New Zealand. The cost per plant growing area has been reduced dramatically, alongside yields which are as high as any in the world, and with some crops much higher than most. Much of this success has been inherited from the skills and attitudes of the traditional pastoral farmers and horticulturists, helped in no small way by the skills of modern electronic technology. As I have said on so many occasions, it is not enough to develop a growing system alone, it also has be cost competitive with any alternative system of producing the same crop. Today in New Zealand this is being achieved hydroponically. Greenhouses are used for the longest possible season, with some tomato growers running a crop for 11 months, two weeks for a holiday, and the final two weeks to remove the old crop, clean up the installation, and plant out the new crop. The absence of the conventional chores such as soil sterilization, and conditioning, and the many other labour intensive jobs, means that expensive growing structures can, and in fact are, used to the greatest possible extent for crop production with little or no down time.

In Europe hydroponics has made big inroads into the very conservative growing community, especially in the area of ornamental plants. Most of these systems use ”Rockwool" culture which is a cross between NFT and media gardens, and nutrient mixes are generally manually controlled. In Britain there are a number of very large NFT installations, many of these were installed in the late 70's and at that time were relatively expensive installations, however the introduction of the NFT system has more than doubled the yields of tomatoes. The biggest advance in Britain in recent years has been the development of hydroponic stock feed growing machines, with several companies producing their own systems. Some would appear to be too complicated for general acceptance, however one company I recently visited have certainly come up with some very innovative designs and have developed the "grass growing” technology to a very advanced stage.

Many farmers are now enjoying intensive production by virtue of an on demand supply of stock feed of the very highest quality. One model I viewed at a prize stock rearing unit was producing between 800 and 1,000 lbs of high quality fresh feed a day (365 days a year in all weathers). Although the growing machines (or grass machines as they call them) are the result of much research and development, the actual concept is very simple. Barley seed is pre-soaked in water for a day and is then spread in a layer across growing trays, so many trays per day, the machine holding enough trays to allow for the daily output, with grass at various stages of growth at all times. From initial seeding the automatic controls take over and create the ideal situation for the germination and subsequent growth of thick, luxuriant, high energy fresh feed, and this is achieved from seed to feed in just four days. I believe that this type of technology will soon be commonplace in most parts of the world

Hydroponic Grass growing units were commercialised in Britain from an idea conceived in the U.S.A. This idea has been further developed and patented (pending in some countries) in New Zealand by fully automating the whole process, seed in at one end and fully grown stock feed out of the other end. The photograph shows a view looking from the discharge end, towards the seeding end of one of the environmentally controlled growing chambers. The growing units are modular and are capable of producing one tonne per day, 365 days of the year irrespective of the climate or obviously the soil conditions.
Photo courtesy of 'Zero Grass NZ Ltd' and 'NZ Hydroponics Ltd'.

In America a lot of research is being done on the production of seed strains that will be tolerant to high levels of sodium, this is an exciting concept, for to be able to grow plants in sea water has some very obvious advantages, especially in areas where fresh water is scarce or non existent. This is not an unrealistic dream since already we know that many plants already thrive in seawater

Other fields of development are the building of fully automated growing factories, those presently running are producing well, however the capital cost of those built to date is enormous and could only be justified in very densely populated areas where there is a continual and guaranteed market.

The important thing to remember about the hydroponic industry is that it is still very young and the scope for development is immense, so take my advice and get started, who knows, one of your innovative ideas could break into a whole new sphere of crop production.

Chapter Twelve: Glossary of Terms

AERATION

The act of inducing air, and by association, oxygen to the nutrient solution, and hydroponic system.

ALGAE

A type of plant growth (actually a sea weed) appears as a light green, to black slime, does not seem to have any ill effect upon the hydroponic system, just looks unsightly. Keep light from entering gullies etc to prevent the growth.

ACID

Acids are used to decrease (lower) the pH value of the nutrient mix. The major acids used in hydroponics are Phosphoric acid, which enables the addition of extra Phosphorus whilst adjusting the pH, and Nitric acid which enables additional Nitrogen to be added into the nutrient mix whilst adjusting the pH. Commercial growers may well use a mix of the two.

ALKALI

The proper alkali Hydroxide of Potassium (Potash), is used in hydroponics to increase (raise) the pH value of the nutrient mix. Often referred to as 'Caustic Potash', or more commonly Potassium Hydroxide.

AMBIENT

Ambient; surrounding air conditions, normally refer to the prevailing air temperature.

AUTOMATIC

Where electronic equipment constantly measures the state of the nutrient and maintains desired values of CF and pH.

CHELATES (pronounced key-late's)

Chelates are complex "organic" compounds in which the element is tightly held within the molecule, preventing it from reacting with other substances, yet when the chelate is taken up by the plant, the nutrient is fully available for use.

CONDUCTIVITY FACTOR, (CF VALUE)

The total strength of dissolved nutrient salts in solution.

MEDIA

The term given to a wide range of inert materials which are used to support the roots of plant material.

pH TEST PAPER

A paper which has been impregnated with a vegetable dye, the dye changing colour depending on the acidity or alkalinity of the solution being tested.

MICRO TUBE

Very small bore plastic tubing used for supplying nutrient from a main feeder line into a gully or onto a media garden. General ranges in bore size of 1mm to 6mm.

PANDA FILM

A trade name for a co-extruded plastic film, white on one side and black on the other. Used for the complete covering of the soil in growing structures to provide a clean environment free of soil born problems and the white surface providing the maximum of reflected light into the plants. Also used as a gully material, the 600mm wide material being brought together to form a growing channel, the black side of the material being to the inside of the gully to reduce the reflection of light, and consequently a reduction of the chance of algae growth.

SYSTEM TIMERS

Electric time clock switches, with switching periods down to quarter of an hour, allowing irrigation cycling, particularly useful for media gardens.

BLUE PRINT TEMPERATURE

The optimum temperatures required for maximum growth factor, generally being a root temperature of 20 - 25 degrees centigrade and an ambient range from 16 to 24 degrees (depends on plant type).

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