

United Nations Development Program
(UNDP)

Training Program

on

HYDROPONICS

Specially designed for

**The Ministry of Fisheries, Agriculture and Marine Resources
(MOFAMR) Male', The Republic of Maldives**

Organized by

HPC Hydroponics & Plant Care Pte Ltd

Mailing Address: Block 461 #13-75 Crawford Lane Singapore – 190461
Tel: 6291-8153 Fax: 6298-7978 E-Mail: HPC@singaporehydroponics.com
Web site: <http://www.singaporehydroponics.com>

hydroponics & organic farming . greenhouses & irrigation systems . garden & landscape design/maintenance . trees & turf grass management .

8-12 July 2003

OBJECTIVES & GOALS

The Objectives & Goals of this Training Program are:

- 1. to establish a Hydroponics Pilot Project in the Republic of Maldives with assistance from UNDP**
- 2. to train the trainee staff from the Ministry of Fisheries, Agriculture and Marine Resources (MOFAMR) such that they will be able to facilitate the training of potential entrepreneurs in the Maldives upon their return**
- 3. to equip the trainee staff, who have had some basic experience in hydroponics, with a broad spectrum of knowledge about the modern trend in the hydroponics technology and the international hydroponics industry**
- 4. to provide enough confidence to the trainee staff to establish a Hydroponics Center in the Maldives which shall also double up as a Research Centre**
- 5. to visit successful commercial hydroponic farms, modular farms for educational and demonstration purposes, community farms that bond the people in the community, charity farms in old folks homes and roof-top farms in hospitals that service the hospital kitchens, etc...**

PROGRAM SCHEDULE

Date	Day	Training Program Details	
8 July 2003	Tuesday	AM	arrival of the trainee staff from the Maldives Settle down at the hotel
		PM	Introduction to Singapore Hydroponics Discussion on the training program details
9 July 2003	Wednesday	AM	Visit Farmart Centre – centralized location where Singapore’s farm produce are sold
		PM	Hydroponics & the eco-farming concept
10 July 2003	Thursday	AM	Visit Tropical Aeroponics Farm – the first large scale aeroponic farm in the world
		PM	Visit Changi Hospital Rooftop hydroponics – the ISO 14000 award winning concept
11 July 2003	Friday	AM	Visit Hydroponic Vegetable Farm – where the Taiwanese DRF system is used
		PM	Visit a School & a Community Hydroponics farm – modular units
12 July 2003	Saturday	AM	Visit a hydroponics shop, view a slide / video presentation & wrap-up Session
		PM	Free & Easy

TRAINERS

This Training Program for the Ministry of Fisheries, Agriculture and Marine Resources (MOFAMR), Male', The Republic of Maldives shall be conducted by Two Experienced Consultants in Hydroponics:

Dr. Mallick Fazalur Rahman, M

B.Sc.(Agriculture), M.Sc.(Horticulture), Ph.D.(Horticulture)

Director Consultant, Hydroponics & Plant Care Pte Ltd, Singapore
& Adjunct Lecturer, Ngee Ann Polytechnic, Singapore

Mr. Gregory Chow

B.Sc.(Agriculture), M.Sc.(Horticulture)

Lecturer, Ngee Ann Polytechnic, Singapore

TRAINEES

Name of Trainees	Designation
Ms. Aminath Shafia	Assistant Director
Mr. Ibrahim Shareef	Project Manager
Mr. Hussein Rasheed	Project Manager
Mr. Ismail Rasheed	Agricultural Officer
Miss. Mariyam Nusrath	Assistant Agricultural Officer

Understanding Hydroponics

An article by Dr. Mallick that clearly explains the concept of hydroponics to the current expectations

Understanding **Hydroponics**

Principles, Practices, Problems & Potential

things all serious consumers, growers, home owners and students of horticulture, decision makers
& investors in agrotechnology projects *must* know!

Introduction to Soilless Culture

Though man has grown plants for centuries, serious work on the soilless culture method of growing plants began only in the 14th century. The basics of commercial hydroponics were developed in the 1940s and promoted in the 1960s. Currently, there are numerous commercial hydroponic farms in many parts of the world. Apart from the government research institutions, many small as well as multinational companies in Australia, Belgium, Denmark, Holland, Japan, Taiwan UK, US and other countries have invested a lot in commercializing this technology. Horticulture, Plant Physiology and Hydroponics Labs around the world are working hard on refining this “futuristic plant-growing technology”.

In organics and traditional soil farming, the nutrient availability to the plant depends on the fertility of the soil and the organic and inorganic nutrient source, the environment and the microbial population that is needed to convert the organic nutrients into inorganic forms. In hydroponics, the plant nutrients are made available directly in the inorganic forms.

Whatever is said and done, plants can absorb their nutrients only in inorganic ionic forms. The growth and yield performance of the plant depends not only on its genetic make up but also on how much nutrients are available in the root zone. The root and shoot environments play a crucial role.

In this article, the author explains the concept of hydroponics, classifies the various techniques, cultures and systems and discusses on the future of crop productivity in general.

Soil Farming, Organic Farming & Hydroponic Farming – a simple comparison

Plants are grown CONVENTIONALLY by THREE methods:

- *traditional farming* where human or animal energy and manures are used to till the soil and to do other related works to cultivate the crops
- *mechanized farming* where mechanical energy like tractors, sprayers, water pumps, harvesters, etc. and fertilizers are used to cultivate the crops
- *modern smart farming* where the best combination of all available technologies and resources are used to cultivate the crops

Plants are grown ORGANICALLY by SIX methods

- *raw plant wastes* like saw dust, moss, sea weeds, cocopeat (coconut husk), etc. are recycled to grow the plants
- *decomposed plant wastes* like bog peat, composted garden/jungle wastes, composted processing factory wastes, etc. is recycled to grow the plants
- *raw animal wastes* like bone/horn/hoof/blood meals, fish meals, etc. are recycled to grow the plants
- *decomposed animal wastes* like worm castes, animal manure, composted animal tissues, etc. is recycled to grow the plants
- *a mixture of composted plant and animal wastes* are recycled as THE ONLY source of nutrients to grow the plants – this is the modern version of Organic Farming

Plants are grown HYDROPONICALLY by THREE methods without using soil (hence, soilless culture)

- *solution culture* where essential plant nutrients are dissolved in water and this nutrient solution is used to grow the plants (the details are discussed later)
- *substrate culture* where sterile substrates like sand, perlite, leca, etc. are used to support the plants and nutrient solution is fed to supply the nutrients to grow the plants
- *aquaponics* or *organic hydroponics* where fish tank water or pond water or water with dissolved nutrients obtained from various organic sources are recycled as a source of nutrition (nutrient solution) to grow the plants

In hydroponics, the naturally occurring mineral deposits (mineral nutrients or fertilizers) are purified and recycled as a nutrient source for the growing plants.

History of Hydroponics

Hydroponics was practiced many centuries ago in Amazon, Babylon, Egypt, China and India where ancient man used dissolved manure to grow cucumbers, watermelons and other vegetables in sandy river beds (organic hydroponics - sand culture). It was then called as “River Bed Cultivation”. The “Hanging Gardens of Babylon” and the Aztec’s floating farms were actually the prototypes of soilless culture systems.

Later, when Plant Physiologists started to grow plants with specific nutrients for experimental purposes, they gave the name “nutri-culture”. Then, terms like “water culture”, solution culture”, “gravel bed culture” etc. were mentioned based on the experience of the persons who reported their findings. The chronology of events, though not complete, is given in Table 1. Even the current practice of growing rice in Tropical Asia using flooded water and the growing of orchids using broken bricks and charcoal can be considered as a form of primitive hydroponics.

Table 1: History of Soilless Culture

Period	Developments
Before 1490s	Compost/manure solution used to grow melons and other vegetables in the river beds during summer in Arabia, Babylon, China, Egypt, India and Persia and on floating rafts by Aztec Indians in Mexico
1492	Plants need mineral elements (Leonardo de Vinci/France)
1666	Plants grown in water in glass vials (Robert Boyle/Ireland)
1699	Nutrients absorbed by ion exchange (Woodward/England) (Liebig/Germany)
1804	Studies on crop nutrition (Nicholas de Saussure/France)
1850	Sand/quartz/charcoal culture (Jean Baussingault/France)
1860	Water/solution culture (Sachs and Knop/Germany)
1920 - 38	Formulating nutrient solution (Hoagland /USA)
1929 - 40	Static hydroponics with aggregates (Gericke/USA)
1945	Nutriculture studies (Withers and Withers/USA)
1955	International Working Group on Soilless Culture (IWOSC) was established in Holland
1960	Nutrient film technique (Alan Cooper/UK)
1960s & 1970s	Commercial hydroponic farms developed in Abu Dhabi, Arizona, Belgium, California, Denmark, Germany, Holland, Iran, Italy, Japan, Russian Federation and other countries
1965	Drip irrigation technique (Cornell University/USA)
1970	Aeroponics (Massantini/Italy)
1970	Rockwool culture (Hanger/Denmark)
1973	IWOSC was renamed as the International Society for Soilless Culture (ISOSC) - organizes International Congresses
1975	Floating Hydroponics (Farnsworth /USA)
1980	Raceways Hydroponics - deep flow technique (? /USA) (? /Japan)
1980s	Many automated and computerized hydroponic farms were established around the world
1990s	Home hydroponics kits gained popularity in Australia, Japan, Singapore, Taiwan and USA. Soilless Culture Societies & Hydroponic Societies/Associations were formed in many countries
1992	Classification of hydroponic techniques (Mallick / Singapore)
1993	Public awareness about pesticide toxicity, demand for uniform quality produce and guaranteed steady supply boosted the demand for hydroponically grown plants and produce
1994	Hydroponics/Soilless Culture entered the cyberspace (internet)
1995-2000	Organic hydroponics, fish tank hydroponics (aquaponics) and hydroponics for fruit trees, plantation crops, etc. gained popularity
2001	Home farming (be it for landed gardens or high-rise gardens) and commercial hydroponic farming gains momentum around the world

In some Asian and European countries, some growers strictly use only farmyard manure or garden compost to grow food crops for their personal use. They rarely use any fertilizers or pesticides. They have been doing this for generations! They, however, use fertilizers and pesticides for the crops they grow for sale! According to them, *it makes sense!* Why? Let us read on...

On the other hand ecologists were concerned about the environmental pollution caused by the indiscriminate use and wastage of fertilizers in commercial farming. In addition, the use of pesticides including herbicides aggravated this pollution problem. This situation led to the study of – both hydroponics and organics under protected cultivation. While hydroponics is controlled by strict professional ethics and standards, regulatory authorities (certification bodies) in some countries control organic farming strictly.

In 1940, Dr. Gericke, an Agronomist working at the University of California, USA, coined the term “Hydroponics” to reflect the importance of “hydros” (water that carries the nutrients) and “ponas” (cultivation of plants). Now, hydroponics is the standard name for all cultivation methods that uses nutrient solution.

Hydroponics and organics have been identified as very promising technologies for crop production not only for urban and health-conscious societies but also for land, labour and resource-scarce societies and remote communities around the world. By hydroponics, it is now technically feasible to obtain fresh supply of vegetables, flowers, herbs, etc. right on top of Mt Everest, deep under the sea in submarines, in remote deserts, in drought prone areas and even in space stations.

Concept of Hydroponics

Soilless culture refers to the method of growing plants using clean water with or without additional plant nutrients and inert aggregates (Fig. 1):

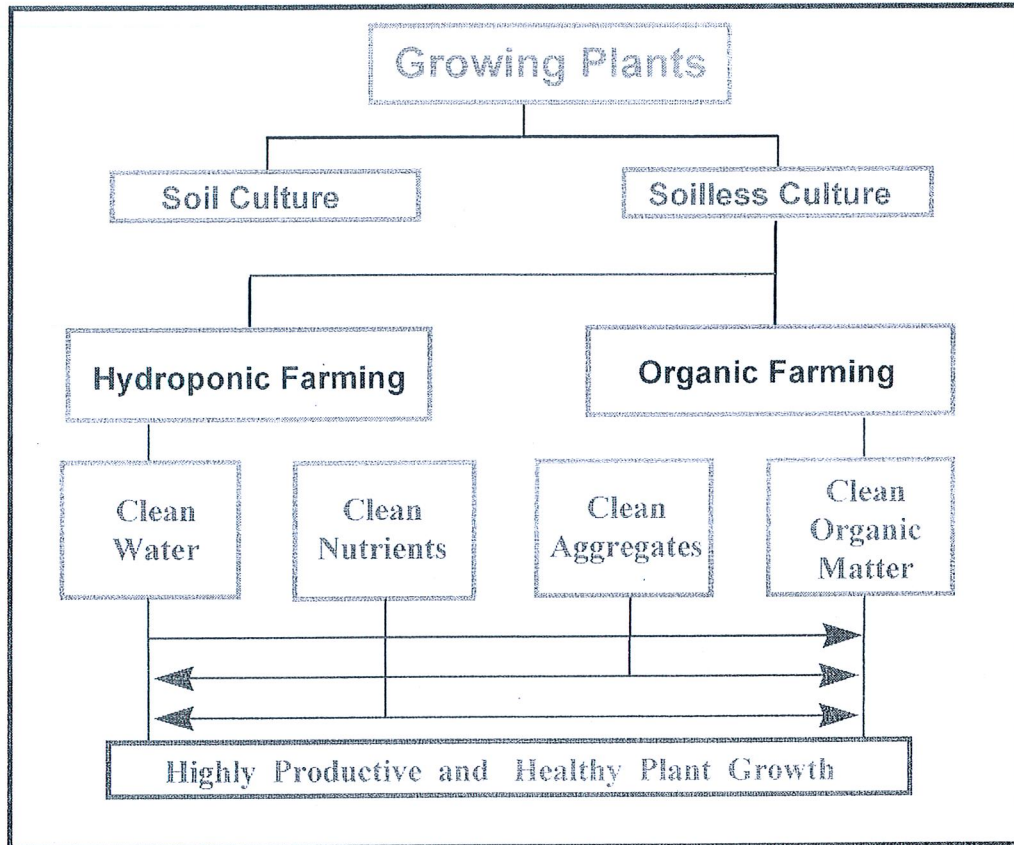
- when clean water and balanced plant nutrients are used, with or without aggregates, it is called “*hydroponics*”
- when clean organic matter like saw dust, coconut husk, wood shavings, peat, composted manure, composted organic wastes or organic extracts are used with or without additional nutrients, it is called “*organic hydroponics*” or simply “*organics*”

Everyone knows that the whole world is surviving by tolerating, accommodating and assisting the fellow creations on the earth – sometimes knowingly and most times unknowingly. The whole life in this planet is made up of the plant kingdom, the animal kingdom and the intermediate microbial facilitators (fungi, monerans and protists). The members of these kingdoms have their own primary, secondary and tertiary food sources but each group is generously, if not graciously, helped by members of the other groups.

Plants mine their nutrients from the soil through their root system. *We call these nutrients as fertilizer nutrients when they are supplied by man and as organic nutrients when they are supplied by microbes.* The former is hydroponics and the latter is organics.

Though not precise, we can liken allopathic medicine to hydroponics and ayurvedic, chinese and homeopathic medicine to organics.

Fig 1: Soilless Cultivation – the Concept



Practices in Soilless Culture

Hydroponics has, popularly, been defined as methods of growing plants without soil. In this paper, the author redefines soilless culture as *"a biotechnology technique that makes use of natural plant growth phenomena in obtaining better results from crop plants using inorganic or organic nutrients and standard agronomic practices"*. The fact is that soilless culture technology is a form of eco-technology that realizes the efficiency and profit from crop plants while maintaining harmony between human activities and the environment.

Thus, hydroponics and organic hydroponics are environment-friendly technologies suitable for growing all kinds of plants using balanced nutrients in a scientific way. This soilless culture technology not only supplements but also complements the normal soil cultivation. It is a clean and scientific eco-technology – a smart way to grow the plants!

Hydroponics is highly productive and yields superior quality crop produce round the year, irrespective of the soil and climatic conditions. Organic farming is as good as hydroponic farming albeit low and slow productivity.

Soilless Culture Techniques

A soilless culture technique refers to the method of applying nutrient solution to the roots in an efficient way. There are TEN techniques in soilless culture (Fig. 2) They are:

1. *Static Aerated Technique (SAT)*

Plants are grown in a depth of static nutrient solution which is aerated either by providing air space in the root zone or by pumping air into the nutrient solution in the tank. In organics, a simple pot or bag of organic medium is used. This is sometimes referred to as a "Passive Technique". Ideally suited for learning the basics of hydroponics or organics and for doing R&D work. Never use this technique for regular growing of plants hydroponically (especially in the tropics) as mosquitos might breed.

2. *Ebb and Flow Technique (EFT)*

Plants are grown as in SAT, but the nutrient solution is drained off 3-4 times a day to permit the roots to breathe. This technique is sometimes called "Flood & Drain Technique" (in solution culture) or "Soak and Drain Technique" (in aggregate culture). In organics, plants are grown in organic medium and only plain water is used for flooding. Good for home gardens and commercial nurseries. Almost any type of plants can be grown.

3. *Deep Flow Technique (DFT)*

A depth of nutrient solution (4-6 cm) is circulated around the roots either by gravity or by using a pump. As the nutrient solution circulates, it absorbs oxygen from the atmosphere. This technique is also referred to as "Dynamic Root Floatation Technique" and as "Raceways Hydroponics". Ideal for leafy vegetables and all shallow rooted plants. In organics, fish tank water or any liquid organic nutrient source is used.

4. *Aerated Flow Technique (AFT)*

This is a modified version of DFT. Here, the nutrient solution is profusely aerated by special mechanisms. Oxygen level of 10-12 ppm is maintained in the nutrient solution. The Japanese "Kyowa Hyponica System" and "Styrofoam Float System" adopt AFT. Excellent for growing both leafy and fruit vegetables and certain ornamentals. In organics, fish tank water or any liquid organic nutrient source is used.

5. *Nutrient Film Technique (NFT)*

A thin film of nutrient solution is always in contact with the roots. While the nutrient solution is circulated, the root surface is exposed to the air. This helps the roots to breathe. Numerous modified versions featuring slant/plane feeding, hypertonic feeding, etc. are available. Very good for producing fruit and leafy vegetables. This

technique works well both in the temperate and tropical regions of the world. In organics, fish tank water or any liquid organic nutrient source is used.

6. ***Gravel Flow Technique (GFT)***

Plants are grown in inert inorganic or organic substrates and the nutrient solution is fed to the roots from beneath the roots. A film of nutrient solution is circulated beneath the substrate. This technique is usually practiced with sand, granite or perlite or other porous substrates which permit free flow of nutrient solution beneath. Commonly practiced in the USA, South Africa, Australia and India for growing lettuces and other kinds of plants. The Bengal System adopts this technique. In organics, fish tank water or any liquid organic nutrient source is used.

7. ***Sub-Irrigation Technique (SIT)***

Plants are grown in inert inorganic or organic substrates and the nutrient solution is fed to the roots from beneath the roots through seepage tubes. Though this method of feeding has been practiced in soil cultivation, it has been refined in hydroponics. Nutrients are fed through capillary action of the growing medium or wicks or any similar water absorbing material that links a pipe or tray containing the nutrient solution to the media surrounding the roots.

8. ***Drip Irrigation Technique (DIT)***

Like SIT, plants are grown in inert inorganic or organic substrates, and the nutrient solution is fed close to the roots 6 - 7 times a day - in drops or trickles. This technique is called as "Drip Fertigation Technique". This technique is also referred to as "Surface Watering Technique" if hand watering or flooding is practiced instead of drippers. Deserts in the Middle-East are exporting crop produce because of this technique. Also suitable for the plantation, orchard and landscaping industries.

9. ***Root Mist Technique (RMT)***

A mist of nutrient solution is sprayed every 4-5 minutes on to the roots of the plants that hang from a holding frame in a rooting chamber. Hydroponic systems that are designed using this technique is popularly known as "Aeroponics". Good for initiating rooting of cuttings and also for extracting ("milking") phytochemicals from the roots for medicinal purposes. Also good for growing any type of plants. Selection of nozzles to adjust the droplet size might promote more fine root hairs which in turn might influence nutrient absorption. In organics, fish tank water or any liquid organic nutrient source is used.

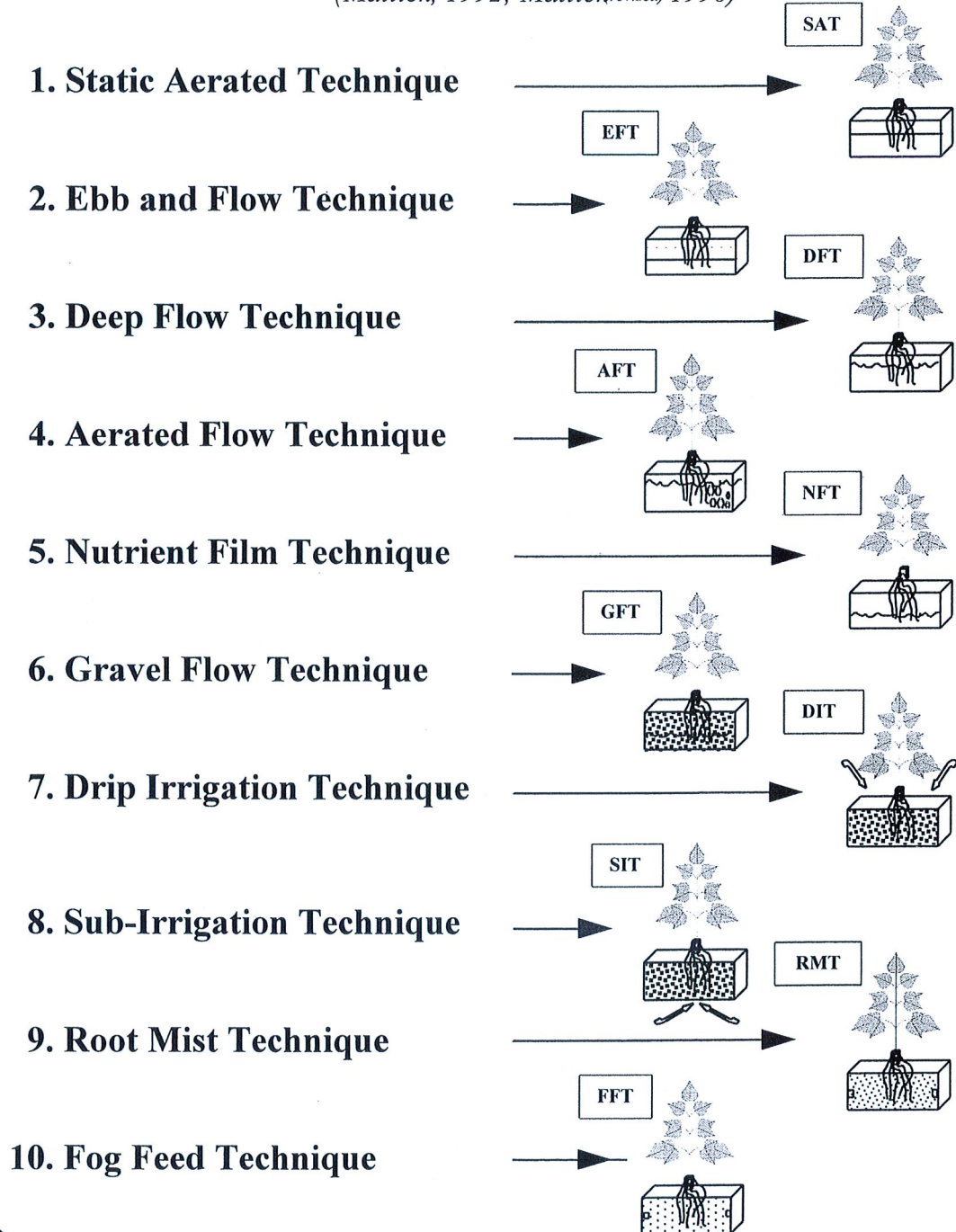
10. ***Fog Feed Technique (FFT)***

This is similar to RMT but the droplet size is so very minute (like a cloud) that the nutrient solution can hardly moisten our hand. This technique has yet to be perfected. Good for plants having aerial roots with spongy water absorbing tissues like "valamen". e.g. orchids, anthuriums, etc. In organics, fish tank water or any liquid organic nutrient source is used.

Classification of Soilless Culture Techniques

TEN Basic Techniques (Methods of Feeding) in Hydroponics

(Mallick, 1992; Mallick^{revised} 1996)

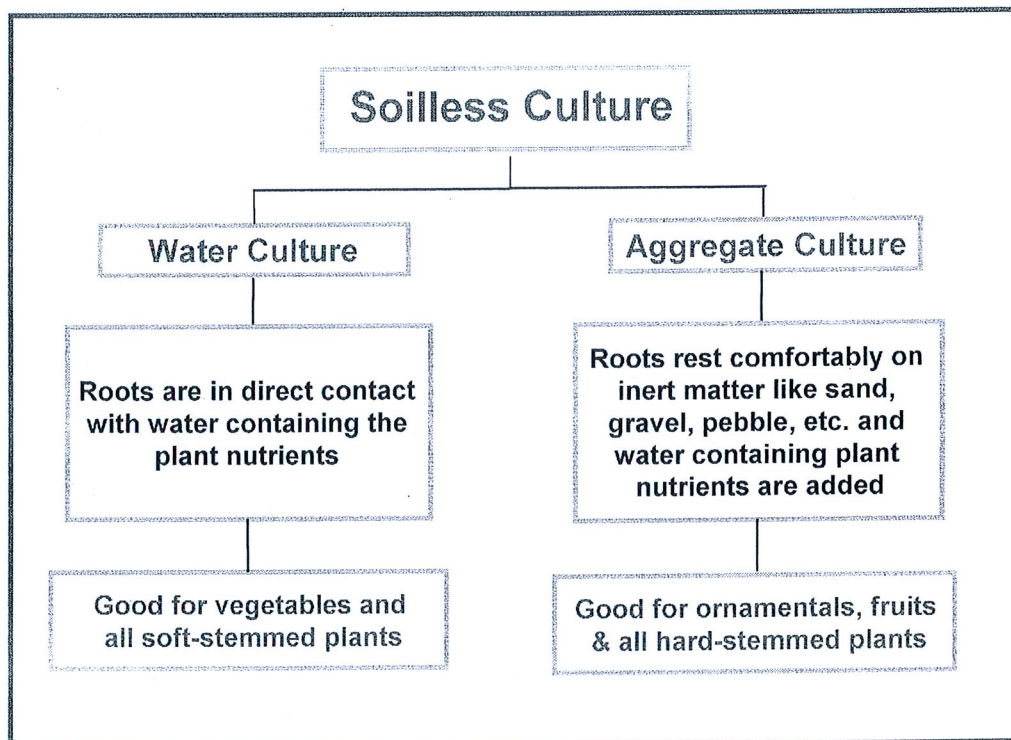


Cultures and Systems in Hydroponics and Organics

Commercial and amateur hydroponic and organic systems are designed by employing one or more of the above ten techniques. All these techniques are ideally suited to any degree of automation. They can be used in any combination to design a hydroponic or organic system to suit a particular plant for a particular purpose and for a particular budget.

If the soilless culture system uses only the nutrient solution, then that system is categorized as "**Water Culture**" or "**Solution Culture**". If the nutrient solution is used in combination with solid inert matter like sand, gravel, rockwool, etc., or organic medium then that system is categorised as "**Substrate Culture**" or "**Aggregate Culture**" (Fig. 3).

Fig 3: Soilless Cultures



The former system is ideal for all types of leafy vegetables and some soft-stemmed vegetables. The latter is suitable for all types of herbs, tuberous and hard-stemmed plants including fruit trees.

If the nutrient solution is recycled, then that hydroponic system is called "**Closed System**", and if the nutrient solution is discarded after a single use, it is called "**Open System**".

At the Ngee Ann Polytechnic's Hydroponics Lab, Singapore, two cherry tomato plants were grown by AFT in the year 1994, where the greenhouse temperature ranged from 36-38 degrees Celsius. These two plants (one m²) yielded over 2400 fruits over a period of six months from seeding to harvest.

However, the record in tomato yield has been set by Prof. Nozawa of Tsukuba University in Japan in 1970. He obtained a yield of over 14,000 fruits from one plant where the greenhouse temperature ranged from 20-25 degrees Celsius. The Dutch and the Japanese tomato growers have recorded yields of 50-60 kg of marketable tomatoes / m². These examples show the potential of hydroponics. The normal yield of tomatoes grown by hydroponics is 40-50 kg / m².

Some of the popular hydroponic systems in the market are listed in Fig 4 and Fig 5.

Fig 4: Popular Soilless Culture Systems using Solution/Water Culture

<p>A-Frame (Tier System (NFT) Aeroponics (RMT) Basin/Trough/Tray System (SAT) Column Culture (RMT) Gully System (NFT) Kyowa (Hyponica) System (AFT) Membrane System Spiral(Tomita)System (NFT) Vertical Tube-O-Ponics (RMT)</p>

Fig 5: Popular Soilless Culture Systems using Substrate/Aggregate Culture

<p>Gravel/Granite Culture (DFT/DIT) Raised Bed Culture (SAT) Pebble Culture (DIT/DFT) Rockwool Culture (DIT) Sand Culture /Sandponics(DFT/DIT) Scoria Culture (DIT/DFT) Leca Culture (DFT/NFT) Vermiculoponics (DIT/DFT) Zeoponics (DFT/DIT)</p>
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Formulating Nutrient Solutions for Hydroponics

All plants need 16 elements to grow. They are C, H, O, N, P, K, Ca, Mg, S, Zn, Cu, Fe, Mn, B, Mo and Cl). In nature, plants derive these elements from the atmosphere or minerals in the soil. Most of the elements used in preparing nutrient solutions are derived from these naturally occurring minerals in the soil. So only they are called as mineral nutrients. As such, they are not only natural but also very safe. They are sometimes purified to remove the impurities (like purified table salt obtained/mined from the sea water or rock deposits). Hence, they are quite safe to our body.

There are hundreds of nutrient solution formulations available in the market. Most of them are published but some of them are “proprietary”. Plant growth regulators and natural plant/animal extracts are sometimes added as ‘secret potions’ to enhance nutrient absorption directly by the roots or indirectly through feeding the soil micro flora which are in symbiosis with the plants. The cost of nutrient solution is subject to the availability and price of the raw materials.

Some are in solid forms as nutrient salts or fertilizers, some in liquid form and some in tablet form. In most cases they are inorganic. Sometimes they are purely organic and sometimes they are a mixture of both organic and inorganic forms. The manufacturers generally tend to maintain the secrecy of their formulation. Certainly, there is no magic. All nutrient solutions contain the essential nutrient elements needed for plant growth. The concentration of each element varies with the application.

Composition of a Nutrient Solution

The composition of a nutrient solution depends on the raw materials available and the intended purpose. Normally, nutrient solution for vegetative growth will have more nitrogen and less potassium (low K/N ratio) and those for flowering and fruiting phase will have less nitrogen and more potassium (high K/N ratio).

The formulation of a typical "standard nutrient solution" is given in Table 2. Dr. Alan Cooper proposed this formulation for his NFT hydroponic system. It works well in the tropical as well as the temperate environment.

Table 2: Chemicals needed to prepare 1000 litres of Nutrient Solution

Nutrient Chemicals	Weight in grams
Potassium dihydrogen phosphate	263.00
Potassium nitrate	583.00
Calcium nitrate	1003.00
Magnesium sulphate	513.00
EDTA iron	79.00
Manganous sulphate	6.10
Boric acid	1.70
Copper sulphate	0.39
Ammonium molybdate	0.37
Zinc sulphate	0.44

This formulation is to be prepared in 1000 liters of water and is ready for feeding the plants. However, in practice, the solution is concentrated 100 times i.e. the same amount of nutrients are dissolved in 10 liters of water.

Nutrient Stock Solution and Nutrient Feeding Solution

In concentrated form, chemical reaction might take place. Hence, it is recommended to dissolve calcium nitrate and EDTA iron in 10 litres of water and label them as "NUTRIENT SOLUTION - A" and the rest of the nutrients in another 10 litres of water and label them as NUTRIENT SOLUTION - B. These are called Nutrient Stock Solutions.

When feeding this solution to the plants, Solution A and Solution B should be diluted 100 times in equal volumes. First, add "X" ml of Solution A. Stir well. Next add "X" ml of Solution B. Again stir well. (e.g. 10 ml of Solution A plus 10 ml of Solution B or 100 ml of Solution A plus 100 ml of Solution B, etc.). The exact volume of Stock Solution to be added will depend on the final volume of nutrient solution required for the hydroponics system. This diluted nutrient solution is called the Nutrient Feeding Solution.

Conductivity Factor in a Nutrient Solution

Incidentally, all elements are present in the nutrient solution as ions (charged particles). An electrical conductivity meter (EC meter) is often used to measure the total concentration of all ions present in the solution in micro Siemen ($\mu\text{S}/\text{cm}$) or milli Siemens (mS/cm). In the US, they use the Conductivity Factor (CF) which is noting but ten times the mS value. In Europe, chemical units like moles and milli equivalents are used.

As a thumb rule, 10 ml (one teaspoon full) each of the Stock Solution A and Stock Solution B in one litre of water will give an approximate concentration of EC 1.0 mS/cm, which is just nice to start any plant.

However, this concentration varies with the atmospheric temperature - higher the temperature, lower the EC and *vice versa*. This is because the physiology and the biochemistry of the plant and the rate of nutrient absorption is controlled by the temperature around the plant.

pH Factor in a Nutrient Solution

Another important factor to be considered in a nutrient solution is the pH factor ie. the concentration of hydrogen ions in the solution. When your body is weak, the hospital will give you a saline or ionic solution orally or through intra-veinous drip. This is to help your body (blood) absorb the nutrients as well as the water. The same principle applies to plants, as well.

This pH factor decides the availability and absorption of nutrients by the plants. The pH scale (read from pH meter) ranges from 0-14 (acid-alkaline) and the neutral value is 7. However, in plants, most nutrients are available at a pH value of 5.5 - 6.5. This value can be increased by using potassium hydroxide (KOH) or decreased by using phosphoric acid (H_3PO_3).

Managing the Nutrient Solution in Soilless Culture

For a small unit using the Static Aerated Technique (SAT), the solution should be changed once a fortnight. For large units using other flow techniques, the nutrient solution can be recycled by topping-up with the Stock Solutions every week. The EC level should range from 1.5 - 3.5 mS/cm depending on the type of the plant and the growing stage of the plant.

In drip hydroponic systems, where plants are grown in inert matter like sand or rock wool or coco-peat (coconut husk), etc. the nutrient solution is dosed at periodic intervals into the irrigation water. The drained water can be successfully recycled.

However, plants themselves are the best indicators. The top 3-5 leaves are called indicator leaves. They speak so much about the health of the plant. Pale leaves indicate nutrient deficiency and charred/burnt leaf margins indicate toxic levels. Observe them and adjust the concentration accordingly – add nutrient stock solution to rectify the deficiency and add clean water to dilute the feeding solution. In case of doubt, do not hesitate to seek the help of a Hydroponics Consultant or an Agronomist or your region's Agricultural Extension Officers or any Agriculture Labs near you. You can also e-mail to the author at <aphmfra5@pacific.net.sg>

Studies on managing nutrient solution in hydroponics is carried out as a major R&D work in many laboratories around the world. The published experimental results are very interesting and thought provoking. Hydroponics magazines, newsletters and conferences give top priority to this topic to satisfy the “hunger” of the hydroponic growers in this field.

The “Chemical” Controversy

There is some sort of wrong notion in the minds of certain people that hydroponically grown plants contain “chemicals - so much chemicals that even insects dare not touch them!”. Such people are usually confused over the terms “nutrient chemicals” and “pesticide chemicals”. It is the pesticide chemicals that are harmful and not the nutrient chemicals.

Talking about chemicals, the whole universe is made of chemicals – either organic or inorganic - including our body, the air we breathe, the water we drink, the food that we eat and almost all things that we use everyday. In nature, the eco-system is well balanced - *all members of the animal kingdom can consume only organic food and all members of the plant kingdom can consume only inorganic food*. In organic farming, the soil micro organisms convert the nutrients present in the organic state to digestible/absorbable inorganic forms. In hydroponic farming, the inorganic nutrients are fed in readily absorbable forms.

In the eco-system, they are ecologically well balanced to keep the earth and the earthlings in a healthy state.

Nobody has ever complained that the table salt is a chemical and the saline drips and medicines that the hospitals give to the patients is a chemical. In fact, most medicines are inorganic chemicals and they are more specific in their actions and reactions. Fertilizer nutrients and organic nutrients can be likened to formulated milk powder and mother’s milk. Even though organic nutrients are preferred, the choice is subject to availability.

Chemicals that become controversial are those pesticide chemicals which are synthesised in the labs to kill the pests by upsetting their physiological system in one way or other. If used wrongly, they might actually upset the physiology of the plant and human systems and might cause irreparable damage. Hence, the current trend is to avoid the use of pesticide chemicals as much as possible. There is a paradigm shift from pest control to pest management.

The colour and taste of a vegetable depends on the genetic make up of the plant and the environmental condition like light, temperature and nutrition available during the growing phase. Different varieties have different taste. There is practically no difference in the taste between the same variety of a hydroponically grown vegetable, organically grown vegetable and a soil grown vegetable. The feeling is more psychological than factual.

Hydroponics vs Organics

Some businesses promote their products as organic products. There is no such thing as organic vegetables or organic fruits or organic rice, wheat or barley. In fact, all the plants and plant products are naturally organic. As indicated earlier, the difference in the taste, the size, the colour and other organo-lyptic and nutritional properties of certain vegetables, fruits and cereals

are mainly due to their varietal/genetic differences and the growing environment rather than their production method.

Organic products cost more purely because of the recycling processes involved. The premium paid is for the "recycling of the urban and rural waste concept" rather than anything else. *Even a recycled paper costs more than a newly manufactured paper!*

Business-wise, the differences between hydroponics and organic farming might be an issue of priority, prestige and marketing strategy, but one should view soilless culture purely from the productivity, efficiency and quality point of view.

Commercial Production of Crops by Soilless Culture

In a commercial hydroponic or organic operation, priority should be given to high-value crops. Some examples include strawberries, tomatoes, japanese cucumbers, muskmelons, dutch radish, lettuces, culinary herbs, medicinal plants, roses, carnations, chrysanthemums, orchids and certain nursery plants for landscaping purposes. The choice of plant species is not critical to the soilless culture industry as a whole, and should be dependent on the prevailing market indicators. For the home, school and hobby gardeners, the choice is entirely upto the growers.

Strictly speaking, almost all plants in this planet are grown by soilless culture. Due to various types of pollution and contamination, the conventional way of growing crop plants was termed "**Soil Cultivation**" (the word soil, literally refers to contamination and pollution e.g. soiled dress). Clean cultivation is referred to as "**Soilless Cultivation**". Hydroponics and organics are two methods of soilless cultivation.

In religious books, heaven has been described as a place which has all the luxuries and comforts needed by mankind, and one thing that is often stressed is the presence of healthy plants, beautiful flowers and juicy fruits (in abundance) with clean rivers (water) flowing beneath. This is hydroponics! *Thus, hydroponics is practiced even in the heaven!*

(Now, let us come down to earth.)

What are the commercial realities? Can a hydroponically grown or organically grown produce compete in the typical open market that is practiced and promoted everywhere? Hydroponics and organics are no exception. **Commercial hydroponic and organic farmers should not expect any special concession from any source. The quality of the produce, high productivity and shrewd management should ultimately promote the soilless culture technology by itself.** However, it is very essential for national research institutes and major corporations to undertake R&D work in hydroponics and organics and provide advisory services to the industry and to the consumers.

Application of Soilless Culture in Urban Societies

Soilless culture technology sounds rather new and high-tech to people in urban societies. It is probably because people are on the look out for high-technology stuff that can help overcome food production shortage. The most important attraction towards hydroponics is its versatility in offering solution to grow plants dirt-free and hassle-free.

People in urban societies are either well educated and gainfully employed or are more daring and exceptionally enterprising. Sometimes, they are both educated and enterprising. So, it is not uncommon to see such people or their spouses taking up high-technology stuff first as a hobby and later develop them into a commercial venture. Computer technology, together with all its electronic paraphernalia, has continued to capture and retain the interest of this group of people as it brings satisfaction in all walks of their life.

Hydroponic and organic growing technologies can be practiced by the knowledgeable as well as by the not so very knowledgeable people. Soilless culture offers a unique challenge to the urban dwellers. What more, it can be merged with the computer technology! Thus, the hydroponic and organic technologies can be automated to the whims and fancies of the practitioners to grow any type of plants anywhere they like to suit their taste, their purpose and their budget.

One favourite past time in urban society is “eating”. In the past, people talked about the food they ate or the food they are eating or the food they plan to eat. In most cases, they spin stories about the “wonderful” this or the “super” that, and adjectives like “fantastic” and “ugh” are quite common.

Now, there is a basic shift in their “spins”. They are talking more in terms of dietary fibres, cholesterol, health food, etc. They are also aware of the ill effects of pesticides, causes of the diet-linked diseases like cancer, kidney stones, blood pressure, etc. They are more and more health-concoious.

With soilless culture, it is now much easier to re-create the once popular kitchen garden - dirt-free and hassle-free - be it in the backyard of the house or be it in the balcony or window sill of a high-rise apartments or be it on the roof tops. This sudden interest in “home farming” will give a boost to the hydroponics and organics industry. By the end of the decade, state of art commercial and domestic home farms will develop rapidly. The thirst for healthy pesticide-free vegetables and ornamentals and automated hassle-free gardens will also increase the demand for soilless culture.

Barren land, rocky areas, unfertile soil, drought and famine prone areas, un-utilized places like empty areas near housing estates, roof -tops of apartment blocks and industrial buildings can be considered seriously for soilless culture projects. The commercial potential is very promising and encouraging. It is also good for humanitarian and emergency operations.

Application of Soilless Culture for the Handicapped People

Plants are highly therapeutic - just the sight of the plants alone relieves stress and working with plants does miracles. Hence, old folks homes and homes for the disabled people are practicing soilless culture to give a meaning to the life of these unfortunate people.

Many have started on hydroponics and organics to impart an educational experience. Schools, community centres, old age homes and homes for the disabled are practicing soilless culture to meet the demand.

Soilless culture is also highly therapeutic to people, especially city dwellers, who are overly stressed in their daily routine.

Landscaping industry is also expected to incorporate hydroponics in its designs, thereby providing more employment opportunities for the handicapped people.

The Science behind the Recycling of Fish Tank Water

Nature has taught mankind numerous ways to survive and even excel in life. As a member of the eco-system, man has learnt to co-exist. Problems arise and persist only when he oversteps the natural processes and tries to behave too smart! Fish tank hydroponics is one such natural process, which when practiced properly will become a boon to mankind. This process has been variously described as “micro-farming”, “aquaponics”, “organic hydroponics”, “organics”, etc.

In fish tank hydroponics or aquaponics, plant and animal products like carbohydrates and protein are used to feed the fish, the fish wastes feed the bacteria, the bacteria wastes feed the plants, and the plants clean the water for the fish. Plant products enter the primary, secondary and tertiary food chain and their wastes start the cycle all over again.

When fed with high-protein diet, fish excrete solid and liquid waste that contains nitrogen in the form of ammonia. This condition will encourage eutrophication in the fish tank. Ammonia is highly toxic to fish and must be removed from the water. This can be done by three methods - by changing the water or by diluting the water frequently or by eliminating ammonia altogether by some mechanism. The third method has been investigated by many researchers and entrepreneurs. The result is the commercial “aquaponic” systems in the market. More consumer-friendly improved designs can be expected in the future.

The Science behind the Recycling of Waste Water

The conversion of ammonia to nitrite is done by a group of beneficial bacteria, *Nitrosomonas* and from nitrite to nitrate is done by another group of bacteria, *Nitrobacter*. Both these nitrifying bacteria are aerobic and colonize naturally wherever ammonia is available.

In ponds, algae will appear if there are no plants to absorb these nutrients. The water will become dark green and the fish will not be visible. The growth of algae is dependant on the amount of nitrates as well as the intensity of solar radiation in the greenhouse. The root system of the plants accumulate enough root mass to house the nitrifying bacteria and filter the solid waste in addition to absorbing enough nitrates.

Similar systems could be designed to treat sewage water and industrial waste water. The choice of plant will decide the efficacy as well as the viability of the project.

Greenhouses in Hydroponics

It is a well-known fact that a plant needs light, heat, air, water and mineral nutrients for its growth and productivity. In most cases, until recently, light, heat and air were taken for granted. All research and production efforts on crop plants were channeled to studies on

water and nutrient management, plant breeding, plant protection, agronomy, economics extension service, etc.

The importance of light, heat and air received very little attention in the tropics, probably due to their abundance. They have been studied in greater detail in temperate regions, mainly out of necessity, to protect the crop plants against adverse factors and to enhance productivity. Thus developed the "**greenhouse technology**" (*Phytotronics?*).

Of late, the study of this greenhouse technology has been gaining momentum in the tropics. Net/shade houses and rain/crop shelters and other similar structures have been developed and are being used in the commercial production of economically viable crops. Studies on the automation of the tropicalized greenhouses have also been initiated in many places.

The Successful Combination

The greenhouse technology and the soilless culture technologies are completely different. However, when these two technologies are practiced together, the results are quite spectacular. Thus, in modern hydroponics and organics, crop plants are provided with all the necessary inputs to promote their genes to perform to their best.

Apart from providing water and nutrients, equal importance is given to providing conducive macro- and micro-climates for the plants. **Micro-Climate** refers to the "**Epi-Climate**" (climate immediately around the plant) and "**Endo-Climate**" (climate within the plant). Rootzone temperature plays a major role in modifying this micro-climate. **Macro-Climate** refers to the lighting, ventilation, pollution and other related factors. The productivity of a crop plant is the result of its physiological processes as controlled by its macro- and micro-climates.

Business in Soilless Culture

Hydroponics and organics have always kindled the interest of business-minded people. It has all the "glamour" that a business looks for - the quality produce, the consumer appeal, the futuristic technology, good return on investment and the still unexplained "X-factor". Some simple guidelines are given below to anyone eager to venture into this wonderful line.

Like any other successful business, a soilless culture business should also have a "mission". A mission statement like "satisfying the consumer needs of 20-30 % of the population in the area of vegetables or flowers or herbs or whatever" should be fixed in the minds of all people involved. If the mission is good, then investment will not be a problem.

However, business means money and money means business. Irrespective of whether the investment comes from personal sweat or personal savings or from borrowings or from venture capitalists, a disciplined businessman should always treat the capital with diligence and handle it with utmost sincerity and honesty. There should be a win-win approach in all business dealings.

To run a successful soilless culture business

- always start small
- plan properly - use experts - you will save your face and a lot of money in the long term
- produce what the market (consumer) wants
- have a “core” product and a few “supporting” products
- allot 50% of the cost of the product and business for marketing
- establish a “sensible” sales and service network
- be flexible in production and marketing strategies
- be patient for a minimum of three years before working on the “return on investment”

Success depends on the efficiency of the management team. There are many successful commercial hydroponics operations around the world. Most airlines, high class hotels and restaurants and fast-food chains use only hydroponically grown vegetables. The cut flower industry, nurseries, landscape, orchard and plantation industries and the pharmaceutical industries are other sectors where hydroponics is practiced successfully.

Future of Soilless Culture

Hydroponics and organics are very viable commercial technologies - a futuristic technology. It is going

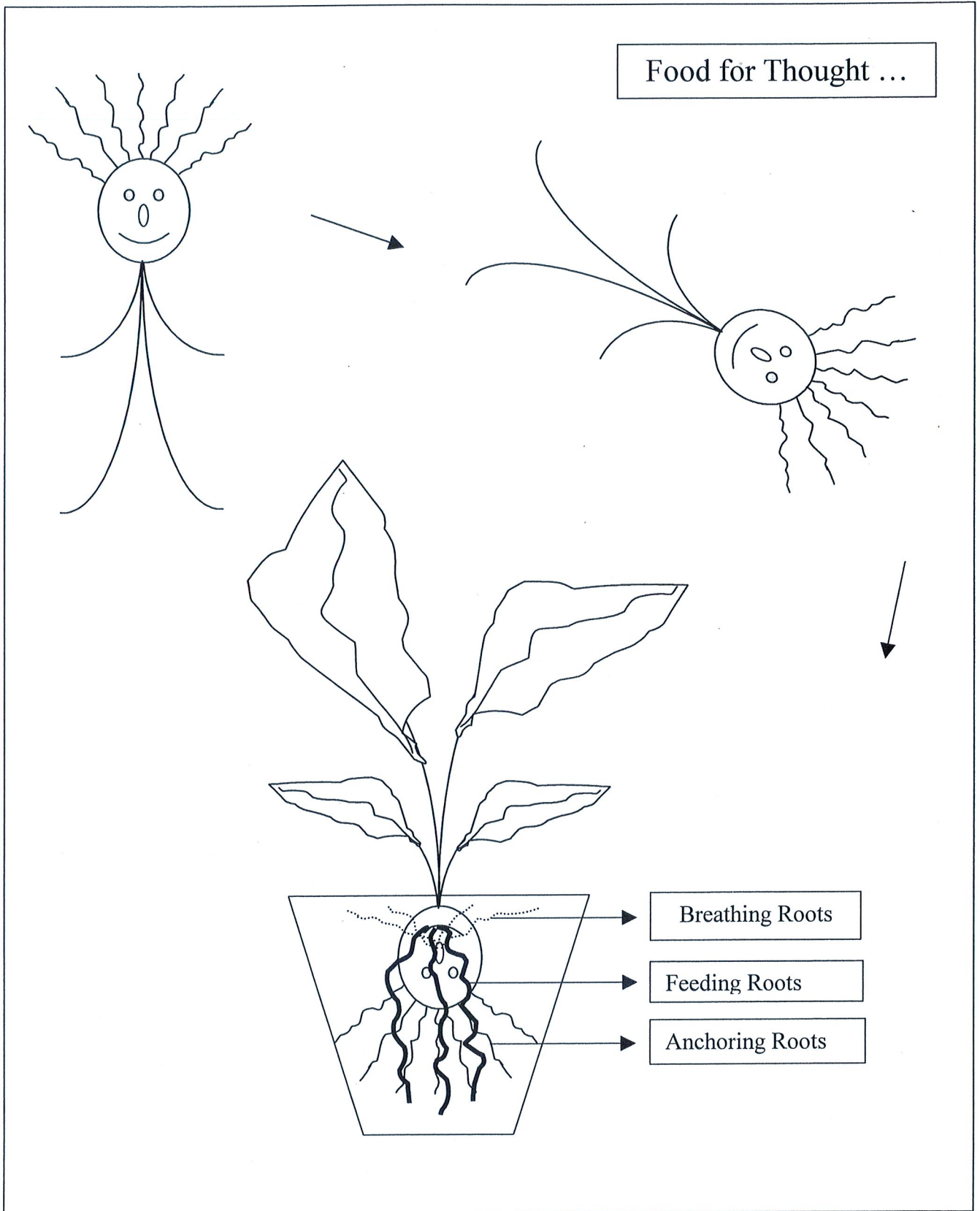
- to be the only technology to overcome food shortage in future, especially in land, labour and resource scarce societies and remote communities
- to be the best technology to “milk” certain phytochemicals from plant roots, especially by the pharmaceutical industries
- to help manage small as well as extensive and complicated landscape projects
- to serve as the best “phyto-therapeutic technology” to overcome stress problems of individuals at work and elsewhere.

When land, labour and natural resources get scarce and when people look for healthy alternatives to farming and gardening, there is no choice but to go in for hydroponics or organics.

Soilless Culture is no miracle. It is the result of hard work on the part of numerous scientists, amateurs and entrepreneurs in their quest to perfect the crop production technology. It is now undergoing rapid development. In a few years time, the productivity and quality of most crops should be increased many fold by employing the hydroponic technology. This technique, together with other biotechnology techniques, will contribute greatly to new developments in plant breeding, seed technology, nursery management, agronomy, post-harvest technology as well as gardening and landscaping (horticultural) technologies. Healthy and hygienic crop produce will become within easy reach of every citizen.

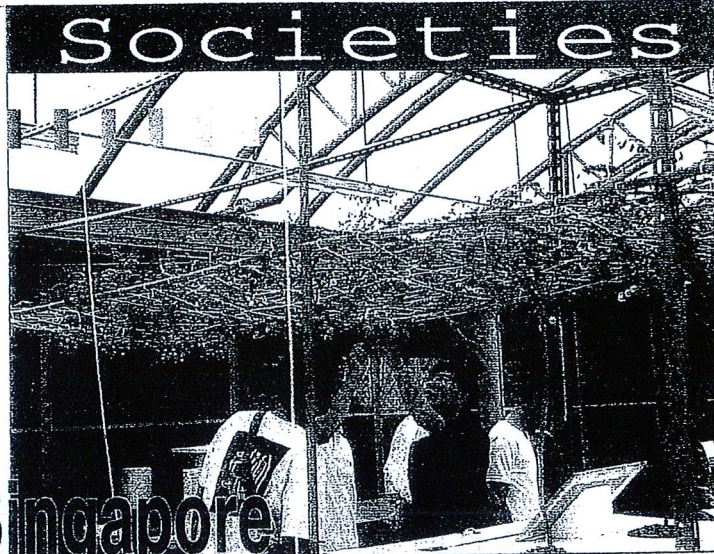
The trend is already there. The public sentiment is one of eagerness to understand more about this wonderful technology and some are even impatient to see the hydroponic production at their doorsteps.

In conclusion, hydroponics and organics are good for environment-friendly and nature-loving people to meet all their plant growing needs.



Notes & References

Hydroponics for Urban Societies



- the Singapore Experience

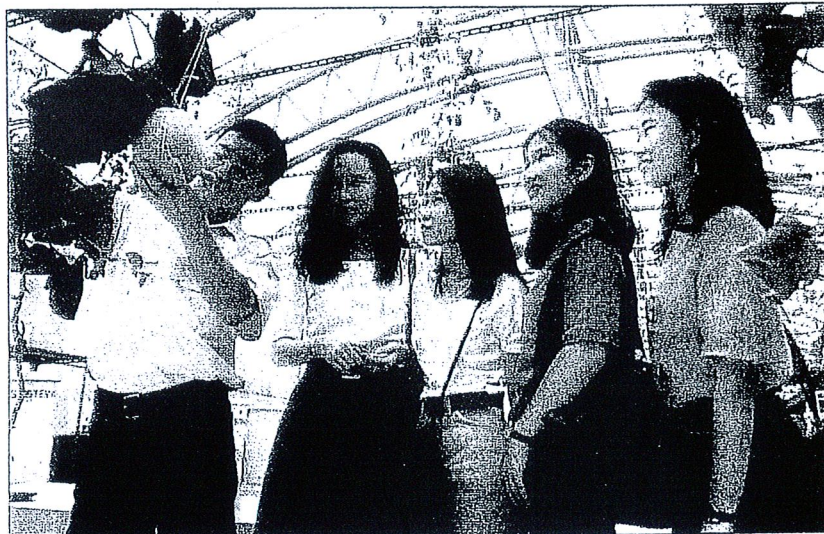
A 'tomato tree' - a cherry tomato plant trained on a pergola and grown by aerated flow technique.

DR MALLICK F. RAHMAN attributes the expanding interest in urban hydroponics to the rediscovery of the simple pleasures of growing plants. And Singapore's experience is a case in point.

Hydroponics Technology sounds rather new and high tech to urbanised people. It is probably because these people are always on the look out for high-technology stuff that rewards them with satisfaction. Yet the most important attraction of hydroponics is its versatility in offering a solution to growing plants around them - dirt-free and hassle free.

Urbanites

People in urban societies are either well educated and gainfully employed, or are more daring and exceptionally enterprising. Sometimes, they are both educated and enterprising. So, it is not uncommon to see such people taking up high technology pursuits as a hobby initially, and later develop them into a



Urbanites appreciating a musk melon grown in hydroponics.

commercial venture. Computer technology, together with all its electronic paraphernalia, has continued to capture and retain the interest of this group of people, as it brings satisfaction in all walks of their life.

Hydroponic technology is another such technology that can be practised by the knowledgeable, as well as by the not so knowledgeable. It offers a unique challenge to today's urban dwellers. What's more, it's a field of horticulture that can be merged with computer technology! Thus, hydroponic technology can be automated to the whims and fancies of the practitioners, to grow any type of plants anywhere they like, to suit their tastes, their purpose and their budget.

The Urban Environment

The urban environment anywhere in the world - Tokyo, London, New York, Paris, Hong Kong, Singapore - is typically characterised by restricted living areas. It is densely populated and the atmosphere is often polluted. Most of the buildings are air-conditioned and plant population is miserably low.

The food which the populus consumes comes from rural areas and is, in most cases, indiscriminately sprayed with pesticides. Until recently, the urban population did not have time to bother about all these so called "minor" issues. But when illness strikes and they get hospitalised, they start to reflect on the reasons. They discover something important - the "missing link" in their life - the plants! They find they have neglected plants all along and they suddenly develop great interest in them.

They feel like having ornamental and food plants around them - not only to keep their surroundings clean and beautiful, but also to provide fresh vegetables and herbs. And in their business life, their marketing strategy suddenly changes! They focus on plants for anything and everything - shares and stocks, real estate, banking and finance, you name it.

At a more personal level, plants are considered to be highly phyto-therapeutic - just the sight of plants alone relieves stress, and working with plants does miracles. This is what is happening in modern urbanised societies. The whole scenario is changing! And Singapore is a typical example.

The Singapore Experience

The favourite pastime in Singapore is "eating". People talk about the food they ate, or the food they are eating, or else the food they plan to eat. In most cases, they spin stories about the "wonderful" this, or "super" that, and enthusiastic adjectives are thrown about.

Now, there is a basic shift in their 'spins'. They are talking more in terms of dietary fibres, cholesterol, health food, and so on. They are also aware of the ill effects of pesticides, causes of the diet-linked diseases like cancer, kidney stones, blood pressure, etc. They are more and more health conscious.

The government of Singapore is promoting the "healthy lifestyle", "happy family life" and "green life" through

many of its campaigns. The Parks and Recreation Department wants to take the "Garden City" of Singapore more towards nature. Exhibitions like "Sky-rise Gardens for High-rise Apartments" really educate the public.

Private bodies are also encouraging people to "recycle" anything and everything and become more "environment friendly and nature loving". The Singapore Society for Soilless Culture and the Singapore Gardening Society aim to make people more aware of their environment.

Many people have adopted hydroponics as an educational experience. Schools, community centres, old age homes and homes for the disabled are practising hydroponics to meet the demand. The surviving hydroponic farms are seeing profits for the first time. new hydroponic farms - market gardens - are appearing.

Roof-top Gardens, Aeroponics and Home Farming

Unutilised places, such as empty areas near housing estates, and roof-tops of apartment blocks and industrial buildings, are now being considered very seriously for hydroponic projects. Traditional places inside apartments, like the kitchen window sill and balconies, and open space on properties with land, are being used efficiently to practice hydroponics.

New hydroponic systems employing the root mist technique (RMT) and fog feed technique (FFT) are getting popular in the name of aeroponics. Because of their light weight design, they can be used to grow both ornamental plants and vegetables.

Major break-throughs and rapid developments in "home farming" will give a boost to the hydroponics industry. By the end of the decade, state-of-the-art commercial and domestic hydroponic farms will flourish. The high cost of labour and land, together with the thirst for healthy food and automated gardens, will also increase the demand for hydroponics. The landscaping industry is also expected to incorporate hydroponics in its designs.

The Future of Hydroponics in Urban Areas

Hydroponics is gaining popularity very quickly, mainly because of the reasons discussed above. I believe the impact will be clearly seen in one or two years' time. The trend is already there. The public sentiment is one of eagerness to understand more about this wonderful technology, and some are even impatient to see hydroponic production at their doorsteps.

Dr Mallick F. Rahman teaches Agrotechnology/ Horticulture in the Department of Biotechnology at the Ngee Ann Polytechnic in Singapore. He has a degree in Agriculture and a Ph.D in Horticulture, and for the last 15 years has specialised in the fields of hydroponics and greenhouse management. ♦

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ISSUE 29

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*Dr Allen Cooper challenges
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- an in-house NEWSLETTER for members

2003 Edition Volume 6

Secretariat

School of Life Sciences
Ngee Ann Polytechnic
535 Clementi Road, Singapore - 599499



The majestic looking Singapore's First
Community Farm in an HDB Estate at Clementi
Ave 2 (near Block 359)

In This Issue: *The Role of Entomologists in Hydroponics - Fancy a farm in your home? - Ebb & flow Hydroponics - Hydroponics NEWS - Community Farm takes off in Singapore! - Aquaponics - Tips from Pipe Dreams- Growing media used in hydroponics - Design your own hydroponic systems - Roof Gardens - and many, many more....., wow!!!*

Editorial.....

So many unexpected events are happening around the world, everyday. Most events are related to people aiming for political gains with selfish motives. Ironically, they are done in the name of PEACE!

Given the current maturity in global understanding, no sane people will go to war. Everyone loves a peaceful life with international exchange of knowledge, goods and services.

Less than 5% of the world population likes to strut their military might and another less than 5% likes to challenge them. This scenario leads to unnecessary stress and strain on the remaining 90% of the population who remain silent & watch the events as they unfold every day.

This silent majority is concerned about the basic necessities like food supply, environmental matters and a whole host of issues related to harmonious and peaceful living.

Soilless Culture is about growing healthy plants for healthy food, feed, onamentals and medicines. It also aims to maintain a balanced eco-system. Whilst a psychological doom and gloom might rule the world currently, it is in fact a bloom time for people involved in soilless culture.

The world has seen many revolutions in the past - some are economically motivated and some are politically motivated. Currently, it is the computer revolution that is motivating all the professions across the board. Believe me, the next revolution will be related to soilless culture - either hydroponics or organics or both.

Everyday, we hear about some new discoveries that are revolutionizing the soilless culture industry. Putting all of them in a few pages is not an easy task. However, I have tried my best to give you the most exciting bits & bytes on soilless culture.

Mr. Gregory Chow, the President of the Singapore Society for Soilless Culture and all our Management Committee members join me in wishing you all with a "bundle of greetings" - Happy Deepavali, Selamat Hari Raya Puasa, Merry Christmas, Happy New Year, Gong Xi Fa Cai and Happy Vesak Day.

I wish you all a happy reading of our society's SIXTH Newsletter. Please do give us your feed back plus some of your experiences in soilless culture. Together, we shall make the next issue of our newsletter more exciting!

- Dr. Mallick F. Rahman, M. / Editor

Role of Entomologists In Hydroponics

In his editorial, to the January 2003 issue of the *Practical Hydroponics & Greenhouses* magazine, STEVEN CARRUTHERS, the publisher, gave an insight into the future direction of Safe Food Production

Sometimes we forget, or simply aren't aware of just how important entomologists and plant pathologists are to the hydroponics industry. More than ever, they are on the front line of our biological battle against insect pests and plant disease, developing the crop management strategies, protocols and tools that growers can use to eliminate or minimize insect pests and plant diseases, and improve plant yields; without the use of harmful pesticides and other chemicals.

Plant pathologist Bill Jarvis writes in his book, *Managing Disease in Greenhouse Crops*, that there were enormous strides in the development of environmental technology for growers of greenhouse crops in the 1980's and 1990's, with matching increases in production potential. However, little of this technology was aimed

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at a reduction in crop losses from insect pests and diseases, even though it is possible to manipulate a crop and its environment specifically for that purpose. Today, the main focus in environmental technology has shifted to the development of Integrated Pest Management (IPM) strategies and biocontrols that can make a significant contribution to reduced pesticide use. Driving this changing focus are consumer expectations for healthy, pesticide-free food.

The importance of safe food production has been recognized by most governments around the world following a number of high profile food scares. In NSW, Australia, the government recently invested in the production of five grower-assist books on IPM. In addition to information on how to implement an IPM program, these publications also provide worksheets that help growers build a database of pests and diseases on their property. Currently, there are no accurate data on key pests and diseases in greenhouse capsicum, cucumber and tomato crops, or on their seasonal occurrence in Australia, and these worksheets will help growers, entomologists and plant pathologists understand what to expect and when to anticipate their occurrence.

The importance of a healthy greenhouse is not just for the benefit of plants, but also for the well being of workers inside the greenhouse. In his story, *Breathing In & Out*, Bill Jarvis provides us with another insight into the valuable work of plant pathologists and entomologists. Here, he explains "everything you don't want to know about" in the air we breathe in the greenhouse, including allergens in plants, and offers some commonsense management practices for a healthy greenhouse environment.

This edited article has been abstracted from the May/June 2002 Issue of Practical Hydroponics and Greenhouses Magazine with due compliments to the author Mr. Steven Carruthers

Readers who are interested in subscribing to the *Practical Hydroponics and Greenhouses Magazine* can log on to www.hydroponics.com.au or singaporehydroponics.com

Fancy a farm in your home?*

- the concept of home farming for self sufficiency

This is a repeat article from the last issue. The purpose is to convey the message about the importance of having a small farm in your home.

To start a *home farm* might be a humble beginning for a family but it is in fact a small step for man but a giant step for mankind. Nothing new - in olden days, they called it the *kitchen garden!*

Talking about hydroponics, this is a very practical concept. Home farming is a refined farm using the best of the hydroponics and organics technologies to grow the best for the family.

The Singapore Society for Soilless Culture (SSSC) encourages all its members to embark on home farming. From now on, we plan to make this section a permanent feature in all our future issues. Importance will be given to the articles or opinions from the readers. So, after reading this, you can start to hatch a plan for your home garden. Record all your experience in a piece of paper and mail it to us with some photographs. You can also send your comments by e-mail to the editor at aphmfra5@pacific.net.sg

Would you like to build an ebb and flow hydroponic system?*

The plants are grown in rock wool blocks or small pots filled with hydrocorn. A system like this works best for plants smaller than 24 inches tall. The nutrient solution is stored in the reservoir and is pumped up to the tray with a submersible pump through the fill/drain fitting. The pump is controlled with a timer that turns on a few times per day. Or enough to keep the growing media moist all the time. The pump only needs to run long enough to reach the top of the overflow fitting. When the pump turns off the solution flows back down the fill/drain fitting and out the pump. The amount of solution that goes into the tray is controlled by the overflow fitting. Ebb and flow is one of the most reliable and easy to build hydroponic systems.

What you need:

Tray
Reservoir
Fill / Drain Overflow fitting Kit
Pump*
Tubing
Timer

The pump needs to be strong enough to lift the water to the tray but not too strong or you will have a fountain! Most pumps have a measurement of how high they will pump. It is measured in HEAD. If a pump is rated at four feet of head, that's how high it will pump. Some pumps only have a rating in PSI (Pounds per Square Inch).

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To find the HEAD, multiply the PSI by 2.31. In most cases, you want a pump with a head rating of twice the height that you need to lift the water. The tray must be above the reservoir so when the pump turns off, the water will flow back down through the pump. You can place the tray directly on top of the reservoir or make a stand for the tray and put the reservoir underneath.

The Fill / Drain and Overflow fittings fit in a 1 inch hole. Some of our trays are drilled and come with the fittings. Install the fittings and connect the pump with a 1/2 inch I.D. tube. The overflow fitting may need to be extended below with a piece of 3/4 inch PVC pipe.

The overflow fitting may need to be adjusted. The tray should only flood to about 80 percent of the height of the growing medium. If you are using rockwool cubes, it should flood about 2 inches. You may need to add or remove PVC pipe on the top too. Test this before filling the tray with growing media. I prefer not to use a screen on overflow fittings. All the leaves that drop collect around the screen and changes the flood depth. The more debris around the screen, the higher the water goes. If the water floods too deep, the growing medium will float and your plants tip over. Or even worse, the tray might overflow!

Acknowledgement: Greentrees Hydroponics Inc
2581 Pioneer Ave. Unit D
Vista, CA 92083

www: hydroponics.net

Hydroponics In HOT SOUP!

Miami police say that they have closed down a home hydroponics lab that was being used to grow marijuana.

Detectives said they went into a home at 1020 N.W. 24 Court and found 41 marijuana plants in a back room. Investigators said the plants have an estimated street value of \$50,000.

Police said that the owner of the home lives on the property in a detached apartment. The main home, where the hydroponics lab was located, is occupied by the owner's daughter, granddaughter and the daughter's boyfriend, police said.

Officers said that when they entered the house, they arrested Jorge Luis Perez, 49, and Alejandro Gutierrez, 37, after they found the men sitting in a living room surrounded by fully grown marijuana plants.

The homeowner's daughter, Maria B. Daizi, 43, was also arrested. Her daughter was put into the custody of other family members.

The men are charged with possession of marijuana and operating a hydroponics laboratory. Daizi is charged with trafficking in marijuana, cultivation and possession with intent to distribute.

So members - please be careful about what you are growing.

Integrated Aquaculture & Hydroponics for Home Hobbyists or classrooms

The Aquaponic System combines fish culture and true hydroponic plant production into one integrated ecosystem. Easy to set up and maintain, the Aquaponic System can provide you with fresh fish and produce from a clean and healthy environment year-round. It operates so well because the fish are providing the nutrients for the plants, and the plants clean up the water to make it a better place for the fish to live in. This mutually beneficial arrangement is the same as what goes on in nature, but this one is completely within your control. It's an ideal way to get started in aquaculture and hydroponics!

Growing fish like tilapia (also known as "Saint Peter's fish," "cherry snapper," "silverbacks," etc.) is easy and you can grow up to 100 lbs. in the Aquaponic System. An optional window in the tank makes learning fun because students can make observations as the fish interact with each other and the environment.

The 4' x 8' hydroponic growing bed is terrific for a kitchen herb cutting garden, dozens of heads of lettuce or other salad greens. Imagine, fresh herbs and salads from your very own hydroponic garden!

In the classroom, there's ample space for individual student projects that simply makes learning fun and exciting. Our instruction manual shows you how easy it is to grow with CropKing!

The Aquaponic System is made with durable, professional quality materials that are fully warranted. It comes complete and ready to set up with a 200-gallon fish tank, 4' x 8' hydroponic growing bed, an energy efficient, UL-listed air pump and hydroponic media. Optional equipment is available. The Aquaponic System package's convenient size fits right through a standard

Hydroponics Soilless Culture

2003 Edition Volume 6

doorway. Fresh veggies and fish year-round - CropKing's Aquaponic System is ready now so order yours today! Literature is also available if you need more information or books on aquaculture and aquaponics.

Acknowledgement:

CropKing Inc.
5050 Greenwich Road, Seville, OH 44273-9413 USA
www.cropking.com

Tips from

Pipe Dreams

This company deals mostly with innovative uses of pipes in hydroponics. It also offers plenty of tips for hydroponic growers.

pH in Hydroponics

In hydroponics, the pH level of a nutrient solution can become essential for proper plant growth. Each species of plant has its ideal pH level. The availability of essential nutrients and elements for that plant is also dependent on pH.

As pH increases, elements such as iron, manganese and zinc can precipitate out of solution and become unavailable to the plants. Even if your nutrient solution has the ideal concentration of these elements at high pH, the plants may not absorb them, resulting in a deficiency. To overcome this problem, many advanced plant fertilizers incorporate special chelating agents which ensure that iron and other nutrients remain in the solutions at higher pH levels.

The few elements like phosphorous and molybdenum can become unavailable to plants at low levels of pH, and when the pH dips below 5.0, there is also a danger of root burnings and the destruction of root tissue.

Levels of pH are easily corrected through the addition of either alkaline or acidic solutions. The diluted solution of potassium hydroxide (KOH) is commonly used to raise the levels in hydroponic nutrient solutions. Phosphoric acid and nitric acid are commonly used to lower levels of pH. Add diluted pH adjusters slowly over time to a well mixed nutrient tank.

Conductivity

There are several ways of measuring the concentration of nutrient solution. In the past, growers measured every primary nutrient individually. Now we feel that, in most cases, simply knowing the total nutrient level is sufficient. Our experience shows that if you start out with the right fertilizer mix, all nutrients will be used at

the same rate. This permits the use of either of the following simplified measuring methods. These methods will not be accurate if your nutrient solution is too old, as evaporation will "distill" pure water leaving concentrated salts which may not be in the proper proportions. For this, and other reasons, it is suggested that the nutrient solution be changed every two weeks. It is critical not to exceed the concentration required, as too much fertilizer can be worse than not enough.

Electrical Conductivity (EC) measures the rate at which a small electrical current flows through a solution. usually measured in micromhos/ centimeter (umhos/cm) or millisiemens/centimeter (uS/cm), 1.0 mS/cm.

Acknowledgement:

Pipe Dreams Hydroponics Hydroponiconline.com

Company Reviews

In this section, we shall find out what hydroponic companies around the world are offering their clients. This is a new series and we shall review one company in each of our future issues - to keep your spirits up on new innovations! In this issue we shall hear what General Hydroponics, a US based company say about themselves.

General Hydroponics

In the mid 1970's a group of scientists, engineers and technicians came together with a common goal, to advance agricultural technology by a quantum leap; together they created the General Hydroponics Company.

Today, over twenty years later, General Hydroponics is a leading innovator in the field of hydroponics with factories in North America and Europe.

Our products are used by NASA in preparation for hydroponics on the International Space Station. Numerous laboratories and universities throughout the world use our products for teaching and research; other clients use our products for commercial crop production as well as high-tech gardening.

Recognizing the importance of the growing international market for hydroponic technology we are pleased that our staff is fluent in many languages.

Our new facility is located in Sebastopol, California. We have over ten acres for testing new crops, hydroponic systems, nutrients and related technologies. Our factory consists of 45,000 square feet (5,000 square meters) of modern industrial space.

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With these facilities we are developing new hydroponic systems and perfecting nutrient formulas to enhance flavor and yield plus vitamin and mineral content in food crops for higher nutritional value. Our farm division is testing many varieties of vegetables for growth rate, yield, flavor, nutrition, appearance, shelf-life and hydroponic viability. We are able to recommend a wide variety of seeds for gourmet fruits, vegetables, herbs, flowers and ornamentals for hydroponic cultivation. We are testing a variety of different hydroponic techniques plus traditional "organic" methods in soil to determine the best ways to grow top-quality crops.

We've never lost sight of our goal, to push the edge in hydroponic technology. Our first objective is to be the best, to produce the best and to lead in technology, quality and innovation.

For further information go to:

General Hydroponics-USA:
P. O. Box 1576, Sebastopol,
California www.genhydro.com

Community Farm takes off In Singapore

**- in an Housing Estate - an attraction &
meeting point for the residents!**

An open space In Clementi Ave 2, near Block 359 has been developed as the first Community Farm in Singapore's residential area.



Drop by & see the beauty for yourself.

Growing Media used In HYDROPONICS

Tips for Designing your own HYDROPONIC GARDENS

Hydroponic Gardens distribute a nutrient formula to plants and use an inert growing medium in place of soil to anchor roots for easier access to food and water. Nutrient food is dissolved in water and goes directly to the plants roots producing faster harvests and higher yields than soil based gardening. Hydroponics Plant Growing Systems can be used indoors or outdoors, year-round.

American Agritech's nutrient film hydro garden's utilize an oxygen rich nutrient solution that runs along the bottom of the of the slightly curved and sloped 4" or 6" grow channels forming a thin nutrient film allowing for roots to feed and the upper roots to breath. Ideal for a wide range of crops - lettuce, strawberries, herbs and flowers, to tomatoes, peppers, eggplant, squash and cucumbers. This hydrogarden system is the easiest to operate and grow with.

Drip watering method growing systems allows the grower greater flexibility with larger configurations that use less water and nutrients than flood systems. Designed to grow tomatoes, cucumbers, peppers, herbs and flower crops. Popular with small commercial growers, hobbyists and schools.

Aeroponic growing system's spray the roots of plants with water and nutrient solution allowing for aggressive growth rates from the high levels of oxygen to the root zone. Excellent for starting large crops of seedlings, transplants and cuttings or growing plants or crops to full maturity. Mist continually or in micro bursts of one minute on and four minutes off.

Ebb & Flow growing systems feed plants automatically with a simple flood and drain watering method. Everytime water floods the bedding tray, stale air is pushed out and all plant roots are equally fed and bathed. As the water drains back into the reservoir, fresh air is pulled in to the root area. Popular system for rooting cuttings, germinating seedlings and vegetating young plants.

Passive Systems are simple to use hydroponics growing systems. The plant determines when it needs water and nutrients. Grows any type of vegetative, flowering or fruiting plant. Great for home or office.

Growing media are inert mineral materials that anchor the plants root system and have a superior

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capacity for holding nutrient solution and oxygen retention. Dividing the world above from the world below, the interface between a plant and its roots is where media come in. The magic of hydroponics happens in the world below, the domain of the roots.

Natural organic growing media that has the superior water holding capacity of rock wool and greater oxygen holding capacity without the disposal hazard. Organic growing media are becoming the preferred choice of environmentally concerned growers

LECA is the non-toxic, pH stabilized expanded clay pebble, Hydroponic growing media that retains water and nutrients and releases it to your plants roots as needed. While initially more expensive than rockwool, expanded clay can be reused by simply washing off the old roots and sterilizing with a 10% bleach 90% water solution.

Horticultural rockwool is spun from molten rock into fibers and compressed into cubes, blocks or slabs. Rockwool has a capacity for absorbing nutrient solutions while retaining oxygen for rapid plant growth. Use food grade pH raise or lower, to precondition rockwool prior to use, in a solution adjusted to a pH factor of 5.5 for 24 to 48 hours prior to use. Rockwool is a disposal hazard and due to its dust & fiber content content should be handled while wearing a dust mask.

A Plant Ready Gro Bag containing a specialized blend of perlite, coir fiber, Pure Blend compost accelerator, earthworm castings, agrimineral 72 silica clay, polymere hydro-crystals and Rootshield Bio-fungicide

Acknowledgement:

PlantLighting.com
9140 Ravenna Road
Twinsburg, Ohio 44087

Readers' Questions & Concerns

Dear Dr. Mallick Rahman

The Neem plant that I grow in my HDB corridor seems very independent and like you said, they are free of pests. However, I also bought another plant sapling called the Ocimum Sanctum/Holy Basil from one of the Mint family.

There is just one major problem with this plant, there are these really tiny black looking bugs. These parasites multiply real fast and even after I cut some of the leaves with their eggs on it. I think its their eggs coz they are like little black dots on some of the leaves they had infested. Can you suggest a solution to this problem?

Some kind of insecticide spray that contains no chemicals coz the leaves are for human consumption. Where can I purchase it? Or is there some insect that I can introduce to wipe out these parasites? Are there places in Singapore where I can purchase such insects?

Best Regards,

Rajesh Moehamad

Dear Rajesh Moehamad

I am glad you are enjoying the neem plant.

The pests that you see on Ocimums are actually Aphids - the sucking pests. Aphids suck the plant juice and excrete the sugars which form the food for the ants. So whenever you see these aphids, you can always see some ants which maintain these Aphid colonies for their sugar supply - clever isn't it?

Now, to get rid of the aphids, you should get rid of the ants. First get rid of the resident aphid colonies by removing the infected leaves. Next, get rid of the ants by trailing the ants movement back to their nests. Spray some Baygon or Shelltox or some kerosene on the nest and kill them. You should repeat this atleast three times a week to completely wipe them out.

Insects used to kill other insects are called predators. They are very useful only inside a greenhouse - they cannot escape! You cannot use them in the open - they will fly elsewhere! Such predators are available in greenhouse producing areas like Holland and Japan. They are not available in Singapore.

Alternately, you can take some neem leaves, mash them in a mortar and squeeze out the juice. Dilute this with water and spray on the Ocimum plants. Not only the aphids but also the ants will go away! Give it a try.

Regards, Dr. Mallick Rahman

The Potential of Roof-Top Hydroponic Gardens

- the way people think!- an interesting correspondence
worth reading ...

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Dear Dr Rahman,

I recently read your article on Ngee Anne's biotechnology website and would like to ask you a few questions regarding educational opportunities in hydroponics. I recently graduated from college in the United States with a BA degree and am currently taking horticulture classes at a local college and need advice as to how to proceed with my horticulture career. I would eventually like to start my own business growing vegetables and herbs on rooftops in cities and selling at farmers markets and to restaurants.

My idea so far is to find a university program where I can take a few classes specifically dealing with hydroponics for a semester or two. I have come across a few programs in the US but from what I see most universities only offer one or two classes. Most programs also seem to not be as advanced as ones found abroad. Ngee Ann's hydroponic facility is particularly interesting to me because of its placement on a rooftop. I believe that rooftop space is extremely undervalued for its productive possibility and that commercial farming can be viable. If possible, please forward any information you may think would be helpful regarding programs you feel are good or any other information you may have.

Thank you for your time,

Benjamin Wiles, Alexandria, VA USA

Dear Benjamin

Yes, you are right. The potential of rooftops as a farming area has been under-estimated. The potential is huge. I have been raising this issue for the past 15 years. Now, we can see some roof top hydroponic farms in Singapore.

Ngee Ann Polytechnic offers courses in Biotechnology and in Horticulture and Landscape Management. Hydroponics is covered as part of the course work.

However, we are planning to have a 1-2 week crash course on hydroponics during 1-4 September 2003 as part of the Second Asia-Pacific Conference and Exhibition on Soilless Culture. I shall keep you informed.

You might wish to visit our site at <http://www.singaporehydroponics.com/> for more information.

Dr. Mallick Rahman

Dear Dr. Rahman,

Thank you for getting back to me and forwarding information regarding the conference.

I have been trying to find courses in hydroponics in the US but it has been difficult. Luckily I was able to find one at North Carolina State Univ. The class is even supposed to cover organic hydroponics, the only one in the US that I have found, and am excited to see how it is done.

I am looking for courses in hydroponics based in colder climates Europe, and North America. Are you familiar with any programs in Canada?

One question regarding rooftop production I had, if you don't mind answering, is where the nutrient tank is kept at rooftop greenhouse facilities. I'm assuming on the rooftop but from my calculations a few hundred gallon tank filled with nutrient would be too heavy for a rooftop (I believe the load for most rooftops here in the North East for instance is 30lbs per square foot). Did you have to reinforce the area supporting the nutrient tank?

Thank you again for your response,

Ben Wiles

Dear Ben

I am glad to hear that you have found a good hydroponics course at North Carolina State Univ. Till today, I am not aware of any formal hydroponic programs in Canada. If I come across any, I shall keep you informed. But we are planning to develop one for the tropical weather.

Location of the heavy nutrient tank at the rooftop greenhouse facilities is the problem of the structural engineer. However, we do it in a simple way. All buildings in Singapore are constructed on a piling foundation - where 1-2 feet diameter sized steel reinforced columns are piled into the ground until they hit the bedrock. In that way the buildings are quite strong as they sit on a strong foundation. We just place steel reinforced concrete cross bars across and place the nutrient solution tank over it.

However, my suggestion for you is not to use heavy nutrient solution tanks. Instead, you can use smaller tanks with water and nutrient top-up gadgets, which

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allow just enough water and nutrients to mix based on pre-adjusted or programmed schedule.

I would like to recommend a couple of very good hydroponic magazines. You can find a wealth of information in them. One is the "Practical Hydroponics and Greenhouse Magazine" that comes from Australia and the other one is the "Growing Edge Magazine" that comes from the US. Please surf the net and hit the right buttons to subscribe.

Please do not hesitate to contact me for any further clarification.

Regards, Dr. Mallick Rahman

aphmfra5@pacific.net.sg

...ooo0000000ooo...

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Ngee Ann Polytechnic
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Note

The views expressed by the contributors are entirely their own and do not in any way reflect those of the SSSC.

H P C

LUSHGro-HYDRO^{Liquid}

The Complete Balanced Liquid Fertilizer for All Plants

- ideal for hydroponics, potted plants and all kinds of foliage, flowering & fruiting plants in the garden -
- suitable for soil drenching, drip irrigation and foliar spray - try and see the difference! -

All plants need sixteen elements to grow. They are carbon, hydrogen, oxygen, nitrogen, phosphorous, potassium, calcium, magnesium, sulphur, zinc, copper, iron, manganese, boron, molybdenum and chlorine. In nature, plants derive these elements from the atmosphere or from the minerals in the soil. Most of the elements used in preparing **LUSHGro** nutrients are derived from these naturally occurring minerals in the soil. So only they are called mineral (mined) nutrients. As such, they are not only natural but also very safe. They are sometimes purified to remove the impurities like obtaining pure table salt from seawater. Hence, they are quite safe to our body. These are popularly known as fertilizers and have been approved world over for crop production.

LUSHGro-HYDRO^{Liquid} is a formulated plant food containing all the essential elements for plant growth & development. This scientifically balanced nutritious liquid fertilizer is the result of more than 15 years of R&D work. **LUSHGro-HYDRO**^{Liquid} is a prepared ready-to-use A/B (two-part) formulation. This set consists of Nutrient Stock Solution A and Nutrient Stock Solution B.

- Directions:**
1. These Stock Solutions A and B are 100 times concentrated. Hence, should be diluted 1:100 with clean water before feeding the plants. This is the Feeding Solution - LUSHGro-HYDRO^{Liquid}
 2. Dilute at the rate of 10 ml of Solution A and 10 ml of Solution B to one litre of water. e.g. to prepare 10 litres of feeding solution, add 100 ml of Solution A and 100 ml of Solution B to 10 litres of water. Mix well and use.
 3. Upon dilution this solution contains an approximate amount of nutrients tabulated below - ideal for most plants.

Nutrients	mg/litre	Nutrients	mg/litre	Nutrients	mg/litre
Nitrogen	225	Sulphur	87	Boron	0.29
Phosphorous	68	Magnesium	56	Copper	0.16
Potassium	316	Iron as EDTA	17	Molybdenum	0.28
Calcium	174	Manganese	3	Zinc	0.37

4. Whilst the above dilution rate can be used as a thumb rule, it is always better to use an Electrical Conductivity (EC) meter. You can adjust the EC level to 1.0 - 1.5 mS/cm for leafy plants, 1.5 - 2.5 mS/cm for flowering plants and 2.5 - 3.5 mS/cm for fruiting plants. Add more **LUSHGro-HYDRO**^{Liquid} to increase the EC or add more water to reduce the EC
5. Use **LUSHGro-HYDRO**^{Liquid} diluted Feeding Solution direct for hydroponics
6. Use **LUSHGro-HYDRO**^{Liquid} diluted Feeding Solution once a week to water potted plants and other garden plants by drenching or by dripping
7. For foliar spray dilute the diluted **LUSHGro-HYDRO**^{Liquid} Feeding Solution further, by adding equal amount of water

Caution: Though not harmful, it is always advisable to keep **LUSHGro-HYDRO**^{Liquid} out of reach of children. Keep away from strong light in a cool and dry place.
This is a twin pack / TWO bottles set. **You pay for the complete set.** - colour code **GREEN and BLUE**

LUSHGro-HYDRO^{Liquid} required by a plant depends on the variety, age and stage of the plant. However, plants themselves are the best indicators. The top 3-5 leaves of any branch are called the "indicator leaves". They speak so much about the health of the plant. Pale leaves indicate the lack of nutrients and brown or burnt leaves indicate too high concentration of nutrients. Add more solution or dilute with plain water accordingly. Observe the growth of the plant and adjust the concentration periodically. In case of doubt, do not hesitate to seek the help of your neighbourhood Agronomist or call us direct at the numbers given below.

Other formulations in the series:

- LUSHGro-HYDRO**^{Solid} - professional's choice to prepare concentrated nutrient solution for hydroponics
- LUSHGro-GREEN**^{Liquid} - ideal for herbs and foliage plants grown indoors and outdoors
- LUSHGro-BLOOM**^{Liquid} - ideal for outdoor flowering & fruiting plants
- LUSHGro-AQUA**^{Liquid} - ideal for aquatic plants grown in aquariums - safe on fish
- LUSHGro-TURF**^{Liquid} - ideal for lawns and turfs
- LUSHGro-MICROS**^{Liquid} - handy trace element supplement - for use in garden / aquatic plants and aquariums

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- at HPC we don't simply sell things - we help you grow your plants to your fullest satisfaction -

H P C

LUSHGro-GREEN Liquid

The Complete Balanced Liquid Fertilizer for All Plants

- ideal for herbs and foliage plants grown both indoors and outdoors -

- suitable for soil drenching, drip irrigation and foliar spray - try and see the difference! -

All plants need sixteen elements to grow. They are carbon, hydrogen, oxygen, nitrogen, phosphorous, potassium, calcium, magnesium, sulphur, zinc, copper, iron, manganese, boron, molybdenum and chlorine. In nature, plants derive these elements from the atmosphere or from the minerals in the soil. Most of the elements used in preparing **LUSHGro** nutrients are derived from these naturally occurring minerals in the soil or from the air. So only they are called mineral (mined) nutrients. As such, they are not only natural but also very safe. They are sometimes purified to remove the impurities like obtaining pure table salt from seawater. Hence, they are quite safe to our body. These are popularly known as fertilizers and have been approved world over for crop production.

LUSHGro-GREEN Liquid is a formulated plant food containing all the essential elements for plant growth & development. This scientifically balanced nutritious liquid fertilizer is the result of more than 15 years of R&D work. **LUSHGro-GREEN** Liquid is a prepared ready-to-use A/B (two-part) formulation. This set consists of Nutrient Stock Solution A and Nutrient Stock Solution B.

- Directions:**
1. These Stock Solutions A and B are 100 times concentrated. Hence, should be diluted 1:100 with clean water before feeding the plants. This is the Feeding Solution - **LUSHGro-GREEN** Liquid
 2. Dilute at the rate of 10 ml of Solution A and 10 ml of Solution B to one litre of water. e.g. to prepare 10 litres of feeding solution, add 100 ml of Solution A and 100 ml of Solution B to 10 litres of water. Mix well and use.
 3. Upon dilution this solution contains an approximate amount of nutrients tabulated below - ideal for most plants.

Nutrients	mg/litre	Nutrients	mg/litre	Nutrients	mg/litre
Nitrogen	326	Sulphur	87	Boron	0.29
Phosphorous	68	Magnesium	56	Copper	0.16
Potassium	89	Iron as EDTA	17	Molybdenum	0.28
Calcium	174	Manganese	3	Zinc	0.37

4. Whilst the above dilution rate can be used as a thumb rule, it is always better to use an Electrical Conductivity (EC) meter. You can adjust the EC level to 1.0 - 1.5 mS/cm for leafy plants, 1.5 - 2.5 mS/cm for flowering plants and 2.5 - 3.5 mS/cm for fruiting plants. Add more **LUSHGro-GREEN** Liquid to increase the EC or add more water to reduce the EC
5. Use **LUSHGro-GREEN** Liquid diluted Feeding Solution direct for hydroponics
6. Use **LUSHGro-GREEN** Liquid diluted Feeding Solution once a week to water potted plants and other garden plants by drenching or by dripping
7. For foliar spray dilute the diluted **LUSHGro-GREEN** Liquid Feeding Solution further, by adding equal amount of water

Caution: Though not harmful, it is always advisable to keep **LUSHGro-GREEN** Liquid out of reach of children. Keep away from strong light in a cool and dry place.

This is a twin pack / TWO bottles set. You pay for the complete set. - colour code **GREEN and ORANGE**

LUSHGro-GREEN Liquid required by a plant depends on the variety, age and stage of the plant. However, plants themselves are the best indicators. The top 3-5 leaves of any branch are called the "indicator leaves". They speak so much about the health of the plant. Pale leaves indicate the lack of nutrients and brown or burnt leaves indicate too high concentration of nutrients. Add more solution or dilute with plain water accordingly. Observe the growth of the plant and adjust the concentration periodically. In case of doubt, do not hesitate to seek the help of your neighbourhood Agronomist or call us direct at the numbers given below.

Other formulations in the series:

- LUSHGro-HYDRO** Solid - professional's choice to prepare concentrated nutrient solution for hydroponics
- LUSHGro-HYDRO** Liquid - the MOST POPULAR nutrient solution for growing all kinds of plants anywhere
- LUSHGro-BLOOM** Liquid - ideal for outdoor flowering & fruiting plants
- LUSHGro-AQUA** Liquid - ideal for aquatic plants grown in aquariums - safe on fish
- LUSHGro-TURF** Liquid - ideal for lawns and turfs
- LUSHGro-MICROS** Liquid - handy trace element supplement - for use in garden / aquatic plants and aquariums

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LUSHGro-BLOOM^{Liquid}

The Complete Balanced Liquid Fertilizer for All Plants

- ideal for flowering and fruiting plants grown outdoors -

- suitable for soil drenching, drip irrigation and foliar spray - try and see the difference! -

All plants need sixteen elements to grow. They are carbon, hydrogen, oxygen, nitrogen, phosphorous, potassium, calcium, magnesium, sulphur, zinc, copper, iron, manganese, boron, molybdenum and chlorine. In nature, plants derive these elements from the atmosphere or from the minerals in the soil. Most of the elements used in preparing **LUSHGro** nutrients are derived from these naturally occurring minerals in the soil. So only they are called mineral (mined) nutrients. As such, they are not only natural but also very safe. They are sometimes purified to remove the impurities like obtaining pure table salt from seawater. Hence, they are quite safe to our body. These are popularly known as fertilizers and have been approved world over for crop production.

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- Directions:**
1. These Stock Solutions A and B are 100 times concentrated. Hence, should be diluted 1:100 with clean water before feeding the plants. This is the Feeding Solution - **LUSHGro-BLOOM**^{Liquid}
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5. Use **LUSHGro-BLOOM**^{Liquid} diluted Feeding Solution direct for hydroponics
6. Use **LUSHGro-BLOOM**^{Liquid} diluted Feeding Solution once a week to water potted plants and other garden plants by drenching or by dripping
7. For foliar spray dilute the diluted **LUSHGro-BLOOM**^{Liquid} Feeding Solution further, by adding equal amount of water

Caution: Though not harmful, it is always advisable to keep **LUSHGro-BLOOM**^{Liquid} out of reach of children. Keep away from strong light in a cool and dry place.
This is a twin pack / TWO bottles set. You pay for the complete set. - colour code **GREEN and YELLOW**

LUSHGro-BLOOM^{Liquid} required by a plant depends on the variety, age and stage of the plant. However, plants themselves are the best indicators. The top 3-5 leaves of any branch are called the "indicator leaves". They speak so much about the health of the plant. Pale leaves indicate the lack of nutrients and brown or burnt leaves indicate too high concentration of nutrients. Add more solution or dilute with plain water accordingly. Observe the growth of the plant and adjust the concentration periodically. In case of doubt, do not hesitate to seek the help of your neighbourhood Agronomist or call us direct at the numbers given below.

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*The Complete Balanced Liquid Fertilizer for Aquatic Plants
- suitable for all kinds of submerged plants and is safe on fish -*

All plants need sixteen elements to grow. They are carbon, hydrogen, oxygen, nitrogen, phosphorous, potassium, calcium, magnesium, sulphur, zinc, copper, iron, manganese, boron, molybdenum and chlorine. In nature, plants derive these elements from the atmosphere or from the minerals in the soil. Most of the elements used in preparing **LUSHGro** are derived from these naturally occurring minerals in the soil. So only they are called mineral (mined) nutrients. As such, they are not only natural but also very safe. They are sometimes purified to remove the impurities like obtaining pure table salt from sea water. Hence, they are quite safe to our body. These are popularly known as fertilizers and have been approved world over for crop production.

This unique **LUSHGro-AQUA for Aquatic Plants** is a formulated plant food containing all the essential elements for aquatic plant growth & development. This scientifically balanced nutritious liquid fertilizer is the result of more than 15 years of R&D work. Care has been taken to keep the nitrate (NO₃) level as low as possible to be safe on the fish and other aquatic fauna. It cannot be totally deleted as nitrogen, which is an essential element for plant growth, is always absorbed by the plants in the form of nitrates. It is a ready-to-use formulation.

Directions: **LUSHGro-AQUA for Aquatic Plants** is a concentrated formulation. Depending on the number of plants in the aquarium or aquatic landscape, add 1-5 drops of this solution PER TEN LITRES to the tank 1-2 times a month or whenever you change the water. NEVER ADD MORE THAN FIVE DROPS AT A TIME. If your aquarium is big, then add 10 ml or ONE CAP FULL PER 100 LITRES of water in the tank. This solution contains an approximate amount of nutrients tabulated below which is ideal for the growth and development of most aquatic plants:

Nutrients	g/litre	Nutrients	g/litre	Nutrients	g/litre
Nitrogen	7.179	Iron as EDTA	1.683	Copper	0.025
Potassium	51.711	Manganese	0.612	Molybdenum	0.016
Sulphur	16.667	Boron	0.314	Other minerals	traces
Magnesium	2.942	Zinc	0.092	Vitamins	traces

Caution: Though not harmful, it is always advisable to keep **LUSHGro-AQUA for Aquatic Plants** out of reach of children. Keep in a cool and dry place, away from strong light. *This is a 500 ml single bottle pack.*

Colour Code: **RED**

LUSHGro-AQUA for Aquatic Plants required by a plant depends on the variety, age and stage of the plant. However, plants themselves are the best indicators. The top 3-5 leaves of any branch are called the "indicator leaves". They speak so much about the health of the plant. Pale leaves indicate the lack of nutrients and brown or burnt leaves indicate too high concentration of nutrients. Add more solution or dilute with plain water accordingly. Observe the growth of the plant and adjust the concentration periodically. In case of doubt, do not hesitate to seek the help of your neighbourhood Aquarist or call us direct at the numbers given below.

Other formulations in the series:

- LUSHGro-HYDRO**^{Solid} - professional's choice to prepare concentrated nutrient solution for hydroponics
- LUSHGro-HYDRO**^{Liquid} - the MOST POPULAR nutrient solution for growing all kinds of plants anywhere
- LUSHGro-GREEN**^{Liquid} - ideal for herbs and foliage plants grown indoors and outdoors
- LUSHGro-BLOOM**^{Liquid} - ideal for outdoor flowering & fruiting plants
- LUSHGro-TURF**^{Liquid} - ideal for lawns and turfs
- LUSHGro-MICROS**^{Liquid} - handy trace element supplement - for use in garden / aquatic plants and aquariums

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H P C

LUSHGro-TURF^{Liquid}

The Complete Balanced Liquid Fertilizer for All Plants

- ideal for home lawns, soccer fields, golf courses, polo fields, race tracks, roadside turf, fodder grasses, etc... -
- suitable for soil drenching, drip irrigation and foliar spray - try and see the difference! -

All plants need sixteen elements to grow. They are carbon, hydrogen, oxygen, nitrogen, phosphorous, potassium, calcium, magnesium, sulphur, zinc, copper, iron, manganese, boron, molybdenum and chlorine. In nature, plants derive these elements from the atmosphere or from the minerals in the soil or from the atmosphere. Most of the elements used in preparing **LUSHGro** nutrients are derived from these naturally occurring minerals. So only they are called mineral (mined) nutrients. As such, they are not only natural but also very safe. They are sometimes purified to remove the impurities like obtaining pure table salt from seawater. Hence, they are quite safe to our body. These are popularly known as fertilizers and have been approved world over for crop production.

LUSHGro-TURF^{Liquid} is a formulated plant food containing all the essential elements for plant growth & development. This scientifically balanced nutritious liquid fertilizer is the result of more than 15 years of R&D work. **LUSHGro-TURF**^{Liquid} is a prepared ready-to-use A/B (two-part) formulation. This set consists of Nutrient Stock Solution A and Nutrient Stock Solution B.

- Directions:**
1. These Stock Solutions A and B are 100 times concentrated. Hence, should be diluted 1:100 with clean water before feeding the plants. This is the Feeding Solution - **LUSHGro-TURF**^{Liquid}
 2. Dilute at the rate of 10 ml of Solution A and 10 ml of Solution B to one litre of water. e.g. to prepare 10 litres of feeding solution, add 100 ml of Solution A and 100 ml of Solution B to 10 litres of water. Mix well and use.
 3. Upon dilution this solution contains an approximate amount of nutrients tabulated below - ideal for most plants.

Nutrients	mg/litre	Nutrients	mg/litre	Nutrients	mg/litre
Nitrogen	417	Sulphur	87	Boron	0.29
Phosphorous	68	Magnesium	56	Copper	0.16
Potassium	89	Iron as EDTA	17	Molybdenum	0.28
Calcium	174	Manganese	3	Zinc	0.37

4. Whilst the above dilution rate can be used as a thumb rule, it is always better to use an Electrical Conductivity (EC) meter. You can adjust the EC level to 1.0 -1.5 mS/cm for leafy plants, 1.5- 2.5 mS/cm for flowering plants and 2.5 - 3.5 mS/cm for fruiting plants. Add more **LUSHGro-TURF**^{Liquid} to increase the EC or add more water to reduce the EC
5. Use **LUSHGro-TURF**^{Liquid} diluted Feeding Solution direct for hydroponics
6. Use **LUSHGro-TURF**^{Liquid} diluted Feeding Solution once a week to water potted plants and other garden plants by drenching or by dripping
7. For foliar spray dilute the diluted **LUSHGro-TURF**^{Liquid} Feeding Solution further, by adding equal amount of water

Caution: Though not harmful, it is always advisable to keep **LUSHGro-TURF**^{Liquid} out of reach of children. Keep away from strong light in a cool and dry place.

This is a twin pack / TWO bottles set. You pay for the complete set - colour code GREEN and PURPLE

LUSHGro-TURF^{Liquid} required by a plant depends on the variety, age and stage of the plant. However, plants themselves are the best indicators. The top 3-5 leaves of any branch are called the "indicator leaves". They speak so much about the health of the plant. Pale leaves indicate the lack of nutrients and brown or burnt leaves indicate too high concentration of nutrients. Add more solution or dilute with plain water accordingly. Observe the growth of the plant and adjust the concentration periodically. In case of doubt, do not hesitate to seek the help of your neighbourhood Agronomist or call us direct at the numbers given below.

Other formulations in the series:

- LUSHGro-HYDRO**^{Solid} - professional's choice to prepare concentrated nutrient solution for hydroponics
- LUSHGro-HYDRO**^{Liquid} - professional's choice to prepare concentrated nutrient solution for hydroponics
- LUSHGro-GREEN**^{Liquid} - ideal for herbs and foliage plants grown indoors and outdoors
- LUSHGro-BLOOM**^{Liquid} - ideal for outdoor flowering & fruiting plants
- LUSHGro-AQUA**^{Liquid} - ideal for aquatic plants grown in aquariums - safe on fish
- LUSHGro-MICROS**^{Liquid} - handy trace element supplement - for use in garden / aquatic plants and aquariums

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H P C

LUSHGro-MICROS^{Liquid}

Specially formulated for use on Garden and Aquarium / Aquatic Plants

- suitable for all types of foliage, flowering & fruiting plants – compatible with most liquid fertilizers. Try and see the difference! -

All plants need sixteen elements to grow. They are carbon, hydrogen, oxygen, nitrogen, phosphorous, potassium, calcium, magnesium, sulphur, zinc, copper, iron, manganese, boron, molybdenum and chlorine. In nature, plants derive these elements from the atmosphere or from the minerals in the soil. Most of the elements used in preparing **LUSHGro** nutrients are derived from these naturally occurring minerals in the soil. So only they are called mineral (mined) nutrients. As such, they are not only natural but also very safe. They are sometimes purified to remove the impurities like obtaining pure table salt from sea water. Hence, they are quite safe to our body. These are popularly known as fertilizers and have been approved world over for crop production.

This unique **LUSHGro-MICROS**^{Liquid} is a formulated plant food containing all the micro-nutrients essential for the growth and development of all kinds of garden and aquatic plants. This formulation *contains ONLY the micro-nutrients* tabulated below. It does not contain any macro-elements like nitrogen, phosphorous, potassium, etc. This scientifically balanced nutritious liquid fertilizer is the result of more than 15 years of R&D work. **LUSHGro-MICROS**^{Liquid} is a ready-to-use formulation.

Hence, it serves as an excellent supplement to all liquid fertilizers. It can also be used as a foliar spray to correct trace-element deficiencies. It can also be sprinkled on the soil around the garden plants to balance their trace-element absorption. This is a highly concentrated formulation. Though not harmful to human beings, it is toxic to the plants at a higher concentration. Please follow the instructions for dilution before use. This formulation is safe on fish and other aquatic life.

Recommended dilution: This formulation very highly concentrated. For general garden use and foliar spray, add 1-2 drops of this solution per TEN litres of water. NEVER ADD MORE THAN FIVE DROPS / TEN LITRES AT A TIME. For aquariums add ONE drop per 100 litres of water. It is advisable to add ONE drop of this **LUSHGro-MICROS**^{Liquid} formulation every time you change the water. This **LUSHGro-MICROS**^{Liquid} contains an approximate amount of nutrients tabulated below: Colour Code: **Brown**

Trace-Elements	mg/litre	Trace-Elements	mg/litre
Iron as EDTA chelate	21,253	Zinc	617
Manganese	5,684	Copper	267
Boron	483	Molybdenum	471

Caution: Though not harmful, it is always advisable to keep **LUSHGro-MICROS**^{Liquid} out of reach of children. Keep away from strong light in a cool and dry place.

This is a 120 ml single dropper bottle pack (Keep this bottle in a cool dry place, away from light and away from children)

LUSHGro-MICROS^{Liquid} required by a plant depends on the variety, age and stage of the plant. However, plants themselves are the best indicators. The top 3-5 leaves of any branch are called the "indicator leaves". They speak so much about the health of the plant. Pale leaves indicate the lack of nutrients and brown or burnt leaves indicate too high concentration of nutrients. Add more solution or dilute with plain water accordingly. Observe the growth of the plant and adjust the concentration periodically. In case of doubt, do not hesitate to seek the help of your neighbourhood Aquarist or call us direct at the numbers given below.

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- LUSHGro-GREEN**^{Liquid} - ideal for herbs and foliage plants grown indoors and outdoors
- LUSHGro-BLOOM**^{Liquid} - ideal for outdoor flowering & fruiting plants
- LUSHGro-AQUA**^{Liquid} - ideal for aquatic plants grown in aquariums - safe on fish
- LUSHGro-TURF**^{Liquid} - ideal for lawns and turfs

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AKZO NOBEL'S REXOLIN ^{Solid}

Specially formulated for foliar feeding, soil drenching and hydroponics

- suitable for all types of foliage, flowering & fruiting plants - compatible with most liquid fertilizers. Try and see the difference! -

All plants need sixteen elements to grow. They are carbon, hydrogen, oxygen, nitrogen, phosphorous, potassium, calcium, magnesium, sulphur, zinc, copper, iron, manganese, boron, molybdenum and chlorine. In nature, plants derive these elements from the atmosphere or from the minerals in the soil. Most of the trace elements used in **REXOLIN** nutrients are chelated with sodium salts. As such, they are not only stable, water soluble, organic and natural but also very safe. These are popularly known as chelated micronutrients or trace elements and have been approved world over for crop production.

This unique **REXOLIN** ^{Solid} is a formulated plant food containing micro-nutrients essential for the growth and development of all kinds of garden and aquatic plants. This formulation *contains ONLY* the micro-nutrients tabulated below. It does not contain any macro-elements like nitrogen, phosphorous, potassium, etc. This scientifically balanced nutritious solid fertilizer is the result of many years of R&D work by Akzo Nobel Corporation of the Netherlands. **REXOLIN** ^{Solid} is a ready-to-use formulation.

Hence, it serves as an excellent supplement to all liquid fertilizers. It can also be used as a foliar spray to correct trace-element deficiencies. It can also be sprinkled on the soil around the garden plants to balance their trace-element absorption. This is a highly concentrated formulation. It might be toxic to the plants at a higher concentration. Mix **REXOLIN** ^{Solid} @ 1-2 g/litre of water.

REXOLIN ^{Solid} range of micronutrients contain an approximate amount of nutrients tabulated below:

Technical Name	Trade name	% Trace Elements
Dissolvine D-Fe-11 (Fe-DTPA)	Rexolin D12	11.50 % iron
Dissolvine E-Fe-13 (Fe-EDTA)	Rexolin E13	13.00 % iron
Dissolvine E-Cu-15 (Cu-EDTA)	Rexolin Cu	15.00 % copper
Dissolvine E-Mn-13 (Mn-EDTA)	Rexolin Mn	13.00 % manganese
Dissolvine E-Zn-15 (Zn-EDTA)	Rexolin Zn	15.00 % zinc
Dissolvine E-Co-14 (Co-EDTA)	Rexolin Co	14.00 % cobalt
Rexolin APN (Micronutrient Mix)	Rexolin APN	mixture containing 5.8% Fe 2.3% Mn, 1.3% Zn, 1.05% B 0.25% Cu, 0.24% Mo & 0.03% Co

Caution: Though not harmful, it is always advisable to keep **REXOLIN** ^{Solid} out of reach of children. Keep away from strong light in a cool and dry place.
This is a 150 g single pack in a plastic bag (Keep this pack in a cool dry place, away from light and away from children)

REXOLIN ^{Solid} required by a plant depends on type of soil, available macro-nutrients in the soil, the pH of the growing medium and also the variety, age and stage of the plants grown. However, plants themselves are the best indicators. The top 3-5 leaves of any branch are called the "indicator leaves". They speak so much about the health of the plant. Pale leaves indicate the lack of nutrients and brown or burnt leaves indicate too high concentration of nutrients. Add more solution or dilute with plain water accordingly. Observe the growth of the plant and adjust the concentration periodically. In case of doubt, do not hesitate to seek the help of your neighbourhood Agronomist or call us or e-mail us direct at the numbers given below.

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