LESSON 3

HYDROPONIC SYSTEMS

LESSON AIM

Compare a range of hydroponic systems.

Hydroponic systems are not a magical way to grow plants. Good growing conditions, including optimum nutrients, light and correct temperature control are vital elements in the health and growth of the plants growing in the system.

For plants to grow successfully it is important to understand a plant's nutrient requirements and how it grows. This applies to conventional soil-grown crops and hydroponic crops alike, the only variation between the two methods being:
*The way the plant is supported, ie. in ground or with a soil-less media etc. and
*The way the plant receives its nutrient supply, ie. organically through the soil or through a nutrient solution.

WHAT MAKES UP A SYSTEM?

A hydroponic system comprises the following components:

The Location

This is a key factor because it influences everything else.

* If the system is indoors, then the environmental conditions are being controlled. There will be fewer temperature extremes and fluctuations; wind exposure is minimised; pests and disease problems may be reduced.
* If the system is outside it will be exposed to temperature and light fluctuations, drying and damaging winds, and rain which may dilute the nutrient solution. Outdoor systems can be vulnerable to damage from dogs, cats or other animals, but may have fewer fungal problems (due to reduced humidity).

The Container or Bed

The roots (as well as the nutrient solution and medium) need to be contained in something.
* You may use gravel, sand or perlite contained by bags, pots or tubs.
* You may have rockwool fibre or scoria contained in a raised bed built from timber, metal or concrete.
You may use polystyrene boxes, hanging baskets, prefabricated fibreglass tanks etc. the list of possibilities is endless.

Watering/Nutrient Application Equipment

Nutrient can be applied dry on the surface and then watered in or mixed with water and applied as a nutrient solution.
Solution may be applied automatically at predetermined times or as required.
It may be applied at the bottom of the media and allowed to move up via capillary action, or alternatively at the top and allowed to filter down.
It may be pumped on, or moved manually or by gravity.
Excess may be collected and reused, or allowed to be lost after passing through the media.

Trellising

This is not always necessary. When growing tall or creeping plants: (eg. tomatoes, cucumber, chrysanthemum, carnation, roses), the root medium alone may not be strong enough to support the plant. A trellis of wire mesh, strings or stakes may be necessary to just prevent the plants from falling over and being damaged.

Root Media

The media which the roots grow in affects your decisions about all of the above. You must consider rooting media with respect to its ability to hold water, air, nutrients, support the plant etc.

TWO SIMPLE SYSTEMS

System 1

There are many and varied ways of doing hydroponics; some very complicated, controlled by electronic devices and very costly to set up. Here is a system at the other end of the scale. It is cheap to set up, simple to operate and is a useful starting point for novice hydroponic growers.

Materials required:

1 ice cream container (plastic bin) or a plastic bucket
1 terra cotta (clay) pot (not glazed)
Coarse granitic sand/aquarium sand
Vermiculite or peat moss (the sand and vermiculite needs to be a quantity which will fill the clay pot)
2 lettuce seedlings
1 small pkt soluble fertiliser (eg. Aquasol)
Gypsum
Epsom salts

Procedure:

1. Mix 60% sand with 40% vermiculite or peat.
2. Fill clay pot to within 3cm or so of its lip.
3. Wash soil off roots of lettuces (as much as you can without harming the roots.
4. Plant the lettuces in the pot.
5. Mix 6 parts Aquasol to 5 parts gypsum to 1 part Epsom salts.
6. Mix one spoonful of the mixed fertiliser powder with 2 gals (one bucket) of water.
7. Measure roughly the depth of the medium (ie. sand and vermiculite) in the pot.
8. Place the pot with the lettuces in the bucket or ice-cream container and pour nutrient into the bucket or ice-cream container until it reaches a level about one-third the depth of the medium as calculate in Step 7.
9. Top up the nutrient solution as often as is necessary to keep the level always between 1/4 and 1/3.

NB: The nutrient is soaked up into the medium from below: this is called capillary action.

There are endless possibilities. The options open to you with creating a system are only limited by your imagination and your budget. Provided you can supply the plant with those things which it needs to achieve growth, you can develop a system any way you wish. Systems can be very simple or very complex! They can be very inexpensive or very expensive!

System 2

Another basic hydroponic system can be built for experimental purposes using black polythene bags about 30 x 45cm or 50 litre black plastic nursery pots.

Growing Media

A mix of vermiculite with peat moss, coarse river sand and charcoal to the following proportions:

4 x 1.2 cubic metre bales of vermiculite
1 x 3.6 cu metre bale peat moss
2.4 cu metres (2 wheelbarrows) of coarse river sand
1.2 cu. metres of charcoal.

To this add 6.5 kg of agricultural gypsum and 3.5kg of triple superphosphate.
Mix thoroughly dry.

Then use the following chemical nutrient solution:

60 litres of water mixed with...
1.8kg potassium nitrate
0.5kg pound epsom salts
60ml Sequestrene (provides iron)
30ml borax (be careful...more borax can cause boron toxicity)

The solution should be bright red when well dissolved.

A trickle irrigation system provides a constant flow of nutrient solution.

SOIL-LESS MIXES

There are many kinds of soil-less, organic mixes that can contain an assortment of ingredients. Most contain things like sphagnum moss or coconut fibre, perlite and vermiculite. This type of medium is frequently used for container gardening, wick systems and non-recovery drip systems. The fine particles can clog pumps and drip emitters so a filtration system would need to be used soil-less mixes usually have very good water retaining qualities, excellent wicking action and are able to hold a good amount of air. This makes them an ideal growing medium for a variety of hydroponic and organic gardens.

Wood chip compost

Scoria

Coarse organic sand

Expanded clay

Perlite

ROCKWOOL

Today rockwool is probably the most popular growing medium on earth, particularly for use in the drip-type of hydroponic growing system. Rock and sand are spun to create fibres which can then be pressed into various shapes and sizes from small starter cubes to large slabs, or used in its loose form.

Advantages of Rockwool
Rockwool has the ability to:

***retain water** – it holds a large amount of water which is an advantage during power outages or equipment failure.
***hold air** – it holds at least 18% air as long as it is not sitting directly in water. This helps to supply the plant's root zone with adequate oxygen making over-watering unlikely.

It is also sterile and light, which reduces the possibility of disease and makes it easy to work with.

Disadvantages of Rockwool

- It is not environmentally friendly. Rockwool is hard to dispose of; if buried it will last indefinitely however it does not harm the environment

- Dust and fibres are a health risk. The fibres and dust from the rockwool are a health risk when breathed into the lungs - a dust-mask should be used at all times when handling this material.

The following excerpts are from a CSR seminar on Horticultural Rockwool. Although it is based on the Australian use of rockwool, it provides a useful background on this subject for hydroponic growers in all areas.

HORTICULTURAL ROCKWOOL - AUSTRALIAN EXPERIENCES

In Denmark during the late 1960's a rockwool was developed for horticultural use and then marketed under the trade name "Grodan". From slow beginnings its commercial use began to expand significantly from the mid 1970's, especially for the production of glasshouse vegetables and cut flowers. A high rate of growth of rockwool use has been maintained ever since.

As an Australian manufacturer of insulation rockwool, Bradford Insulation (part of CSR Limited) had taken an interest in this trend. Following approaches from several Australian growers the decision was taken to develop a local horticultural rockwool. This development took two years, resulting in the release of an Australian rockwool, known by the trade mark "Growool", onto the local market in mid 1982.

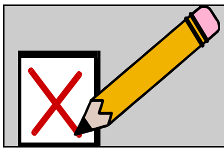
Rockwool Manufacture

Rockwool has been manufactured as an acoustic and heat insulation material for over 70 years. The production technology has been extensively improved over the intervening period, but the basic product has remained virtually unchanged.

The raw materials are natural rocks such as basalt plus coke as the fuel. These are fed into a blast furnace through which air is blown so that the coke burns and lifts the temperature to over 1600C. Consequently the rocks melt to form a type of lava which settles to the bottom of the furnace and is tapped off.

The stream of lava flows onto a series of high speed rotors. These spin off molten droplets which lengthen into fibres and are then cooled by a blast of air. Binder is sprayed into this air stream which also carries the fibres clear of the rotors and deposits them on a conveyor as a thick felt. The felt is conveyed along a production line where it is pressed, hardened, trimmed and finally cut into slabs. One aspect of the manufacture the mat of rock fibres is that the fibres orientate in a horizontal plane. This has implications that are important when the material is used for horticultural purposes.

Insulation rockwool and fibreglass are useless for horticultural purposes. However, the rockwool manufacturing process can be modified to produce a suitable horticultural product. The slabs of base material can be shaped into the specialised forms of product. The slabs of base material can be shaped into the specialised forms of product such as propagating blocks, etc.



SELF ASSESSMENT
Perform the self assessment test titled ' Test 3.1
If you answer incorrectly, review the notes and try the test again.

Rockwool Properties

As rockwool has properties which often differ significantly from other growing media these properties should always be considered if the material is to be used effectively.

Density - When dry, rockwool is a very lightweight medium with its density averaging 70 kg /cub m.

Rigidity - Although granulated forms are available, basic rockwool is bonded into relatively rigid slabs which can then be shaped to make up the component parts of complete horticultural systems.

Sterility - Because of the high temperature of its manufacture (1600 C), rockwool is sterile when packed. If it is to be reused, e.g. slabs in a soil-less system, it may be sterilised with steam or appropriate chemicals - it will withstand low pressure steam or steam/air treatment but no high temperature autoclaving which tends to break down the bonded structure.

Solubility_- Rockwool is insoluble in normal water or nutrient solutions, i.e. those with a pH between 5 and 8. Because the material is inert, all nutrition must be supplied and fertilisers used must be balanced and complete.

Cation exchange capacity - this is effectively zero and the material will not absorb or exchange nutrient ions from solution. One effect is that the material can be leached clean of any solution it contains.

Biodegradability - Rockwool is a bonded form of natural rock fibres. Although it can be physically broken down by expanding roots or by mechanical action, it is not biodegradable. It causes no environmental problems as it may easily incorporated through the soil where it should improve aeration and drainage.

Void space - the rock fibres making up the bonded structure occupy only 3% of the material volume, leaving 97% void space.

Air/water-holding capacity - because of its void space rockwool can retain a very high volume of water while continuing to hold a high production of air.

The water content (and hence air content) of any piece of rockwool is influenced by the thickness of the material, the drainage characteristics of the surface upon which it stands, and the method of watering. For example, 75 mm rockwool slab standing on polythene holds an average of 80% water and 17% air. The water content also varies through the thickness of the slab starting from very wet at the base and getting drier with increasing height. The water in the rockwool is also only lightly bound and hence is readily available to the plant.

pH Buffer Capacity - rockwool has no long term pH buffer capacity, however, an initial pH rise. The rate and degree of reaction are dependent upon the pH and buffer capacity of the solution used to wet the rockwool.

Development of Propagating Blocks

Initial development - The propagation blocks first manufactured in Australia were based on the European blocks of the time, i.e. made from a 40mm thick slab of rockwool with horizontal fibre orientation and slit from the top to give individual blocks 40 mm square.

The initial Australian growing trials were intended to check for any signs of phytotoxicity. Numerous sensitive plants such as antirrhinum and daphne were propagated successfully in fact in all trials done to date there has been absolutely no sign of phytotoxicity. However there were some other problems associated with the horizontal fibre directional lay in the original propagating blocks. The early propagation trials had a limited number of failures due to the rockwool being too wet. This can usually be avoided by deliberately controlling the water content - techniques for doing this are described later.

Australian rockwool propagating blocks.

Standard propagating blocks - each block is 35mm square and 40 mm high, 21 blocks per sheet. Three sheets fit into the tray.

The horizontal fibred blocks were still giving problems with separation and roots growing into adjacent blocks. Similar problems were observed on a visit to Europe, so an improved propagating block was developed which had vertical fibre orientation, and was grooved underneath. This type of block is less convenient to manufacture but has since proved to be very successful. Some advantages of this type of block are: roots grow vertically rather than mostly horizontally; the gap gives a degree of aerial pruning; and they are very easy to separate.

Sheet and block sizes - A major advantage of rockwool propagating blocks is that they can be manufactured in sheets, with consequent convenience and time savings. However there needs to be a rational basis for selecting the sheet and block sizes. In Australia there is a standard nursery propagation tray which, while certainly not used universally, is very widely used. Consequently it was decided to size the propagating block sheet to sit this tray.

The dimensions of this tray are 280 x 340mm. After experimenting the most convenient size of sheet was found to be one that would fit 3 sheets to the tray. The corresponding sheet size was set at 266 x 110 mm, and 40 mm thick. This is grooved from underneath to give 3 rows of 7 individual blocks, i.e. 21 blocks per sheet, or 63 blocks per tray. The blocks are each 35 x 35mm and 40 mm high. On top of each block is a hole which is mainly an indication of the location of the block underneath. The use of a vertical fibre format makes the diameter of the cutting less critical.

These blocks are packed 100 sheets, i.e. 2100 blocks, in a carton which weighs about 10 kg.

The original release was of only one height of block, namely 40 mm. This was suitable for propagating indoor plants and vegetables. However when used for shrubs and Australian native plants, it was less successful unless care was taken to increase aeration by reducing water content. This could also be achieved by increasing the height of the block. Consequently a 57mm tall block was developed in the same 35 x 35mm format as the standard 40 mm type. This tall block also suits long cuttings.

There was also a demand for smaller blocks giving more per tray. In this case a product was developed with the same sheet size and 40mm height. The sheet is subdivided into 4 rows of 9 blocks, i.e. 36 blocks per sheet, or 108 blocks per tray. The individual blocks are 25 x 25 mm x 40 mm high.

Propagation Applications

Shrubs propagated in tall rockwool propagating blocks

It is important to know the major Australian nursery techniques with which rockwool systems will compete. Typically cuttings are propagated under mist in sand based media contained in either trays or individual propagation tubes from which they are potted into their final container.

Initial applications

Wide ranging growing trials were undertaken for over a year before the product was released and these had a major influence on the form of the blocks finally produced.

The first commercial scale propagation was the striking of plants for soil-less crops - tomatoes from seed and seedlings, cucumbers from seed, roses and carnations from cuttings. These were very successful but highlighted important areas for further work. The rose cuttings needed control of the water content of the blocks and liquid feeding the vegetables showed that some commercial fertilisers are very low in iron and hence need supplementing with iron chelates. There were major problems with some single solution concentrated liquid fertilizers which precipitated calcium phosphate leading to the development of deficiencies of both these elements.

Initial commercial scale nursery propagation in rockwool was done where propagators were having problems either with striking or transplanting. Examples of these were Grevillea ‘Robyn Gordon’ and miniature roses. Both struck very well in rockwool and transplanting losses were reduced to effectively zero, although Grevillea ‘Robyn Gordon’ required careful management of the water content in order to give a reliable strike.

Although the initial incentive for using rockwool was to solve problems, once propagators were using the system they came to realise some of the other benefits involved. One of those was Andrew Burton, who then integrated rockwool into his production system to make maximum use of its benefits and their consequent labour cost savings.

The propagation of shrubs and native plants at first had only mixed success as these plants required more air in the medium than indoor plants. Problems could be overcome by management of the water content of the 40 mm blocks, but to help make this less critical, a taller 57 mm block has been released which is inherently more aerated and has proved very successful.

Triggered off by the need to supply soil-less crop growers, several major specialist carnation and chrysanthemum propagators began propagating to order in rockwool.

A grower of tube stock commenced selling plants propagated in rockwool instead of by traditional methods in tubes. The change to propagation in rockwool was unannounced, however, and had some resistance from customers who did not know the material. He now advertises some lines as grown only in rockwool and provides most other lines in rockwool unless requested otherwise.

Recent applications - Rockwool was launched onto the Australian market in 1983 and by 1985 well over 300 different plant species were successfully propagated in rockwool propagating blocks. The range of plants grown extends over flowers, indoor plants, vegetables, trees, shrubs and Australian native plants. Propagation has been initiated from a range of seeds, seedlings, tissue culture plants, hardwood and softwood cuttings. Since then rockwool and other similar products have become more extensively used as a preferred medium for many hydroponic growers particularly for specific species.

The bulk of rockwool propagation to date has been of nursery plants from cuttings. These have then been potted on into conventional potting media. A major use has been the propagation of vegetables for growing on in the soil as well as in soil-less systems, although this use with soil has been limited to date. Large seeds such as cucumber, zucchini, melon, sweet corn, legumes, etc. are normally sown direct, whereas it is usually more convenient with smaller seeded vegetables to pick out seedlings into the blocks. Flower plants are propagated for growing cut flower crops, also for use in the soil as well as in soil-less systems.

Particularly when plants are intended to be grown on into a soil-less system, they are often propagated directly into a rockwool wrapped cube. This is often cheaper and more convenient than propagating into a block and later transplanting into a wrapped cube which has a hole to take the block.

Propagation of micro-cuttings from tissue culture

There has been considerable expansion in using rockwool for de-flasking tissue cultured plants. It has proved to be a very compatible medium for this purpose and particularly in the case of micro-cuttings it enables good support of these very small plants.

Several trial shipments of plants using rockwool as the propagating and growing medium have been exported to countries where the import of soil and similar growing media is not permitted. This use could have considerable potential particularly because of the beneficial effect on plant quality.

Recommended Practices for Propagation

In consequence of its properties, the following principles need to be considered when using rockwool propagating blocks:

* Select the appropriate block size for the plant and the propagating system.

* If the sheets of blocks will later have to be moved then it is preferable that they be supported, e.g. placed in a tray. Otherwise some form of lifter or spatula will be needed.

* The blocks must be thoroughly wet before using, either by quickly dunking or by hosing until water runs out of the blocks. Soaking is unnecessary.

* Take special care with hygiene for, although rockwool is sterile when unpacked, disease can spread easily. Clean water, trays, propagation facilities and cuttings are essential, along with a sensible handling and maintenance system.

* Insert the cutting only as far as necessary for support. Do not push it in too far as the cutting is then in a zone of lower air content.

* If liquid feeding is required then a complete feed including race elements must be used. Normally the plant is not fed before it has struck. However, if nutrient is needed from the start, e.g. with tissue culture plants, then the wetting solution pH should be lowered to allow for the initial alkaline reaction. With rooted cuttings that have small roots, it is advisable to add some nutrient solution to the block before transplanting so the roots can continue to grow out into the medium.

* Control the water content (and hence air content) to a suitable percentage for the plant. Take into account: the height of the block; the depth of insertion of the cutting; the drainage characteristics of the supporting surfaces on which the blocks stand (remembering that there will be interactions between trays and the supporting surfaces); the method and frequency of watering.

The authors have prepared a paper on the air/water characteristics of rockwool and other mediums used in propagation systems. Some results of interest are that the fibre orientation has no influence on the water holding capacity, and the grooving of rockwool propagating blocks increases the air content within the block by about 5%.

* Allow for the influence of the propagation system and environment upon the blocks. Rockwool has proved compatible with all types of propagation systems, e.g. closed tent, wet tent and open systems, heated and unheated beds, all with and without mist. These can have different effects upon the blocks, e.g. heavy misting can cause water-logging, open heated beds will increase evaporation.

* Most watering systems work well with rockwool, e.g. hand, sprinkler, mist, or capillary matting (using weed mat on top to prevent weed penetration). However modifications may be advisable, especially to the frequency of watering.

* Allow for the effects of change of environment upon the blocks, e.g. in summer evaporation will increase hence there will be some concentration of liquid fertilizer.

* It is advisable to transplant the propagule as soon as the roots are showing. This takes full advantage of the beneficial properties of the material and avoids the potential problem of root growth into adjacent blocks. The simplest technique for separation is to split off a long row of blocks from the sheet, then split off the individual blocks (similar to separating postage stamps).

* When converting from another propagating medium to rockwool it can be vital to recognize any differences and allow for them as indicated above. For example, a recipe for failure would be to push susceptible cuttings through to the bottom of the blocks, place these on a non-draining surface and then use frequent, heavy mist.

Benefits of using Rockwool Propagation Blocks

In any technical investigation it is important to consider systems that are comparable. In this case the use of rockwool propagating blocks to produce plants for subsequent potting must be compared with the complete process of producing similar plants by traditional methods. In Australia the traditional method of pot plant production is to strike cuttings in a small tube containing a mixed propagating medium. Once rooted the cutting is "knocked out" of the tube and transplanted into a pot.

The use of rockwool for propagation can be of advantage to nurseries of all sizes from one man operations to large mechanised one. Typical benefits to be obtained are as follows:

* Being supplied in cartons weighing only 10 kg, the material can be conveniently stacked ready to immediate use. It can also be carried where ever required by any staff member, who therefore is not dependent upon anyone else to do the mixing, sterilising, etc.

As rockwool propagating blocks come as sterile light rigid sheets, they make preparation to propagate very quick and easy. All that is required is a cleaned tray into which the sheets are laid and wetted.

This substantially reduces the boring and costly work spent in preparation, i.e. mixing and sterilising propagating mix, cleaning, sterilising and filling tubes, placing tubes into trays, and cleaning up afterwards.

Table 1 - Comparison of days to strike and percentage strike
rockwool v. conventional mix (peat:perlite 1:1)

Item		Rockwool	Peat:Perlite	
	Days	%	Days	%
Aeschynanthus javanicus	20	90	26	90
Arisia Crispia	18	100	24	90
Begonia Semperflorena	12	100	14-16	100
Begonia Orange Rubra	12	100	17	100
Bougainvillea Var.	21	70-100	26	70-100
Cissus discolor	9	100	14	100
Clerodendron Thom.	8	100	13	80
Fatshedera green	17	90	20-24	90
Fatshedera var.	21	80	24	80
Fittonia	10	100	11	100
Ficus radicans	17	90	21	90
Hoya carnosa	10-11	100	13-17	100
Impatiens Yellow Dragon	8	100	11-12	100
Ixora chinenis	15	90	28	90
Maranta	11	100	18	100
Oxalis rubra	9	100	16	90
Pothos	15	100	17	100
Columnea varieties	13-15	100	12-15	100
Peperomia 'Aztec'	20	100	17	100
Columnea microphylla	30	100	17	90
Tolmiea menziesii* *(leaves) failed	0	14	100	

* Cuttings are easily inserted. Soft cuttings may require a hole to be "dibbed", but most cuttings can be pushed directly into the rockwool.

* Experience has shown that a wide range of plants are quicker to strike in rockwool than in conventional media. The accompanying table of results, published by Andrew Burton, appears to represent results obtained in general with indoor plants.

* Plants propagated in rockwool can be transplanted as soon as the roots are emerging from the block, or even earlier in some circumstances. By comparison, with a tube the root system has to develop sufficiently to bind the medium together before it can be transplanted. In our experience this has resulted in the great majority of plants propagated in rockwool being ready to pot significantly sooner than tube propagated plants.

If this potential benefit is fully utilised, then not only do direct cost savings result, but output could be increased or propagation areas converted to other uses. Also the shorter the time in propagation: the less chance of disease and less cleaning up.

Table 2 - Limited cost comparison - propagation (cents per plant)

Component	Rockwool	Tube + Mix
Material (block, mix incl. preparation)	1.3	1.0
Labour in potting	2.0	4.0
Cost of slower turnaround of propagating space	nil	0.5
Opportunity cost of mixing and storing		
propagating medium	nil	0.5
total:	3.3	6.8

These figures assume plant densities and losses, etc., remain unchanged. In practice further cost benefits can be gained using rockwool. Details provided by Andrew Burton, N.S.W.

* Because the blocks are so easy to separate then potting costs are significantly reduced. Much of the boring and costly work has been eliminated, i.e. knocking out of tubes, re-tubing and separation of plants insufficiently rooted. The time saved is substantial - Andrew Burton has doubled the output of his potting machine with the same manpower.

* Because the block is taken complete then transplant shock is virtually eliminated and the plant is not set back. This factor, combined with others mentioned earlier, can result in pot plants being ready for sale far earlier than those grown by conventional methods.

* Overall cost comparisons are difficult to establish in general terms because they depend upon the individual grower's capital investment, for example. However, if those costs are assumed constant, then there are some aspects which can be compared. This has been done in Table 2.

Limitations Experienced in the use of Rockwool

These limitations are cited from Australian experiences and many have been overcome as growers become more familiar with the products and their properties.

* There will obviously be cuttings which are too large for standard propagation blocks. If they are forced into the blocks these tend to split. "Dibbing" can help, otherwise a larger block or wrapped cube should be used.
* Propagating blocks are rarely suitable for holding plants for extended periods once they have rooted. If plants are fed as they need to be, then their roots will eventually grow into the adjoining blocks. This makes them difficult to separate and will cause root damage at that time. A tendency to dampening off has been reported for some plants held for long periods, although in some cases additional drainage has helped. The material certainly gives its optimum benefits when cuttings are transplanted soon after striking.
* Transplanting rockwool blocks into soil may result in failure if the soil has draining capacity. Because the water in the rockwool is only lightly bound, it can be drained away before the plant roots have grown into the soil. Consequently care must be taken to keep the blocks moist after planting. This may require watering and mulching.

NFT SYSTEMS

NFT stands for Nutrient Film Technique. NFT involves running nutrient solution continuously along an enclosed channel, collecting it and recycling it. The channel is normally made from plastic (rigid or flexible polythene or PVC). The plants roots grow in the channel, and the top is usually supported by a wire mesh or trellis framework.

The film of nutrient must flow continuously. If it is being pumped by an electric motor, there should be a backup facility to cover power failure. NFT is perhaps the most popular hydroponic system used in the UK.

The key requirements in NFT are:
a) To have a gradient which water flows along which will achieve an even flow: not too steep or low gradient: no depressions or uneven spots.
b) Inlet flow rate must be controlled: not too fast or slow.
c) Width of channels where flow occurs must be wide enough to avoid damming up of solution by the root mat.
d) Base of channel must be flat to ensure even depth of solution across the width.

Alternative Layouts for NFT

1. A Horizontal Rectangular Plane
This is the most common NFT system. The area being used has a slope both along and across the plane. The slope on the land should be graded evenly to achieve a smooth slope.

A catchment trench is dug along the low side of the area, and a watertight lining is put into the trench. NFT channels are laid across the slope at right angles to the trench. Nutrient solution is pumped into top end of the channels and allowed to trickle to the bottom end where it flows out into the catchment trench for recycling.

2. Vertical Tubes
EXAMPLE: PVC pipes hanging vertically from a framework.
Nutrient solution is sprayed into the top of the pipes where it creates a film.
The film of nutrient solution runs down the inside of the pipe.
Holes cut at intervals down the pipe have plants inserted into them.

3. Tier System
This involves a series of tubes mounted one above another, frequently on a wall. he nutrient solution is pumped to the top from where it is fed simultaneously into the ends of each of the tubes at the high ends of those tubes.

Solution trickles down the tube, is drained off at the low end and recycled into a storage tank from where it is pumped back to the top of the system.

METHODS OF SOLUTION DISPENSATION

a) **Closed System**
Solution is re-circulated around the system (eg. by means of a pump and returned to a storage tank by gravity - as with an NFT system).
Flow rate is controlled by valves, drippers, micro-tubes emitters etc.
There is minimal wastage of water or nutrients, but it is more difficult to control nutrient concentration in the solution.

b) **Open System**
Solution is not re-circulated, but applied to plants and any excess is drained away and lost. This method has fewer problems with spreading disease and development of salt toxicity.

Nutrient solution dispensed automatically as long as the system tank is kept sufficiently filled

TECHNIQUES

DRIP
Solution is exuded in slow continuous dripping from a micro orifice.

SLOP
The solution is flooded over the beds at regular intervals, percolating down through the growing medium, and draining off to a catchment tank.
Root temperature and aeration are influenced by the frequency of irrigations.
Open manual slop system. Apply solution with a bucket.

WICK
A glass wool wick draws nutrient solution from a nutrient tank below the medium and distributes it through the root zone using capillary action.

Wick system

MISTING
Nutrient solution applied by a fine mist. (Aeroponics)
Can cause leaf burn on some plants under some conditions.
Air movement (wind) can cause uneven distribution of solution.

DRY FERTILISATION

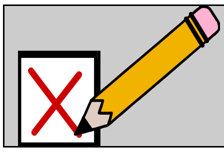
Dry mix of nutrients is sprinkled over the beds periodically and immediately watered in. This can sometimes cause temporary toxicity problems.

CAPILLARY

Solution is applied to the bottom of the media beds, and soaks up into the media by capillary action. Excess is then drained off. Effectiveness depends on quality of medium for transfer and capacity to hold water and nutrients.

INJECTOR OR PROPORTIONER SYSTEM

Quantities of a pre prepared concentrated stock solution are injected into the water feeding lines proportionately: normally this is used in an open system.

	**SELF ASSESSMENT** Perform the self assessment test titled ' Test 3.2 If you answer incorrectly, review the notes and try the test again.

Growool

how to get the most from Growool soilless systems

Introduction

Crops are grown without soil for a variety of reasons. There may be no soil available or it may be so poor that crops cannot be grown economically. Crops like carnations are particularly susceptible to soil-borne diseases such as Fusarium. Supplies of good water may be limited, especially in arid and island situations. There is the *potential* for greater control over plant growth or even increased growth and yield. These potential advantages are only realised with very good management and attention to detail.

Soilless systems do not guarantee success. They require better management than soil-based systems.

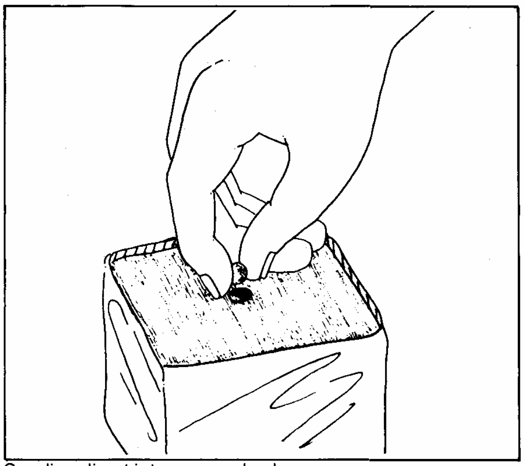
Systems must be set up very carefully and then monitored closely and accurately. Plants and nutrient solutions must be checked carefully and regularly. Horticultural skills are vital since familiarity with the crops is necessary for early detection of growth changes, pest and disease incidence etc.

As with all production systems, it is essential to research and organise markets before embarking on large-scale production.

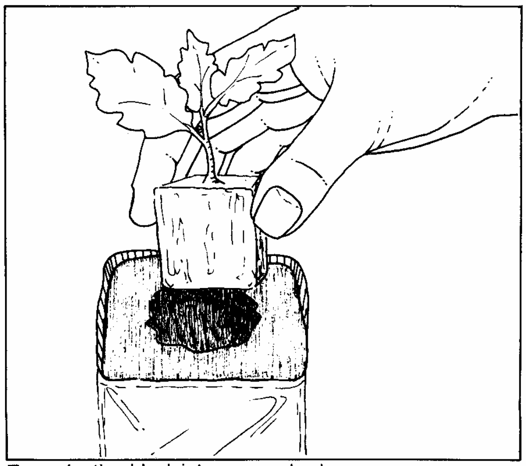
Properties

Growool has a unique combination of properties which make it an excellent growing medium. These properties need to be considered if the material is to be used to its maximum effectiveness.

- *Its rigid shape makes it very easy to handle.*
- *It is very light when dry — density 70kg/m^3.*
- *It is sterile when packed.*
- *It is inorganic and inert, i.e. contains no nutrients.*
- *It has no cation exchange capacity, i.e. won't bind nutrients.*
- *It has no pH buffer capacity, i.e. maintains the pH of the water or liquid feed.*
- *It is natural rock and is not biodegradable.*
- *It has a very high void space of 97%.*
- *It has very high water and air holding capacity, typically 80% water plus 17% air. This is influenced by the height of the Growool and the drainage characteristics of the surface upon which it stands.*



Seeding direct into wrapped cube



Transplanting block into wrapped cube

Growool Products

Growool is a water absorbent rockwool with a mat of long, fine fibres spun from rock. In soilless cropping the plants are either propagated in Growool PROPAGATING BLOCKS and then transferred into Growool WRAPPED CUBES *or* propagated directly into Growool WRAPPED CUBES. At an advanced stage the cubes are placed directly onto Growool GROWING SLABS and fed with a complete nutrient solution via a suitable dripper system.

Hygiene

Rockwool is sterile when packed but, as with soil-based systems, diseases can be introduced unless rigorous hygiene precautions are taken. Seeds, cuttings, water, propagation facilities, etc. must be all free from disease while the growing area should be disinfected before the system is established. Covering the ground with polythene sheet before laying out the slabs will reduce disease infection from the soil and prevent weed growth. Maintain hygienic management throughout the life of the crop. For example: do not allow soil to splash onto the Growool surfaces; do not allow nutrient run-off to contaminate water supplies.

Propagating the Plants

Detailed instructions are given in the leaflet "How to get the best from Growool Propagating Blocks" and the same methods are used when the plants are to be grown on Growool growing slabs.

An alternative method is to establish the plants in Growool wrapped cubes. Cucumbers, melons, zucchinis, etc. produce rapidly growing seedlings which are best accommodated by sowing the large seeds in wrapped cubes. Carnations, chrysanthemums, gerberas, etc. may be purchased as rooted cuttings (sometimes in Growool propagating blocks) and transferred directly into wrapped cubes where they are maintained until the plants are ready to transfer to the growing slabs.

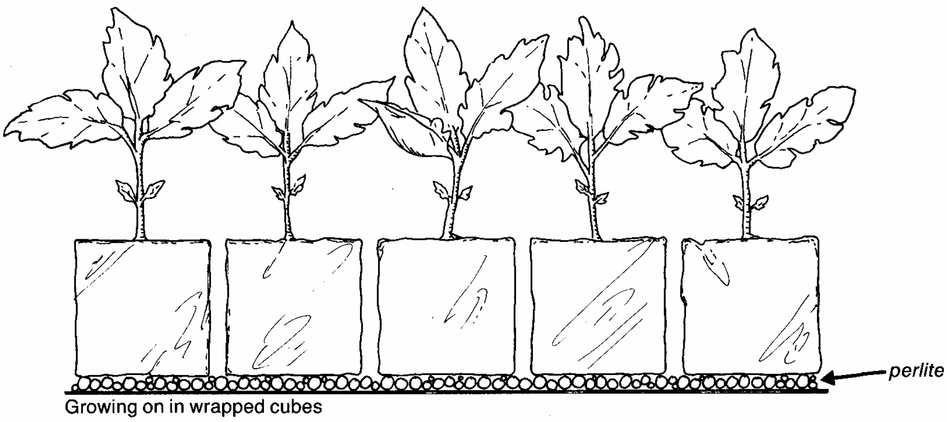
Transplanting into Wrapped Cubes

Plants which are raised from seeds or cuttings in propagating blocks should be transplanted into wrapped cubes with holes as soon as roots appear.

Thoroughly wet the propagating blocks and the wrapped cubes with a complete nutrient solution before transplanting. The wrapped cubes are easy to wet by immersion in a bucket or tank of nutrient solution. Due to the pH rise which results when Growool is wetted initially, the nutrient solution should have its pH reduced using acid. Refer to "Planting the Crop" for details.

To separate propagating blocks split off a long row of blocks from the sheet, then tear off individual blocks and insert them into the hole of the wrapped cube. Space out the wrapped cubes in trays or on polythene sheeting.

Do not allow stagnant water to accumulate around the base of the cubes. Most plants will benefit from standing the cubes on a thin layer of perlite to improve drainage.



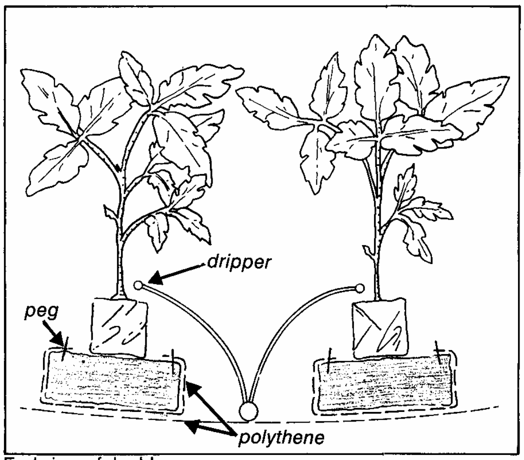
Growing on in wrapped cubes

Growing on in Wrapped Cubes

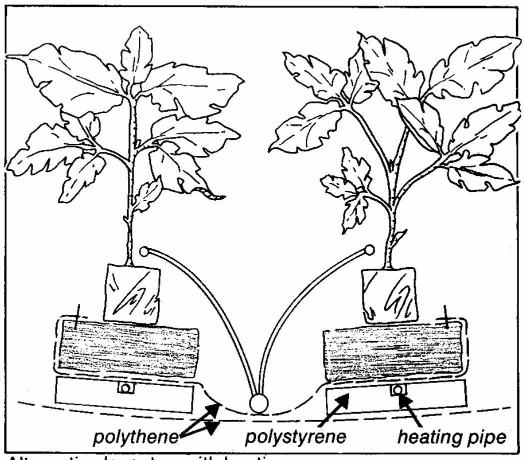
Plants which have been transplanted into wrapped cubes should be liquid fed with a complete nutrient solution at every watering. Plants which are direct sown into wrapped cubes must be similarly liquid fed as soon as the first true leaves appear.

It is unlikely that plants will need to be given plain water while they are in the wrapped cubes but this may be necessary to wash out nutrient salt accumulations when plants are in the cubes for a long time.

A simple test of whether liquid feeding or watering is needed, is to check the weight of the wrapped cubes, to ensure they are not becoming too light.



End view of double row



Alternative layout — with heating

Laying out the Slabs

Most commonly the growing slabs are laid onto black or white polythene sheeting on the ground, although some growers of flower crops construct low level benches to support the slabs and increase air circulation around the plants.

Contour the ground before laying out the polythene. Most soilless systems are based on crops growing in single or double rows. With double row systems the ground should be graded to allow the slabs to slope very gently (a 2% slope is ideal) towards the space between the rows. Excess nutrient solution or water will then drain into the space which, when lined with polythene, acts as a drainage gully. Single row systems must also have drainage gullies to carry away the excess nutrient solution or water.

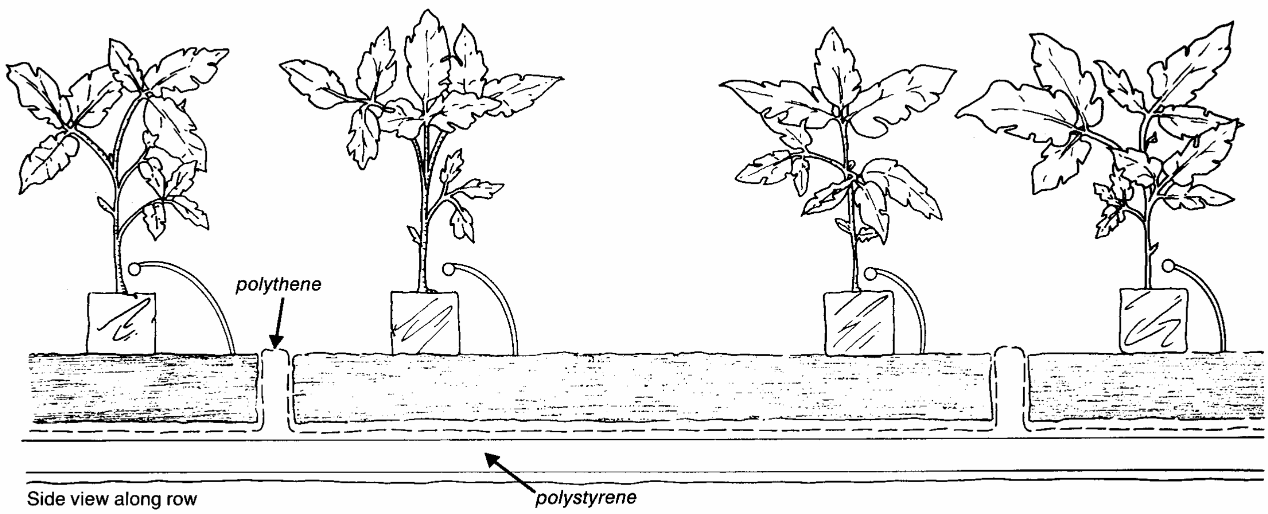
Construct drainage gullies so that the nutrient solution or water runs away to waste and cannot re-enter the slabs.

After contouring, the ground should be covered with polythene sheeting. In colder climates the Growool slabs can be laid on slabs of polystyrene which provide insulation against low ground temperatures. High density polythene hot water pipes can be set into the polystyrene slabs to provide root zone heating. This may allow air heating to be reduced.

Lay a strip of polythene of suitable width (depending on whether it is a single row or double row system) on the ground down the length of each row. Lay the growing slabs lengthways to form more or less continuous rows.

Separate the slabs regularly by folding the polythene up between them. This prevents liquid draining to the lowest points of the rows. The height difference between the highest and lowest points on the surface of individual slabs or groups of slabs should not be more than 30mm.

Fold the edges of the polythene sheet over the sides of the slab and secure them with plastic or wooden (non-toxic) pegs. Alternatively completely overwrap each slab to prevent evaporative losses and cooling at the slab surface. Separately wrapping individual slabs allows easier isolation of diseased plants in crops such as carnations.



Side view along row

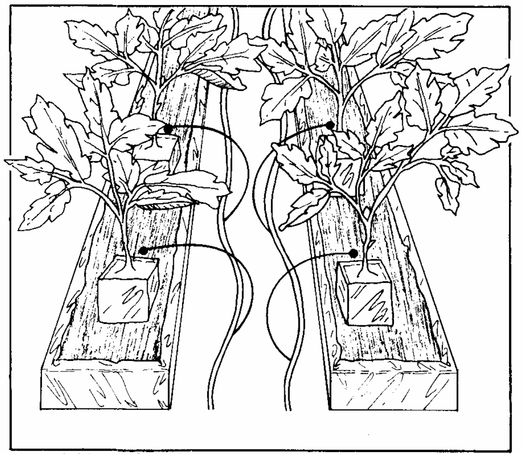
Setting up the feeding system

The easiest to manage rockwool soilless systems are typical non-recirculatory with minimum run to waste liquid feeding and watering. This is achieved by applying a complete and balanced nutrient solution to plants via drippers onto the growing slabs or into individual wrapped cubes.

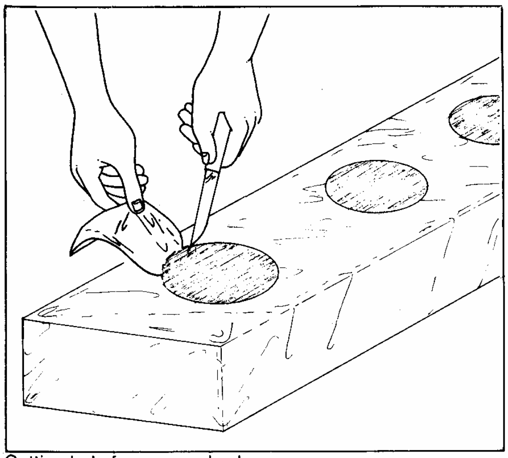
The nutrient solution may be premixed in its fully diluted form and held in a large volume storage tank. Alternatively it may be produced as required from concentrated solutions either by mixing in a diluting tank or by injecting into the water supply using proportioners. When using concentrated solutions it is essential to use 2 separate solutions to avoid precipitation. Consequently these systems require 2 nutrient holding tanks plus an acid tank for pH adjustment.

In either case it is vital that metal components are kept out of the water collection storage and liquid feeding system. Plastic tanks and pipework are much safer and minimise the risk of contamination while pumps without metallic parts should be used. The liquid feed which reaches the plants must have the correct pH and electrical conductivity (E.C.).

There are automatic pH and E.C. controllers but they are not essential in small, non-sophisticated systems. However, every commercial soilless system must have pH and E.C. meters for checking the liquid feed and the solution in the slabs.



Typical dripper layout



Cutting hole for wrapped cube

Preparing nutrient solutions

The preparation of nutrient solutions depends on the quality and chemical composition of the water supply.

Obtain a detailed analysis of the water and contact the Bradford Insulation Growool Consultant concerning suitable nutrient. formulations. If the water quality is likely to change, eg. bore water during drought, it must be checked regularly.

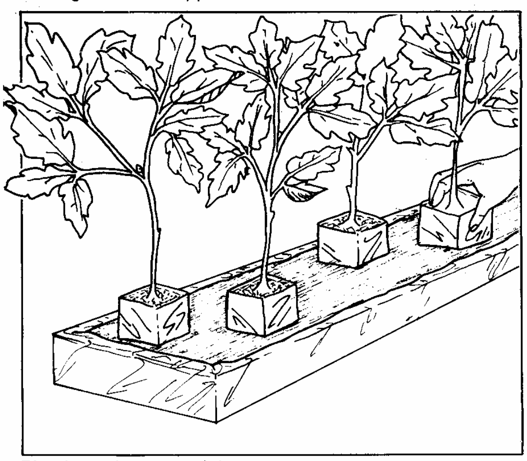
Planting the Crop

Saturate the slabs with nutrient solution immediately prior to planting. A lot of nutrient solution is needed for each slab (approximately 16 litres) and it is best applied via hosepipe with a spray rose from the nutrient tank.

When Growool is initially wetted with a nutrient solution there is an increase in alkalinity. This should be compensated by acidifying the initial wetting solution.

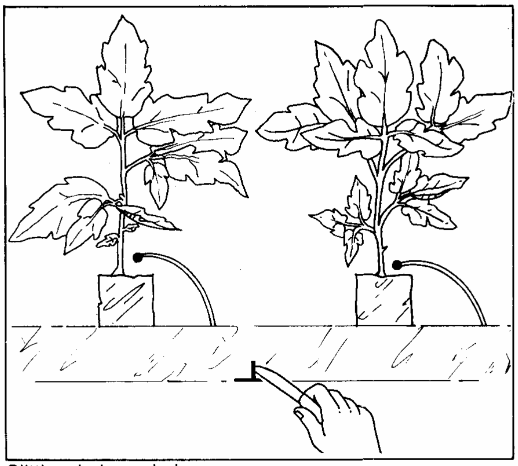
Reaction rates and degree of pH change depend upon the characteristics of the water, acid and nutrient and can vary considerably. As a practical rule of thumb the solution should have its pH lowered by 1.0 unit using phosphoric acid — but take care! For example, if normal feed has a pH of 6.2 then it should be lowered to 5.2. The compensating reaction will be virtually complete within several hours. We advise individuals to check the above rule of thumb using their own nutrient solution, especially when their water quality is suspect.

Plants are ready for transferring to the growing slabs when a reasonable number of roots are emerging from the base of the wrapped cubes. Planting involves placing the wrapped cubes at appropriate spacings on the upper uncovered surface of the laid out growing slabs. Covered slabs must have holes cut in the polythene at appropriate spacings.
Refer to the relevant crop leaflet for plant spacing details.

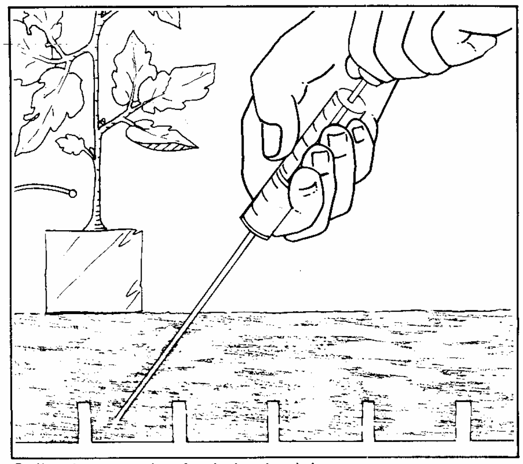


Planting cubes onto slab

A proportion of the liquid in the wrapped cube will drain out into the slab and this can cause problems until the plants have rooted into the slabs. Keep the cubes moist by frequently watering into them either via the drippers (a good reason for having the dripper into the cubes especially in early stages of the crop) or with a hosepipe. In order to retain the maximum amount of solution in the cubes and slabs it is important not to cut drainage slits in the polythene wrapping at this stage.



Slitting drainage holes



Collecting sample of solution in slab.

Feeding and Watering

When roots have established in the slab it becomes important to drain the slab properly. This can be done, for example, by slitting holes in the polythene wrapping around the slab. The slits should be large enough and placed as far as possible from the drippers and as close as possible to the base of the slab. Holding a "reservoir" of water in the base of the slab is not desirable as it gives a small increase in water holding capacity, at the expense of producing anaerobic conditions which may create problems.

Saturated slabs hold a lot of nutrient solution or water but this is quickly removed by rapidly growing plants, especially in hot weather.

Plants on the slabs should be liquid fed with a complete, balanced nutrient solution at every watering.

The pH and electrical conductivity (E.C.) of the nutrient solution must be controlled. Specific pH and E.C. figures may be recommended for particular crops (see relevant crop leaflet) but as a general rule they should be pH6.0 - 6.5 and 2.0 - 2.5 milli Siemens (or 2000 - 2500 micro Siemens) respectively.

Feeding and watering is best done on the principle of "little and often". It is safest not to allow slabs to dry out too much. Run to waste systems are easiest to operate since the slabs are watered/liquid fed until the solution just begins to run out of them. In normal systems the run to waste volume will be approximately 10% of the applied solution. When water quality is poor (high dissolved salt concentration) greater run to waste volumes are needed.

Important. A properly managed system is worked around monitoring the nutrient solution available to the plants. This requires regular sampling of the solution in the slabs and analysing for pH and E.C. These results are used as the basis for any future adjustments.

Flush the slabs regularly with water only to wash away nutrient salts which have accumulated. This condition is most likely to occur in hot weather conditions. Sampling and analysing liquid from the slabs for electrical conductivity (E.C.) will indicate when flushing is required.

Managing the Crop

Other than watering and feeding, the management of crops grown in Growool systems is identical with those grown in soil.

Removing the Plants

Stop watering and feeding at the end of the crop.

Plants will use up all the water/liquid feed in the Growool and will then wilt and finally dry out. Remove any support systems (wires, string, etc.) and then remove the dried out plants from the slabs by twisting or cutting off the wrapped cubes. Cut off the wrapped cubes and dispose of the rockwool plus polythene wrappers. They will not burn or compost. The plant debris should ideally, be burnt since it will probably be diseased at the end of the crop.

Thoroughly wash down growing houses with disinfectant through a high pressure hose before replanting.

Reusing of Growool Slabs

The slabs will collapse somewhat during crop growth and will contain masses of plant roots but it may be possible to re-use them provided the structure is reasonable. Growers in Europe have used slabs for three successive crops of tomatoes.

Slabs must be sterilised again before re-use. The most efficient method is to stack them on a wooden pallet, cover them with polythene sheeting and introduce steam at the bottom of the pallet. The best way to maintain the structure of the slabs is to stack them on their sides. Steam spreads up through the slabs and kills residual pests and diseases. Steaming for 30 minutes should be adequate.

Bradford Insulation, a unit of CSR Limited

Queensland	Victoria	SA	NSW	Tasmania	WA
768 Boundary Rd, Coopers Plains	159 Wellington Rd, Clayton	62 Bedford St, Gillman	7 Percy St, Auburn	Howard Rd, Derwent Park	21 Sheffield Rd, Welshpool
(07) 277 3422	(03) 560 0755	(08) 47 5244	(02) 646 9111	(002) 72 5765	(09) 451 4444

Consultant: Rick Donnan (02) 631 7007

Run off is collected and piped to a sump for re-circulating.

SET TASK

1. Pumps are used in automatic systems to circulate nutrient solution. Corrosion can be a problem if the nutrients come in contact with some types of metals. The other major consideration is to maintain an appropriate (slow) flow rate through the system. Automatic systems can be catastrophic if the pump stops, particularly where the root zone has minimal ability to retain water (such as NFT systems). Sometimes a backup pumping system is used. The main pump should be reliable and, in the case of systems like NFT, able to run constantly 24 hrs per day all week long.

   Given these considerations find out what is available in pumps and try to discover pumps suitable for the following types of systems:
   - NFT in a 60ft igloo growing carnations
   - Rockwool in a small home system growing vegetables (under cover on a balcony or veranda
   - Troughs filled with gravel growing strawberries supplied by trickle irrigation.

2. Visit at least three suppliers of hydroponic equipment. Find out what types of products they supply.
   Find out all that you can about these products, including costs. If possible obtain literature/brochures, etc. on as many different types of equipment as possible.

	**ASSIGNMENT** Download and do the assignment called ‘Lesson 3 Assignment’.