Hydroponics in the classroom

Merran Sell

Growing plants without the use of soil has many advantages for school science investigations and can also have cross-curricular applications

Last year I was awarded one of the ASE Travelling Fellowships to Australia and New Zealand. The trip gave me the opportunity of developing my interest in the use of hydroponics in schools, as it is widely used in those countries. I visited a variety of institutions, as well as attending the Third Annual Australian Hydroponics Conference in Sydney.

Hydroponics in Australia, New Zealand and the USA means growing plants without the use of soil whereas in Europe it tends to mean growing plants in water without any medium for support. The information and methods described in this article are based on the Australian meaning of hydroponics.

I teach science in a school for pupils with moderate learning difficulties and am continually looking for ways of making science more interesting and relevant. Hydroponics has applications across a wide range of ages and abilities, and offers possibilities for innovative biological investigations.

Some of the major advantages in using hydroponics for investigations are:

- There is no problem about watering plants over weekends, half-terms or short holiday periods.
- It is possible to be more precise about measuring the uptake of nutrients; when growing in soil one never knows exactly which nutrients are present.
- There is very little maintenance once the system has been installed.
- Only a small amount of time is needed each lesson to monitor the progress of the plants.

ABSTRACT
The benefits of using hydroponics in school for investigational work are summarised. Requirements are listed, including advice on choice of suitable plants. Different types of growing media and growing systems are then outlined, including those that can easily be made and set up in schools. The article concludes with some suggestions for science investigations using hydroponics.

- Hydroponics projects can be organised on a cross-curricular basis.
- It is the technology of the future.

Requirements

- **Growing system.** Various types can be bought or made – see below.
- **Growing media.** Choice will depend on costs and system chosen – see below.
- **Nutrients.** These are available commercially or can be made up by the science department. If your school is in a hard water area then hard water nutrient solutions are available to compensate for the increased minerals present in hard water.
- **pH and conductivity meters.** Various meters are available but after attending the Australian Annual Hydroponics Conference I bought a conductivity truncheon that was manufactured in New Zealand and is now available in this country.
- **Lighting.** The minimum lighting required is 400W per square metre for indoor growing. Since returning from Australia I have now realised that the lack of lighting was the reason why my students' plants did not fruit. The recommended light is the Son-T-Agro (sodium tubular agricultural light).
- **Pump.** A small submersible fish tank pump is usually adequate and is inexpensive. More powerful pumps become progressively more expensive.
- **Heater.** It is very important that the water is not too cold, otherwise the roots are not able to take up the required nutrients. If plants are being grown in a laboratory a heater may not be necessary, but in a greenhouse it may well be needed. A fish tank heater is suitable.

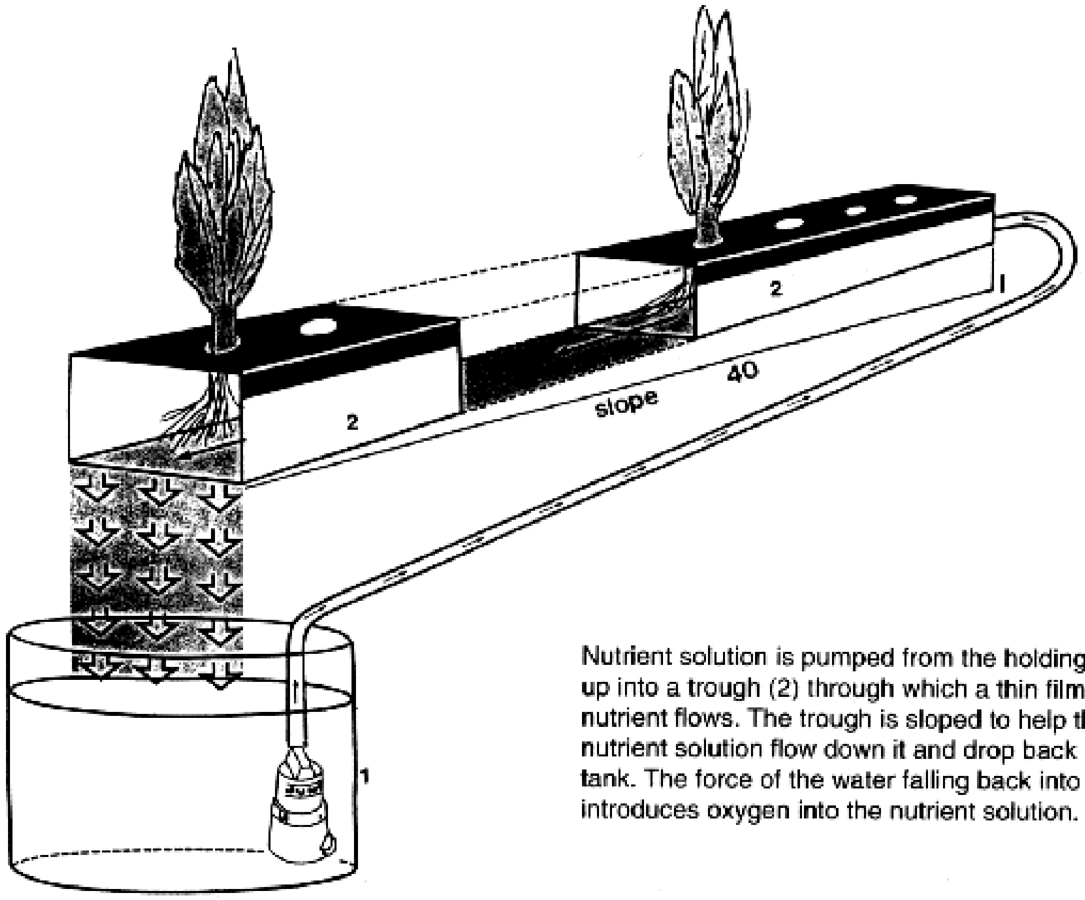


Figure 1

Nutrient film technique (NFT) system; reproduced with permission of NZ Hydroponics (Dayton and Smith, 1993)

Choice of plants

This depends on the time available for the investigation. If only 6/8 weeks are available then herbs are the most suitable choice. A slightly longer time would suit lettuces, courgettes or cabbages. If using cucumbers, it is best to use the female-only varieties as the male varieties are bitter and the former do not require pollination. Root crops, although they do not require pollination, are not really suitable. Silverbeet and flowering plants can be very successful and are easy to grow.

Many gardening books give an approximate guide to the length of time plants need to grow to maturity.

If you grow plants, such as tomatoes, which need pollination and you grow them indoors, the bee stick method of pollinating is suitable (SAPS). However, the possibility of the plants flowering during school holidays is an important factor to take into consideration when choosing plants.

Growing media

- **Perlite**. This is made from expanded rock. It is relatively inexpensive and can be used in any size of pot so pupils are able to have their own pots and can make adjustments to individual pots. Perlite has to be washed after use and tends to become powdered after several uses.
- **Perlagold,** which is a mixture of Perlite and vermiculite, is more satisfactory than Perlite as it is better at retaining the nutrient solution and is less likely to dry out.
- **Expanded clay** is more expensive than Perlite but is easy to wash and can be re-used continually. There are various sizes according to the plants' requirements, from granules for seeds and seedlings to marble-sized pieces for more mature plants grown on a large scale.
- **Rockwool**, which is similar to loft insulation material, has to be sterilised before it can be re-used; as this is rather expensive to do on a small scale, it would probably have to be thrown away. For very small

A submersible pump (1) is used to pump the nutrient solution from the holding tank (2) through a feed pipe (3) up to the surface of a growing container (4). The nutrient solution drains through the support medium (expanded clay) in the growing container into a drainage pipe (5) which returns it to the holding tank. Oxygen is introduced into the nutrient solution by the waterfall effect achieved when the concentrated flow of drainage nutrients drops back into the holding tank.

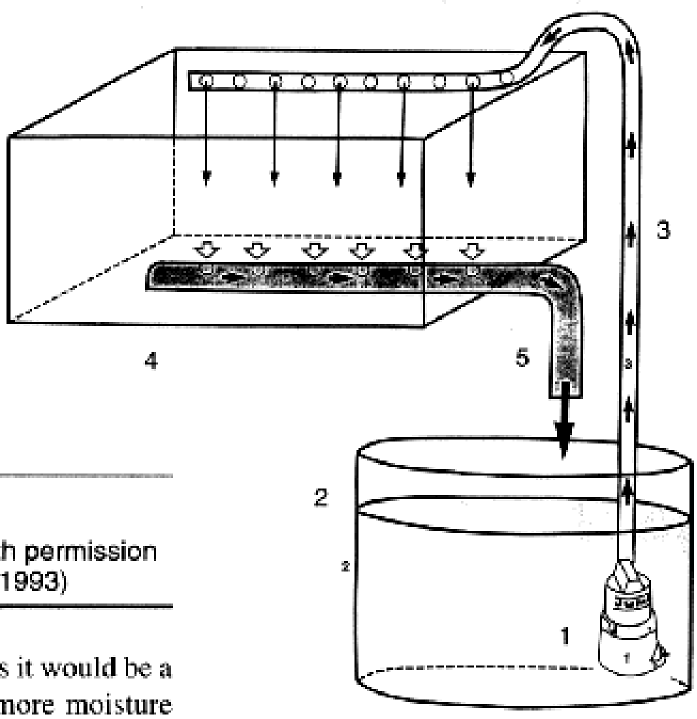


Figure 2

Flood and drain system; reproduced with permission of NZ Hydroponics (Dayton and Smith, 1993)

systems using, say, ice cream containers it would be a viable proposition. Rockwool retains more moisture than the other media.

Nutrient mixture. For most plants the total concentration of nutrient elements in a solution should be between 700 and 1500 ppm, so that osmotic pressure will facilitate absorption. However, some plants, such as tomatoes, need a nutrient concentration as high as 1400 to 3500 ppm. Lower values, of 280 to 900 ppm, are preferred by low-feeding crops such as watercress or lettuce. The middle values are preferred by medium-feeding crops such as cucumbers.

Growing systems

Nutrient Film Technique (NFT) (Figure 1). This system is the most widely used commercially and is also used by some schools. It uses long troughs through which a thin film of nutrient flows. Seedlings are inserted through holes cut in the top of the trough above small squares (5 cm by 5 cm) of Rockwool. Alternatively seeds can be planted in small yoghurt-type pots filled with Perlite, with slits cut in the base of the pot to allow the roots to grow through. Once the plants have started growing, these pots can be transferred to the NFT troughs. The plants remain in these troughs and obtain all their requirements from nutrients circulated through the troughs. Taller plants such as tomatoes require support by strings attached to the ceiling. The advantage of this system is that it does not require any kind of support medium. The disadvantage is that on a small scale it is relatively expensive to buy and set up. Also, all the plants in the system have to be grown under the same conditions.

Flood and drain system (Figure 2). I saw this in use in large greenhouses at an agricultural school I visited. This system can also be used on a small scale, either in a small greenhouse or in the laboratory. The advantage of this system is that as the water drains out of the troughs air is drawn in which helps to replace the oxygen that has been used up by the plants. It is the lack of oxygen in the water rather than the lack of nutrients which often causes problems with the plants. Expanded clay provides the support medium. A disadvantage of this system might be that the header tank would require a timer to regulate the times when the troughs had to be flooded. This system can be adapted for use on a small scale using Rockwool, which retains moisture more than the other media, placed into ice-cream containers.

Continual flow system. The agricultural school also used a continual flow system as they grew a variety of vegetables and flowering plants. It was very interesting to see that different plants in the same bed grew differently: some looked very healthy and others less so. This is because the pH is very important for different types of plants and the conductivity is very critical for the plants' growth and development. This system uses pots filled with Perlite, Perlagold or expanded clay.

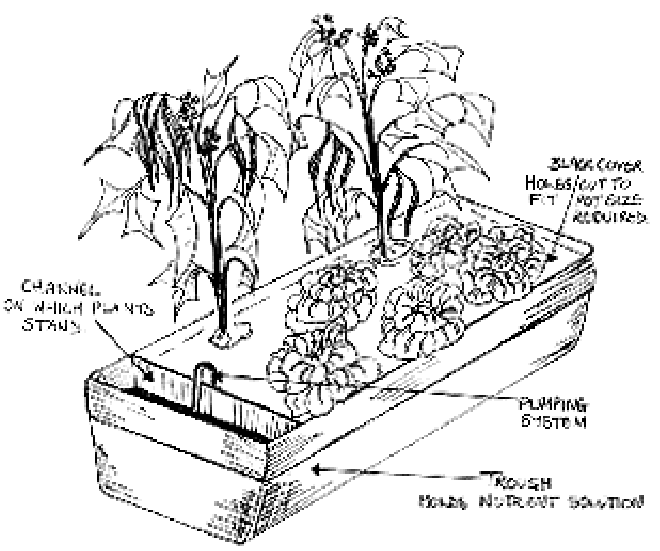
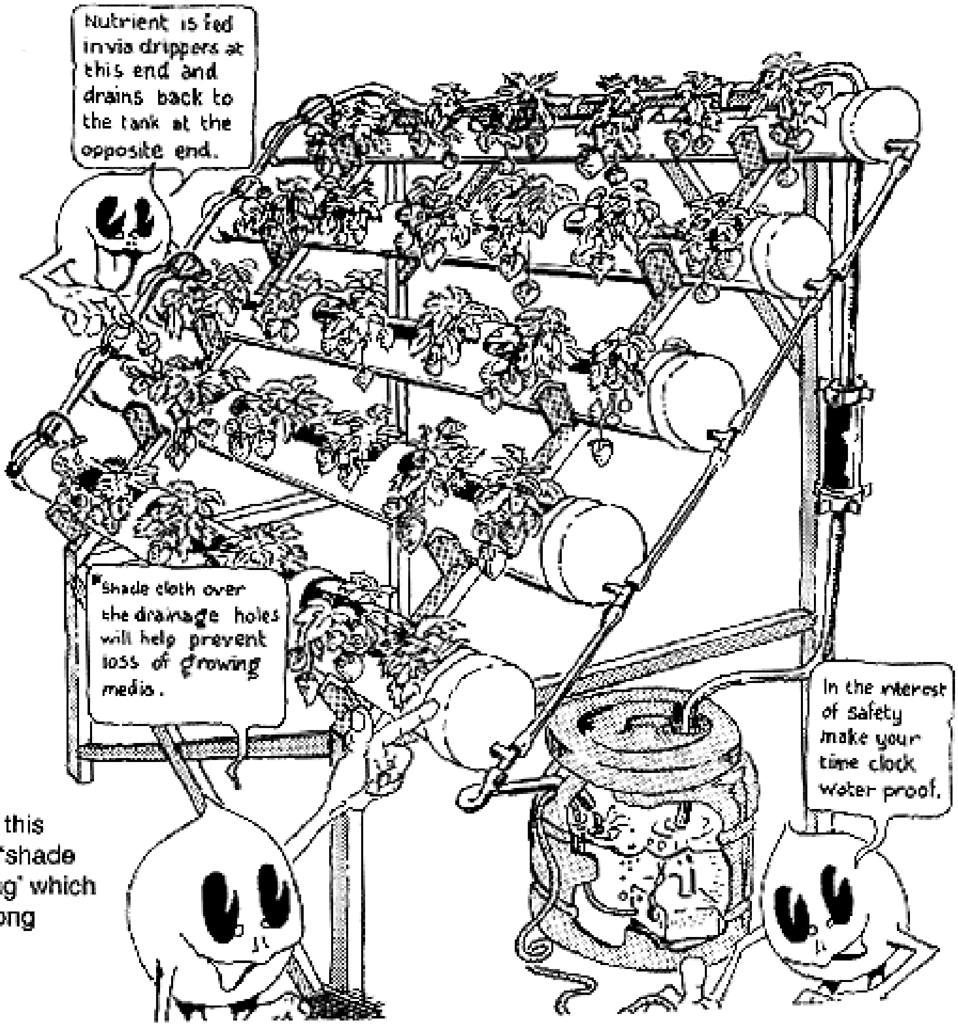


Figure 3

Recirculating trough system

- **Recirculating trough system** (Figure 3). This is the system we use at my school. It operates on a similar basis to the continual flow system, in that a reservoir is filled with water and nutrients. This is then pumped up to the upper level tray. The excess water then runs down the sloping tray back into the reservoir to be recirculated.

- **Recycled pump feeding** (Figure 4). This simple and inexpensive system uses drainpipes. Longitudinal sections are cut out of the drainpipes and the ends are capped. The ends are connected by pipes and mounted on a stand so that the water can be recirculated by being pumped up to the top pipe from the tank containing the nutrients.



'Shade cloth' in this country means 'shade fix screen netting' which screens out strong sunlight.

Figure 4

Recycled pump feeding – drip feed technique; reproduced with permission of the Natural Resources Conservation League (NRCL), 1992

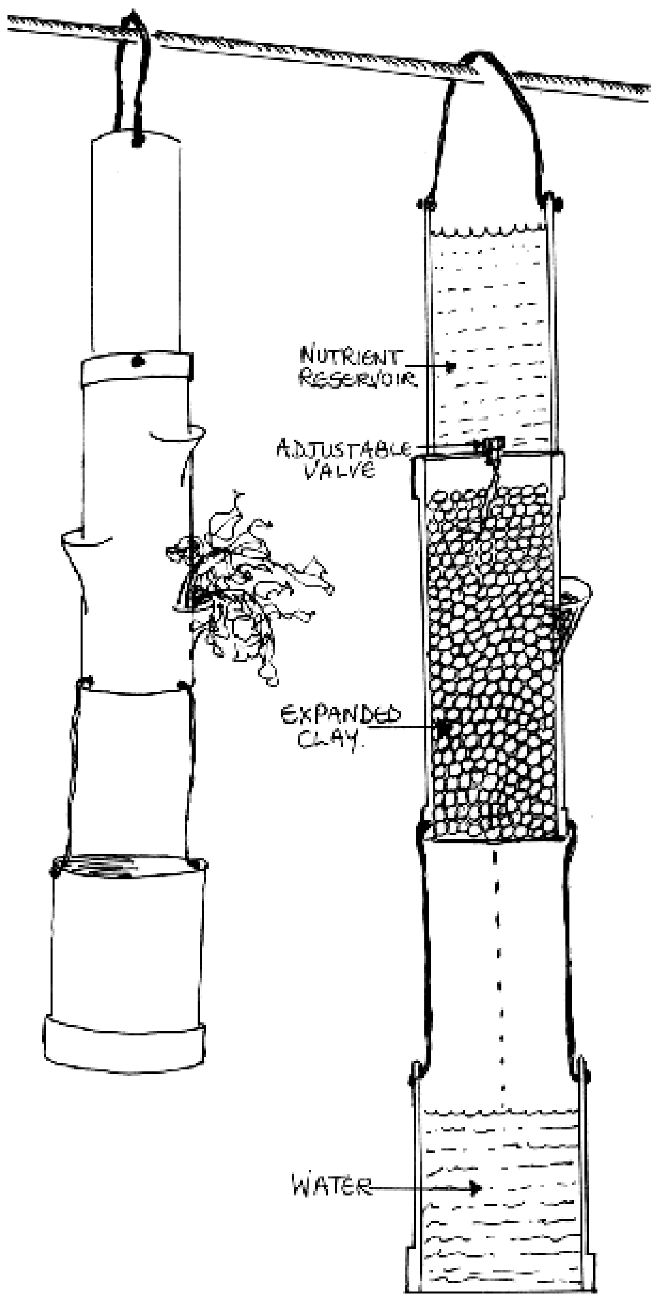


Figure 5
Hanging pot system

■ **Hanging pot** (Figure 5). Another method uses a hanging pot with a small reservoir of water and nutrients at the top. The hanging pot is made from drainpipe cut into sections. The main pot is filled with expanded clay pebbles. The sides have slits cut in them; using an electric paint stripper, the area around each slit is warmed and the lower lip pushed out to form a cup, as found on strawberry tubs. The reservoir is attached by self-tapping screws. The flow of nutrient solution is controlled by an adjustable drip-feed valve into the main pot. Once it has passed through the main section containing the plants the solution drips into a collecting cup; when this is full it can be unclipped and poured back into the top reservoir.

A variety of other home-made systems can be used, especially if the school science department has a good relationship with the technology department. In one school a large, old sink filled with expanded clay pebbles was being successfully used to grow lettuces for sale to the school canteen.

Hydroponics as a cross-curricular activity

One school in Melbourne I visited had developed a highly successful cross-curricular project making and marketing hydroponics systems. The school technology department designed and made the containers, the science department prepared the nutrient mixtures and carried out investigations, and the business studies department did the costing and accounting. The hydroponics systems were marketed to elderly people living locally with small gardens. The students started up the systems for their customers and maintained them for a while, making progress reports on the success of the project. The school received external funding for the project.

Considerations when choosing a hydroponics system

Which system is chosen will depend on the space and funds available, and the exact requirements of the science department in terms of the investigations to be carried out.

Apart from the NFT system, one disadvantage of most of the above systems, in particular those using Perlite, is the growth of algae. Carruthers (1994) states *'However, algae is not harmful to the plants. It may rob the nutrient solution of minute elements, including oxygen, but not enough to cause alarm. Algae growth can be limited by ensuring that channels, pipes and the nutrient tank are light-proof. This can be done by cutting black plastic to size, placing it over the growing medium in the pots and covering the channels with black corrugated plastic or black polythene. The best way to prevent algae growth is to block light from the nutrient reservoir with a lid.'*

Scientific investigations

Here are some suggested investigations:

- Measuring the nutrient uptake of different varieties of plants.
- The effect of different conductivity levels on plants.
- The effect of different types of nutrients – organic fertilisers versus inorganic.
- The effect of salinity on plant growth, using separate troughs, possibly using silverbeet seedlings.
- The effect of nutrient strength.
- The effect of growing media.
- The effect of light on plant growth.
- The effect of frequency of watering and fertilising.
- The effect of varying the pH by changing the amounts of acid (e.g. phosphoric acid) or alkali (e.g. potassium hydroxide) added to the different troughs.
- The effect of aeration of the water.
- The effects of nutritional deficiencies.

Conclusion

The more I find out about hydroponics the more exciting I find the subject as I realise the increased potential for the application of this topic, especially as it is difficult to find biological investigations which can be quantitative. Once the system has been set up it runs itself and, as mentioned above, there is no problem about having to water the plants over the weekend, half-term or holidays. The students at my school became so involved with their plants that they decided to continue growing them as a small business enterprise once they had completed their course work. There can be no better recommendation for using hydroponics than the fact that the pupils have enjoyed the work and become so involved that they want to continue with the project.

Acknowledgements

I should like to thank the teachers, lecturers, education officers and suppliers in South Australia, Tasmania, New South Wales and Victoria, Australia, and Wellington and Tauranga, New Zealand for their help and hospitality in my research.

Sources

Growell Hydroponics, The Jardinerie Garden Centre, Kenilworth Road, Hampton in Arden, Solihull B92 0LP. This supplier allows a 10% discount for all school orders. They have a wide range of books in stock. They are also willing to give advice with any problems which might be encountered, either with equipment, pests or growth of the plants.

Royal Horticultural Society, Wisley for help with plant problems.

Royal Botanic Gardens, Kew, Richmond, Surrey for help with plant problems.

Zeneca Agrochemicals, Jealott's Hill Research Station, Jealott's Hill, Bracknell, Berkshire RG12 6EY (tel. 01344 424701) for help and information about plant problems, choice of plants and visits to their site.

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Dayton, L. and Smith, R. (1993 revn) *Hydroponic gardening. A practical guide to growing plants without soil*. New Zealand Hydroponics. (Available from Growell Hydroponics.)

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SAPS. *Growing Fast Plants: Brassica campestris*, information booklet. Homerton College, Cambridge CB2 2PH: SAPS.

Further technical information and a booklist are available from the Editor at ASE.

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