CONDITIONING OF PLANTS FROM SOIL MEDIA TO HYDROCULTURE

KEITH MAXWELL
Hawkesbury Agricultural College
Richmond, New South Wales

HISTORICAL BACKGROUND

Civilised man has for thousands of years been endeavouring to grow plants in such a manner as to improve yields and quality. The famous Hanging Gardens of Babylon was an early attempt at the culture of plants under artificial conditions.

The early history of soilless culture of plants is closely interwoven with the study of plant physiology. In 1600 a Belgian, Jan Van Helmont grew willow shoots in a protected pot of soil and applied only water. After five years there was practically no loss of weight of the soil and he believed that plants obtain their food only from water. Since then, of course, scientists have shown that plants need 16 elements, these being supplied by gases and soil constituents, as well as by water.

Today there are many horticultural books in which reference is made to the use of soilless medium. The main reasons for such interest in alternatives to soil are that plants in such a manner can be cultured more precisely and irrigation and fertilizer practices much simplified.

SOILLESS CULTURE — WHAT, WHY AND HOW

What. The term soilless culture literally means "growing plants without soil". Mr. Steiner, the secretary of the International Society for Soilless Culture, defines soilless culture as "the growth of non-aquatic plants with their roots in a completely inorganic medium, where the roots are supplied with a nutrient solution".

The name "hydroponics", which comes from the Greek "hudor" and "ponos", which means "waterworks", was first suggested by Dr. W.A. Setchell from the University of California. The term hydroponics is popular, very widely used in the literature, and internationally accepted.

Why. Perhaps the first commercial interest in the "soilless" growth of plants was a direct result of the difficulty experienced by greenhouse growers in America in getting suitable soil during the 1920's. Professor Gericke, University of California, (1929), completely dispensed with soil and grew the first commercial crop of tomatoes in water to which all the necessary nutrients had been added. Because of a number of problems which were costly to overcome a range of solid, inert, relatively sterile media have since been successfully used — gravel, perlite and vermiculite, expanded clay being the most popular today.

There are many reasons why there has been such interest in hydroponics in recent years in Australia, namely:

1. Lack of suitable soil.
2. Great expense involved in sterilising soils.
3. Restricted supply of suitable water.
4. Urbanisation and high cost of vegetables and flowers.
5. The "boom" in indoor plants.

One of the most recent examples of why hydroponics is being considered as the most likely alternative to normal cultivation of field grown crops is to be found in Singapore. Because of the problem of soil borne disease and the high price of vegetables and ornamentals during the wet months, a study of hydroponics was initiated about ten years ago and the results using a wide range of plants, including orchids, is most promising.

Many people in various parts of the world consider that hydroponics is the most economical way of supplying water and nutrients to plants with the opportunity of maximising results The costly operations of soil preparation, weed control, disease and pest control are very much minimised.

How — Types of Hydroponic Systems.

There are two main types of systems for growing plants without soil, namely:

1. Liquid culture, the plant roots grow in a nutrient solution with the plant supported in some way. Here again, there are two main variations:
   (i) tank culture, where the solution is held in tanks in which the roots are immersed, and
   (ii) flowing culture systems, in which the solution flows past the roots in shallow troughs or pipes.
2. Aggregate culture, the plant roots grow in sand, gravel, expanded clay, scoria, or other inert material, which is kept moistened with a nutrient solution.

WHAT IS HYDROCULTURE?

The general definition adopted by the International Society for Soilless Culture (I.S.O.S.C.) is "all methods and systems of soilless culture, if used especially for growing ornamentals in homes and offices". More specifically it is using pots of various sizes and compositions, which contain inert material like expanded clay or scoria. Necessary nutrients are supplied via water.

The use of soilless media for the culture of plants is really not new and in nature many plants like epiphytic orchids, of course, live in soilless environments Bark is relatively inert and only supplies very small quantities of trace elements. In England cinders have been used, again the main function being to provide support for the plant.

Thus, except in a very modern sense, the use of soilless media for the propagation and culture of plants is not a recent development.

WHY HYDROCULTURE?

A striking development of the last few years, possibly resulting from environmental problems, has been that many more people have consciously or unconsciously begun to appreciate the growing of living plants as interior decorations in administration buildings, hospitals, business premises, and homes (2,11). The use of greenery and flowers is being highlighted for their aesthetic and decorative value, but an additional advantage is the more healthful climate in living and working rooms. By releasing moisture into the atmosphere plants tend to compensate for the drying effects of air conditioning

As it will cost a little more to establish plants by the hydroculture system it is reasonable to expect additional advantages. As a consequence of research, mainly in Europe, it has been proved that soillessly cultivated plants develop better than those growing in soil. "There is no mould, no moss, no putrefaction, no smell or soil, and no soil parasites . . . The plants are healthy despite little necessary care". This is a direct quotation from Prof. Penningsfeld's paper, "Growing Ornamental Plants in Living Rooms — Using New Soilless Culture Systems" which he presented at the I.S.H.S. Congress, Sydney, August 1978.

Baumann in Switzerland first developed a hydroculture system involving — an inner culture pot containing expanded clay — a simple water level indicator — and an attractive outer pot made of pottery, glass or plastic. There were many reasons (and advantages) for the development of this simple system, namely:

Hygiene, healthy and vigorous growth due to efficient nutrition, plants need less attention, provide a nice decoration for living rooms.

The "hardware" generally required includes special hydroculture pots; media, such as expanded clay; and the nutrients essential for plant growth.

Characteristics to look for when choosing a trough or reservoir and/or plant container have been indicated by Bruijn (2)·

1 Some thought should be given to how the plant container will fit in with its surroundings.
2. Troughs of all kinds should be watertight
3. Plastic troughs are very durable, common, and the least expensive, thus these should be given due consideration
4. Metal troughs are undesirable because the oxidation of certain metals may precipitate some nutrients from the solution and consequently make them unavailable to the plant. Other metal containers may release substances which are toxic to plant growth; for example, zinc and copper.
5. Transparent troughs or those that allow light to go through them make versatile containers but are more prone to algae growth.

The pots or troughs must be at least 10 cm high to ensure sufficient water reserve and movement by capillary action to the plant roots. The specially designed inner culture pot has holes or slits to ensure the necessary movement of air and water. A simple water level indicator shows when the water reserve is exhausted and how much water (normally the nutrient solution) must be added to replenish it to the correct level.

There has been considerable research into what is the best soilless medium to use in the hydroculture system and, up to the present time, expanded clay is the most satisfactory. This material, which is now manufactured in at least eleven countries, is used mainly as lightweight aggregate in the building trade. It is important to ensure that the expanded clay used is suitable for horticultural purposes. Also the optimum aggregate size range depends on the species and age of the plant being grown, e g for young orchids, 4 to 8 mm and for older orchids, 8 to 16 mm appears to be the most satisfactory. By attention to size, the correct balance of air and water around the roots is obtained.

Like expanded clay, the quality of the water used for making up the nutrient solution is very important. Only water of the standard of good quality drinking water should be used.

As in all hydroponic systems, it is considered that the "key" to success is the nutrient solution. Due to the inert growing media used it is most important that ALL the nutrients essential for growth be provided. Only specially prepared, ready mixed salts, or concentrated solutions, should be used. Ion exchange resins, charged with the desired nutrients are being used, mainly overseas, but are more expensive in comparison to nutrient solutions.

THE ROOT SYSTEM

The utilisation of essential elements by higher plants from the supporting medium is very much dependent upon the morphology of the root system (1). Bowen and Rovira have shown, in the case of wheat, that lateral roots are very important in the uptake and translocation of phosphate and, associated with particular temperature regimes, the length and morphology of the roots are also affected.

Moorby & Graves (8) have carried out research with tomatoes and lettuce grown in a nutrient film system of soilless culture. They showed that heating the root environment resulted in faster growth rates and usually larger mature plants. This could be an advantage with leafy plants like lettuce, but was of doubtful benefit with tomatoes and perhaps other plants where reproductive development is important. Roots produced below 16°C developed more slowly, were thicker than the very branched, fine roots produced at 23°C and higher A factor not investigated, but of relevance, was the production of growth substances like gibberellins which are known to be synthesised in roots. It is agreed that there is need to study further the effect of temperature on root form and structure.

To grow and function properly, roots require sufficient oxygen for aerobic respiration, and a minimal accumulation of gases such as ethylene and carbon dioxide. Increasing concentrations of ethylene, which results under anaerobic conditions, causes a reduction in root length. Also it is considered that under these conditions, as a consequence of hormonal, nutritional, and water relationships, the growth rate of the shoot slows down, accompanied by senescence and abscission of leaves (5).

The above brief discussion of some factors affecting root development serves to indicate its extreme importance in nutrition and efficient growth of plants.

PROPAGATION

For obvious reasons, it is desirable that all propagating material be started off in a soilless medium but in practice, particularly in commercial ventures, this is not always possible (4)

The common methods of propagation in hydroculture include firstly, plants being rooted in soilless mixes; secondly, especially with aeroids, the cuttings may be planted directly into the expanded clay. The third method is to use rooting blocks of rockwool or rigid phenolic foam (13). At present, the first method is the most common and hence the procedure and precautions which receive most attention.

The germination of seeds directly in the expanded clay is also another method as an alternative to vegetative production (2)

CONVERSION OF PLANTS TO HYDROCULTURE

The obvious reason why it is desirable to start with plants that have commenced their growth cycle in a soilless medium, (in the very *strictest* sense) is the avoidance of most diseases which are soil-borne. Penningsfeld (12) has evidence that orchids, even with poor root development, completely recover in many cases when planted in expanded clay, which is indicative of the excellent micro-environment.

The increasing demand for well developed hydroculture grown plants has necessitated the initial use of plants growing mainly in normal soil mixes. The plants must be strong, healthy, not too old and preferably not a flowering type or one with a delicate root structure. Spring and summer are the most favourable times to commence (2).

It is most important that the plant roots be completely freed of the old medium by washing carefully. With some species this is a rather delicate process and some of the finer roots may be damaged and these should be carefully removed.

The expanded clay is then thoroughly washed to remove the fine particles and to make the transplanting operation simpler — strict hygiene is essential at every stage of the conversion.

Potting up is broadly similar to that with conventional plants but the inner culture pot is made of meshed plastic, black polypropylene with slits, or polystyrene.

A layer of the wet expanded clay is placed in the culture pot and the plant is firmly positioned, and then the pot is filled with washed expanded clay. It is important that the roots or base of the cutting be about 5 cm from the bottom of the pot and thus within the height of capillarity or ascent of the nutrient solution from the reservoir.

The next stage, namely the changing of the roots to so-called "water roots" is the most critical stage in the conversion process. Rochford (13) recommends that nearly all kinds of plants be regularly misted or placed into a polythene tent to reduce the risk of dehydration.

In hydroculture, plants develop a root system that is different, both externally and internally, from those in conventional soil culture It is smaller and most of the roots are thick and succulent with only a small number of the fibrous feeding roots

In the Netherlands the newly-potted plants are stood in large shallow trays on mobile benches and moved into sections of the greenhouse held at 26°C with very high humidity and sub-irrigated at regular intervals with water only. A complete nutrient solution is not used until the "water roots" are well established (personal observation, 1980).

When the plants are ready for sale (varies from 6 weeks to 6 months according to plant species), they are placed in attractive outer pots. The optimum nutrient level is visible by means of a simple water level indicator.

The dual problems of correct watering and nutrition is simplified because this is attended to by adding the nutrient solution *only* when the water level indicator falls to minimum. Regular topping up should *not* be carried out because it will prevent adequate air reaching the roots and also brown spots may form around the leaf edges (13).

With established plants and, especially during periods of below optimum temperature, if in doubt, wait, even if the indicator is at a minimum because the moisture retained in the expanded clay will last at least a week without the plants being severely stressed.

CONCLUSIONS

Australia's once leisurely nursery trade is blooming into a multi-million dollar industry with growing overseas markets (9).

The technology for conditioning of an extremely wide range of plants from soil media to hydroculture is known and no longer remains a barrier.

The knowledge gained during the last decade about all aspects of hydroponics, in the home and commercially, is most impressive (7).

I would like to forecast big developments in hydroponics in the eighties. This "Plant Growing Revolution" will help us overcome many of the present day problems (7).

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VIRUS-FREE STRAWBERRY PROPAGATION IN NEW SOUTH WALES

DAL DUTCH

Mountain Lagoon Strawbery Nursery
Bilpin, New South Wales

First let me qualify the term virus-free strawberry plants. This has become an accepted term for strawberry plants (i.e. by commercial strawberry growers) for strawberry plants that have been grown in certified strawberry plant schemes similar to that which exists in New South Wales. In actual fact the plants we propagate should be more correctly described as plants grown from virus-tested mother stocks The scheme that presently exists in New South Wales is similar to many operating around the world The principles of virus eradication in the initial instance remain basically the same, however, varying climatic conditions and differences in pest and disease controls necessary for the many environments in which these