Greenhouse Plant Growing Systems

By: James W. Brown
http://www.cropking.com/articlegpgs

Whatever the growing system used, plant roots need oxygen. Oxygen is used in the root for respiration of photosynthate – the process that releases the energy needed by the root to take in the water and nutrients and to send them up to the rest of the plant.

Some plants, like rice and cattails, have roots that can get enough oxygen while growing in standing water. However, most of the plants we grow in the greenhouse have higher oxygen requirements than what is available when the roots are submerged in stagnant water.

Each plant production system must foster the availability of oxygen to the plant roots. This includes every plant production system, ranging from the garden or agricultural field outside to the commercial and hobby hydroponics system in the greenhouse. In successful production systems, this happens. It may be due to a favorable air/water relationship in the media or a media component. It may be due to the way the water or nutrient solution is exposed to the air in the delivery or operation of the system. Oxygen must be dissolved in water for it to be available to the root system. Oxygen dissolves in water in proportion to the surface area existing between the two. For example, thin layers of water in channels and water sprayed through air are more effective in getting oxygen into the water solution than is bubbling air through water, although bubbling air through nutrient solution may supply adequate oxygen levels in small hobby systems.

Kits and Systems

Most of the hobby-level hydroponics systems or kits are patterned after one of the basic types of hydroponics systems, and are likely to be slightly modified versions – either smaller kit size or a system which provides a little more flexibility for the hobby user.

In the past, performance of some of the hydroponics kits was restricted due to the limitations of the inexpensive timers used in hobby systems. Up until just a few years ago, timers costing less than about 50 dollars had only six or seven “on” and “off” settings per day. This meant that the system could only be irrigated that many times a day. Often that was not enough for optimum plant growth and development in the system, or for maintaining growth in larger plants whose needs have outgrown a system that was adequate when the same plants were smaller.

Recently highly programmable electronic timers have become available in the 50 dollar and less range. They have the potential of allowing the user to set many feed cycles per day. This has expanded the capabilities of many of the hobby systems without significantly increasing their cost.

The timer and other control equipment is often a significant part of the overall cost of the hobby hydroponics kit. To a considerable extent, this is also true of commercial hydroponics systems.
Achieving optimal growth in the hydroponics system requires close control of the input and environmental conditions.

**Hydroponic Systems**

Hydroponics production systems include solution-based systems and systems containing media that are low in cation exchange capacity. That is to say that the media do not interact with fertilizer supplied in the solution. The media is inorganic and does not provide an environment for substantial microbial involvement in the processing of fertilizers or fertilizer ingredients. In this system, the role of the media is to support the plant roots and provide an environment for the water and needed nutrients.

**NFT System**

The Nutrient Film Technique (NFT) consists of plants growing in a thin film or recirculating nutrient solution. The fertilizer solution is usually housed in a reservoir from which it is pumped out to the plants. It makes one pass by a number of plants and is then returned to the reservoir.

Although many kinds and types of plants can be grown in NFT systems, experience has taught us that shorter-term plants and crops – such as lettuce and some herbs - are better suited to this production system than are longer term plants such as tomato plants. However, commercial NFT tomato-production systems are still in use by some growers. New hydroponic growers have a higher success rate with some of the hydroponic media based systems than do new tomato growers starting with an NFT system.

Lettuce and many herbs are commonly grown in NFT systems. The plants are started in a nursery, where they are spaced fairly closely. After two to three weeks, the plants are transplanted into the NFT system, which usually consists of a number of parallel channels.

**Ebb & Flow**

Ebb and Flow systems are used commercially by a few bedding plant and potted plant producers. Such a system includes specialized benches, pumps and drainage systems. It provides for individual watering and fertigation of a number of different plants on different spacing without individual feed lines going to each plant and without overhead watering.

In the Ebb and Flow system, recirculated nutrient solution is periodically pumped onto a table where containerized plants are sitting. Many hobby-sized kits are basically small Ebb and Flow systems.

When used in large commercial production of plants, the recirculated nutrient solution is pumped onto the table and allowed to drain off the table several times a day, making the pumping costs high. For this reason, commercial ebb and flow systems are used chiefly for plants that are on the production tables for a relatively short period of time. Other types of hydroponic systems have lower pumping costs, so they are the popular choice for commercial production of plants that are
grown in the system for a long period of time or are harvested and not sold as an on-growing plant.

Pond System

The Pond System, the Raft System and the Raceway System are similar in many ways. They usually consist of relatively small plants floating on a volume of solution ranging from six inches to over a foot in depth. The plants, such as lettuce or herbs, are supported by a floating media such as a sheet of styrofoam. Because of that, the system is sometimes called the Raft System.

Most of the nutrient solution is housed in the system under the plants. It is recirculated one or two times a day. It is pumped into one end of the system and drained out of the other end. The surface of the pond is covered with styrofoam or other floating material. Such a covering eliminates the introduction of oxygen to the solution from the air above. The oxygen critical to plant growth must be introduced into the solution some other way. Although pond systems tend to be inexpensive and are touted by some as easy to use, the introduction of oxygen into the solution is tricky and thus the system usually does not work when growing temperatures are in the upper ranges.

Aeroponic

In the aeroponic system, nutrient solution is intermittently sprayed onto the roots of plants that otherwise hang in the air. The stems and leaves of the plants are supported in a variety of ways depending on the kind and size of the plants being grown. This is an attention-getting display that has only limited commercial application. Because no media needs to be cleaned off the roots at harvest time, and roots can be readily viewed to determine harvesting schedules, plants that are grown for their roots or for products of their roots are often grown in aeroponic systems. Aeroponic systems are used as hobby hydroponic kits. They are different and novel.

Media-based Systems With & Without Significant Cation Exchange Capacity

The media used for plant production in the greenhouse will vary depending on the production approach being used. Each media has its specific properties, and resulting advantages and disadvantages.

Soilless Media

Soilless media of various kinds and mixtures of various soilless media have been used in greenhouses for several years. Commercial media mixes are available, but most of the basic ingredients are also available separately.

Soilless media is isolated from the ground so that diseases and insects are not transferred because of contact. The media is therefore used in containers, and can be used for a period of time and then replaced with new, fresh media.
Different containers characterize the different production systems within this category. They include upright bags that can be filled with a number of different media or media mixes. Rockwool slabs are rather characteristic of the type of bonded material they contain. Foam rubber slabs are similar in appearance to rockwool from the outside. Horizontal bags are filled with perlite, or any number of different soilless mixes. Long troughs, almost the length of the greenhouse, are used to house organic soilless mixes where microbial activity within the media will be relied upon extensively in the provision of the fertilizer to the plants.

The fertigation and drainage of these systems are all somewhat similar. Differences in the media will require minor adjustments in the frequency and amounts of solution to be applied.

**Inorganic Media**

Inorganic media – defined as media that do not interact with fertilizer ingredients supplied to them - include material like sand, gravel, rockwool, perlite, LECA. These materials will not support microbial growth. Vermiculite is the exception. It is expanded mica and has many chemically reactive sites. This allows it to interact with and hang onto or tie up fertilizer ingredients supplied to it. Although this may have some advantages for growers, this characteristic eliminates it as a media in a purely hydroponic system. Conversely, in organic media, microbes break down organic material and receive energy and nutrition from the process.

In a strictly hydroponic system, the nutrient needs of the plant are supplied to it in a water solution. The fertilizer ingredients all need to be water soluble and available to the plant in the form supplied. Any media utilized in the system does not chemically interact with the fertilizer solution to any appreciable extent.

Sand and gravel are usually not used as media in hydroponic systems within the continental United States. Although they are relatively inexpensive, they are heavy and would need to be heated to high temperatures or otherwise treated to assure the absence of disease organisms. They have only a barely functional air-water availability relationship.

Horticultural rockwool, perlite and LECA (Light Expanded Clay Aggregate) are all processed or manufactured at sufficiently high temperatures to eliminate any living substance within them. This is one of the attractions for these substances as media or media components in hydroponic and other soilless production systems.

Perlite is created through a heat process. When heated, it is popped in a similar fashion to the way popcorn is popped. The individual perls are full of small air spaces that can also hold water. Water can be wicked up to a height of about 8 inches in perlite. The availability of both water and oxygen in the perlite media makes it a very good environment for the growth and development of plant roots.

Horticultural rockwool is manufactured with characteristics that provide an ideal air-water relationship also. The basalt rock from which it is made is ground, heated and dropped onto a spinning disk. The hot particle cools into a fiber as it leaves the spinning disk. At that point, the fiber could be part of an insulation pad or it could become horticultural rockwool. The specific
resin used and the density of the fibers is what creates a product with the properties that support
the environment needed for root growth and plant development. Although rockwool is available
as a loose product, it is often used in the greenhouse in the form of a plastic-wrapped slab. The
slab has a limited usable life because the structure breaks down with time. When the structure
breaks down, the air-water relationship changes. The availability of oxygen in the media
decreases as the structure of the media breaks down.

**Organic Media Based Systems**

Organic production systems include certifiably “Organic” systems and systems consisting of
recycled plant material. These types of systems are more complex than the hydroponic systems,
involving a series of processes within the media. The organic media in the system harbor
microorganisms that will break down the organic matter itself, and sometimes also break down
fertilizer ingredients that are supplied to the system. The fertilizer ingredients from the organic
matter are made available to plants in the system by the activity of the microorganisms living in
the media. At the same time, the microorganisms themselves will use some of the fertilizer
supplied to the system. A system like this is more difficult to use, requiring monitoring of the
various simultaneous processes. The observant grower will gain valuable experience over time.

Within the complex organic system, microorganisms break down organic molecules during the
decomposition process. Ingredients being provided to the plants growing in the media will also
be taken and used by the microorganisms themselves. The grower needs to realize that both
microorganisms and plants need to be fed some fertilizer ingredients. As the microorganisms
break down the organic media, certain fertilizer ingredients can be released from it. Some media
can release toxic quantities of one or more micronutrients during at least one stage of the
decomposition process. This needs to be accounted for in the fertilizer program.

Certifiably “Organic” systems may contain many – and more - of the ingredients mentioned here.
Certain ingredients are prohibited in “certified” systems. Due to its complexity, we will refrain
from fully exploring the Certifiable “Organic” System in this article.

The media used on an organic system is often recycled plant material from other agricultural or
forestry production or processing operations. A major exception to this is the use of sphagnum
peat - a natural deposit of plant material that occurred in ancient bogs. Conservation concerns
and decreasing availability have reduced the reliance on sphagnum peat as a component in many
soilless plant production mixes. Alternative materials are becoming more readily available.

Other materials used in organic systems include sawdust, pine bark, rice hulls, ground corncobs,
ground peanut shells, and coco coir. These are used alone or in combination with each other and
with aggregates such as perlite or vermiculite. The media used often depends on the local
availability of the component or components. Rice hulls, for example, are more commonly used
in or near rice producing areas.

The different organic components decompose at different rates. Ground corncobs and rice hulls
decompose more quickly than pine bark and coco coir. The decomposed or partially decomposed
media will consist of smaller particles that will settle closer together and can restrict the
availability of oxygen to the roots of plants growing in the media. Often, coco coir, pine bark or an aggregate such as perlite is used in the soilless mix to provide aeration after some of the other components have partially or even extensively decomposed.

Organic media and organic media mixes have been used in two different ways with respect to the decomposition process within them. In the first, organic media have been used as a substitute for aggregates in an otherwise hydroponic system. In these instances, the fertilizer supplied to the system is a completely soluble and plant-available preparation that does not need to be processed by the media. The decomposition within the media is accepted as part of the nature of the system and is adjusted for in the production process. Rice hulls, for example, release levels of manganese during the early stages of decomposition that are toxic to tomatoes. Many growers, therefore, wet the rice hulls down and let the decomposition begin and continue for a couple weeks so that the manganese-producing stage of decomposition has passed before transplanting the tomato plants into the media.

When used in this type of system, where the fertilizers are completely soluble and readily available to the plant roots, the volume of organic media used per plant is similar to the aggregate media per plant because the decomposition process within it is not being depended upon by the plant production system.

In the second type of organic system, organic media components are used with less soluble and insoluble fertilizer ingredients. In this instance, the fertilizer ingredients are processed and made available to the plants by the microorganisms living on and decomposing the organic media. This is the type of system that can be certified as “Organic” when certain allowable components are used.

For these types of systems, larger media volumes per plant are needed since the fertilization is made available to the plants through microbial decomposition of the media itself. The larger media volumes provide for more organisms and more processing of fertilizer ingredients per plant. Plants growing in such systems will need to develop a more extensive root system because some of the needed fertilizer ingredients may be scarcer or more slowly available.

To remedy this, at least some of the insoluble or slightly soluble fertilizer ingredients can be mixed with the media before the plants are transplanted. Finely ground, insoluble fertilizer ingredients can also be supplied in suspension through irrigation drip tape. This can be supplied to the plants at the same time water is supplied each day.

**Soil Based Systems**

Although soil is readily available at most places where a greenhouse is located, many people, including commercial growers, no longer use soil as a growing media in the greenhouse as they did a few decades ago. There are several reasons for this:

- Soils in different regions or even within the same field can be quite different. The way the soil would be used and the supplements needed vary widely from one soil to another.
- Any instructions or suggestions for growing techniques for plants in a greenhouse soil-based system would be very general or of limited value because of the wide variations in the conditions created in the soil or soil-based media.
- Soil is expensive and heavy to transport. If soil is harvested for greenhouse use and not replaced, the usable soil can be consumed in a few years.
- Soils harbor diseases and insects. Introduction of insects and diseases to the greenhouse environment is undesirable. Effective heat or chemical treatment of soil is not available to small growers and hobby growers. It is being phased out for commercial growers. Heat treatment is very expensive and ineffective if not done correctly.

The greenhouse grower has many choices in plant growing systems. The choice of system will depend on the plants to be grown, the size of the system and the financial and time investment the grower wishes to make. Many growers will try a variety of growing systems over time, finally settling on a system that works well for their variety of plants, and with which they experience success.

http://www.cropking.com/articlegpgs