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IFAS Extension

Grow Your Own Vegetables Without Soil[1]

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Growing plants without soil is often called hydroponics. The name implies that the plants are grown in water containing dissolved nutrients. However, pure water culture is only one of the many methods employed. All of the other methods might simply be grouped as "soilless" culture, which would include sand culture, gravel culture, and culture utilizing other soil substitutes such as sawdust, wood shavings and vermiculite.

The information reported here in "Grow Your Own Vegetables Without Soil" should be beneficial to the gardening enthusiast who wishes to try hydroponics as a hobby. The commercial production of vegetables utilizing hydroponic techniques is complicated and should be employed by only the most competent grower. Commercial growers should refer to Florida Cooperative Extension Service Bulletins specifically developed for the hydroponic industry.

How Water Culture Works

In water culture, plants are grown with roots submerged in a nutrient solution, with the stem and upper parts of the plants held above the solution. With this system, the main considerations are: provision of a suitable container, suspension of the plants above the water, provision of a suitable nutrient solution, and proper aeration of the water solution.

Containers For Water Culture

There are many kinds of containers that might be used — a cement trough, glass jars, earthenware crocks, metal containers, or fiberglass tank. Of course, these all must be leak proof. Glass containers should be painted dark on the outside to keep sunlight from making chemical changes in the solution and to prevent the growth of algae. Leave an unpainted narrow strip down the side so the level of the solution can be checked. Metal and concrete containers should be painted inside with asphalt emulsion to prevent corrosion and toxicity to the plants. Fiberglass is more resistant to corrosion than the other materials.

Supporting The Plants

A "platform" for planting into and supporting the plants as they grow will be needed. This is sometimes called the "litter bearer." It is often made of chicken wire or hardware cloth (wire) base on which is placed about three inches of wood shavings, excelsior or similar material called litter. The metal wire should be constructed to fit across the top of the container and should be plastic covered or painted

1. This document is HS510, one of a series of the Horticultural Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date March 1994. Reviewed May 2011. Visit the EDIS website at http://edis.ifas.ufl.edu.
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with asphalt-based paint. The platform and supporting material need to be porous to allow for aeration.

Styrofoam has also been suggested as a means of stabilizing the plants above the solution. Plants are inserted into holes in the floating styrofoam. Holes should be large enough to avoid constriction of stems at maturity. Cotton or other material may be used as shims in the holes around the stems. Punch holes at random in the styrofoam to allow for better aeration. The tops of heavy or cumbersome plants need to be further supporting by trellising.

Aeration

For young plants, leave about one inch of air space between the litter and the solution. As plants grow, allow 2 or 3 inches of air space below the litter. Lack of oxygen in the water and resulting growth impairment may occur unless air is pumped through the solution with a pump, compressed air or other equipment. Bubbles should be spaced 1/2 to 1 inch apart as they rise through the solution. Aerators normally used to keep fish alive in bait wells or aquariums are suitable for small units.

Nutrient Solution For Water Culture

There is no one ideal nutrient solution. Any good solution will contain all of the essential elemental nutrients needed for plant growth. The sources and amounts of these nutrients will vary from on suggested solution to another, but are commonly available as commercial fertilizer and chemically-pure salts. Along with the many formulas suggested, there is a variety of ready to use solutions on the market. Most all of these combinations give fair to excellent results when used as directed and are suggested for hydroponic hobbyists. These mixes are easily dissolved in water for a proper nutrient solution.

With any solution, the composition changes as the plants grow and utilize the nutrients. Therefore, care and attention must be given to controlling the content, either by additions of certain ingredients as needed, or by changing the solution completely from time to time. Since frequent testing is necessary to determine which nutrients have gotten out of balance, it is easier to change the solution. Table 1 gives a popular formula for general plant production. Some elements are required in very small or trace amounts and must be added to the forumula given in Table 1. The formula in Table 2 will provide a satisfactory solution for this purpose.

Using the Solution in Water Culture

In a small setup, the nutrient solution can be mixed in small containers and added as needed. At the beginning, the container is filled with solution almost to the level of the litter. Then, at predetermined intervals, the old solution is thrown out and new solution added. The frequency and number of changes of the solution will depend on the size of the plants, how fast they are growing, and the size of the container. Just as a starting point for beginners, solution changes might be made at weekly intervals for the first few weeks, then twice weekly for older plants. Should the water level get too low between changes, add only water until time to change solutions.

Adjustment of the acidity or alkalinity (measured as pH) of the water may be necessary to keep it within an adequate plant growing range of pH 6.0-6.5. This means testing with indicator paper and adding sulfuric acid, if needed, to lower pH or an alkaline material such as sodium hydroxide to raise pH.

Nutrient Flow Technique (NFT)

Many commercial systems today utilize a series of plastic tubing through which a nutrient solution is circulated around the roots of vegetables inserted into the tube. This modern system is called the nutrient-flow technique (NFT).

For NFT, two types of tubing are most often used: 1) black polyethylene film folded and stapled to form a 6-8 inch wide channel; and 2) PVC pipe (4-6 inch diameter). In both cases, plant holes are spaced at proper intervals along the tubing. Nutrient flow can be a continuous or intermittent recirculation of a nutrient solution from a supply tank.

Aggregate Culture

Gravel is sometimes used by commercial operators in Florida. However, gravel is only one example of a solid material substitute for soil or water. The use of such solid media is generally referred to as *aggregate culture*. This technique has good possibilities for home gardeners as well.

Crops are grown in shallow tanks or troughs that serve as the container for the gravel. The gravel, sand or other aggregates are used much as soil is used in conventional plantings — to provide anchorage and support for the plants. Nutrients can be supplied in solution form or as dry fertilizer in any one of several fashions: 1) flooded from the bottom up; 2) drenched on the surface; 3) trickled onto the surface; or 4) scattered dry on the surface and watered into the root zone. Whenever it is to be applied from the bottom, fairly coarse materials such as gravel should be used so that the medium will flood and drain easily. Sand usually is not coarse enough for bottom feeding, but works well with top feeding.

For single rows of tomatoes, beds 24 to 36 inches wide are adequate. Usually, it is made of plastic-lined wood, fiberglass, plastic or poured concrete with sides about 8 inches high and with a V bottom so the center is 12 inches deep. If concrete is not lined, the inside should be painted to prevent chemical injury from the concrete and chemicals reacting. Thus, a half-tile or similar device through the center of the bed will feed or drain the solution rapidly from one end of the bed to the other. At one end of the trough there must be a pipe connection to the lowest point in the V with a little slope toward that end. The slope should be precise, without low areas to impede drainage. The nutrient solution can be pumped into the trough through that pipe and to within one inch of the surface and then drained out again when the pump is shut off. Such flooding and drainage should be accomplished within a 10-30 minute period, and at intervals of 1, 2 or more times daily. By personal inspection, it can be determined how often applications are needed to maintain adequate moisture in the root zone.

Some combinations of aggregate materials other than gravel which have been tried successfully with tomatoes are as follows: 1) sand; 2) 1 part sand to 1 part vermiculite; 3) 1 part sand to 1 part rice hulls; 4) 1 sand to 1 redwood bark; 5) 1 sand to 1 pine bark; 6) 1 sand to 1 peat moss; 7) 1 sand to 1 perlite; and 8) 1 or 2 sand to 1 peat moss. In most cases, sand alone has been as satisfactory as sand mixed with other materials. Sawdust and wood shavings are also acceptable. More recently, a fibrous stone material called "rockwool" has become increasingly popular.

Nutrient Solutions For Aggregate Culture

With aggregate culture, the same nutrient solution as prepared for water culture may be used. Various techniques might be used to apply the solution the plants. For larger troughs, a pump is often used to fill the trough to within an inch of the top. When the pump is shut off, the liquid solution drains back into the supply tank, leaving the aggregate medium moist. A time clock may be used to start and stop the pump at selected intervals.

For small units, a simple system consists of a 5-gallon bucket of solution supported by a pulley and attached by a hose to the aggregate tank. At feeding time, the bucket is raised above the height of the tank so the solution will flow by gravity into the medium. Then, when lowered the excess solution drains back into the bucket. This feeding technique is best suited to porous aggregate such as gravel; some difficulty might be experienced where organics such as peat are included.

With organic mixes, and for very small containers such as cans, buckets and hampers, solutions could be sloshed by hand on top of the aggregate medium. This should be done at the required intervals. Excess solution merely drains away through holes in the bottom of the containers and does not involve recirculation. The nutrient solution can also be delivered to each individual container by a dripline or spaghetti tube, as is commonly done with bag culture.

Prepared Mixes

A rather popular technique is to use commercial grade fertilizer to pre-mix nutrients into the aggregate just as the medium is being prepared. One popular mix is the Cornell Peatlite Mix, listed in Table 3 for the preparation of one cubic yard of mix.

As the plants grow in the prepared mix, it is necessary to add more nutrients from time to time. Again, any one of several preparations could be utilized satisfactorily for this purpose, but one of the easiest to prepare solutions results from the use of commercially available soluble fertilizer. Two suggested solutions for weekly feedings are made with 20-20-20 analysis fertilizer at 1 pound per 100 gallons and 25-5-20 at 1 pound per 100 gallons. A suggested schedule for their use would be to use the 20-20-20 for the first three weeks, followed by 25-5-20 the rest of the way. Where tomatoes are the primary crop, substitute 2 pounds of calcium nitrate (per 100 gallons water) for the complete fertilizer. This should be done about every two weeks to insure adequate calcium and reduce blossom-end rot.

Amateurs Only

Please keep in mind that this guide is for use by hobby hydroponics enthusiasts only. Commercial production of vegetables using soilless culture is a capital-intensive, complicated, and high management- intensive enterprise. A commercial producer should seek advice from the county agricultural agent and literature written specifically for the hydroponics industry.

Table 1. Formula for preparing a general purpose nurient solution (Hoagland).

			Amount for 25 gallons of solution	
Salt	**Grade**	**Nutrient**	**Oz.**	**Level tbsp.**
K phos.(mono-basic)	Technical	Potassium, Phosphorus	1/2	1
K nit.	Fertilizer	Potassium, Nitrogen	2	4
Ca nit.	Fertilizer	Calcium, Nitrogen	3	7
Mg sulf.	Technical	Magnesium, Sulfur	1 1/2	4

Table 2. Formula for solution providing trace elements.

Salt (Chemical Grade)	**Nutrients**	**Amount water to add to 1 level tsp salt**	**Amount to use for 25 gal. solution**
Boric acid, powdered	Boron	1/2 gal.	1/2 pint
Manganese chloride ($MnCl_2 4H_2O$)	MnCl	1 1/2 gals.	1/2 pint
Zinc sulfate ($ZnSO_4 7H_2O$)	Zinc Sulfur	2 1/2 qts.	1/2 tsp.
Copper Sulfate ($CuSO_4 5H_2O$)	Copper Sulfur	1 gal.	1/5 tsp.
Iron tartrate (chelated Fe330)	Iron	1 qt.	1/2 cup
Mo trioxide (MoO_3)	Molybdenum	1 qt.	1 oz.

Table 3. Cornell Peatlite Mix

Material	**Amount**
Shredded sphagnum peat moss	11 bushels
Horticultural vermiculite	11 bushels
Dolomite	12 pounds
Calcium sulfate (gypsum)	5 pounds
Superphosphate	2 pounds 20%
Calcium or potassium nitrate	1 1/2 pounds
Iron (chelated Fe330)	1 ounce
Fritted Trace Elements	6 ounces