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HYDROPONICS

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Figure 1. This typical hydroponic pot contains gravel and fits into the larger pot, which contains the solution.

Figure 2. In this large-scale hydroponic operation, tomato plants in long, narrow beds are supported with twine strung from a wooden frame at each end of the bed.

Hydroponics is the culture of plants in nutrient solutions. Controlled applications of a properly balanced, diluted nutrient solution are made at regular intervals to meet plant needs for nutrients and water. This results in uniformly high-quality produce—in taste, appearance, and nutritional content.

The United States Armed Services use hydroponic gardens to provide fresh produce on isolated islands. Hydroponics is suitable for use by homeowners and amateur gardeners as well as commercial growers. It is an interesting and rewarding hobby or occupation.

WHERE TO USE HYDROPONICS

Hydroponics allows for crop production where good soil is unavailable, maintenance of favorable soil conditions is too expensive, or cultivation of high-value crops out of season is desired. The hydroponic installation may be placed on any suitable site without regard to soil fertility.

Hydroponics may be used where adequate supplies of good water are available but where soil is not available—in apartments, for example. Hydroponics may be used where soilborne diseases may be transmitted to humans from soil-grown crops. It also provides physical and occupational therapy for those who are handicapped.

Hydroponic installation may be small, simple, and inexpensive to large, elaborate, and expensive (Figs. 1 and 2).

LIMITATIONS OF HYDROPONICS

Hydroponic systems are relatively expensive,

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requiring proper preparation of containers, good-quality water, careful maintenance of the pH of the nutrient solution,* careful monitoring of the nutrient solution, and either changing or adding additional nutrients to meet the needs of the plants.

Sanitation practices are required to eliminate toxic substances from the containers or solution. Control of disease and insect pests is necessary. In Hawaii, wind protection is required to reduce evaporation of the solution and prevent mechanical damage to the plants.

Intensive labor is required to promote and maintain proper conditions for crop production.

PLANTS THAT CAN BE GROWN HYDROPONICALLY

Tomatoes, eggplants, peppers, cucumbers, green onions, chrysanthemums, geraniums, zinnias, poinsettias, begonias, African violets, and many other vegetable, ornamental, and spice crops have been successfully grown hydroponically. It is possible to double-crop to some extent; for example, a crop of lettuce, radishes, or other quick-growing plants can be harvested before the main crop grows to fill up the area provided. Such plants as tomatoes and cucumbers are transplanted in rows about 2 to 3 feet apart, allowing about 5 square feet per plant. If supported on trellises and allowed to grow 6 to 8 feet high, each plant may yield as much as 30 pounds of harvestable crop in a 6-month period.

HYDROPONIC SYSTEMS

Hydroponic systems can be divided into two basic types, open systems and closed systems. In both systems, nutrients are in intimate contact with the plant roots.

In an open system, the nutrient solution is not saved for recycling onto the same crop. Generally, the system includes a growing bed, a nutrient-holding tank, a pump, a time clock to activate the pump, a sprinkler or drip distribution system, and a growing medium. The distribution of nutrients in a dry form followed by irrigation is considered a type of open system. In this case, the only difference from conventional growing is that a substitute for soil is used.

In a closed system, the nutrient solution is recycled and reused. The materials are similar or the same as those required for an open system. The growing bed, however, must be constructed so that the nutrient solution quickly drains back into the holding tank for reuse. The total liquid system has the roots suspended in a nutrient tank without a growing medium, thereby constantly exposing every root to the nutrient solution. Wood and wire frames are used to physically support the plants over the nutrient tank. Small plants can be stabilized in floating styrofoam 1 to 2 inches thick. The solution must be agitated or otherwise aerated. For the amateur, a fish aquarium can work very well.

Closed systems are more expensive to build because they require leakproof beds and flumes for nutrient solution transport. Growing beds may be made of fiberglass or of wood lined with two layers of a heavy-gauge plastic film. Fiberglass is more permanent, but plastic film is less expensive. Growing beds can be made to any convenient size. If the crop to be grown is a low, flowering plant, the bed may be somewhat wide, provided it is convenient to reach the middle from either side. If tomatoes are to be grown, narrower beds—only wide enough for two rows of plants—are preferred, since it is difficult to prune and train interior rows.

Plants grown hydroponically are more vulnerable to extremes in weather due to greater and faster fluctuations in temperature and dilution of the nutrient solution. Because hydroponic systems are more expensive and sophisticated than conventional framing, they must be protected and sheltered for maximum performance. Plastic, fiberglass, or conventional glass greenhouses can be used, or a more simple roof may be enough for rain protection with some screening to keep out birds and large insects and provide wind protection. Several companies sell greenhouses complete with hydroponic growing beds.

MEDIA SUITABLE FOR HYDROPONICS

Suitable media include coarse sand, silica-gravel, granite, basalt, smooth inert riverbed gravel,

*** For the pH range most suitable for the crop to be grown, see "The pH Preference of Plants," General Home Garden Series No. 18, available from the University of Hawaii Cooperative Extension Service.**

cinder, vermiculite, perlite, and styrofoam. Vermiculite, an expanded mica material, is often used because it is relatively inert and has greater water- and nutrient-holding capacity. Consequently, it is easier to overirrigate vermiculite than most other media. It is particularly important in closed systems that the medium be free of salts and soluble alkaline materials; otherwise, plants may experience toxicities. Tanks, pumps, and pipelines will also accumulate sludge or particulates, reducing their effectiveness. Closed systems flooded from the bottom are limited to media with aggregate sizes that will both flood and drain readily. Aggregates of 1/4 to 3/8 inch are best. Larger aggregates will dry out too soon and smaller ones do not allow rapid drainage, resulting in poorly aerated root systems. Open systems may use a wider range of aggregate sizes, as small as 1/8 inch but no larger than 3/8 inch.

FORMULAS FOR NUTRIENT SOLUTIONS

The following are several solutions that may be used in hydroponic culture:

Major Nutrient Solutions

Type I—for flowers, tomatoes, and cucumbers.

	For flowers and tomatoes	For cucumbers
	ounces/100 gallons	
Sodium nitrate	6.2	12.4
Potassium sulfate	20.1	26.8
Calcium sulfate	5.1	5.1
Magnesium sulfate	7.2	7.2
Monocalcium phosphate	7.2	4.2
Ammonium sulfate	1.9	3.8

Add a 0.5 percent solution of iron sulfate, iron tartrate, or iron chelate at the rate of 14.3 ounces per 100 gallons of nutrient solution once or twice a week or as the appearance of the plant indicates need.

Type II—for general use.

	ounces/100 gallons
Monopotassium phosphate	2.0
Potassium nitrate	8.0
Calcium nitrate	12.0
Magnesium sulfate	10.0

Iron should also be added to this solution.

Micronutrient Solutions

The major nutrient formulas do not supply the micronutrients needed by the plants. It is necessary to make a micronutrient solution, as follows, which is to be added at the rate of 0.8 pint or 12.8 ounces per 100 gallons of major nutrient solution when the latter is being made up or changed.

	ounces/100 gallons
Boric acid	38.0
Manganese chloride	24.0
Zinc sulfate	3.0
Copper sulfate	1.0
Molybdic acid	0.32

The chelated form of manganese may be substituted for the manganese chloride.

Technical-grade salts are best, as many of the fertilizer-grade salts are insoluble or only partially soluble in water. Mix the salts in the order given for best results. Micronutrient concentrates are available commercially.

Level of pH has a great influence upon the availability of nutrients to the plant. Great fluctuation in pH will precipitate some plant nutrients or change their form, making them unavailable to the plant. In addition, rapid or wide fluctuation in pH will cause serious physiological problems in the plant, resulting in poor growth or quality. Test pH frequently and adjust as necessary by the addition of an acid such as phosphoric acid or a base such as calcium hydroxide. These should be added in small quantities and the solution tested after each addition until the desired pH is obtained.

PESTS

Whenever possible, select crop varieties that have been bred for genetic resistance to insects, mites, viruses, and other plant pests. The University of Hawaii develops and sells seeds of assorted vegetable varieties that have resistance or tolerance to specific diseases and are culturally adapted to Hawaii's climatic conditions. The use of pest-resistant or pest-tolerant varieties in a properly managed hydroponic system will result in vigorous plant growth that is not easily invaded by pests or diseases. As a result, little or no pesticide will be required for adequate crop protection.

Leaf mold (*Cladosporium*), grey mold (*Botrytis*), and root rot (*Pythium*) are diseases often encountered on tomatoes, other vegetables, and ornamentals. Keeping the humidity below 75 percent through manipulation of air movement and temperature will help control the mold diseases. Some measure of control can be obtained for most pathogenic diseases by sanitation. Rigid sanitation procedures should be adopted to eliminate disease sources and the possibilities of infection.

Plants may be attacked by several insects. Your county agricultural agent and garden supply dealer can advise you on selection of the appropriate chemical control. Follow the manufacturer's directions very carefully.

Blossom-end rot is a physiological disorder of tomatoes caused by nutritional imbalance in the plant. Excess nitrogen and potassium or a deficiency of calcium may contribute to this problem.

IMPORTANT CONSIDERATIONS IN USING HYDROPONICS

The first consideration is the size of your operation. It may vary from a single small container to many large beds. Larger operations require greater amounts of capital to establish and maintain. They have a greater need for competent supervision and labor, but they provide greater economic returns.

Plant protection must be considered. In Hawaii, shade will be needed at low elevations. Wind protection will be needed in exposed areas. Protection from disease and insects will be required. Protection also is needed from rain to prevent loss of quality and dilution of the solution.

The containers and the solution must be free of toxic substances such as lime, excess salts, and so on.

Adequate support must be provided for the aerial portion of the plant, using stakes, wire supports, trellises, or similar methods.

An adequate reservoir is required for the nutrient solution to prevent contamination and to help maintain the strength and balance of the solution.

A source of good water is necessary to make solutions, flush containers, and clean equipment. Clean water results in better sanitation.

There is little buffering in hydroponic solutions. This results in rapid changes in the pH of the solution, often promoting poor conditions for plant growth. Care is required in providing and monitoring a solution of the correct levels of plant nutrients and pH for plant growth.

Precautions must be taken to provide adequate aeration for plant growth. Poor root aeration is the most frequent cause of failure in growing plants hydroponically.

REFERENCES

Growing plants without soil. 1981. University of Hawaii Cooperative Extension Service, Circular 440. 20 pp.

The pH preference of plants. 1976. University of Hawaii Cooperative Extension Service, General Home Garden Series No. 18. 2 pp.

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