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HYDROPONICS

Many people think of hydroponics as growing plants in water, but hydroponics production actually is defined as growing plants without soil. This production system may use a wide variety of organic and inorganic materials. The nutrient solution, rather than the media in which the plants are growing, always supplies most of the plant nutrient requirements. This method of growing has also been referred to as *nutrient-solution culture, soil less culture, water culture, gravel culture* and *nutriculture.*

Hydroponics culture is not new. One of the first experiments in water culture was made by Woodward in England in 1699. By the mid-19th century, Sachs and Knop, the real pioneers in the field, had developed a method of growing plants without soil. The term "hydroponics" was first used by Dr. W. F. Gericks in the late 1930s to describe a method of growing plants with roots immersed in an aerated, dilute solution of nutrients.

Today, hydroponics is used in commercial greenhouse vegetable production around the world. There are several advantages to hydroponics culture with some problems. In automated hydroponics culture, some of the watering and fertilizer additions can be computerized, reducing labor input.

Liquid (Non-Aggregate) Hydroponics Systems

In this system, no rigid supporting medium for the plant roots is used. Liquid systems are, by their nature, closed systems; the plant roots are exposed to the nutrient solution, without any type of growing medium, and the solution is recirculated and reused.

Nutrient Film Technique (NFT)

This hydroponics system was developed during the late 1960s by Dr. Cooper at the Glasshouse Crops Research Institute, Little Hampton, England. The principle of the NFT system is to provide a thin film of nutrient solution that flows through either black or white-on-black polyethylene film liners supported on wooden channels or some form of PVC piping which contains the plant roots. The walls of the polyethylene film liners are flexible, permitting them to be drawn together around the base of each plant, which excludes light and prevents evaporation.

The nutrient solution is pumped to the higher end of each channel and flows by gravity past the plant roots to catchment pipes and a sump. The solution is monitored to determine the need for replenishment of salts and water before it is recycled. A capillary mat in the channel prevents young plants from drying out, and the roots soon grow into a dense, tangled mat. A principal advantage is that a greatly reduced volume of nutrient solution is required, and this system is more easily heated during winter months or cooled during hot summers to avoid bolting and other undesirable plant responses.

The slope of the channels in NFT needs to be approximately 3 inches per 100 feet. Slopes less than that are not sufficient. Depressions in the channel must be avoided, or puddling of the solution will lead to oxygen depletion and growth retardation. A cold nutrient solution will prevent plant uptake of nutrients. By heating the nutrient solution, growers can lower greenhouse night air temperatures without adversely affecting crop yield and total value. Crops also benefits from a heated solution, especially when plants are small and close to the solution.

The NFT system also allows for economical cooling of plant roots, avoiding more expensive cooling of the entire greenhouse.

Aggregate Hydroponics Systems

Aggregate systems such as vertical or flat plastic bags are "open" and the solution is not recirculated, while porous horticultural grade rockwool may be "open" or "closed." In a "closed" rockwool system the excess solution is contained and recirculated through the system. Not reusing the nutrient solution means there is less sensitivity to the composition of the medium used, or to the salinity of the water.

Bag Culture

In bag culture, the growing mix is placed in plastic bags in lines on the greenhouse floor. The bags may be used for at least two years, and are much easier and less costly to steam-sterilize than soil. Bags are typically made of UV-resistant polyethylene, with a black interior, and generally last for two years. The exterior of the bag should be white in regions of high light intensity levels, to reflect radiation and inhibit heating the growing medium. Conversely, a darker exterior color is recommended in low-light latitudes to absorb winter heat. Growing media for bag culture may include peat, vermiculite, or a combination, with perlite is sometimes added to reduce cost. Examples of lay-flat bags are Plant-in-Bags and Fertile-Bags. Bags are placed on the greenhouse floor at normal row spacing for the crop. It is beneficial to first cover the entire floor with white polyethylene film, increasing the amount of light reflected back into the plant canopy. A covering may also reduce relative humidity and the incidence of some fungal pathogens.

Paired rows of bags are usually placed flat, about 5 feet apart (from center to center), with some separation between bags. Holes are made in the upper surface of each lay-flat bag for transplants, and two small slits are made low on each side for drainage or leaching. The soil in the bag is moistened before planting. Drip irrigation with nutrient solution is recommended. A capillary tube should run from the main supply line to each plant. Moisture conditions near the bottom of the bagged medium should be examined frequently. It is normally best to be on the wet side, rather than dry.

Rockwool Culture

The use of horticultural rockwool as a growing medium in open hydroponics systems has been increasing rapidly. This technology is the primary cause of rapid expansion of hydroponics systems. Rockwool was first developed as an acoustical and insulation material. It is made from a mixture of diabase, limestone and coke, melted at a high temperature, extruded in small threads, and pressed into lightweight sheets. Insulation rockwool and fiberglass batting are not appropriate for use in horticulture. For use as a growing medium, rockwool must first be modified by a special proprietary process.

As a growing medium, rockwool is not only relatively inexpensive, but is also inert, biologically non-degradable, takes up water easily, is approximately 96 percent "pores," or air spaces, has evenly sized pores (important for water retention), lends itself to simplified and lower-cost drainage systems, and is easy to heat during winter. It is so versatile that rockwool is used in plant propagation and potting mixes, as well as in hydroponics.

In "open" rockwool hydroponics systems, plants are usually propagated by direct seeding in small rockwool cubes with a hole punched in the top. The cubes are saturated with nutrient solution and are usually transplanted into larger rockwool cubes manufactured specifically to receive the germinating cubes, and side-wrapped with black plastic film. The large cubes are then placed atop rockwool slabs on the greenhouse floor. The slabs are usually 6 to 12 inches wide, 29 to 39 inches long, and 3 inches thick.

The greenhouse floor is covered with white polyethylene film for sanitation and light reflection. A bed normally consists of two rows of rockwool slabs, each wrapped in white film, in rows spaced 12 inches apart. The slabs should have a slight inward tilt toward a central drainage channel. If bottom heat is required, the slabs are placed on polystyrene sheets, grooved in the upper surface to accommodate hot water pipes.

Due to the porosity of the rockwool, and given an appropriately modest irrigation schedule, almost all the solution remains in the slab for plant use. If there is a surplus, it will drain out of the slab and into the shallow channel. Before transplanting, the rockwool slabs are soaked with nutrient solution. The plant remains in the small rockwool cubes in which it was established. Plants are set along the slabs through holes cut in the plastic film. If a root system is well developed in the cubes, roots will move into the slab within two or three days. Each plant receives nutrient solution through individual drippers, with irrigation rates varying by plant demand and environmental conditions.

The advantages of the rockwool system are:

1) Rockwool is lightweight when dry, and is easily handled.

2) It is simple to bottom-heat.

3) It permits accurate and uniform delivery of the nutrient solution.

4) It uses less equipment and has lower fabrication and installation costs; and there is less risk of crop failure due to the breakdown of pumps and recycling equipment.

The disadvantage is that rockwool may be:

1) Relatively costly, unless manufactured nearby.

Nutritional Disorders

Nutritional disorders are plant symptoms or responses that result from too much or too little of specific nutrient elements. Generally, there are no nutritional disorders unique to hydroponics. Plants are more likely to experience nutritional disorders in a closed hydroponics system than in an open system. In a closed system, the levels of impurities or unwanted ions in the recycled liquid, or from the chemicals used, may more easily destroy the balance of the formulation and accumulate to toxic levels.

The most common nutritional disorders in hydroponics systems are caused by:

1. High levels of ammonium (NH4). This causes various physiological disorders in many crops, and is avoided by supplying no more than 10 percent of the necessary nitrogen from ammonium.

2. Low levels of potassium (less than 100 ppm in the nutrient solution) can affect tomato acidity and reduce the percentage of high-quality fruit.

3. Low levels of calcium. This induces blossomed rot in tomatoes.

4. Zinc toxicity, caused by dissolution of the elements from galvanized piping used in the irrigating system. It is avoided by using plastic or other non-corrosive materials.

Symptoms of Plant-Nutrient Deficiencies

Plants usually display characteristic symptoms if nutrients are not present in adequate amounts. Below is a guide to the symptoms that may occur if the level of one mineral nutrient is below the range needed for best plant growth. There may be other reasons, such as ratio of nutrients that may cause a plant to display a definite symptom. If one of the deficiency symptoms occurs, however, a lack of the proper nutrient may be suspected, and the amount of that nutrient increased. Nutrient-related disorders of crop plants can be avoided if crops are closely observed and the composition of the nutrient solution adjusted, particularly in closed systems.

Deficient Nutrient	Symptoms
Nitrogen	Leaves are small, light green; lower leaves lighter than upper; weak stems.
Phosphorus	Dark-green foliage; lower leaves sometimes yellow between veins; purplish color on leaves or petioles.
Potassium	Lower leaves may be mottled (light to dark blotches); dead areas near tips and margins of leaves; yellowing at leaf margins continuing toward center.
Calcium	Tips of shoot die; tips of young leaves die; leaf tips are hook-shaped.
Magnesium	Lower leaves are yellow between veins (veins remain green); leaf margins may curl up or down or leaves may pucker; leaves die in later stages.

Sulfur	Tip of the shoot stays alive; light-green upper leaves; leaf veins lighter than surrounding areas.
Iron	Tip of shoot stays alive; new upper leaves turn yellow between veins (large veins remain green); edges and tips of leaves may die.
Manganese	Tip of the shoot stays alive; new upper leaves have dead spots over surface; leaf may appear netted because small veins remain green.
Boron	Tip of shoot dies; stems and petioles are brittle.

Advantages of Hydroponics

- Land is not necessary. It can be practiced even in upstairs, open spaces and in protected structures.
- Clean working environment. The grower will not have any direct contact with soil.
- Low drudgery. No need of making beds, weeding, watering, etc.
- Continuous cultivation is possible.
- No soil borne diseases or nematode damage.
- Off-season production is possible.
- Vegetable cultivation can be done with leisure sense.
- Many plants were found to give yield early in hydroponics system.
- Higher yields possible with correct management practices.
- Easy to hire labour as hydroponics system is more attractive and easier than cultivation in soil.
- No need of electricity, pumps, etc. for the non-circulating systems of solution culture.
- Possibility of growing a wide variety of vegetable and flower crops including Anthurium, marigolds, etc.
- Water wastage is reduced to minimum.
- Possible to grow plants and rooted cuttings free from soil particles for export.

Limitations of Hydroponics

- Higher initial capital expenditure. This will be further high if the soil-less culture is combined with controlled environment agriculture.

- High degree of management skills is necessary for solution preparation, maintenance of pH and Ec, nutrient deficiency judgment and correction, ensuring aeration, maintenance of favourable condition inside protected structures, etc.

- Considering the significantly high cost, the soil-less culture is limited to high value crops of the area of cultivation.

- A large-scale cultivator may have to purchase instruments to measure pH and Ec of the nutrient solution.

- Energy inputs are necessary to run the system.

- Yields were found to decrease when temperature of the solution rises during warm periods.

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