Hydroponic Systems and Techniques

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Introduction

Hydroponics is a practice of growing plants in nutrient solutions with or without use of medium such as gravel, vermiculite, rockwool, peat moss, saw dust, coir dust, coconut fibre, etc. to provide mechanical support. In the year 600 B.C.E., the climate was arid and dry along the Euphrates River in Western Asia, but there were lush gardens climbing up the walls of the metropolis, Babylon. It is believed that the Hanging Gardens of Babylon were surviving through a pulley-system of water from the river, a technique of agricultural that today is known as hydroponics. More specifically, hydroponics is the method of farming where plants can be grown in nutrient-fortified water, instead of in soil. Given concerns of feeding a growing human population in a changing climate, scientists believe hydroponic technology may be able to mitigate impending food shortages. The United Nations (UN) has projected the global population to reach nearly 10 billion people by 2050, with "roughly 83 million people being added to the world's population each year until then." In 2019 alone, an estimated 124 million people faced acute food shortages from climate-related events such as flooding, irregular rains, droughts, and high temperatures. Given that hydroponics can grow food in a controlled environment, with less water and in higher yields, the Food and Agriculture Organization of the United Nations has been implementing hydroponic farming in areas of the world that suffer from food shortages. There are currently ongoing projects to establish large hydroponic farms in Latin American and African countries.

In the 19th century, a German botanist at the University of Wurzburg, Julius Sachs, dedicated his career to understanding the essential elements that plants need to survive. By examining differences between plants grown in soil and those grown in water, Sachs found that plants did not need to grow in soil but only needed the nutrients that are derived from microorganisms that live in the soil. In 1860, Sachs published the "nutrient solution" formula for growing plants in water, which set the foundation for modern day hydroponic technology (Trejo and Gomez, 2012).

Hydroponics became popularized in 1920s when Dr. William F. Gericke, University of California put laboratory experiments in plant nutrition on a commercial scale. He termed the these nutri-culture systems Hydroponics. The word was derived from the Greek words, Hydro (Water) and Ponos (labour) literally "Water Working". In 1937, an American scientist, Dr. W.E. Gericke described how this method of growing plants could be used for agricultural purposes to produce large amounts of crops. Gericke and others demonstrated that the fluid dynamics of water changed the architecture of plant roots, which allowed them to uptake nutrients more efficiently than plants grown in soil, causing them to grow larger in a shorter amount of time. Since then, scientists have optimized the nutrient solution, a total of 13 macronutrients and micronutrients (showing in above figure), that are added to water for hydroponic farming.

Basic requirement

The basic requirement for successful hydroponic are

1. Root aeration: root environment must be aerated to anaerobic respiration.
2. Root darkness: darkness around the roots to eliminate algae growth.
3. Physical support: for holding plants erect in water.
4. Nutrient supply

Advantages

- Automation is possible Plants are healthier and reach maturity faster.
- Weeds are eliminated.
- Soil-borne pests and diseases are eliminated (Shrestha and Dunn, 2013).
- Indoor gardens grown using full-spectrum horticultural lighting.
- Grow, bloom and boost formulas used at the appropriate growth stage.
- Nutrients precisely controlled. θ Higher yields achieved in a smaller space.

Disadvantages (Ikeda *et al*., 2002)

- Some water borne diseases can spread rapidly in recirculation system
- Specially formulated, soluble nutrients must always be used.
- Daily attention is necessary.
- A high level of expertise is required.
- Production is management, capital and labour intensive.
- Cost of initial investment

Types of hydroponic system

1. **Wick system**

It is the most simple and basic form. It is a passive system *i.e.* it contains no moving parts. Easier to establish and cheaper. Consists of parts like, grow tray, reservoir, wick and aeration system. Wicks are used to transport nutrition solution to the roots of plants in grow tray through capillary action. Aeration system is required to maintain level of oxygen in nutrition solution which is useful for the health of plants.

2. **Water culture**

Simplest of all active hydroponic systems. Roots of plants are in direct contact with nutrient solution. Floating platform generally made up of Styrofoam and is used to hold plants. It consists of air pump, airline, air stone for supply of oxygen. Fast growing water loving plants like lettuce, herbs are ideal choice.

3. **Ebb and flow**

As the name suggests, this system follow a continuous process of flowing nutrient solution to the roots and then falling back from the flood stage to the reservoir with certain period of time. The time period depends on type of plants, temperature and humidity and the type of growing medium used. Solution is flooded using water pump and drained out using drain tube. Main drawback is there is vulnerability to power outages and pump failures. The roots can dry out quickly when the watering cycles are interrupted.

4. **Drip system**

Drip system of hydroponics is divided into two methods, based on water back flow from reservoir tank.

i. Recovery drip system and ii. Non- recovery drip system.

i. Recovery drip system: This is the most commonly used type of drip growing system for home growers. This is because recirculating or recovery drip system collects back the nutrient solution that runs off into the water reservoir so that it may be used again. Thus, this type of drip system uses water more efficiently. Aside from that, this system works well even with an inexpensive timer since this doesn't require exact control of the watering cycles. However, same as the other hydroponic system that recirculates, a recovery drip system's nutrient solution may change both the pH and nutrient strength levels. This is because the plants use up the water's nutrients when it circulates repeatedly. Hence, there's a need to periodically check the system, adjust the pH when needed, and change the nutrient solution regularly for the plants to have a balanced nutrient solution.

ii. Non- recovery drip system: This is the kind of drip system that is used mostly by commercial growers. Though this does not reuse runoff water like the recovery system, non-circulating actually saves. This is because they require precise control of the watering cycles. With the use of the system's special cycle timers, they adjust the watering times to ensure that the plants get enough nutrient solution, as well as to avoid having much runoff. Unlike the recirculating system, non-recirculating doesn't require heavy maintenance. Since this doesn't collect back the runoffs, then the reservoir may be filled with balanced pH and nutrient solution. Thus, this doesn't require regular monitoring. However, there's still a need to keep the water circulating or moving in the reservoir for the heavy minerals not to settle at the bottom. This will keep a balanced pH adjusted nutrient solution.

5. **NFT (Nutrient film technique)**

Plants roots are placed in a shallow stream of re-circulating water containing dissolved nutrients. Plants produce a thin root mat, part of which is located above the solution. Because the roots are only partially submerged, plants are never in danger of the consequences of water logging.

Advantage: There is no need of pasteurization, the plastic film, used for lining is removed after each production cycle. No growing medium other than air. Plant is supported in a small plastic basket with the roots dangling into the nutrient solution. The nutrient solution is pumped into the growing tray (usually a tube) and flows over the roots of the plants, and then

drains back into the reservoir. Constant flow of nutrition solution so no timer required for the submersible pump. **Disadvantage:** The high probability of pythium infestation. Very susceptible to power outages and pump failures. The roots dry out very rapidly when the flow of nutrient solution is interrupted

6. Aeroponics

Aeroponics is the process of growing plants in an air or mist environment without the use of soil or an aggregate medium. The word aeroponic is derived from Greek words 'Aero' means air and 'ponos' means labour. It is the most high-tech type of soilless culture. In aeroponic system the roots hang in the air and are misted with nutrient solution. The misting is usually done every few minutes, because if the roots are exposed to the air, they will dry out rapidly if the misting cycles are interrupted. **Advantages:** The crops mature faster, which means there will be more harvests. Plants are not exposed to soil disease, so pesticide is needed. Crops are grown closure together, so more crops can be grown (AlShrouf, 2017). **Disadvantages:** Maintenance of an aeroponics farm very expensive. Many consumers believe that aeroponically grown plants are not as nutritious as other grown plants. Costly to set up

Future scope of this technology:

Hydroponics is the fastest growing sector of agriculture, and it could very well dominate food production in the future. As population increases and arable land declines due to poor land management, people will turn to new technologies like hydroponics and aeroponics to create additional channels of crop production. In Tokyo, land is extremely valuable due to the surging population. To feed the citizens while preserving valuable land mass, the country has turned to hydroponic rice production. The rice is harvested in underground vaults without the use of soil. Because the environment is perfectly controlled, four cycles of harvest can be performed annually, instead of the traditional single harvest. Hydroponics also has been used successfully in Israel which has a dry and arid climate. A company called Organitech has been growing crops in 40-foot (12.19-meter) long shipping containers, using hydroponic systems (Sagar *et al.*, 2018). They grow large quantities of berries, citrus fruits and bananas, all of which couldn't normally be grown in Israel's climate. The hydroponics techniques produce a yield 1,000 times greater than the same sized area of land could produce annually.

Most Profitable Hydroponic crops (Bulgari *et al.*, 2016)

Below are the profitable crops for commercial hydroponic farming in India.

- Microgreens
- Lettuce
- Basil
- Radishes
- Sweet Bell Peppers
- Herbs
- Flowers
- Straw berry

Conclusion

Hydroponics is an age-old method which is getting lime-light again as it is a promising technological solution to the problems faced by current agricultural system. Hydroponics may be used in underdeveloped countries for food production in limited space. It is even feasible to grow hydroponically in areas of poor soil conditions such as deserts. It has many pros but major drawback is its high capital investment and needs clear knowledge. With the help of this technique, the demand and supply gap can be filled providing fresh and better quality also consistency can be maintained.

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