Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 04, Issue: 01 (JAN-FEB, 2024)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

# Hydroponics: A Technology for Sustainable Food Production

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## Abstract
Providing nutritious food to over 1.6 billion people by 2025 will be a difficult task due to challenges such as increasing population, limited land and water resources, urbanization, industrialization, and global warming. Open field agricultural systems are also threatened by various biotic and abiotic stresses worldwide. To address this problem, soilless culture, which involves growing crops without soil using different types of growing media, is a promising alternative. Soilless media offer several advantages, including significant water savings of up to 85-90% through recycling, higher crop yields compared to traditional cultivation methods, and minimal environmental pollution. Hydroponics is one of the successful techniques that have emerged in recent years. Plants grown in soilless culture exhibit superior quality, high yield and nutrient-rich content and can be harvested quickly.

**Keywords**: Hydroponics, Soilless cultivation and biotic and abiotic stresses.

## Introduction
Soil serves as a natural medium for plant growth, providing support, nutrients, water, and other essentials for plants to develop. However, there are limitations to plant growth in soil due to various factors, such as the presence of diseases and insects, poor drainage, erosion, and unsuitable soil conditions like high pH or acidity (Ellis *et al*., 1974). In urban and peri-urban areas, accessing cultivable land for crops can be challenging, leading to a shortage of arable land. This poses a problem in providing nutritious food for the growing population. In such circumstances, soilless culture can be an effective solution (Butler and Oebker, 2006). Hydroponics is a method of growing plants without soil, usually using water or other soil-less materials. This technology allows plants to absorb nutrients in a balanced solution, providing all the necessary elements for their growth. Many farmers, entrepreneurs, and professionals in peri urban and urban areas around the world use hydroponics to grow vegetables, flowers, seedlings, and herbs. Hydroponics is a widely used method in precision farming and protected cultivation. Its main advantage lies in the ability to have a consistent supply of healthy and safe produce throughout the year. As a result, more and more growers and professionals are embracing hydroponics in various settings such as home gardens, rooftops, balconies, and traditional farms. However, the lack of technical expertise, systematic protocols, proper management of inputs, and plant protection measures have hindered the widespread adoption and popularity of hydroponics.

## Classification of hydroponics cultivation
Hydroponics cultivation can be classified based on the type of substrate and container used, as well as the method of nutrient delivery to the plants and drainage system.

**1. Solution culture or liquid hydroponics:** It is based on the solution culture, also known as liquid hydroponics. Solution culture involves growing plants in a fully liquid medium contained in a pipe or suitable container. This can be further divided into circulating methods and non-circulating methods.

**a. Circulating methods (closed system):** In a closed system where nutrients are circulated, the solution moves around the plant's roots and can be gathered, replaced, and reused as required by the plant. This circulation can be achieved through methods like nutrient film technique (NFT) and deep flow technique (DFT).

**i. Nutrient Film Technique (NFT):** The nutrient film technique is a method used in hydroponics, where the roots of plants are in direct contact with a thin film of nutrient solution flowing through a channel. This channel is usually made of flexible PVC or plastic sheeting and it helps to support seedlings that are placed in customized pots filled with growing media. As the nutrient solution flows through the channel, the plant roots absorb it through their porous roots. (fig. 1)

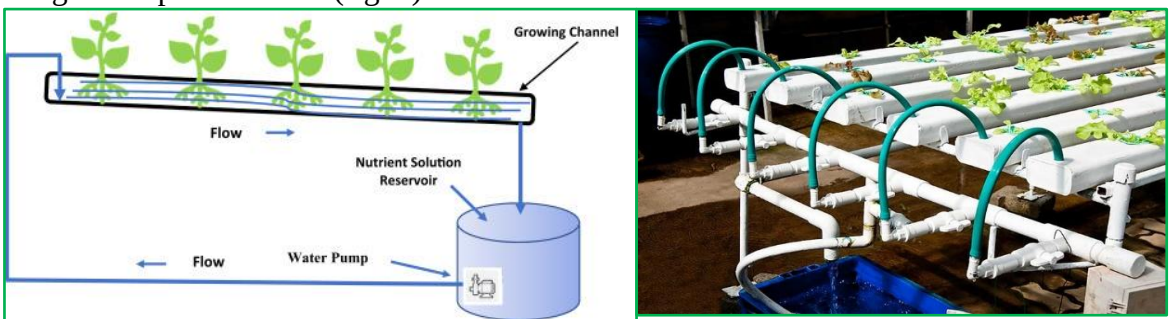


**Figure 1: Nutrient Film Technique (NFT)**

**ii. Deep Flow Technique (DFT):** The Deep flow technique is a type of hydroponics system that involves the continuous flow of a nutrient solution through PVC pipes. Plastic pots are used to hold the plants and are connected to the PVC pipes at regular intervals. The main and sub-main pipes are elevated on a platform inside a protected structure (as shown in figure 2). Various equipment such as pumps, tanks, valves, timers, and nutrient monitoring systems are placed on the floor of the protected structure. The PVC pipes can be arranged in a single flat plane or in multiple vertical planes in a zigzag pattern.

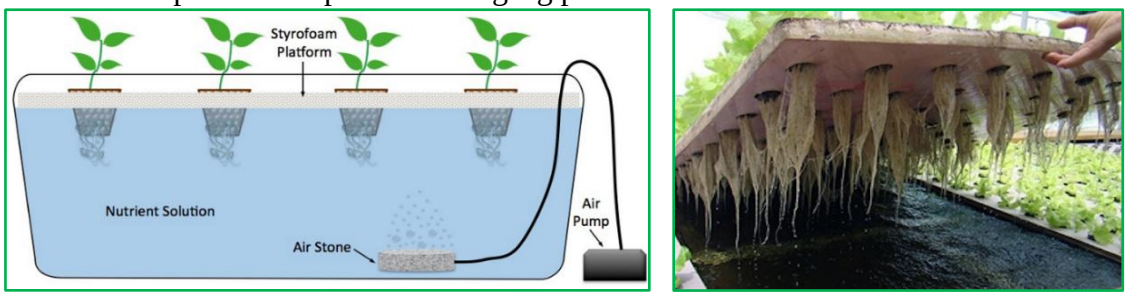


**Figure 2: Deep Flow Technique (DFT)**

**b. Non-circulating method (open systems):** Non-Circulating open system refers to a system in which the nutrient solution is not continuously circulated but instead utilized for a prolonged period based on the solution's EC and pH levels. This approach incudes three methods: root dipping, floating, and capillary action.

**i. Root Dipping Technique**: This method consists of cultivating plants in small containers filled with growing material (fig.3a). The lower portion of the containers, about 2-3 cm, is placed in the nutrient solution, enabling the roots to hang in the air while being submerged. This approach is cost-effective, and simple to establish.

**ii. Floating Technique**: The Floating Technique is a method that resembles the box technique, but it involves using shallow containers that are only 10 cm deep. In this technique, plants are placed in small pots and attached to a buoyant material such as

Styrofoam, enabling them to float on the nutrient solution in the container (fig.3b). To maintain optimal conditions, the solution needs to be artificially aerated.

**iii. Capillary Action Technique**: This technique involves using pots of various shapes and sizes filled with a highly porous substance like a mixture of old coil dust and sand or gravel (fig.3c). The pots absorb the nutrient solution through capillary action, aided by artificial aeration. This method is well-suited for nourishing indoor plants and decorative flowers.

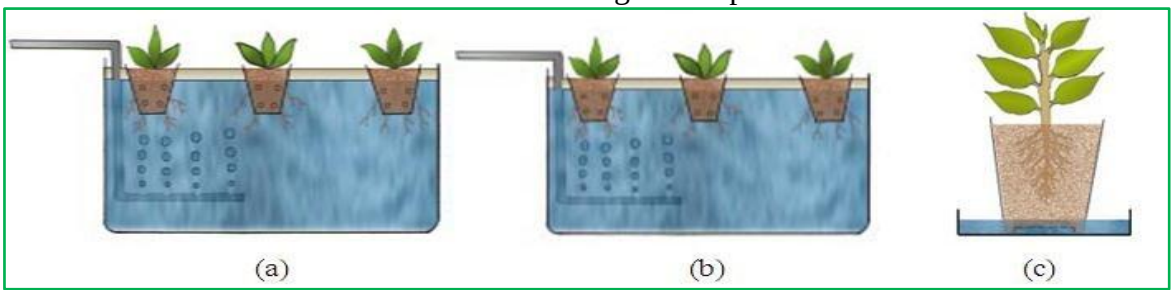


**Figure 3: Different non-circulating methods (a) Root dipping technique, (b) Floating technique, (c) Capillary action technique**

**2. Solid media culture (Aggregate systems):** Sterilized forms of solid media that have high porosity, improved aeration, high capacity for holding water and air, and effective drainage are utilized for cultivating plants. Some commonly used examples include coco-peat, perlite, vermiculite, vermi-compost, gravel, tur, rockwool, sawdust, coconut fiber, and peat moss. Different techniques such as the hanging bag, grow bag, trench or trough, and pot techniques are employed in aggregate systems.

**a. Hanging bag technique**: The hanging bag technique is a technique where durable bags made of polyethylene are filled with coco peat or coconut fiber and shaped into cylindrical forms. These bags, which are one meter tall, are then vertically suspended and supported from above. A channel is placed underneath the bags to collect the nutrient solution. The bags are equipped with micro sprinklers, which release water and nutrients through small openings, providing the plants inside with the necessary resources. This method is particularly suitable for cultivating lettuce, leafy vegetables, strawberries, and small flowering plants.

**b. Grow bag technique:** This technique involves using UV stabilized polyethylene sheets in the form of bags, to cultivate plants. Depending on the type of crops, these bags are arranged in single or paired rows, with a spacing of 30-60 cm between plants. This technique is widely used due to its affordability. Before placing the grow bags, the entire floor is covered with white UV resistant polythene to ensure sufficient sunlight exposure, reduce humidity, and prevent fungal diseases.

**c. Trench or trough technique:** This technique involves growing plants in sunken channels or containers made from strong materials like PVC or HDPE sheeting, bricks, concrete, or local materials. These channels or containers are filled with different substances, such as organic or inorganic materials, or a combination of coco-peat, sand, perlite, and vermiculite. Watering and fertilizing are done using specialized stake drippers with poly tubes and lateral pipes. Ensuring proper drainage is essential, which can be achieved by creating holes or installing a dedicated drainage pipe.

**d. Pot technique:** The Pot technique is a gardening method that utilizes plastic pots of varying sizes, ranging from 4 to 12 inches in diameter, to cultivate plants. These pots are filled with inert materials such as coco-peat, sand, perlite, vermiculite, or a combination of them. The choice of pot size and growing media depends on the type of plants being grown, with container volumes ranging from 1 to 10 litres.


**Figure 4**: **Different solid media culture method (a) Hanging bag technique, (b) Grow bag technique, (c) Trench or trough technique, (d) Pot technique.**

## Advantages of hydroponics

- Hydroponics in a greenhouse enables efficient crop production by providing the opportunity to grow crops year-round and achieve high yields with improved product quality.
- This method allows for flexibility and intensification of crop production in regions with challenging growing conditions.
- The key benefits of this technology include precise control over water and nutrient supply, pH and root temperature, prevention of soil-borne diseases, reduced labor requirements, and the ability to grow multiple crops in a year.
- This technology is gaining popularity as a substitute for areas with poor soil health and frequent soil-borne diseases.

## Conclusion

Hydroponics is an emerging technology that is gaining traction rapidly. As cultivable or fertile land is decreasing due to urbanization, road construction, over use of pesticides and poor land management *etc*., and increase in population, this is best alternative to meet the demand of the population. This technique also helps with water conservation, making it suitable for areas with water scarcity as water is recycled. Hydroponics is being embraced in protected cultivation, including both advanced glasshouses and simpler greenhouses, using various techniques and media to optimize favourable climate conditions. This method is beneficial for producing high-value, low volume crops in densely populated areas. However, the initial cost of implementing, lack of knowledge, reliable information and inadequate dissemination of technologies is a major constraint in adapting hydroponics cultivations.

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