



Farming Without Soil: The Rise of Hydroponics-Revolutionary Soilless Technique or Future Farming Solution?

*Pooja Tanwar¹, H. N. Leua² and Ramesh Kumar³

¹PG Scholar, College of Horticulture, SDAU, Jagudan, Gujarat, India

²Associate Professor, Dept. of Fruit Science, College of Horticulture, SDAU, Jagudan, Gujarat, India

³PhD Scholar, Dept. of Vegetable Science, SKRAU, Bikaner, Rajasthan, India

*Corresponding Author's email: tanwarpooja95115@gmail.com

Hydroponics is an innovative and scientifically advanced technique of growing plants without the use of soil, where plants are cultivated using a nutrient-rich aqueous solution. Dr. W. F. Gericke coined the term 'Hydroponics' in 1936 and "hydroponics" is derived from the Greek words *hydro* meaning water and *ponos* meaning labour, which together imply "water working." In this system, plants receive all essential nutrients directly through water, eliminating the dependency on soil as a growth medium. The roots of plants may either be fully immersed in the nutrient solution or supported by inert substrates such as perlite, gravel, mineral wool or coconut husk. These materials do not supply nutrients themselves but provide structural support and aeration to the root system. Hydroponics has gained significant importance in recent years due to increasing challenges such as soil degradation, water scarcity, urbanization and the need for sustainable agricultural practices. It represents a shift towards precision farming and controlled environment agriculture.

Historical Background and Development

The concept of hydroponics is not entirely new and can be traced back to ancient civilizations. Early examples of soilless cultivation include the famous Hanging Gardens of Babylon, the floating agricultural systems of the Aztecs and crop cultivation along the fertile banks of the Nile River in ancient Egypt. Scientific development of hydroponics began during the 19th century when French and German scientists conducted detailed studies on plant nutrition. These studies led to the development of "solution culture" techniques, also known as water culture or nutriculture, by scientists such as J.V. Sachs and W. Knop. A major milestone in the advancement of hydroponics was achieved in 1929 when Dr. William F. Gericke of the University of California successfully demonstrated the commercial potential of hydroponics by growing tomato plants up to 7.5 meters in height using nutrient solutions alone. During World War II, hydroponics proved its practical importance when the U.S. Army used this technique to grow fresh vegetables for troops stationed on infertile Pacific islands. This highlighted its potential in areas where traditional agriculture was not feasible.

Basic Requirements for Hydroponic Cultivation

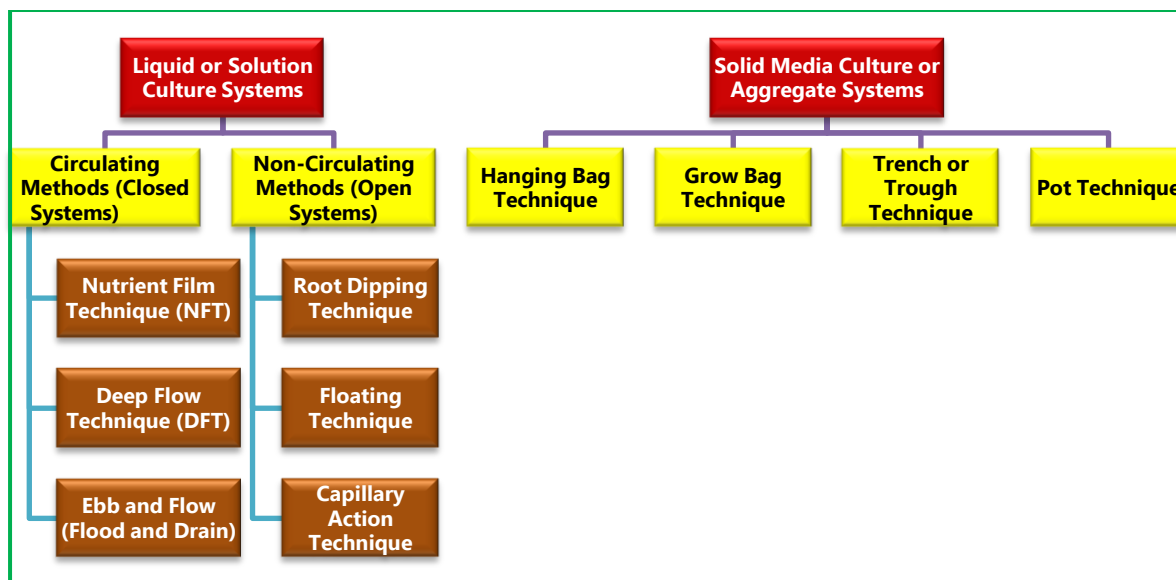
- 1. Water Quality:** It is essential to use clean, contaminant-free water. Testing of water sources is recommended to ensure suitability for irrigation and nutrient preparation.
- 2. Light:** The light requirement varies depending on the crop like fruit crops require higher light intensity while leafy vegetables and herbs require comparatively less. Artificial lighting systems such as fluorescent and LED lights are commonly used in hydroponics. A timer is often employed to regulate light exposure for about 16 to 24 hours per day.

3. Temperature: It affects plant metabolism and growth rate. Cool-season crops like lettuce require temperatures of 65–70°F while herbs and other crops may require slightly higher temperatures.

4. Nutrient Management: Proper formulation and balance of nutrients in solution are crucial, any deficiency or excess can directly affect plant growth and yield.

Classification of Hydroponic Systems

Hydroponic systems can be broadly classified into two major categories:

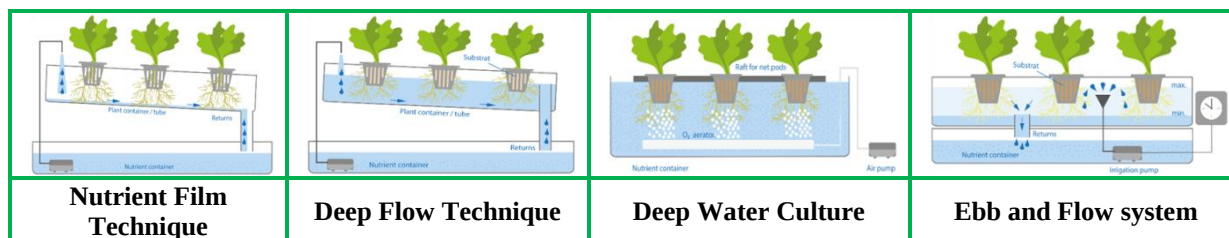


1. Liquid or Solution Culture Systems

In these systems, plant roots are directly exposed to the nutrient solution without the use of solid media.

A. Circulating (Closed) Systems: In closed systems, the nutrient solution is continuously circulated around the roots, with excess solution collected, replenished and reused, making the system efficient and cost-effective.

- **Nutrient Film Technique (NFT):** A thin film of nutrient solution continuously flows over roots, making it ideal for lightweight crops like leafy vegetables, herbs and strawberries.
- **Deep Flow Technique (DFT):** Roots are submerged in a deeper nutrient solution (5–20 cm), ensuring a constant supply of water and nutrients.
- **Deep Water Culture (DWC):** Plant roots are suspended in an aerated nutrient solution, providing continuous oxygen and nutrients.
- **Ebb and Flow System:** The growing bed is periodically flooded with nutrient solution and then drained, allowing proper nutrient uptake and aeration.



B. Non-Circulating (Open) Systems: In open systems, the nutrient solution is used only once and is not recirculated.

- **Root Dipping Technique:** Lower roots are submerged in nutrient solution, while upper roots remain exposed to air for oxygen.
- **Capillary Action Technique:** Nutrient solution reaches roots through capillary movement from a reservoir via inert media.

2. Solid Media Culture Systems: In these systems, plants are grown in inert solid media that provide support, aeration, and water retention. Common media include coco-peat, perlite, vermiculite, rockwool, gravel, sawdust and coconut fibre, which are sterilized before use. Techniques include hanging bag, grow bag, trench/trough and pot culture.

Advanced Soilless Techniques

- **Aeroponics:** A highly advanced hydroponic system where plant roots are suspended in air and sprayed with nutrient-rich mist. Efficiency depends on droplet size (20–100 microns) and intermittent misting helps save energy while ensuring proper nutrient supply.
- **Aquaponics:** Aquaponics is an integrated system combining hydroponics with aquaculture. It creates a symbiotic relationship between plants and aquatic organisms, enhancing sustainability.

Advantages of Hydroponics

- ✓ Efficient utilization of water, nutrients and sapce
- ✓ Elimination of soil-borne diseases
- ✓ Higher yield and faster growth rate
- ✓ Suitable for urban agriculture and vertical farming
- ✓ Better control over environmental conditions
- ✓ Reduced dependency on land resources

Limitations and Challenges

- ✓ High initial investment cost
- ✓ Requirement of technical knowledge and management skills
- ✓ Dependence on continuous monitoring
- ✓ Risk of system failure affecting entire crop
- ✓ Limited adoption in traditional farming systems

Future Prospects

- ✓ Will play a key role in feeding the growing population (9.6 billion by 2050)
- ✓ Helps meet the ~70% increase in food demand
- ✓ Reduces pressure on limited arable land (already 80% utilized)
- ✓ Promotes sustainable agriculture with efficient land and water use
- ✓ Highly suitable for water-scarce and arid regions
- ✓ Ensures precision nutrient management → no wastage or pollution
- ✓ Enables year-round production under controlled environments
- ✓ Minimizes risks from climate change, pests, and diseases
- ✓ Supports urban and vertical farming systems
- ✓ Contributes to environment-friendly and resource-efficient food production

Conclusion

Hydroponics represents a transformative approach to modern agriculture by eliminating the need for soil and enabling precise control over plant growth conditions. With its historical significance and scientific advancements, it has emerged as a viable solution to address challenges such as land scarcity, water limitations, and the need for sustainable food production. Although certain limitations exist, the potential of hydroponics in enhancing productivity and resource efficiency makes it a promising technology for the future of agriculture.