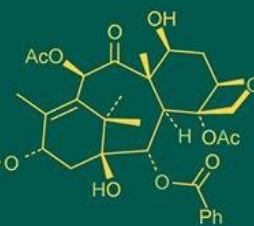
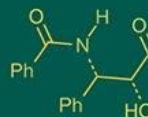
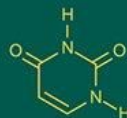
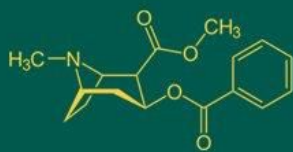


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating: 5.29
IJABR 2025; 9(6): 784-789
www.biochemjournal.com
Received: 16-04-2025
Accepted: 19-05-2025

Abhishek

Research Scholar, Department
of Vegetable Science,
Maharana Pratap
Horticultural University,
Karnal, Haryana, India

Shiv Pratap Singh

Department of Vegetable
Science, Dr Yashwant Singh
Parmar University of
Horticulture and Forestry
Nauni Solan, Himachal
Pradesh, India

Romika Thakur

Department of Seed Science
and Technology, Dr Yashwant
Singh Parmar University of
Horticulture and Forestry
Nauni Solan, Himachal
Pradesh, India

Hydroponics and Aeroponics new emerging tool and technique in agriculture

Abhishek, Shiv Pratap Singh and Romika Thakur

DOI: <https://www.doi.org/10.33545/26174693.2025.v9.i6i.4614>

Abstract

Nowadays, traditional soil-based agriculture is encountering various challenges, such as climate change, natural disasters, and declining soil fertility. In response, hydroponic farming is gaining global popularity due to its efficient use of resources and ability to produce high-quality food. This method has shown excellent results in vegetable cultivation. This article explores the advantages of hydroponic and aeroponic systems, such as shorter crop growth cycles compared to conventional soil farming, reduced risk of pests and diseases, and the elimination of many labor-intensive practices like weeding, spraying, and watering. It also discusses the different types of these systems, their limitations, and their potential for future development.

Keywords: DWC, NFT, Aeroponics, hydroponics, drip irrigation

Introduction

Hydroponics refers to cultivation of plants without soil, either in water or based on various soils-less media. Utilizing this technology, the roots absorb balanced nutrients dissolved in water that meet all the developmental requirements of plants.

The term hydroponics is derived from two Greek words 'hydro' and 'ponos' which stand for water and labour respectively. Basically, in hydroponics plants are grown in different types of substrates (sand, gravel or liquid) in which nutrients are added already. A person who involves in practices of hydroponics is called hydroponics and a garden or building in which hydroponics is practised is called hydroponicum. At first, the word hydroponics was described by Professor William Gericke in early 1930s. At first, hydroponics was introduced in India by W. J. Shalto Douglas at Kalimpong area of West Bengal in 1946. As we know, photosynthesis process in plants completes in following reaction and it shows there is no need of soil to plants for growth and development. Carbon dioxide + Water = Glucose + Oxygen $6\text{CO}_2 + 6\text{H}_2\text{O} = \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$ (Dorren *et al.*, 2004) ^[5]

Advantages of hydroponics

- Soil borne diseases can be controlled
- it saves crops from weeds
- hydroponics saves 70-90% water
- off season production of vegetables is possible
- better growth rate than geponics
- space management is possible with vertical hydroponics system
- the vegetables are easier to harvest in hydroponics than open field condition
- plants may be protected by UV radiations
- produce quality products which have better marketability

Hydroponics system**1. Deep Water Culture (DWC) System**

- Deep water culture (DWC) hydroponics involves suspending plants in oxygenated water.
- In a DWC system, net pots containing the plants hang over a large container filled with nutrient-rich, oxygenated water.

Corresponding Author:**Abhishek**

Research Scholar, Department
of Vegetable Science,
Maharana Pratap
Horticultural University,
Karnal, Haryana, India

- The roots remain submerged in this solution, giving the plants continuous access to nutrients, water, and oxygen.
- To oxygenate the system, an air stone connected to an air pump is placed at the bottom of the reservoir; the resulting bubbles also help mix the nutrient solution.
- Most commercial DWC setups are primarily used to cultivate leafy greens like lettuce, large-leafed vegetables, and herbs.

2. Wick system

- In a wick system, plants are placed in growing media within a tray positioned above a reservoir. This reservoir contains a nutrient-rich water solution. Wicks connect the reservoir to the growing tray, allowing water and nutrients to move upward through the wick and moisten the growing media surrounding the plant roots.
- Hydroponic wick systems only function effectively when paired with growing media that can support the movement of water and nutrients.
- The best growing media for wick hydroponics are coco coir (fibers from coconut husks), perlite, and vermiculite.
- E.g. Small herbs and non-fruit vegetables like lettuce.

3. Nutrient film technique (NFT)

- NFT was developed in the mid-1960s by Dr. Alan Cooper.
- NFT is a hydroponic method in which a thin flow of nutrient-rich water continuously circulates over the exposed roots of plants within a sealed channel or trough.
- Nutrient film technique systems are best suited for lightweight plants, like kale, lettuce, spinach as well as fruits like strawberries.

4. Ebb and flow system (Flood and Drain)

- Ebb and flow (also called flood and drain systems) hydroponics work by flooding a grow bed with a nutrient solution from a reservoir below.
- The submersible pump in the reservoir is equipped with a timer. When the timer starts, the pump fills the grow bed with the water and nutrients. When the timer stops, gravity slowly drains the water out of the grow bed and flushes it back into the reservoir.
- The purpose of Ebb and flow system momentarily floods the grow tray with nutrient solution and then drains the solution back into the reservoir.
- E.g. lettuce, cucumbers and tomatoes

Drip System

- Drip systems are another common and simple technique whereby a pump on a timer delivers a slow feed of the solution to the base of each plant individually.
- The excess solution can be either returned to the reservoir or not collected. It works well with growing mediums with high water retention (i.e. coco coir, peat moss, or rock wool).

System of hydroponics

Based on growing techniques of farmers, scientists and researchers' hydroponics system may be classified in two

groups:

1. On the Basis of nutrient flow
2. On the Basis of Structure and material

1. On The Basis of Nutrient Flow (Kumari *et al.*, 2019) [6]

A. Ebb and flow technique

This is one of the simplest methods of hydroponics and also popular by the name food and drain system among farmers. This system utilizes a grow tray and a reservoir which is filled from a nutrient solution. But root rot, algae and mould are common problems in this system.

B. Nutrient film technique (NFT)

This is most popular technique of hydroponics and it was developed by Dr. Alan cooper in mid of 1960s in England. In this System, nutrient solution is pumped constantly through channels in which plants are placed (Domingues *et al.*, 2012) [2]. Plant absorbs the nutrient solution through the porous root system of the plants (Hasan *et al.*, 2018) [4].

C. Deep flow technique (DFT)

In deep flow technique plants roots are suspended in 2-3 cm. deep nutrient solution through PVC pipes. This technique works very well for larger vegetable plants e.g. tomato and cucumber.

2. On the Basis of Structure and Material

A: A-shaped hydroponic technique

In this system pipes are arranged in a manner which forms A shape. UPVC pipes are better option for the construction of this hydroponic system commercially. This system takes small space with maximum plant population.

B: U-shaped hydroponic technique

As the name indicates, in this system pipes are arranged in a manner which forms U shape. This is suitable for small growers.

C: Vertical hydroponic technique

In this system, pipes are arranged in vertical manner. This system increases productivity of land and suitable for fitting in small space such as in corners or rooms also.

D: Horizontal hydroponic technique

In this system, pipes are arranged only in horizontal manner. Instalment of this type system takes large space comparatively than vertical hydroponics system.

Suitable vegetable crops in hydroponics system

List of some most common vegetables suitable to grow in hydroponics (Ashoka and Sujitha, 2020) [1]

S. No.	Crop Name	Scientific Name
1	Bell pepper	<i>Capsicum annum</i>
2	Brinjal	<i>Solanum melongena</i>
3	Cabbage	<i>Brassica oleracea var. capitata</i>
4	Cauliflower	<i>Brassica oleracea var. botrytis</i>
5	Celery	<i>Apium graveolens</i>
6	Cucumber	<i>Cucumis sativus</i>
7	Green onion	<i>Allium sativum</i>
8	Lettuce	<i>Lactuca sativa</i>
9	Parsley	<i>Petroselinum crispum</i>
10	Spinach	<i>Spinacia oleracea</i>
11	Swiss chard	<i>Beta vulgaris</i>
12	Winged Bean	<i>Psophocarpus tetragonolobus</i>

Media used

Substances those are used as substitute of soil and provide support to plants are termed as medium. Some most

common media which are widely utilized in hydroponics system are: Coco peat, rice hull, perlite, vermiculite, rock wool and expanded clay pellets

**Global and Indian market for commercial hydroponics**

Hydroponics cultivation has great prospectus for international as well Indian agriculture market. In 2019, the Indian hydroponics market was estimated at 3100 metric tons and valued for 35 crores. The market is expected to grow at a compound annual growth rate (CAGR) of about 26% to reach 10500 MT by 2023. Some of the major government agencies in India which are promoting hydroponics cultivation are as follows-

1-National Horticulture Board (NHB) Gurugram

The National Horticulture Board (NHB) was created by the Indian government in 1984 as an independent organization under the Ministry of Agriculture and Farmers Welfare. Registered as a society under the Societies Registration Act, its headquarters are located in Gurugram. NHB operates through 29 regional offices across the country. The Board's primary mission includes developing production hubs and clusters for advanced commercial horticulture, establishing

post-harvest and cold chain infrastructure, ensuring the supply of quality planting materials, and promoting the use of innovative tools, technologies, and techniques in commercial horticulture.

Porosity and bulk density of important soil-less media (Maucieri *et al.*, 2019) ^[3]

Media	Porosity (% v/v)	pH	Bulk density (kg/ m ³)
Cocopeat	90-95	5.22-6.8	80-100
Perlite	85-90	6.5-7.5	80-120
Vermiculite	90-95	6.0-7.2	90-150
Rock wool	95-97	7.0-7.5	80-90
Expanded clay pellets	85-90	4.5-9.0	600-900

2-National Horticulture Mission (NHM)

The National Horticulture Board is carrying out the National Horticulture Mission (NHM), which is a part of the broader Mission for Integrated Development of Horticulture. This initiative was mainly designed to encourage the expansion of the horticulture sector, covering crops such as cashew, cocoa, flowers, mushrooms, spices, and root and tuber crops. To support this goal, 85% of the funding for the development activities is provided by the Government of India (GOI), with the remaining 15% funded by the State Governments.

Objectives

- Boost the growth of the horticulture sector by focusing on research, technology adoption, post-harvest handling, processing, and marketing, among other areas.
- Improve nutritional security, raise horticultural output, and aim to double farmers' incomes.
- Encourage coordination and synergy among various existing and upcoming horticulture development programs.
- Advance technology by combining traditional wisdom with modern scientific knowledge.
- Increase job opportunities, especially for youth who are unskilled or lack formal training.

3. Horticulture Mission for North East & Himalayan States (HMNEH)

Defence Institute of Bio-energy Research, Haldwani, Uttarakhand developed a tomato variety DARR which yields 6.5 kg tomato/plant in hydroponics.

Limitations

- Expensive set up.
- Lack of proper trainings programmes for farmers.
- Since, in hydroponics nutrient status of soil and plants become almost same so if infection starts it increase very rapidly.
- Need regular water and electricity.
- Need regular care of crops.

Future Scope

Although hydroponics is a relatively new scientific method, it has the potential to feed millions of people, especially in areas with limited land and water resources. Countries like Japan and Israel have already adopted proactive strategies in hydroponic farming. This technology is adaptable to all agro-climatic zones. Incorporating solar heating can help

lower the costs associated with hydroponics. Additionally, the future integration of the Internet of Things (IoT) offers significant opportunities for advancing hydroponic systems.

Considerations for achieving optimal hydroponic growing conditions

- **Water-pH** measurements between 5.0 and 7.0 are a rule of thumb.
- **Light**-direct sunlight exposure or supplemental lighting is required on average of 8-10 hours per day.
- **Nutrients**-the primary nutrients required for plant growth are nitrogen, phosphorus and potassium.
- **Temperature**-18 to 26 °C
- **Oxygen**-supplemental oxygen supply is required for optimal nutrient uptake.
- **Structure and Support**-stakes and strings are usually needed to support plants as they grow.

Common Nutrient Ranges in Hydroponic Nutrient Solutions

Elements	Chemical Ionic Form	PPM
Nitrogen	Nitrate (NO ₃ ⁻) Ammonium (NH ₄ ⁺)	100-250
Phosphate	Dihydrogen phosphate Phosphate (PO ₄ ³⁻) Monohydrogen phosphate	30-50
Potassium	Potassium (K ⁺)	100-300
Calcium	Calcium (Ca ²⁺)	80-140
Magnesium	Magnesium (Mg ²⁺)	30-70
Sulphur	Sulfate (SO ₄ ²⁻)	50-120
Iron	Ferrous ion (Fe ²⁺) Ferric ion (Fe ³⁺)	1-5
Copper	(Cu ²⁺)	0.04-2

Non-Circulating Open system

- **Root Dipping Technique:** Plants are cultivated in small pots containing a growing medium. The lower 2-3 cm of these pots are immersed in a nutrient solution. The roots are both suspended in the air and partially submerged in the nutrient solution. This method is straightforward, cost-effective, and easy to set up.
- **Floating Technique:** This method utilizes shallow containers about 10 cm deep, where plants are grown in small pots attached to a Styrofoam sheet or a similar lightweight board, which then floats on the nutrient solution inside the container.
- **Capillary Action Technique:** This method involves using planting pots of various shapes and sizes. The pots are filled with a highly porous material, such as old coil dust mixed with sand or gravel. Nutrient solution moves up into the pots containing the porous material through capillary action. This technique is ideal for indoor plants and decorative flowers.
- **Solid media culture (Aggregate systems):** Sterilized solid media that have high porosity, improved aeration, strong water and air retention, and effective drainage are used for cultivating plants. Common examples include coco-peat, perlite, vermiculite, vermi-compost, gravel, tur, rockwool, sawdust, coconut fiber, and peat moss.
- **Hanging bag technique:** This method uses thick UV-resistant polyethylene bags filled with cocopeat or coconut fiber, shaped into cylinders about one meter tall, to cultivate plants. These bags are hung vertically and supported from above, with a collection channel positioned underneath to catch the nutrient solution.

Micro sprinklers are installed inside the hanging bags to deliver water and nutrients to the plants through holes made in the bags. This technique is ideal for growing lettuce, leafy greens, strawberries, and small flowering plants.

- **Grow bag technique:** This method uses grow bags made from UV-stabilized polyethylene sheets measuring 1 meter in length, 15-20 cm in width, and 8-10 cm in height for cultivating plants. Plants can be arranged in single or double rows with spacing between 30 to 60 cm, depending on the crop type. Fertigation is applied using special stake drippers connected to poly tubes and lateral pipes. This approach is widely used because it is affordable and simple. To enhance sunlight exposure, reduce humidity, and minimize fungal infections, the entire floor is covered with white UV-resistant polythene before placing the grow bags.
- **Trench or trough technique:** In this method, plants are cultivated in trenches or troughs constructed using UV-stabilized PVC/HDPE sheets, bricks, concrete, or other locally available materials. These trenches or troughs are filled with inert organic, inorganic, or a combination of materials such as coco-peat, sand, perlite, and vermiculite, with a depth varying between 30 to 60 cm depending on the crop type. Fertigation is carried out using specialized stake drippers connected to poly tubes and lateral pipes. Proper drainage is crucial and is ensured by incorporating holes or a separate drainage pipe.
- **Pot technique:** This method uses pre-made plastic pots, ranging from 4 to 12 inches in diameter, for cultivating plants. These pots are filled with inert materials, which can be organic, inorganic, or a combination, such as coco-peat, sand, perlite, or vermiculite. The size of the container and the amount of growing medium depend on the crop type and typically range between 1 to 10 liters. Fertigation is carried out using specialized stake drippers with single or multiple outlets, connected to polyethylene tubes and lateral pipes.

Fertigation accessories for hydroponics system

- Ressure gauge to maintain ideal pressure range (2-6 bar)
- Filters with 120-200-micron rating
- PVC storage tanks ranging from 200 to 1000 liters
- Fertilizer injection system using venturi, reciprocating pump, or mixing tank
- Devices for measuring EC (electrical conductivity) and pH
- Controllers and valves for automated operation

Range of climatic parameters for crops grown in hydroponics cultivation

Crops	Optimal Day Temp. (°C)	Optimal Night Temp. (°C)	Relative Humidity (%)
Capsicum	25-30	21-24	60-75
Cucumber	25-30	15-20	50-70
Tomato	18-25	16-22	50-65
Rose	24-26	16-20	50-60
Carnation	18-23	10-15	50-60
Gerbera	16-22	12-15	50-70
Chrysanthemum	18-21	10-16	50-60
Lilium	18-25	12-18	40-60

Advantages of Hydroponics

1. Longer period for plant development
2. Enhanced plant growth and productivity
3. Increased number of plants per area
4. Cultivation possible in various locations
5. Reduced need for water
6. Decreased issues with pests

Disadvantages of Hydroponics

1. Expensive to set up
2. Requires constant monitoring and maintenance
3. Problems affect plants quicker

Aeroponics: In 1957, F. W. Went was the first to introduce the term "aeroponics" to describe a cultivation method where plants, such as coffee and tomatoes, were grown with their roots suspended in air and nourished by a fine mist of nutrients. The term "aeroponic" comes from the Greek words *aer*, meaning "air," and *ponos*, meaning "labor."

Aeroponics: The technique involves cultivating plants in an environment of air or mist without using any soil or growing medium. In this method, the plant roots hang freely in the air and are regularly sprayed or misted with a nutrient-rich solution or its aerosol form.

Tools Needed

- A tank or container for storing the nutrient solution
- A pump to circulate the nutrients
- Spray nozzles to create mist
- Tubing to carry the nutrient solution from the pump to the misting heads inside the grow chamber
- Plant holders or baskets to support the plants
- An enclosed chamber to house the roots
- Leak-proof containers to hold the plant roots within the grow area
- A timer (ideally a cycle timer) to control the on/off operation of the pump

Types of Aeroponics and its benefits (Kumari *et al.*, 2019)^[6]

1. Low-pressure units

In many low-pressure aeroponic systems, plant roots hang above a nutrient solution reservoir or a channel linked to one. A low-pressure pump or ultrasonic transducers spray the nutrient solution through nozzles, and any excess solution drips or flows back into the reservoir for recirculation.

1. High-pressure: In high-pressure aeroponic systems, mist is generated using high-pressure pumps and is typically employed for growing high-value crops. This technique incorporates technologies such as air and water purification, nutrient sterilization, lightweight polymers, and pressurized systems for delivering nut.

2. Ultrasonic fogger (Fogponics): In fogger aeroponics, water is broken down into extremely fine particles, approximately 5 microns in size. This fog is enriched with both water and essential nutrients that plants need for healthy growth. The plant roots absorb this nutrient-laden mist, fulfilling their water and nutrient needs.

Benefits

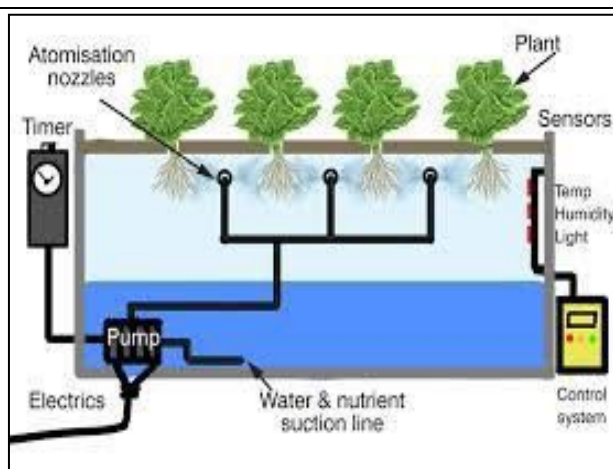
- Year-round growing capability
- Rapid plant development

- Simple to maintain system
- Reduced demand for water and nutrients
- Easily movable setup
- Space-efficient with high productivity
- Supports healthy root development
- Produces crops free from diseases

- Grows more nutritious and healthier plants

Disadvantages

- Dependence on the system
- Technical knowledge required
- Sanitary conditions of the root chamber
- High cost



Hydroponics

Aeroponics

Difference between hydroponics and aeroponics:

Hydroponics	Aeroponics
Hydroponics is a method of growing plant in nutrient enriched water and without soil	Aeroponics is a method of growing plants, also without soil, where roots are exposed to air
Roots are exposed to nutrient rich water	Roots are exposed to nutrient rich mist
Water requirement is higher	Water requirement is lower
Inert material is required to hold roots like clay gravel etc.	Inert material is not required to hold roots of plant
Low maintenance system	High maintenance system
Support more variety of plants	Mainly used in olives and citrus

References

1. Ashok AD, Ravivarman J, Sujitha E. Chapter-1: Recent trends in hi-tech production of *Capsicum* (*Capsicum annuum* L.). In: Ahirwar MK, editor. Recent Trends in Hi-Tech Production of Capsicum. 2020;1.
2. Domingues DS, Takahashi HW, Camara CA, Nixdorf SL. Automated system developed to control pH and concentration of nutrient solution evaluated in hydroponic lettuce production. Computers and Electronics in Agriculture. 2012;84:53-61.
3. Maucieri C, Nicoletto C, Os Ev, Anseeuw D, Havermaet RV, Junge R. Hydroponic technologies. In: Goddek S, Joyce A, Kotzen B, Burnell GM, editors. Aquaponics Food Production Systems. Cham: Springer; 2019. p. 77-110. https://doi.org/10.1007/978-3-030-15943-6_4
4. Hasan M, et al. Hydroponics technology for horticultural crops. Technical Bulletin TB-ICN 188.2018. 2018; p. 30.
5. Dorren L, Rey F. A review of the effect of terracing on erosion. In: Boix-Fayos C, Imeson A, editors. Briefing Papers of the 2nd SCAPE Workshop. 2004; p. 1-7.
6. Kumari R, Kumar R. Aeroponics: A review on modern agriculture technology. Indian Farmer. 2019;6:286-292.