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A Concept of Hydroponic System in Horticultural Crops

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In now a day's soil based cultivation is major difficulties due to different man made reason such as urbanization and industrialization. Hydroponic system such as the deep flow technique, nutrient film technique and aeroponic systems are essential tools in plant factories more over sudden natural disaster, climate change and unlimited use of chemical for agriculture purpose lead to reduction in soil fertility and quality. That's why scientist have evolved a new alternative approach to the agriculture system is called as hydroponic system. Hydroponic is a technique of growing plants in a water based and nutrient rich solution by hydroponic large number of crops for plants can be grown easily. The quality of yield and nutritive value of end products produced by hydroponically is generally greater than the natural soil based cultivation. This type of cultivation is diseases free, eco-friendly and growing popularity across the whole world including the both developed and developing countries.

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1. INTRODUCTION

Hydroponics is a method of cultivating plants without the use of soil, providing a year-round growing solution that offers numerous advantages. In comparison to traditional soil-based systems, hydroponics utilizes less water while facilitating accelerated growth and higher yields. This technique enables the cultivation of fruits both outdoors and indoors, with artificial lighting indoors aiding faster growth [1]. The term "hydroponic" originates from the Greek words "hydro" meaning water and "ponens" meaning labor. Coined by Professor William Gericke in the early 1930s, hydroponics involves growing plants with their roots submerged in water containing essential mineral nutrients [2]. The largest market for hydroponics is in Europe, with France, the Netherlands, and Spain emerging as top growers, closely followed by the United States [3]. To implement a hydroponic system, a nutrient-rich water supply, a means of oxygenating the water, and a mechanism to transport water to the plants are required. The term "Hydroponics" was officially introduced by Dr. William F. Gericke in 1924 at the University of California, where he described the cultivation of crops without soil, both indoors and outdoors, using water and nutrients [4]. Considered the father of hydroponics, Dr. Gericke's pioneering work laid the foundation for the development of this innovative growing method. In India, the Hydroponic system took root in 1946 when English scientist W.J Shalto Duglas established the first Hydroponic Laboratory in Kalimpany, West Bengal [5]. Recognized as the father of contemporary Hydroponics systems, English scientist John Woodward played a pivotal role in shaping the present-day hydroponic techniques. Hydroponics has found success in developed countries and can be adapted with simpler technologies in urban areas, aligning with the concept of urban agriculture [6]. Various hydroponic systems, including deep flow, nutrient film, and aeroponics, are indispensable tools in plant factories, contributing to efficient and controlled plant cultivation [7].

Different types of hydroponics techniques:

There are several types of Hydroponics techniques are follows.

1. NFT (Nutrient Film Technique): In this technique, a thin film of nutrient-rich water continuously flow over the plants roots, providing them with the necessary nutrients [8].

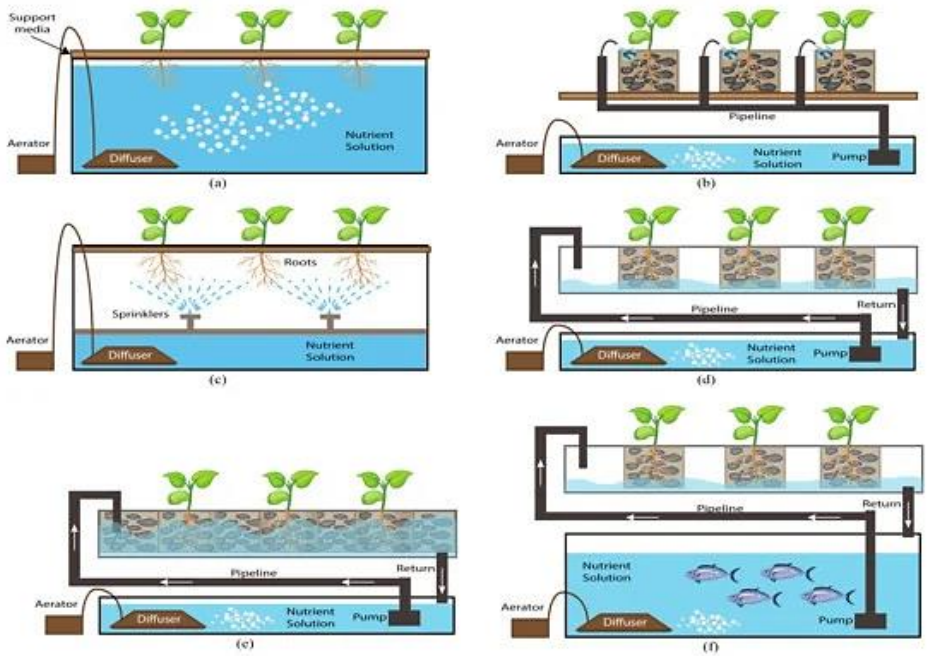

Fig. 1. Different types of hydroponic systems. (a) Deep Water Culture. (b) Drip System. (c) Aeroponics. (d) Nutrien Film Technique (NFT). (e) Ebb and flow. (f) Aquaponics

2. DWC (Deep Water Culture): In DWC, the plant roots are suspended in a nutrient solution that is aerated with oxygen. This allows the roots to receive both nutrients and oxygen directly [9].
3. Aeroponics: Aeroponics involves suspending the plant roots in a mist or fog of nutrient solution. This method provides high levels of oxygen and nutrients to the roots, promoting fast and efficient growth [10].
4. Drip system: This method involves periodically dripping nutrient solution onto the base of the plant, allowing it to soak into the growing medium, and reach the roots [11].
5. Wick system: In this system, a wick is used to draw the nutrient solution from a reservoir to the plants roots. It is a passive system that does not require pumps or electricity [12].
6. Ebb &Flow (Flood and Drain): This system periodically floods the plants roots with nutrient solution and them drains it back into a reservoir. It is controlled by a timer and provides a cycle of flooding and draining [13].

Major elements of hydroponic system:

In hydroponic systems, the absence of soil necessitates the use of a growing medium to support plant roots. Common mediums include perlite, vermiculite, coconut coir, rockwool, or clay pellets, providing stability and aeration for optimal root development [14]. The nutrient solution is a fundamental component, constituting a water-based mixture containing all essential nutrients vital for plant growth. This solution encompasses macronutrients such as nitrogen, phosphorus, and potassium, alongside micronutrients like iron, calcium, and magnesium, ensuring comprehensive nutrition for the plants [15]. A crucial element in hydroponic setups is the reservoir, serving as a container for the nutrient solution. To prevent algae growth, the reservoir must be lightproof. It is equipped with a pump or aerator to maintain adequate oxygen levels within the solution, facilitating the well-being of plant roots [16]. The delivery system encompasses tubing, pumps, and fittings responsible for transporting the nutrient solution from the reservoir to the plant roots. Various hydroponic techniques, such as drip irrigation or the nutrient film technique (NFT), may necessitate specific delivery mechanisms tailored to their requirements [16]. Monitoring and maintaining optimal pH and electrical conductivity (EC) levels in the nutrient solution are critical for successful hydroponic cultivation. pH signifies the acidity or alkalinity of the solution, while EC measures nutrient concentration. Regular testing and adjustment of these parameters are essential to ensure optimal plant growth and nutrient absorption [17]. Since hydroponics often takes place indoors, artificial lighting becomes imperative to facilitate photosynthesis. LED or fluorescent lights are commonly employed to mimic natural sunlight, providing plants with the light energy necessary for their growth and development. Proper airflow and ventilation play a pivotal role in sustaining a healthy growing environment by preventing the accumulation of heat, humidity, and stagnant air. Fans or ventilation systems are employed to ensure adequate air circulation, promoting an optimal growing environment. Finally, the use of pH meters and EC meters is indispensable for regular monitoring and adjustment of the nutrient solution's pH and nutrient levels. These testing tools contribute to the precision and success of hydroponic cultivation [18].

Fertigation technique in hydroponics:

Fertigation is a form of Hydroponics that can help you grow plants in a controlled environment. Fertigation systems can be constructed using drip irrigation or an open pipe system.

1. Drip Irrigation Fertigation system: In a drip irrigation system, a timer controlled valve release water from a reservoir when it reaches a certain level [19].
2. Open Pipe Fertigation System: In an open system, water flows from one end to another through gravity alone. Because fertigation systems require less labor than traditional forms of watering [20].

Cultivation of horticultural crops in hydroponics:

Hydroponic systems can be used for the cultivation of various Horticultural crops. With hydroponic, you can grow crops like tomatoes, spinach, kale, lettuce, cucumbers, herbs, strawberries, blueberries, nuts, and even flowers like roses and orchids.

The controlled environment of hydroponics allows for optimal nutrient delivery, water efficiency, and faster growth. It is a fascinating way to grow crops without soil.

Advantages of hydroponic system:

There are many scientists who give the advantages or disadvantages of hydroponics system. In 1981, Jenon has given the advantages & disadvantages of the hydroponic system for vegetable and fruit production [21].

- ✓ Water efficiency: Hydroponic systems use up to 90% less water compared to traditional soil based farming. Water is recirculated within the system, reducing water waste [22].
- ✓ No Soil Required: Hydroponic eliminates the need for soil, which means no wedding, tilling, or dealing with soil borne pests and disease. It also allows for cultivation in areas with poor soil quality [23].
- ✓ Higher Yields: With precise control over nutrient levels, pH, and environmental factors, hydroponic systems can optimize plant growth, resulting in higher yields and faster growth rates compared to traditional farming methods [24].
- ✓ Year-Round Cultivation: Hydroponic systems can be set up indoors or in greenhouse, providing a controlled environment that allows for year-round cultivation regardless of weather conditions [25].
- ✓ Space Efficiency: hydroponics is ideal for urban environments or areas with limited space. Vertical farming techniques can maximize the use of vertical space, allowing for more plants in a small footprint [26].
- ✓ Reducing chemical Usages:___Since hydroponic systems provide a controlled enviorment, there is less reliance on chemical pesticides and herbicides. This can lead to cleaner, more sustainable food production [27].
- ✓ Nutrient Control: Hydroponic systems allow for precise control over nutrient levels, ensuring plants receive the optimal balance of nutrients for their growth. This can result in healthier and more nutritious crops [28].

Disadvantages of hydroponic systems:

- ✓ Initial investment: Setting up a hydroponic system can require a higher initial investment compared to traditional soil-based farming. The cost of equipment, infrastructure and specialized nutrients can be significant upfront expense [29].
- ✓ Technical knowledge and Maintenance: Hydroponic system require certain level of technical knowledge and expertise to set up and maintain. Monitoring nutrient levels, pH balance, and environment factors like temperature and humidity can be more complex compared to traditional farming methods [30].
- ✓ Disease spread: While haydroponic systems can reduce the risk of soil-born diseases, there is still a potential for the spread of diseases among plants within the system. Proper sanitation and hygiene practices are essential to minimize this risk [31].
- ✓ Power Dependency: Hydroponic systems often rely on electricity to power pumps, lights, and other equipments. This dependency on electricity means that poweroutpages or disruptions can have a direct impact on system's functionality [32].
- ✓ Limited crop selection: Certain crops may not thrive in hydroponic systems, there is a risk of systems, there is a risk of systems failure due to equipment malfunctions, power outages, or human error. Regular monitoring and maintenance are necessary to prevent and address any potential issues [33,34].

2. CONCLUSION

Hydroponic systems present a controlled and efficient approach to plant cultivation, bypassing the need for traditional soil. Directly supplying water, nutrients, oxygen, and light to plants fosters accelerated and more prolific growth. This method not only conserves water but also optimizes space utilization, reducing the susceptibility to pests and diseases. The versatility of hydroponics allows for the cultivation of a diverse array of plants, making it a promising avenue for sustainable agriculture. It stands as an exciting and innovative technique that warrants further exploration in the realm of plant science. The quality of fruits can be significantly enhanced through hydroponics in several ways. Firstly, the controlled environment facilitates precise nutrient delivery, ensuring an optimal balance for plant growth, resulting in healthier and more flavorful fruits. Secondly, the elimination of soil-borne diseases and pests in hydroponics yields cleaner and safer produce. Thirdly, the controlled water supply mitigates the risks of overwatering or underwatering, positively impacting fruit quality. Lastly, the ability to regulate environmental factors such as light and temperature contributes to an improved development and taste of fruits. In essence, hydroponics emerges as a valuable tool for growing high-quality and delicious fruits, offering a technologically advanced and sustainable solution for modern agriculture.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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