Ecofarming
e-Magazine for Agriculture and Allied Sciences
http://www.ecofarming.rdagriculture.in
e-ISSN: 2583-0791

HYDROPONICS

Transforming Agriculture for a Sustainable Food Future

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Received: November, 2023; Accepted: November, 2023; Published: January, 2024

Hydroponics, a soilless farming method, has emerged as a promising solution to address global food demand, enhance food sustainability and combat food insecurity. It offers a novel, highly efficient and low-maintenance approach to food production. Over the period from 2017 to 2023, the global hydroponics market is expected to grow by 18.8%, reaching an estimated value of USD 490.50 million by 2023. One of the primary advantages of hydroponic cultivation is its ability to provide continuous crop yields in a shorter growth cycle, making it less susceptible to climate variations, soil quality limitations, and the availability of arable land. This adaptability is crucial for mitigating the rising threat of global hunger. Hydroponics is particularly valuable in regions facing extreme droughts or poor soil conditions, where access to leafy green vegetables can be challenging. In fully controlled hydroponic systems, the reliance on pesticides is significantly reduced and the need for fertilizers is minimized, leading to environmentally-friendly production with minimal waste.

Lettuce stands out as one of the most commonly grown hydroponic crops, with approximately 99% of its leaves being healthy and marketable. These high-quality hydroponically grown lettuces can command premium prices, about 40% higher than conventionally grown lettuce. Consumers are willing to pay this premium due to the superior quality of the produce and growing awareness of Sustainable Development Goals (SDGs). Numerous studies have confirmed that hydroponics not only contributes to environmental preservation but also enhances food stability and sustainability on a global scale.As such, it offers a promising path forward in our efforts to address food-related challenges and promote a more sustainable food supply system.

Types of Circulating Systems in Hydroponics

Hydroponic systems can be broadly categorized into two major groups:

1. **Open System :** In an open hydroponic system, the nutrient solution that comes into contact with the plant's root system is used only once. This means there is no recycling or circulation of the nutrient solution. The main advantage of this approach is that it eliminates the risk of plant infection due to infrequent changes in the nutrient solution.
2. **Closed System :** In a closed hydroponic system, the entire nutrient solution provided to the plant roots is collected and then returned periodically. This results in a continuous recycling of the nutrient solution. In this method, plants can be grown using either a liquid medium or a solid substrate such as sawdust, rice husk, charcoal, sand, gravel, or pumice. While recycling occurs regularly, the levels of water and nutrients are carefully controlled. It's important to note that this system relies on energy for its operation. Some examples of closed hydroponic systems include Deep Water.

Types of Closed System

1. **Wick System (Passive System):** The wick system is a cost-effective method in which plants absorb nutrients through the capillary action of their roots and fibers, drawing water to them. Unlike other systems, it does not involve recycling the nutrient solution. This system is especially useful in regions where electricity access is limited, as it does not require power for nutrient transfer. However, it is typically more suitable for small-scale production and is not recommended for long-term crop growth.
2. **Nutrient Film Technique (NFT):** NFT is a closed hydroponic system that continuously recycles the nutrient solution. It pumps a highly oxygenated nutrient solution through PVC pipes to provide plant roots with the necessary nutrients. Allan Cooper developed this technique in the 1960s. In NFT, plants absorb nutrients and oxygen from a thin film of the nutrient solution that flows over their roots. The runoff solution is collected and recycled regularly. Initially, plants are grown in opaque containers with inert growth material. This system has seen recent improvements with various growing and support media.
3. **Deep Water Culture (DWC) or Deep Flow Technique (DFT):** DWC involves growing plants on floating or

hanging supports, like rafts or boards, in containers filled with a nutrient solution that is approximately 10 to 20 cm deep. A pump and aeration system help immerse the plant roots in the nutrient solution, ensuring proper growth. Controlling factors like conductivity, pH, and oxygen levels is crucial for maximizing plant growth.

4. **Drip Hydroponic System :** The drip hydroponics system comprises two containers, with plants placed in the top container and nutrient solutions in the bottom container. Nutrient solutions are pumped up to the root zone through drippers. After use, the nutrient solution is filtered and returned to the nutrient tank. Aquarium stones are added to oxygenate the water, making this system suitable for plants with deep roots.
5. **Ebb and Flow System :** Similar to the drip system, the ebb and flow system uses two containers, one for plants and the other for nutrient solution. Instead of dripping nutrients, this system floods the root zone directly. The top container includes an overflow pipe to manage nutrient solution levels and redirect excess solution to the bottom container. Like drip hydroponics, this system is suitable for plants with large root balls.
6. **Aeroponics System :** Aeroponics is an advanced hydroponic system where plants are horizontally positioned at the top of a growing container, supported by inert materials such as plastic or polystyrene panels. The root system is suspended, and nutrient solutions are sprayed directly onto the roots at regular intervals using various nozzle types. A computerized system regulates the spray frequency and pressure, which varies depending on crop type, growth stage, and duration. While efficient, aeroponics is costly to set up and manage and is best suited for small horticultural crops