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Roots in the Sky: Transforming Agriculture with Hydroponics, Aquaponics and Aeroponics

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SUMMARY

Hydroponics, the art of growing plants without soil, has transformed agriculture by utilizing nutrient-rich water solutions to nourish plant roots directly. Originating from experiments in the 1920s, the practice offers multiple systems like wick, water culture, EBB & flow, drip, NFT, and aeroponics, each tailored for different types of crops. This soil-less technique is ideal for regions with unsuitable farming conditions, providing precise nutrient control and boosting plant growth. While the initial setup can be costly, hydroponics promotes sustainable agriculture, allowing year-round cultivation and offering a promising alternative for modern food production.

INTRODUCTION

It is technique for growing plants without soil. Utilizing this technology, the roots absorb balanced nutrient dissolved in water that meets all the plant developmental requirements. Many aggregates and media support plant growth. Also called as "The cultivation of plants without using soil".

History of Hydroponics

Hydroponics became popularized by the news media in the 1920s when a scientist named Dr. William F. Gericke of the University of California when he put laboratory experiments in plant nutrition on a commercial scale. So he termed these Nutri culture systems
HYDROPONICS. The word was derived from the Greek words, HYDRO (water), and PONOS (labor), literally "water working".

Advantages

- Ideal for areas unsuitable for traditional farming, like deserts or cold regions.
- Offers precise control of nutrients and growing conditions.
- Boosts growth with more oxygen at roots and reduces pests.
- Increases yields and minimizes labor with easier planting and harvesting.

Disadvantages

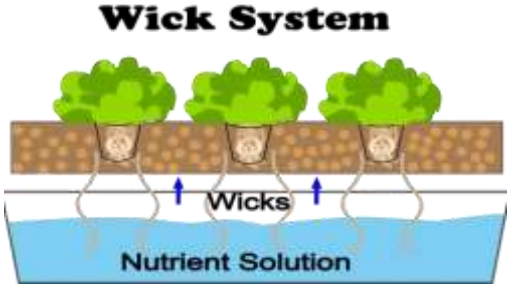
- Higher initial and operational costs, with skilled operation required.
- Some diseases can spread quickly, though resistant crop varieties are available.

Types of Hydroponic System:

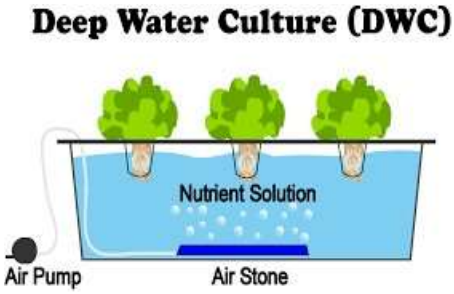
1.Wick System 2.Water Culture 3.Ebb & flow (Drain and flow) 4.Drip system Recovery/ Non- recovery 5.N.F.T.(Nutrient film Technique) 6.Aeroponic system

1.Wick System

The wick system is passive, with no moving parts, and is also the simplest type of hydroponic system. The nutrient solution is drawn into the growing medium from the reservoir with a wick. The grower using this system can use a variety of growing media such as perlite, vermiculite or coconut fibre. However large plants tend to draw and use the nutrient water at a faster rate than the wick can supply it.

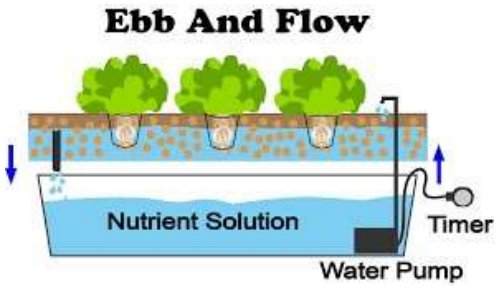


2. Water Culture



The water culture system is the simplest active system to use. A Styrofoam platform floating on the nutrient solution holds the plants. Oxygen is supplied to the roots of the plants through a bubbling air stone that is attached to an air pump. Water culture is the system most often used for leafy vegetables such as lettuce that require fast growth and ample water. It is not suitable for most other plants that require a longer growing period.

3. EBB & Flow (Drain and Flow)

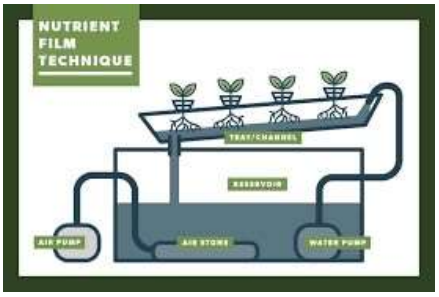


The ebb and flow is a versatile system that floods the grow tray with the nutrient solution for a short period and then drains the solution back into the reservoir using a submerged pump and timer. The timer cuts in several times a day and as it cuts in the nutrient solution washes onto the tray, then as it cuts out the solution drains back into a reservoir. The frequency is dictated by the type of plants being grown and the growing medium used. Several types of growing media such as perlite, rockwool, gravel or grow rocks can be used in this system. It is advisable to use medium with greater water retention abilities such as rockwool as the incidence of root dehydration during power outages is lessened.

4. Drip System Recovery/ Non- Recovery

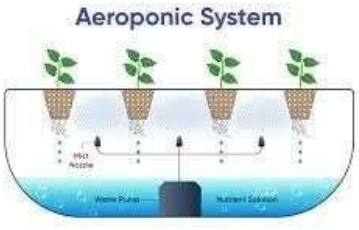
Drip systems are popular and easy to use, involving a timer-controlled pump that delivers nutrient solution to each plant's base through drip lines. There are two types: recovery and non-recovery. The recovery system recycles excess nutrients, making it more efficient but requiring regular monitoring to maintain pH and nutrient levels. The non-recovery system doesn't recycle runoff, needing precise control to provide the right nutrient amount, but requires less maintenance since the solution is not reused.

5. N.F.T. (Nutrient Film Technique)



N.F.T. systems do not use a growing medium. Instead, the plants are supported by a basket and the roots dangle in the nutrient solution. There is a constant flow of nutrient solution which means a timer is not required for the submersible pump. The nutrient solution is pumped into the growing tray using a tube it flows over the roots of the plants, and then drains back into the reservoir. This is an inexpensive method as it does not require the expense of replacing the growing medium for each successive crop. Roots dry out rapidly however during power outages or equipment failure when the supply nutrient solution is interrupted.

6. Aeroponic System



The aeroponic system is probably the most hightech type of hydroponic gardening. Like the previous system, the plants are suspended in the air. The root system is periodically (every few minutes) misted with the nutrient solution using a timer and nutrient pump on a short cycle for a few seconds at a time. Due to root exposure in this system the roots can dry out rapidly during power outages or equipment failure

Media Suitable for Hydroponics

Suitable media for aquaponics include coarse sand, silica gravel, granite, basalt, inert riverbed gravel, cinder, vermiculite, perlite, and Styrofoam. Vermiculite is favored for its inert nature and high water- and nutrient-holding capacity, but it can easily be overirrigated. In closed systems, it's crucial that the medium is free of salts and soluble alkaline materials to prevent plant toxicity. Closed systems require aggregates sized between 1/4 to 3/8 inch for optimal flooding and drainage, while open systems can use aggregates as small as 1/8 inch, but not larger than 3/8 inch.

Plant Requirements
- 17 essential elements needed for growth: Hydrogen, Oxygen, Carbon, plus 14 others.
- Macro-elements: Nitrogen, Phosphorous, Potassium, Calcium, Magnesium, Sulphur.
- Micro-elements: Iron, Manganese, Copper, Zinc, Boron, Chlorine, Molybdenum, Nickel.

System Requirements
- pH: 5.8-6.4 (slightly acidic).
- Electrical Conductivity (EC): 1.2-3.5 mho.
- Lighting: Metal Halide (MH) or High-Pressure Sodium (HPS).
- Temperature: 68-78°F.

Aeroponics

Aeroponics is an innovative method for growing plants in limited spaces, where roots are suspended in the air and misted with nutrient-rich water. This soil-free system requires 95% less water than traditional farming, minimal space, and allows for year-round cultivation. Plants grown aeroponically tend to absorb more minerals and vitamins, making them healthier and more nutritious. The system also boosts oxygen and carbon dioxide availability, accelerating plant growth and enhancing yields.

History

Since its origins in the 1920s, aeroponics has evolved from a research tool to a practical agricultural method. Early breakthroughs included W. Carter's air culture research in 1942 and NASA's tests in the 1990s, which showed increased plant growth in space environments. Today, aeroponics supports crop production on Earth and in space.

Types of Aeroponics

Low-Pressure Units: Simple systems suitable for small-scale use, where roots are misted with low-pressure nutrient solutions.
High-Pressure Devices: Advanced setups for high-value crops, featuring purified nutrient delivery and air purification.
Commercial Systems: High-tech solutions incorporating extended crop life and advanced growth technologies.

Benefits of Aeroponics
- Allows year-round cultivation in a controlled environment.
- Promotes rapid growth with higher oxygen availability at the roots.
- Requires less water, nutrients, and space than traditional methods.
- Reduces disease risk and produces clean, disease-free plants.
- Enables vertical farming and urban gardening with minimal space.

Challenges
- System dependence: Equipment failures can damage plants.
- Technical skills: Knowledge of nutrient management and maintenance is required.
- High initial costs and power dependency.

Growing Vegetables and Herbs

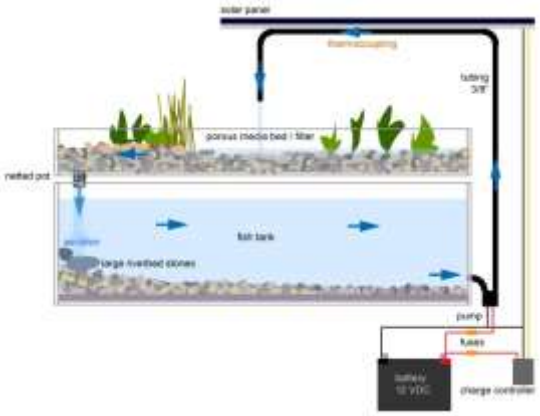
Aeroponics is ideal for a variety of vegetables like lettuce, cucumbers, and carrots, as well as herbs like basil and mint. It provides a rapid growth rate, good taste, and high yields.

Aquaponics

Aquaponics is the farming of fish and plants in a single recirculating system. The waste from the fish becomes the nutrients for the plants, and the plants in turn remove these nutrients from the water, purifying it for the fish. In this way, the fish waste is used to grow a plant crop that becomes a second income stream for little extra cost. In fact, it works so well that the plants become the primary crop by volume and value.

Types of Aquaponics

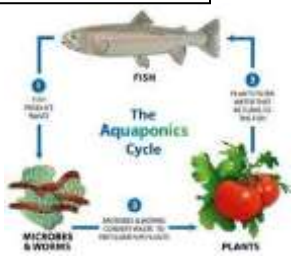
There are three main types of Aquaponics:
Gravel Bed Culture (GBC)
Deep Water Culture (DWC)
Nutrient Film Technique (NFT)



Aquaponics cycle

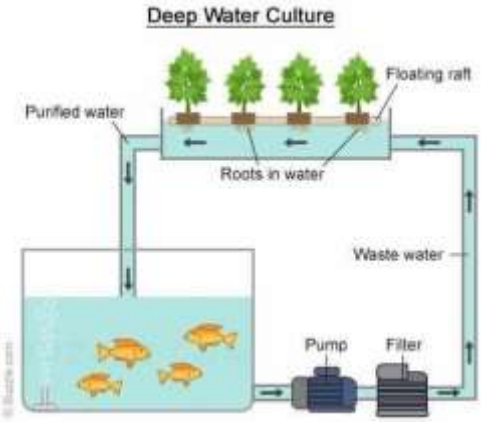
Gravel Bed Culture (GBC)

- In this the plants are rooted in coarse gravel or aggregate media. Bacteria grow on the media and convert the ammonia excreted by the fish to nitrate.
- Plants within the grow beds remove the nitrate from the water, which then returns to the fish in a clean and healthy form.
- No mechanical or biological filtration is required as the gravel beds suit both purposes.
- This method is most variable in terms of the range of crops that can be grown and there is no waste water discharge.



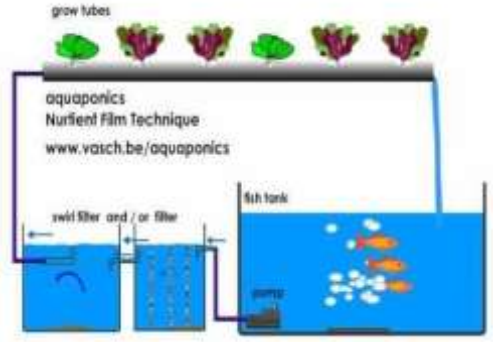
Deep Water Culture (DWC)

- The water from the fish is filtered mechanically and biologically to remove the solids from suspension and convert the toxic ammonia to benign nitrate.
- This clean water then travels down the length of a tank of water in which polystyrene rafts are floated.
- Plants are rooted through the holes in the polystyrene sheets and into the water below, where the roots take up nutrients from the water.
- DWC is most suited to leafy crops and there is some discharge of water during the filtration process.



Nutrient Film Technique (NFT)

- As with DWC the water is filtered prior to going to the plants, but in this case the plants are rooted through holes in pipes.
- The tip of the root touches the bottom surface of the pipe and absorbs nutrients from a thin film of water trickling down the length of the pipe.
- NFT is very susceptible to heat uptake or loss as the air temperature changes, and the plants can be lost quickly through drying out during a power failure.
- This method also results in the loss of water and nutrients during filter cleaning, and is also best suited to leafy crops.



Advantages of Aquaponics in Food Production

✓ Fish waste naturally feeds plants, providing organic nutrients.
✓ High-quality crops with faster growth and higher yields.
✓ Low power usage, minimal labor, and no soil-borne diseases.
✓ Year-round production in compact spaces with stable conditions.

Cultivable Plants in Aquaponics

Aquaponics systems can support the cultivation of a variety of plants, including popular choices like okra (bendi) and cherry tomatoes, which thrive in the nutrient-rich environment. Herbs such as mint (pudina), pandan (daun pandan), and lemongrass (serai) also grow well, benefiting from the steady water flow and nutrient supply. Leafy greens like water spinach (kangkong) flourish in aquaponics, while even root crops like turmeric (kunyit) can be successfully grown, making aquaponics a versatile approach for diverse plant cultivation.

CONCLUSION

Rapid progress shows soil-less cultivation is practical, with clear advantages over traditional methods. Higher crop yields, city dwellers can grow fresh produce, and barren areas can be made productive at low

costs.Aeroponics conserves water, land, and nutrients, offering a sustainable solution for modern agriculture. Its ability to grow crops in diverse environments from urban settings to arid lands makes it a promising technique for future farming. With proper training and system management, aeroponics can revolutionize crop production globally.

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