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HYDROPONIC CULTURE

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Abstract: Hydroponic culture is probably the most intensive production method in today's agricultural technology. In combination with greenhouses, solariums or protective covers, it uses advanced technology and is of great importance for the future of agriculture. It is very productive, conserves water and land, ensuring advanced environmental protection. Even though there has not been much interest over time in the use of hydroponic techniques in protected spaces (most vegetable crops are grown in soil), with the increasing market demand for fresh produce throughout the year, hydroponic cultivation systems have developed strongly in recent years.
Keywords: hydroponic, the wick system, technologies, floating hydroponic system, NFT

INTRODUCTION

Hydroponics is a technology for growing plants in nutrient solutions (water and fertilizers), with or without the use of an artificial medium (e.g., sand, gravel, vermiculite, rock wool, peat moss, sawdust), to provide mechanical support. Liquid hydroponic systems have no other support medium for the plant roots. Aggregate systems have a solid support medium[1,2]. Hydroponic systems are further classified as open (i.e., once the nutrient solution is delivered to the plant roots, it is not reused) or closed (i.e., excess solution is recovered, fed, and recirculated).

Virtually all hydroponic systems in temperate regions of the world are enclosed in greenhouses or sunrooms, structures designed to provide temperature control, reduce water loss through evaporation, provide better disease and pest control, and protect hydroponic crops from the elements such as wind and rain. While hydroponics and controlled organic farming (COF) are not synonymous, COF usually accompanies hydroponics, and they share many of the same potentials and problems. Although hydroponics is widely used to grow flowers, foliage plants, and certain high–value food crops, this paper will focus primarily on vegetable crops, [2,3].

The principle of hydroponic culture includes high density planting, maximum crop yield, agricultural production where there is no suitable soil, freedom from constraints such as ambient temperature and seasonality, more efficient use of water and fertilizers, minimal use of land, and suitability for mechanization and automation of production and disease control.

A major advantage of hydroponic culture, compared to soil culture, is the isolation of the crop from soil, which can have problems associated with diseases, salinity, or low fertility, etc. The costs and time consumption required to sterilize the soil for cultivation are not necessary in hydroponic systems. In hydroponic culture, all essential elements are supplied to the plants in the form of a nutrient solution and success or failure depends mainly on strict nutrient management, which is achieved by carefully correcting the pH level, temperature, and electrical conductivity. Most plants grown hydroponically require a neutral or slightly acidic pH, with optimal values between 5.8 and 6.5. A pH above 7.5 will limit the availability of metal ions for absorption, [4].

Temperature fluctuations in a hydroponic solution can affect the pH of the solution and the solubility of nutrients. The optimal water temperature is 20–20°C. Electrical Conductivity (EC). EC is used as a measure of the nutrient concentration of the hydroponic solution. In commercial installations, the quality of the hydroponic solution is constantly monitored and automatically adjusted as needed. Ambient air temperature is also an important requirement for plants, which generally grow well in a specific temperature range. Warm–season vegetables and most flowers prefer a temperature range between 15°C and 24°C. Cool–season vegetables such as lettuce and spinach grow best between 10–21°C, [3,4].

A variety of fruits, vegetables, plants and flowers are shown in Table 1, along with their pH and EC requirements. This is just one example of the number of species that have potential for growth with this technology. In this context, EC is a measure of the nutrient content of the water that feeds the plant root system and can be: L (low) = 0.6–1.5 mS / cm, M (medium) = 1.5–2.4 mS / cm and H (high) = 2.4–5.0 mS / cm[2].

Table 1. Requirements of some plants grown in the hydroponic system, [2,4]

Culture	pH	EC
Tomatoes	6,0–6,5 H	H
Lettuce	6,0–7,0	L
Cucumbers	5,5	5,5
Bell peppers	6,0–6,5	M
Pumpkins	6,0	M
Strawberries	6,0	M

MATERIALS AND METHODS

In practice, six basic types of hydroponic systems are distinguished; Wick system, Floating system, Flood & Drain, Drip system with or without recovery), NFT (Nutrient Film Technique) and aeroponics. There are many other variations on these basic systems, but all hydroponic methods are a variation (or combination) of these six.

- ***The wick system*** (fig. 1.) is by far the simplest type of hydroponic system. It is a passive system, meaning there are no moving parts. The nutrient solution is drawn into the growing medium from the system's reservoir by means of a wick.

This system can be used with a variety of growing media such as granules, perlite, vermiculite, rock fragments and rarely sand.The plants are placed in the growing medium, and next to each one there is a wick that absorbs and transports the nutrient solution from the tank to their root system. For better growth, the solution is aerated using a pump and an air diffuser.

This model is extremely simple, but it also has the disadvantage that some plants absorb the nutrient faster than the amount brought by the wick to the root zone (the wick provides less nutrient than the plant needs, which causes some deficiency problems in development), [2,5].

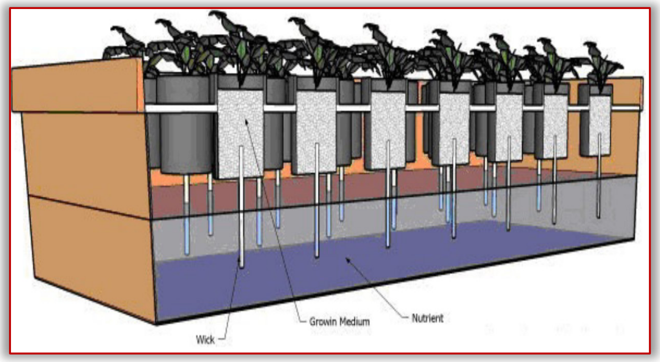

Figure 1. Hydroponic system with nutrient solution absorption wick, [2,9]

Floating hydroponic system (fig. 3.2.). The water culture system is the simplest of all active hydroponic systems. The platform that supports the plants is usually made of expanded polystyrene and mineral wool, which floats directly on the nutrient solution. An air pump sends pressurized air with the formation of bubbles (via the distributor), the bubbles in the nutrient solution providing the necessary oxygen to the plant roots. Floating hydroponics or floating hydroponics is the system used to grow lettuce, which are water–loving and fast–growing plants, making them an ideal choice for this type of hydroponic system. Very few plants other than lettuce will grow well in this type of system.

- ***Floating hydroponic system*** (fig. 2.). The water culture system is the simplest of all active hydroponic systems.

The platform that supports the plants is usually made of expanded polystyrene and mineral wool, which floats directly on the nutrient solution, [7]. An air pump sends under pressure air with the formation of bubbles (via the distributor), the bubbles in the nutrient solution providing the necessary oxygen to the roots of the plants. Water culture or floating hydroponics is the system used for growing lettuce, which are water–loving and fast–growing plants, which makes them an ideal choice for this type of hydroponic system. Very few plants, other than lettuce, will grow well in this type of system, [6].

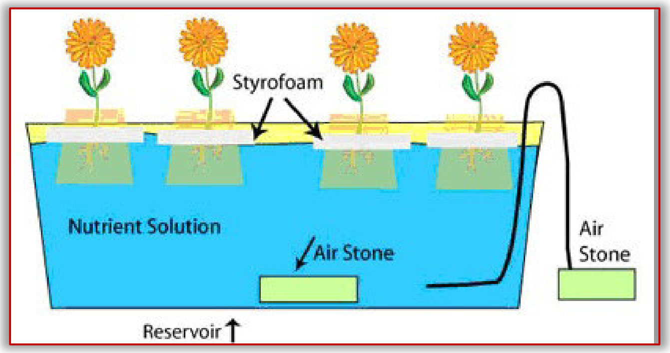

Figure 2. Floating hydroponic system, [2]

The main disadvantage of this cultivation system is that it is not suitable for large plants or those that are grown for a long time, since the lack of air leads to rotting of the root system. This last aspect can be fixed by raising the roots 2–7 cm above the water and blowing air under them.

- ***Flood & Drain System*** The Flood & Drain system works by temporarily flooding the container in which the plants and the growing medium are located with nutrient solution and then draining the solution back into the tank. This action is normally carried out with a submersible pump that is connected to a timer (fig. 3.).

When the timer controls the pump, it sends the nutrient solution into the pot with the growing substrate and its level rises. When the timer stops the pump, the nutrient solution flows back into the tank. The timer is set to perform the flood and drain cycle several times a day, depending on the size and type of plants, temperature, humidity and the type of growing medium used, [17]. Flood & Drain is a versatile system that can be used with a wide variety of growing media, from gravel granules to rock wool.

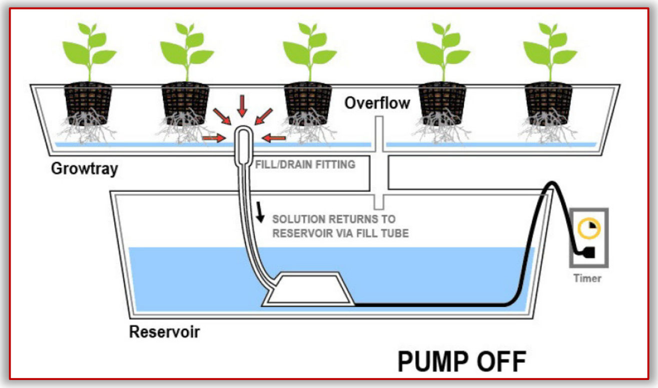

Figure 3. Flood & Drain culture system, [2]

The main disadvantage of this type of system is that with some types of growing media, there is a vulnerability to voltage drops, as well as timer failures. The roots can dry out quickly when watering cycles are interrupted. This problem can be mitigated somewhat by using growing media that can retain water for longer (rock wool, vermiculite, coconut fiber).

- ***Nutrient Film (NFT) Culture System***. This is the type of culture system that most people think of when they think of hydroponics. NFT systems (Fig. 4) have a constant flow of nutrient solution and do not require a timer to control the submersible pump. The nutrient solution is pumped into the growth pipe (usually a tube with holes at the top) arranged with a drainage slope, and the solution flow passes over the roots of the plants, after which it drains back into the tank.

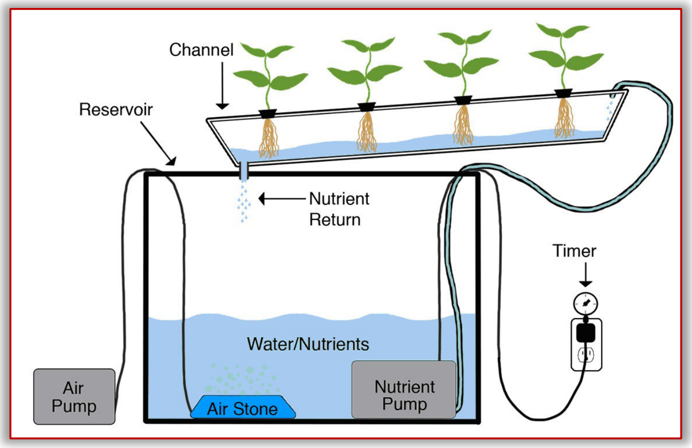

Figure 4. Nutrient film tube (NFT) culture system, [2,14]

Usually no other growing medium is used than air, which eliminates the potential cost of replacing the growing medium after each crop. Normally the plant is supported in a small plastic basket with the roots suspended in the nutrient solution. NFT systems are very sensitive to power outages and pump failures. Roots dry out very quickly when the flow of nutrient solution is interrupted, so periodic checking of the system is necessary, with the provision of an alternative power source. Also, since the nutrient solution is recirculated, the nutrient concentration and pH of the solution must be periodically corrected, [2,8].

- ***The aeroponic system*** (fig. 5) is probably the most high–tech way of hydroponic culture.

Like NFT, the aeroponic growth system uses air as the root development medium. The roots hang in the air and are sprayed with nutrient solution using sprayers, arranged in such a way as to cover the entire root area of the plants. Typically, the solution is sprayed at intervals of a few minutes, followed by a pause in which the excess solution drains from the roots into the tank. As with the NFT system, the disadvantage is that a possible interruption of the electricity supply could cause, over a longer period of time, drying of the roots, wilting of the plants or development deficiencies. Also, by recirculating the nutrient solution, it is necessary to correct its composition and pH at short intervals.

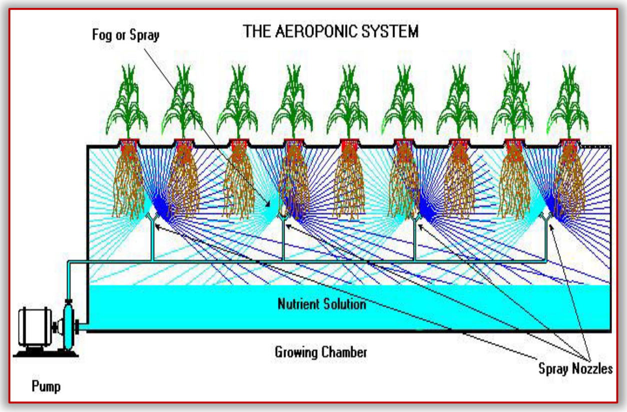

Figure 5. Aeroponic culture system, [2]

Another approach to hydroponic systems is that they are divided into liquid systems and aggregate systems. The first category includes NFT, aeroponics and floating hydroponics. The nutrient film technique was developed in the 1960s by Dr. Allan Cooper at the Littlehampton Research Institute, England; a number of subsequent improvements have been developed at the same institution.

Along with other systems, NFT seems to be the fastest growing type of hydroponic system today. In a nutrient film system, a thin layer of nutrient solution flows through plastic channels containing the plant roots. The walls of the channels are flexible to allow for individual plant extraction, to exclude light, and to prevent evaporation. Lately, special pots (fig. 6.) are used in which a substrate is inserted as a growth support (fig. 7), the roots developing through the spaces of the substrate, [9]. This way of organization allows the cultivation of certain crops in optimal conditions. Nutrient solution is pumped to the upper limit of each channel (fig. 8), flows by gravity passing through the roots of the plants, is collected in a trough (fig. 9) and from here is directed to the supply basin.

The solution is monitored for reconstitution of salts in the water before being recycled. The development of the root system creates a network of capillary threads that prevents the roots from drying out for a certain period of time, [10].

Figure 6. Special pots for NFT cultivation, [2]

Figure 7. Substrates used as support, [2]

A main advantage of this system, compared to others, is that it requires a small volume of nutrient solution, which can be easily heated during the winter months to achieve optimal temperatures for plant growth or cooled during hot summers to avoid heat stress. Smaller volumes of solution are easier to work with if disease control treatment is required, [13,18]. The maximum length of the channels should not exceed 15–20 m as it can restrict the height available for plant growth, as the channel slope usually has a decrease of 1 in 50 to 1 in 75.

Figure **8.** Feeding with nutrient solution

Figure 9. Nutrient solution leakage

To ensure good aeration and plant nutrition, the nutrient solution can be introduced into the channels at two or three points along them. The flow of nutrient solution into each channel should be 2–3 liters per minute, depending on the oxygen content of the solution. The temperature of the nutrient solution should not exceed 30 °C, [14, 15]. Temperatures higher than this will negatively affect the amount of dissolved oxygen in the solution.

CONCLUSIONS

Advantages of Aquaponic Farming:

— Efficient Resource Utilization. One of the biggest advantages of aquaponic farming is the extremely efficient use of resources. Aquaponic systems combine aquaculture (fish farming) and hydroponics (soil–free plant cultivation), allowing water and nutrient recycling in a sustainable manner. Compared to traditional agriculture, aquaponics uses up to 90% less water.
— Reduced Water Consumption. Water is continuously recirculated within the system, reducing losses caused by evaporation and infiltration. This makes aquaponics an ideal solution for arid regions or areas with limited access to water.
— No Chemical Fertilizers Needed. Aquaponic systems eliminate the need for synthetic fertilizers because the nutrients required by plants are provided by fish waste. This reduces the negative environmental impact, preventing groundwater pollution with harmful chemicals.
— Increased Productivity. Aquaponic crops grow faster than those cultivated in soil due to the constant availability of nutrients and controlled environmental conditions. Additionally, the system allows multiple harvests throughout the year, increasing production efficiency.
— Minimal Space Required for Production. Aquaponics allows for vertical farming, maximizing the use of available space. This is particularly useful in urban areas or places where agricultural land is limited.
— Elimination of Weeds and Reduced Pests. Without soil, weeds cannot grow, eliminating the need for herbicides. Additionally, aquaponic systems are less susceptible to insect attacks and soil–borne diseases, reducing the need for pesticides.
— Healthier and Safer Products. Vegetables and fish produced in aquaponic systems are healthier because they contain no pesticide, herbicide, or synthetic fertilizer residues. This appeals to consumers seeking organic and eco–friendly foods.
— Sustainability and Reduced Environmental Impact. By recycling water and avoiding harmful chemicals, aquaponics is one of the most sustainable farming methods. Furthermore, it helps reduce carbon emissions since it eliminates the need for fertilizer transportation and minimizes deforestation for conventional agriculture.

In conclusion, aquaponic farming represents an innovative and sustainable solution for food production, offering multiple advantages for both the environment and the economy. As demand for healthy food and eco–friendly agricultural methods grows, aquaponics is becoming a viable and profitable alternative for the future.

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