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Thriving without Soil: Exploring the World of Hydroponics

M. Harshitha[1], K. Gnaneswari[1], P. Ramya Sri[1], M. Sriram[1], K. Keerthi[1], P. Morsen[1], Achugatla Kesav Kumar[1*], P.R.L. Bhavani[1], Manoj Kumara[1] and P.V.K. Jagannadha Rao[1]

[1]Polytechnic of Agricultural Engineering, Regional Agricultural Research Station (RARS), Anakapalle, Andhra Pradesh- 531001,

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Introduction

The population size of the world (788.84 crores (2021)) is indiscriminately increasing, and this is one of the major reductions in the availability of arable land. Since arable land area continuously reducing, it is becoming difficult to produce staple crops for large populations. The most important problem that is faced by humans in the current era, is access to clean, healthy, and safe food (Fung et al., 2018). This results from the widespread use of fertilizers and pesticides in agriculture that led to the contamination of the soil and made it harmful environment. Soil fertility status has attained a saturation level and productivity is not increasing further with increased levels of fertilizer application. Besides, in some of the cultivable areas, less chance of natural soil fertility building up by microbes due to continuous cultivation, frequent drought and predictability of climate and weather patterns, rise in temperature, etc. Due to these problems always looking for better methods to produce health-secure food. From here the idea of cultivation without soil (Hydroponics) has been introduced to get rid of an arable land problem and to get healthy food.

The word hydroponics is derived from a combination of two Greek words, *hydro* means water and *ponos* means labour (working water) (Britannica., 2024). It is defined as the technique of growing plants in nutrient-rich solutions instead of soil. In hydroponics, non-soil farming media can be used to provide mechanical support to the roots, which support the plant's weight and hold it upright. The hydroponic farms require less space and water, and growth is comparatively higher than traditional farming. Fruits, vegetables and flowers will be grown fast. This farming will reduce pests and weed production at alarming levels. Therefore, the use of pesticides, insecticides and herbicides will be reduced.

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Hydroponics has the potential to sustain a large proportion of the world's population and to allow third-world countries to feed their people, even in places where soil is less fertile and water is limited. The technology can also be used as a valuable source of food protection in places where space is scarce. In hydroponics, non-soil growing media can be used to provide mechanical support to the plant weight and hold it upright. Rockwool, perlite, vermiculite, coco coir, oasis cubes, clay pebbles, sawdust, sand and gravel are commonly used media in hydroponics. They are different types of hydroponics are available

Horizontal Hydroponics

There are different types of horizontal hydroponics systems are discussed as follows:

1. **Horizontal Nutrient Film Technique (NFT):** The traditional NFT systems (Fig 1a), but the channels are oriented horizontally rather than vertically. The nutrient solution flows through the channels, providing plants with water, oxygen, and nutrients (Shanmugabhavatharani et al., 2021).
2. **Horizontal Drip System:** Instead of dripping nutrient solution onto plants from above, this horizontal drip system (Fig 1b) delivers the solution horizontally along a flat surface, such as a bench or table. The solution is then collected and recirculated.
3. **Horizontal Deep-Water Culture (DWC):** Horizontal Deep-Water Culture (Fig 1c) plants are placed in a horizontal tray or raft, with their roots suspended in a nutrient solution. This method is commonly used for growing leafy greens like lettuce.
4. **Horizontal Ebb and Flow (Flood and Drain):** The traditional ebb and flow systems (Fig 1d), but plants are grown horizontally on a flat surface rather than in pots or trays (Naghedifar et al., 2021). The nutrient solution floods the growing area periodically before draining away.
5. **Horizontal Wick System:** In the horizontal wick system (Fig 1e) the plants are arranged horizontally rather than vertically. A wick draws nutrient solution from a reservoir to the roots of the plants.
6. **Aeroponics:** The practice of aeroponics (Fig 1f) growing plants in air or mist in an environment without the use of any substrate.

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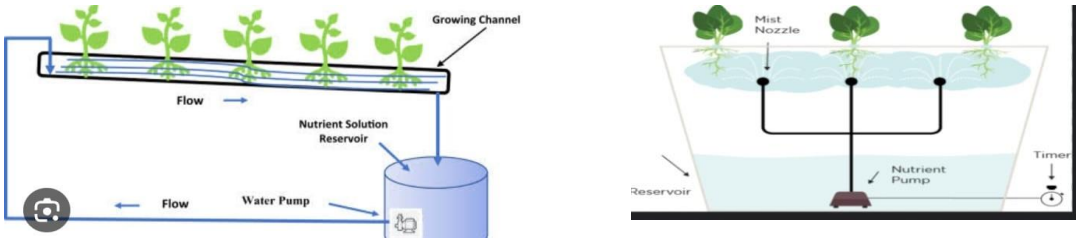

(a) Nutrient film technique **(b) Drip system**

(c) Deep water culture **(d) Ebb and flow**

(e) Wick system **(f) Aeroponics**

Fig 1. Different types of horizontal hydroponic systems

Vertical Hydroponics

There are different types of vertical hydroponics systems are discussed as follows:

1. **Vertical Tower Systems:** Plants are grown in stacked or tiered towers (Fig 1.3 a), with nutrient solution continuously circulating or dripped down through the towers. Each tier may have its reservoir or share a common one (Putri et al., 2023).
2. **A-Frame Systems:** A-frames (Fig 1.3 b) are structures shaped like the letter "A" where plants are grown on both sides of the frame. The nutrient solution is typically delivered through a drip system or by flooding the top of the structure, allowing it to flow down to each level.
3. **Vertical NFT (Nutrient Film Technique) Systems:** In the vertical NFT systems (Fig 1.4 b), the channels are oriented vertically. The nutrient solution flows down the

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channels, providing plants with water, oxygen, and nutrients. This method is often used for leafy greens and herbs (Singh and Rajan, 2022).

4. **Wall-Mounted Systems:** These systems are mounted on walls, either indoors or outdoors, and allow plants to grow vertically. They can be hydroponic or aquaponic and use various methods such as NFT, drip systems, or wicking systems.
5. **Rotating Vertical Gardens:** These systems consist of vertical columns or towers that rotate on a central axis. Plants are grown in pockets or trays attached to the columns, and they receive water and nutrients as they rotate through a reservoir at the base.
6. **Zip Grow Towers:** This system uses tall, narrow towers with a strip of growing of the tower and flows down through the medium, providing water and nutrients to the plants.

(a) vertical tower **(b) A- frame**

(c) Vertical NFT **(d) Wall mounted**

(e) Zip grows (f) Stacked tray

Fig 2. Different types of vertical hydroponic systems

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7. **Stacked tray system:** Growing trays are stacked vertically providing a compact solution for cultivating multiple crops.

The plants are grown in hydroponics such as lettuce, spinach, basil, tomatoes, cucumber, pepper, beans, strawberry, kale, chives, cilantro, herbs, microgreen, scallion, blueberries, radish, etc. The flowers are grown: marigolds, orchids, gerbera daisies, carnations, roses, tulips, sunflowers, lilies, chrysanthemums, petunias, freesia, lavender, etc. Hydroponics has several advantages compared to traditional cultivation as follows

1. **Water Efficiency:** Hydroponic systems use significantly less water compared to conventional farming methods because water is recirculated in the system, with minimal losses due to evaporation or runoff.
2. **Nutrient Control:** In hydroponics, nutrients are directly delivered to the plant roots in a dissolved form, allowing for precise control over nutrient levels. This ensures that plants receive the exact nutrients they need for optimal growth, leading to healthier plants and higher yields.
3. **Faster Growth Rates:** Plants grown hydroponically often grow faster than those grown in soil because they don't need to expend energy searching for nutrients. This accelerated growth can result in quicker harvest times and increased overall productivity.
4. **Space Efficiency:** Hydroponic systems can be set up vertically or in small spaces, making them ideal for urban environments or areas with limited land availability. This allows for higher crop yields per square foot compared to traditional farming methods.
5. **Reduced Pest and Disease Pressure:** Hydroponic systems can be designed to minimize exposure to pests and soil-borne diseases, reducing the need for chemical pesticides and fungicides. This leads to cleaner, healthier produce and lower environmental impact.
6. **Year-Round Production:** Hydroponic systems can be operated indoors or in controlled environments, allowing for year-round production regardless of external weather conditions. This can provide a more reliable and consistent food supply, especially in regions with harsh climates or limited growing seasons.
7. **Optimized Resource Use:** Hydroponic systems can be tailored to use renewable energy sources, such as solar or wind power, further reducing their environmental

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footprint. Additionally, since hydroponic systems typically produce higher yields with less input, they can help optimize resource use and reduce overall agricultural waste.

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