



Aeroponics: A Polytropic Research Tool in the New Era of Agriculture

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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

Aeroponics is a technique of cultivating or culturing plants in the absence of soil or a consolidated medium. It is that the plant is just grown in the moist air or mist medium to transmit the nutrients required by plants. To be honest I call it as a tool for research and commercial production activities because when we talk about practical application there will be many aspects for consideration such as orientation, site selection, skilled technicians, economic costs weather, and climate mainly the traditional farmers. All these operations cannot be handled by a small and simple farmer with ease, this is the reason for the current trend of aeroponics which is new to people and being practically utilized only for research, aesthetics, and for commercial purposes. Aeroponics need special structures which can maintain a controlled environment for the fulfillment of all the basic and required conditions by the plants being studied or grown inside. It requires proper equipment like aeroponic growth chambers, phytosanitary conditions, cooling mechanization, etc. aeroponics has many uses as they can be grown in less space, are useful for seed production, and used in parks and restaurants for ambiance, can grow crops extraterrestrial, pollution free but can't be termed as organic as it is grown without the soil but yes, we can say it organically as there is no use of chemical fertilizer or pesticide n herbicides. There is a big debate going on this outside but this is just what my perspective is. Further development should come up for the sustainability of aeroponics as a medium for agricultural practice.

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1. INTRODUCTION

What is aeroponics? Aeroponics is the modern way of cultivating plants where we do not use the soil as a medium which helps us to culture plants in limited spaces [1]. "Instead, roots are suspended in the air and irrigated with a nutrient-dense mist. The word aeroponics is derived from aer (air) and ponos (Labour) in Greek. No, this is not the same as hydroponics. It differs from hydroponics, where plant roots are submerged in a solution of water and nutrients" [2]. "In aeroponics, the roots have greater access to oxygen, which results in healthier plants, significantly faster crop growth rates, and increased yields" [2].

"Types of aeroponics includes Low-pressure units, High pressured devices, and Commercial systems. A low-pressure pump delivers nutrient solution via jets or ultrasonic transducers, which then drips or drains back into the reservoir" [3,4]. "As plants grow to maturity in these units, they tend to suffer from dry sections of the root systems, which prevent adequate nutrient uptake" [5]. "These units, because of cost, lack features to purify the nutrient solution, and adequately remove continuities, debris, and unwanted pathogens. Such units are usually suitable for benchtop growing and demonstrating the principles of aeroponics" [6]. "High-pressure aeroponic techniques include technologies for air and water purification, nutrient sterilization, low-mass polymers, and pressurized nutrient delivery systems, where the mist is generated by high-pressure pump(s), are typically used in the cultivation of high-value crops [7-9] and plant specimens that can offset the high setup costs associated with this method of horticulture". "Commercial aeroponic systems consist of high-pressure device hardware and biological systems" [10,11]. The biological systems matrix includes enhancements for extended plant life and crop maturation [12], effluent controls systems, disease prevention, pathogen resistance features, precision timing and nutrient solution pressurization, heating and cooling sensors, thermal control of solutions, efficient photon-flux light arrays, spectrum filtration spanning, fail-safe sensors [13,14] and protection, reduced maintenance & labor-saving features, and ergonomics and long-term reliability features" [15]. "Commercial aeroponic systems, like high-pressure devices, are used for

the cultivation of high-value crops where multiple crop rotations are achieved on an ongoing commercial basis. Advanced commercial systems include data gathering, monitoring, analytical feedback, and internet connections to various subsystems" [16].

1.1 Ultrasonic Aeroponics

"Ultrasonic technology is used to create high-frequency sound waves that shake water, until it disperses into lots of tiny droplets, like a mist. This removes the need for nozzles and increases the viability of using aeroponics in much larger, commercial growing spaces, where its impact is maximized" [17]. At LettUs Grow (a United Kingdom-based private company located at Brislington), they use ultrasonic aeroponics.

1.2 Objectives of Aeroponic Farming or Vertical Farming

The objective of aeroponic farming is to cultivate crops (especially horticultural and commercial) with minimal use of soil and water. In aeroponics, it takes an average of 45 days to harvest crops like lettuce, basil, and baby spinach. The same would take around 90 days when grown the traditional way. Water (in the medium supplied as spray or mist) consumed to grow these crops is 90% less. to grow plants suspended in a closed or semi-closed environment by spraying the plant's dangling roots and lower stem with an atomized or sprayed, nutrient-rich water solution. The goal of helping plants grow healthier, aeroponics is carried out in a closed environment in which the grower controls all aspects of the system. Plants are held in large vertical grow racks. Essential organic liquid nutrients, such as nitrogen, phosphorus, and potassium, are added to a large water reservoir as stated above.

2. MECHANISM OF AEROPONICS

The plants are maintained in a closed or semi-closed medium in a suspended manner. The canopy stays quite upright and the roots are below in the container which is sprayed with the nutritive medium [18] so that the plant gets the desired nutrients. Aeroponics requires controlled conditions like temperature, atmospheric moisture, humidity, light intensity, and mainly the media. Aeroponic farming commonly uses nozzles to create mist. However, technical complexities and issues with maintenance have

prevented aeroponics from being successful in larger-scale agricultural applications, such as greenhouses.

2.1 Applications of Aeroponics as a Research Tool

Multiplication, in plant research multiplication, takes time and consumes [19] much space which is a major problem now. So, aeroponics or vertical farming is the new method of farming that fits in the spot-fixing problem. Using aeroponics we can grow more plant population in less time in less space as we can grow the plants vertically not only in a horizontal lining. In the seed industry, Aeroponics is used in the production of seeds, recently potato seed production using aeroponics has shown extraordinary results [20]. Aeroponics is a newly developing farming technique, being used where limited space is provided. Especially in Potato aeroponics is being vividly used in tuberization and seed production. In Horticulture research is going on the effect of ultrasonic aeroponics on Horticultural crop improvement. Using the ultrasonic waves, the nutrient solution will be converted as the mist which is supplied to the roots through nozzles. "Floriculture involves floriculture with plant cultivation in an enclosed chamber by aeration of roots through micro-spray of aqueous nutrient mist. Aeroponics in floriculture includes the propagation of orchids which is a highly commercial floriculture used for decoration, landscaping, and beautification. In space research, NASA, the National Academy of Space Administration, USA, is using the Aeroponics technique in space for research on microgravity, and propagation in extraterrestrial spaces. In pathological research, Researchers have described aeroponics as a valuable, simple, and rapid method for preliminary screening of genotypes for resistance to specific seedling blight or root rot. The isolating nature of the aeroponic system allowed them to avoid the complications encountered when studying these infections in soil culture". [21] Studying plant moisture provides researchers with a non-invasive way to examine roots that are under development, creating a wide range of experimental parameters for scientific work. The ability to control moisture levels in precise ways makes this growing option ideally suited for studying plants under high levels of water stress.

2.2 Uses of Aeroponics

- "Higher growth rates, Crops grown with aeroponic systems can develop up to twice

as fast as with hydroponics. This is based on comparing crop productivity with yields made publicly available by directly comparable hydroponic systems" [22].

- "We continually run growing trials in-house expanding our range of crops and improving our datasets over time" [22].
- Ambience n aesthetic value in hotels, restaurants, and in commercial spaces.

Aeroponics is plant friendly too:

- Higher growth rates create a quicker turnover of your product.
- "Greater control of nutrient application enables you to consistently tune crop quality. Because mist is applied only to the root zone, the growing medium remains dry, so there is less chance of losing profit to pests or disease" [23].
- "Reliable, year-round harvests mean you can have consistent sales projections and estimates" [23].
- Up to 95% less water than outdoor farming.
- No pesticides or harmful chemicals.
- Fewer food miles and reduced carbon footprint. No fertilizer runoff into waterways.

3. DEMERITS

- Incur the highest cost of all hydroponic systems.
- Require more monitoring and maintenance than other hydroponic systems.
- Aeroponics requires the highest parts count of all hydroponic systems.
- Generally, can be used for a single purpose and is not easily adaptable for vastly different crop types [24].
- Difficulties in hardening.
- Aeroponics is highly susceptible to power outages as the equipment relies heavily on automatic systems.
- Must have a certain level of technical knowledge.
- Aeroponics facilities require constant monitoring to be successful.

4. CONCLUSION

Aeroponics is one of the most efficient and innovative methods of farming, which promises sustainable future production of agricultural products. Furthermore, Aeroponics has minimal

or no negative impact on the environment, while traditional farming uses water and land resources insufficiently. There are many uses with this new innovative method of farming such as Higher growth rates creating a quicker turnover of your product. Greater control of nutrient application enables you to consistently tune crop quality. Because mist is applied only to the root zone, the growing medium remains dry, so there is less chance of losing profit to pests or disease [25]. Well, apart from the pros there are a few cons too like in developing countries like India, Thailand, China, etc. especially I find it hard to see the way to practical implementation on a large scale due to lack of proper infrastructure, capital, skilled working technicians.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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