Aeroponics: Soilless cultivation for vegetable crops

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Introduction:

Aeroponics involves cultivating crops without soil by suspending them in the air or mist. It is based on growing vegetables in containers filled with flowing plant nutrition instead of soil. This method provides optimal conditions for root oxygenation and moisture, leading to improved plant nutrition assimilation and faster plant development. The aeroponic system is user-friendly, with plants suspended separately in the air and their roots not in contact with soil or water. Harvesting crops is easy, and various vegetables such as potatoes, yams, tomatoes, lettuce, and leafy greens are commercially cultivated using aeroponics. The term "aeroponic" is derived from the Latin words "aero" (air) and "ponic" (labor/work). It is an alternative method for soil-less cultivation in controlled environments. Aeroponics differs from conventional hydroponics, aquaponics, and in-vitro (plant tissue culture) growing. Currently, aeroponics is successfully applied in South America, and there are efforts to introduce this method elsewhere. In contemporary horticulture, various soil-less cultivation methods like aeroponics and Nutrient Film Techniques have been created.

Previous studies have demonstrated the effectiveness of NFT for growing potato tubers. Nonetheless, tuber initiation was less successful in a nutrient solution without solid media compared to porous media like perlite or vermiculite. The hindrance of tuberization in stolons submerged in a solution may be due to the absence of mechanical resistance. The use of aeroponic systems for potato seed production has only recently emerged in Europe. Until a decade ago, the utilization of these technologies was limited globally, with only a few countries such as China and Korea employing them for commercial potato quality seed production.

The aeroponic culture technique is an alternative method for soil-less cultivation in controlled growth environments like greenhouses. This approach involves enclosing the root system in a dark chamber and providing a mist of nutrient solution. It has been widely adopted in horticultural species such as tomato, lettuce, cucumber, and ornamental plants like chrysanthemum and poinsettia. The establishment of aeroponic systems for seed production has been driven by the growing demand for more efficient and high-quality seed production methods. In Korea, the aeroponic system has been successfully applied for potato seed tuber production.

Aeroponics or aero hydroponics have become the preferred choice over traditional hydroponic systems for producing mini tubers. Despite the increasing interest in soilless culture methods for commercial

horticultural production, there is limited information available for potatoes. Aeroponic systems are more efficient in water resource utilization compared to hydroponic systems. One notable advantage of aeroponics is the minimal contact between the support structure and the plant, which allows for unrestricted plant growth. Aeroponic systems are extensively utilized in NASA space research programs.

Nutrients used in aeroponics system

The nutrients utilized in aeroponic systems are optimized because the plant roots are sprayed at intervals with a precise drop size, allowing for efficient utilization through osmosis. This results in minimal loss of excess nutrient solution to evaporation or runoff. The open exposure of roots to air in aeroponics minimizes plant disease by avoiding stagnant moisture. Aeroponics offers the possibility of cultivating plants without soil or substrate, achieving optimal yields, conserving water and nutrient solutions, and preventing environmental contamination. Air and water contain carbon, oxygen, and hydrogen. Water may contain various elements, including primary nutrients such as nitrogen, phosphorus, and potassium, as well as secondary nutrients like calcium, magnesium, and sulfur. Micro-nutrients such as iron, zinc, molybdenum, manganese, boron, copper, cobalt, and chlorine may also be present. Roots use nutrients as ions in water, including positively charged cations and negatively charged anions. For instance, ammonium (NH4+) and nitrate (NO3−) are important nitrogen sources for plants. As plants utilize these ions, the pH of the solution can change, potentially leaning too far positive or negative.

The optimal pH for plant growth falls between 5.8 and 6.3. In aeroponic systems where water and nutrients are recycled, it is crucial to monitor the pH levels to facilitate nutrient absorption by plants. Aeroponics, which uses spraying to nourish roots, utilizes a smaller volume of liquid, making it easier to manage nutrient concentration and maintain pH stability. The main nutrients used in aeroponics are;

Nutrient	Concentration (g/L)
$N\text{-}NH_4$	0.54
$N\text{-}NO_3$	0.35
P	0.40
K	0.35
Ca	0.17
Mg	0.08
Na	0.04
Fe	0.09
Zn	0.03
B	0.03
Cu	0.04

Aeroponics growing system:

The concept of aeroponics revolves around growing vegetables without their roots being in soil or a hydroponic substrate, but in a container filled with flowing plant nutrients. These containers provide the roots with optimal oxygenation and moisture, leading to better assimilation of plant nutrition and faster plant development. Aeroponic systems

involve mounting plant containers vertically, allowing for easy movement based on agricultural needs. Nutrients trickle down through the growth columns, and young plants are initially exposed to direct sunlight before being progressively moved down the columns using a rotational mechanical system. This rotational process allows for continuous production without interruptions. Aeroponic systems operate in a closed circuit, limiting nutrient consumption to only what the plants absorb, resulting in significant water savings. For instance, traditional land cultivation requires 200 to 400 liters of water to produce a kilogram of tomatoes, while aeroponics only uses about 20 liters. The enclosed space of the aeroponic system reduces agricultural labor to routine operational tasks, allowing workers to gain considerable skill within a short period. Aeroponic equipment is housed within greenhouses or anti-hail coverings, and climate controls within the greenhouse ensure optimal growing conditions for high yields.

Aeroponics Working Method

In the aeroponic system, young plants can be raised as seedlings using specially designed lattice pots or by placing cuttings directly into the system for rapid root formation. The high success rate of plant cuttings rooted in aeroponics has made it a widely-used research tool for studying root development in various plant species. Once established in the aeroponics system, the root system rapidly develops in the chamber or channel, with the maintenance of optimum droplet size being crucial for maximum efficiency.

The variety of aeroponic nozzles available makes it relatively easy to choose a droplet size range that best suits the plant and system being used. Droplets smaller than 30 microns tend to stay in the air like a 'fog' and are not easily absorbed by the roots. The optimal droplet size range for most plant species is between 20 and 100 microns. Smaller droplets within this range help maintain humidity levels in the growth chamber, while larger droplets between 30 and 100 microns make better contact with the roots. Droplets over 100 microns tend to fall out of the air before reaching the roots.

Aeroponics is based on the cultivation of vegetables without their roots being inserted in soil, instead hanging in containers filled with flowing plant nutrition. In these containers, roots can experience optimal oxygenation and moisture, allowing for better plant nutrition assimilation and faster plant development. Plant nutrition is supplied in a closed circuit, limiting consumption to only the quantities absorbed by the plants and resulting in water savings. For instance, traditional land cultivation requires 200 to 400 liters of water to produce a kilogram of tomatoes, while hydroponics requires about 70 liters, and aeroponics utilizes only about 20 liters.

Conclusion

Aeroponics growing enables plants and crops to thrive without the use of pesticides,

leading to disease-free growth. The natural and healthy growth conditions in aeroponic systems, which closely resemble environmental conditions found in nature, allow almost any plant to mature in air with an abundant supply of carbon dioxide, water, and nutrients.

Aeroponics contributes to the conservation of water, land, and nutrients, making it a promising method for crop cultivation in the future. It also appears to be a highly viable method for producing both aerial parts and roots as raw materials for the herbal dietary supplement and phytopharmaceutical industries.

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