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Aeroponics System of Cultivation in Horticultural Crops

Deeptimayee Sahoo

Ph.D Research Scholar
Dept. of Vegetable Sciences,
Orissa University of Agriculture and Technology, BBSR, Odisha-751003
Mail- deeptimayeesahoo94@gmail.com

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Population of earth is expected to rise by 3 billion people. It is estimated that approximately 109 hectares of additional traditional land will be needed to feed them. Only 80% of the Earth's arable land is suitable for farming now. A greater quantity of hectares with optimum inputs is needed every day to feed the rising population. This chain of high priority problems requires an improvement in the management of the use of resources so that human consumption has the priority in its use. To solve the problems mentioned, new farming methods have been searched, one of them being aeroponics. With this technique, the plants are held by certain structures that are maintained in a way that the roots are sustained up in the air.

Aeroponic literally means "growing in air." An aeroponic system is medium-less in that the roots of the plant are free hanging inside an open root-zone atmosphere. Aeroponics structure supplies optimum levels of water, nutrients and air to the growing chamber. Aeroponics is the process of growing plants in an air or mist environment without use of soil or an aggregate media. The word aeroponic is derived from the Latin word 'aero' (air) and 'ponic' means labour (work). This is an alternative method of soil-less culture in growth-controlled environments. The aeroponic culture technique is an optional device of soil-less culture in growth-controlled environments such as greenhouses. This method consists of enclosing the root system in a dark chamber and supplying a nutrient solution of mist device. This was widely used in horticultural species including potato, tomato, lettuce, cucumber and ornamental plants such as chrysanthemum. Aeroponic systems for seed production have been established following increased demand for more efficient high quality seed production

methods. Aeroponic system has been applied successfully in Korea for potato seed tuber production. Aeroponic systems are more water resource efficient than hydroponic system. Another remarkable advantage of the aeroponics is the minimal contact between the support structure and plant, due to which the unconstrained growth of the plant is possible. The aeroponics systems are widely used for NASA space research programs.

Importance of Aeroponics in Vegetable crops

1. Use of water efficiently- Outcomes of using aeroponics system over their counter parts are more efficient use of water. Almost 99 percent of the water is used. Since pesticides and soil compatible fertilizers are not used, fruits and vegetables obtained are pure and doesn't need to be washed before use.

2. Efficient use of nutrient- Delivers nutrients directly to the plant roots, which results in a faster growth of crops. Fruits and vegetables obtained from an aeroponics-based greenhouse are healthy, nutritious, pure, rich, fresh and tasteful. Aeroponics system uses nutrient solution recirculation.

3. Uniform growth among all crops was also observed. The system has the ability to conserve water and energy., a limited amount of water is used. It comparatively offers lower water and energy inputs per unit growing area.

4. The aeroponics system optimizes root aeration. This is true because the plant is totally suspended in air, giving the plant stem and root systems access to 100% of the available oxygen in the air which promotes root growth. Such environment also gives plants 100% access to the carbon dioxide concentrations ranging from 450 to 780 ppm for photosynthesis hence, plants in an aeroponics environment grow faster and absorb more nutrients than regular hydroponics plants. This is in line with Sun *et al.* (2004) who reported that, the aeroponics system increased stomatal conductance of leaf, intercellular CO2 concentration, net photosynthetic rate and photochemical efficiency of leaf

5. Aeroponics method of propagation is one of the most rapid methods of seed multiplication. Another advantage of aeroponics system is that of easy monitoring of nutrients and pH. Aeroponics system also allows the measurement of nutrient uptake over time under varying conditions. Aeroponics production system is very space efficient, with plants taking up minimal room.

Nutrients used in aeroponics system

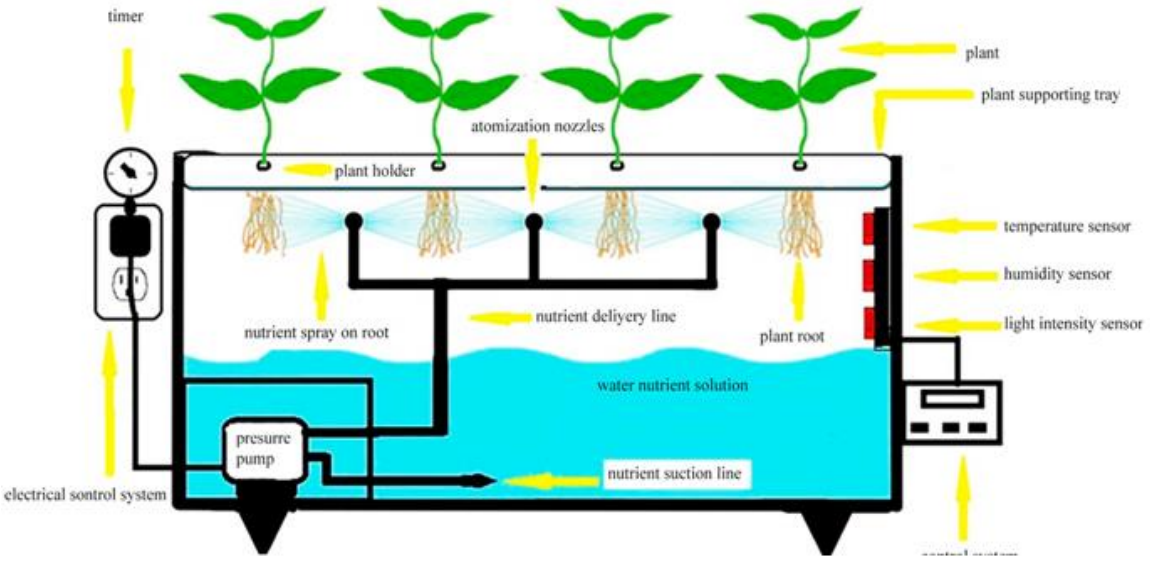
Carbon, oxygen and hydrogen are present in air and water. Water may contain a variety of elements with primary nutrients such as nitrogen, phosphorus, potassium and secondary nutrients viz., calcium, magnesium, and sulphur, micro-nutrients are iron, zinc molybdenum, manganese, boron, copper, cobalt and chlorine. The optimal pH for plant growth is between 5.8 and 6.3. In aeroponic system where water and nutrients are recycled, it is important to measure the acid/base or pH measurement to allow plants to absorb nutrients. Aeroponic using spray to nourish roots use much less liquid resulting in easier management of nutrient concentration with greater pH stability. The main nutrients used in aeroponics are:

Nutrient	Concentration (g/L)
N-NH4	0.54
N-NO3	0.35
P	0.40
K	0.35
Ca	0.17
Mg	0.08
Na	0.04

Aeroponics Growing System

The principles of aeroponics are based on the possibility of cultivating vegetables whose roots are not inserted in a substratum (the case with hydroponics) or soil, but in a container filled with flowing plant nutrition. In these containers root can be find the best condition regarding the best oxygenation and moisture. These conditions allow for the better plant nutrition assimilation in a more balanced way, with consequential faster development of the cultivated plant. The principles of Aeroponics are based on the possibility of cultivating vegetables whose roots are not inserted in a substratum (the case with hydroponics) or soil,

but in containers filled with flowing plant nutrition. In these containers roots can find the best condition regarding oxygenation and moisture. These conditions allow for better plant nutrition assimilation in a more balanced way, with consequential faster development of the cultivated plants. Plant containers can be mounted on top of one another and because they are light and handy, they can be easily moved according to agricultural needs. Numerous plants are mounted in vertical columns within a greenhouse or shade house space. Nutrients are allowed to trickle down through the growth columns. Most agricultural plants need a direct exposure to the sun during the first vegetative development. Afterwards this direct exposure is no longer relevant. Based on this observation, plant containers are periodically displaced. Young plants are placed at the highest level of the growth column. Afterwards they are progressively lowered utilizing a rotational mechanical system. With the rotation periodically repeated, this permits constant production without any interruption. The Aeroponic system is agriculture with a non-stop production cycle. Plant nutrition is supplied into a closed circuit. Consumption is consequently limited to only the quantities absorbed by the plants, allowing for substantial water savings. The aeroponic system is a continuous-cycle in an enclosed space it reduces the agricultural labor into a series of mechanical routine operational tasks which are carried out daily and throughout the year. This enables workers to acquire considerable skill within a short period of time.



Components of aeroponics system

Spray misters

Atomization is achieved by pumping water through nozzles at high pressure. Nozzels come in different spray patterns and orifices. Larger nozzles and orifices reduce the chance of clogging but need pressure to operate and have high flow rates. Droplet size in a given spray may vary from sub microns to thousands of microns.

Droplet size

The ideal droplet size range for most plant species is 20 - 100 microns. Within this range the smaller droplets saturate the air, maintaining humidity levels within the growth chamber. The larger droplets 30 - 100 microns make the most contact with the roots. Spray droplets less than 30 microns tend to remain in the air as a fog. While any droplets over 100 microns tend to fall out of the air before containing any roots. Too large of a water droplet means less oxygen is available to the root system.

High pressure water pump

High pressure aeroponics requires a pump that can produce enough to pressurize the water to produce the ideal droplet size of 20 to 50 microns. These pumps are generally diaphragm pumps or reverse osmosis booster pumps. The pump must produce a steady 80 PSI with required nutrient flow.

Light and Temperature

Replacement for Sun light is very essential. It can be replaced by fluorescent tubes of required Intensity.15000-20000 lux – for vegetative growth.35000-40000 lux –for flowering and fruiting. The optimum temperature for all plants is 15°C – 25°C.

Misting Frequency and Nutrient Reservoir

Aeroponic systems may mist the root system continuously, or intermittently and both methods work well, since water logging and oxygen starvation are not a problem in aeroponics. The major advantage of intermittent aeroponics systems is the saving in running cost, since the pump is only on for a short period of time, but the roots are still contained within the nutrient, moisture and oxygen rich environment between mistings. As a general

rule, a misting cycle of 1 -2 minutes of misting followed by 5 minutes off will ensure the root system does not dry out under most conditions.

Aeroponics Working Method

In aeroponic system the young plants can be either raised as seedlings using especially designed lattice pots or cuttings can be placed directly into the aeroponic system for rapid root formation. Lattice pots allow the root system to develop down into the aeroponic chamber or channel where it is regularly misted with nutrient. The base of the cutting is supplied with high levels of oxygen and moisture in a humid environment which prevents desiccation and accelerates root formation. Once the young plant has been established into the aeroponics system, the root system rapidly develops in the chamber or channel. What is important at this stage is that the optimum size of the droplets is maintained within the system for maximum efficiency. The principles of aeroponics are based on the possibility of cultivating vegetables whose roots are not inserted in a substratum or soil, hanging in a containers filled with flowing plant nutrition. In these containers root can be find the best condition regarding the best oxygenation and moisture. These conditions allow for the better plant nutrition assimilation in a more balanced way, with consequential faster development of the cultivated plant. Plant nutrition is supplied into a closed circuit. Consumption is consequently limited to only the quantities absorbed by the plants, allowing for water savings. For example: to produce a kilogram of tomatoes using traditional land cultivation requires 200 to 400 liters of water, hydroponics requires about 70 liters, aeroponics utilizes only about 20 liters.

Crop Production

Potato

The International Potato Center (CIP) has recently developed and promoted mini-tuber production based on a novel, rustic and publically available aeroponics system. Results showed that the aeroponics system is a viable technological alternative for the potato mini-tuber production component within a potato tuber seed system producing more number of tubers, high tuber yield tuber weight. Thus aeroponic system, has potential to increase income and reduce cost of production of quality seed, thereby, making it more accessible to growers

in developing countries where potato production is heavily constrained by the use of poor quality seed tubers.

Yams

The aeroponics technology should be considered as an effective yam propagation method. Genotypes of both *D. rotundata* and *D. alata* were successfully propagated in it using both pre-rooted and fresh vine cuttings. Results of these studies revealed that vines cutting from five months old plants rooted successfully (95%) within 14 days in aeroponics.

Other vegetables like lettuce, tomato and leafy greens are also cultivated through aeroponics.

Advantages

1. Reduction in fertilizer use - Since all the nutrients are contained, they don't end up in groundwater or sinking too deep into the soil to be of any help.
2. Reduction in water use - Very important for space travel and those in arid climates. Much of the water lost in traditional gardening is from water evaporating out of the soil. The rest of it just sinks past the roots and the plants never get a chance to drink it.
3. More Cost Effective - Since less nutrient solution is needed as compared to hydroponics the costs to operate an aeroponic garden are less than to operate a hydroponic garden. There are also fewer moving parts and complicated systems involved.
4. Reduced Disease Damage - Because the plants are seperated from each other and not sharing the same soil, an infection in one plant has a much lower chance of spreading to the rest of your plants.
5. Faster and healthier growth since it has enough oxygen (in the root region) Increased harvest rate is 45–70% faster than conventional agricultural techniques.
6. Studies has shown that plants grown *via* the aeroponic system have an increase in flavonoids.

Disadvantages

1. .More expensive for long scale production.
2. Ordinary farmers will struggle to manage all these sophisticated instruments.

3. Mister spray heads may also have a tendency to clog and not produce mist when needed.
4. Many consumers believe that aeroponically grown plants are not as nutritious as other grown plants.
5. Maintenance of an aeroponics farm is very expensive.

Conclusion

Aeroponics growing allows plants and crops to grow without the use of pesticide and thus it will be disease free. The crops will grow in a natural healthy manner as the aeroponic system is very similar to nature environmental conditions. Aeroponics is conducted in air combined with micro-droplets of water, almost any plant can grow to maturity in air with a plentiful supply of carbon dioxide, water and nutrients. Aeroponics helps conserve water, land and nutrients, so the aeroponics system is the way of the future, making cultivation of crops easier. Aeroponics appeared to be a highly feasible method for the production of both aerial parts and roots as raw materials for the herbal dietary supplement and phyto pharmaceutical industries.

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