Aeroponics vs Hydroponics: A suitable approach *via* smart agriculture

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Abstract

As the climatic conditions still keep on changing drastically due to global warming leading to adverse effects on the soil and water conditions throughout the world which in turn affects agriculture industry. This has resulted in the discovery of numerous tools and methods that can assist us in providing a more sustainable, healthy, and advantageous plant cultivation. One such technique is Aeroponics. Aeroponics is a comprehensive system providing for the growth and development of unattached plants. In essence, it is an air water culture in which the bare root system is fed with nutrients in a water mist. When compared to traditional farming, this method produces a yield that is significantly higher while requiring only one worker's contribution. It is also economic in the use of both fertiliser and water as the nutrient solution required is reusable. This allows the system to be highly helpful in regions with poor soil and/or water quality. The system has been successfully tested with a variety of plants, including woody plants, vegetables, and fruit trees as well as ornamental plants like dracaena, croton, carnation, citrus, olive, grapes, etc and lettuce. So the main objective of this study to make awareness of this techniques and provide the training to farmers as well as common man, which will be fulfil the mandate of Sustainable Development Goals.

Keywords: Climate change, aeroponics, hydroponics, fertilizers.

Introduction

Over two billion people are anticipated to live on Earth in the upcoming years. It was discovered that in order to feed them, more than 100 hectares of traditional farming would need to be added. The long travel and increased shelf life in neighbourhood stores were factors in the creation of this product. Off-season farming is irrelevant since there are just a few months in a year when high-quality, delectable, limited-quantity goods are accessible. Crop yields are another problem since they are so weather-dependent. In many parts of the world, one bad growing season can result in the deaths of thousands of people. (Mangaiyarkarasi, R 2020)

An approach to plant culture known as aeroponics involves misting mechanically supported plant roots with nutritional solution on a regular or continuous basis. (Mbiyu et al.,2012). Without the need of soil, plants are cultivated in an aeroponic system. The roots are manually hung in the air and are provided with the nutrient solution needed for plant growth in the form of a fine mist. Botanists initially created this method of cultivating plants in the 1920s, using it to investigate the composition of the root system (Francis et al.,2018), (Weathers & Zobel,1992),(Macwan et al.,2020). These contemporary methods make far more use of automation and cutting-edge technology to optimise land utilisation. By implementing these methods, contemporary farms may anticipate to generate bigger yields of higher quality while spending less money in a sustainable manner. All forms of agricultural output may be realised using soilless cultivation in either solid or liquid environments. A total of 31 000 hm2 of soilless systems are recorded in the literature, and the technology is widely employed to produce various types of fruits and vegetables in many nations across the world. In order to learn more about the development and upkeep duties necessary for using the aeroponic system, this research was designed (Lakhiar et al.,2020).

Aeroponic design

A good monitoring and control system for the delivery of nutrients and water is part of the aeroponic setup in order to get the most out of it(Farran et al.,2006).The spray from the machine is distributed using a system of pipes, spray nozzles, a pump, and a timer. It is necessary to have a tank for nutritional solutions . It makes use of a tiny internal microjet spray to spray the roots in the rooting chamber with a fine, high-pressure mist that is rich in nutrients from the nutrient reservoir (Kumari,& Kumar,2019). High-pressure atomization is a typical process in which a high-pressure nutritional solution is driven through an opening, converting the liquid into droplets. This technique creates droplets of 10-100 m in diameter (Fasciolo et al.,2023).

This work's aeroponic system comprises of two distinct chambers. The growth chamber is the area on the top side where the stem, leaves, or fruits develop. the website is exposed to light. The root chamber is the space on the bottom side. The roots are suspended upside-down in the root chamber (Jamhari et al.,2020)

Nutrients used in aeroponics

By periodically misting the root zone with fertiliser solution containing all the necessary macro and micronutrients, the root zone was kept saturated. The nutritional solution's pH was kept between 5.5 and 6.5, and its electrical conductivity (EC) was in the range of 2.0 to 2.5 mS/cm. Every two to three weeks, the nutrition solution was changed in order to restore the nutrients and maintain the ideal pH (Bag et al.,2015). Nutrient Concentration (g/L) is the primary nutrient utilized in aeroponics.

N-NH4 is 0.54, NO3 is 0.35, P is 0.40, K is 0.35, Ca is 0.17, Mg is 0.08, Na is 0.04, Fe is 0.09, Zn is 0.03, and B is 0.04(Gopinath et al.,2017)

Hydroponics

Soil is where plants often grow. The soil environment gives the below-ground plant components nourishment, water, oxygen, and mechanical support. In soilless growing techniques like hydroponics, plants are cultivated in nutrient solutions. The Greek terms "hydros" (meaning "water") and "ponos" (meaning "labour"), or the Latin "ponere" (meaning "put in," are the origin of the name "hydroponics. "Different hydroponic systems differ in the following ways: the type of solid material used; whether plants are grown on nutrient solution alone or in conjunction with a solid material (often referred to as a "substrate"); how the nutrient solution is supplied to the plants; and how frequently the nutrients in the solution are replenished, the pH is adjusted, or the solution is renewed or recycled (Lommen.,2007),(Sheridan et al.,2017). By using a precisely dosed fertilizer solution (fertigation), this production approach eliminates the need for agricultural land and soil, lowers the prevalence of illnesses, and can lessen the consequences of harsh weather occurrences (**Woznicki** et al.,2021)**.**

Nutrient use in hydroponics

To succeed commercially, commercial hydroponic growers must have a more precise control over the elements in a nutrient solution. There are several different hydroponic solution "recipes" available. To get comparable overall end compositions, several people combine various chemical substances (Shrestha & Dunn.,2010). Everything in the soil must be in great condition to provide plants a well-balanced diet. Plants need seventeen different components in order to grow properly. Nine of these are needed in substantial quantities for plant growth and are referred to as macronutrients: carbon (C), hydrogen (H), oxygen (O2), sulphur (S), phosphorus (P), calcium (Ca), magnesium (Mg), potassium (K), and nitrogen (N). Small quantities of the remaining eight macronutrients—Iron (Fe), Zinc (Zn), Copper (Cu), Manganese (Mn), Boron (B), Chlorine (Cl), Cobalt (Co), and Molybdenum (Mo)—are also required (Khan et al.,2020), (Benton & J. B. 1982).

Cultivation of potato in aeroponics

In an aeroponic system (Urozhai 9000) built at the All-Russia Research Institute of Agricultural Biotechnology, Moscow (total area, 3 m2), potato minitubers were manufactured. The plants were cultivated in the initial stage of development under a 16-hour photoperiod at a temperature of 25 °C during the day and 20 °C at night (Tkachenko et al.,2021). Aeroponic potato production encourages the availability of good seed potatoes. Aeroponics also makes it simple to identify and remove sick plants. Additionally, potato seeds created using this technique could experience rapid development as a result of better root aeration and optimal nutrient absorption gained from an atomized nutritional solution (Barak et al., 1996; Nichols, 2005). There is an ideal nutritional balance for each crop. Different fertilizer solutions could be necessary for various potato cultivars. This also relies on the chemical composition of the water and the nutrients employed to prepare the nutrition solution. The EC increases when nutrients are added to water. In general, if we wish to prevent phytotoxicity issues, we should have an EC of no more than 2.0 mS/cm. Nutrient sources for hydroponic and aeroponic systems are widely available fertilizers. Use of fertilizers with sodium (Na) or chlorine (Ch) is not advised. Some fertilizers work better than others at raising EC. Fertilizers with nitrogen (N) and potassium provide good contributions to EC. Additionally, certain fertilizers have a greater or smaller impact on the alkalinity or acidity of the soil. The knowledge about this is helpful. Ammonium phosphate, ammonium sulphate, urea, and ammonium nitrate are examples of acidic fertilizers. Calcium phosphate, potassium carbonate, potassium phosphate, and potassium nitrate are examples of alkaline fertilizers. For regular growth, plants require the macronutrients Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (K), Magnesium (Mg), and Iron (Fe), as well as the micronutrients Sulphur (5), Manganese (Mn), Copper (Cu), Zinc (Zn), Boron (8), and Molybdenum (Mo). These substances ought to be dissolved in water for plants to take up through their roots (Otazu,2010),(Chang et al.,2011) . The same components were present in the nutritional solution used in the second and third phases, but each one was present at a 2-fold higher concentration, with the exception of NH4NO3, which was left out. Minitubers were carefully picked as soon as they had developed (Tkachenko et al.,2021). In comparison to 8–10 minitubers under the net house, an average of 30-35 minitubers may be gathered from a single plant. These minitubers are used for sowing the following generation and kept at a temperature of 2-4 °C (Buckseth et al.,2021).

Cultivation of tomato in aeroponics

The goal of this paper was to prepare guide for tomato Cultivation, particularly for beginners, and experimenters with not much experience with tomato. Actually, there are a lot of rules and useful manuals that explain and compile information on how to produce tomatoes. The family Solanaceae and the genus Solanum are the home of the domesticated tomato. They are not only the most widely grown vegetable crop, but they are also grown on 4.7 million acres of land globally. The tomato is also one of the most researched fleshy fruits because to its ease of cultivation, frequent usage in examining its properties, or use as a model plant (Schwarz et al.,2014). To employ the rock wool system or the AP/NFT method, tomato (Solanum lycopersicum L., cv. Pannovy) seeds were planted in peat, sprouted, and then moved to pots filled with perlite or blocks of rock wool of the same size (Dannehl et al.,2017). The six nutrients that a plant must have are nitrogen (N), potassium (K), phosphorus (P), Sulphur (S), calcium (Ca), and magnesium (Mg). Steiner (1961) developed the idea of an ionic mutual ratio, which is based on the mutual ratios of the cations K+, Ca2+, and Mg2+ as well as the anions NO3 -, H2PO4 -, and SO4 -. It is difficult to feed one ion without introducing a counter ion due to the ionic balancing limitation (Kishorekumar,2021), (Minjuan et al.,2014).

At all plant densities, the average fruit weight was within the range of differences that were not statistically significant. On average, there are significant variations between 12.6 and 21.2 kg m2 (OSVALD.,. et al.,2014).

Cultivation of potato in hydroponics

One of the most significant agricultural plants in the world is the potato (Solanum tuberosum L.). Its annual global production ranks fourth, only behind that of wheat (Triticum aestivum), barley (Hordeum vulgare), and rice (Oryza sativa). Due to their low cost and great nutritional content, potatoes are the primary daily diet in various nations (Nhut et al.,2006). Each of the plant-filled culture tables included a tank for the nutrient solution and a separate system for solution circulation. Therefore, the irrigation conditions at each table might be different (nutrient solution composition, continuous or subirrigation, water stress, pH stress). During the first month of the culture, a standard nutrient solution, the composition of which is described above, was evenly distributed throughout the entire group of plants. Different nutrient delivery conditions and two different nutrient solutions were employed starting in the second month of the culture. The micro and macro nutrients are essential The amount of each basic nutrient in a litre (in mg/l) N P K Ca Fe Mg Zn Cu Mo Mn B Cond pH 180, 40, 300, 200, 3, 50, 0.1 ,0.1 ,0.05, 1 ,0.3, 2.2, 5.8 (Rolot & Seutin .,1999), (Corrêa et al.,2009) . Additionally, nutritional testing shows that hydroponic tubers have nutritional qualities that are on par with those of tubers that are cultivated in the wild. The hydroponically produced tubers turned out to be much richer in several mineral components than those grown outdoors (Molders et al.,2012).

Cultivation of tomato in hydroponics

With a global production of 182 Mt in 2017, tomatoes (Solanum lycopersicum L.) are a common horticultural commodity with a significant economic value. Due to its excellent organoleptic qualities (palatable acidity balanced with sweetness, bright red colour, texture, etc.) as well as its high health-promoting qualities (antioxidant, anticarcinogenic, anti-inflammatory, cardiovascular protection, etc.), this product is extremely well-liked (Antolinos et al.,2020). Carotenoids, flavonoids, and lycopene, three nutrients and vitamins linked to good diet, are abundant in tomatoes. While fruit nutrient content reveals the nutritional worth for human consumption, leaf nutrient concentrations may be utilised to determine the mineral nutritional status of the plants and may thus aid to disclose changes in nutrient availability in different growth systems (Schmautz et al.,2016). The plants were grown in an ionic-rich vegetative development solution. The nutrition solution was changed when bunches started to emerge, and a fruiting solution—adapted from Fernandes et al. (2002)—was used instead. In the solution used during the vegetative development phase, there were the following amounts of N, P, K, Ca, Mg, S, and Mn: Fe = 35 mmol L-1, Mn = 19 mmol L-1, B = 21 mmol L-1, Zn = 4 mmol L-1, Cu = 0.9 mmol L-1, and Mo = 0.7 mmol L-1. The solution used in the fruiting phase contained: N = 12 mmol L-1; P = 3 mmol L-1; K = 8.6 mmol L-1; Ca = 3 mmol L-1; Mg = 1.5 mmol L-1; S = 1.5 mmol L-1; Fe = 59 mmol L-1; Mn = 20 mmol L-1; B = 25 mmol L-1; Zn = 4 mmol L-1; Cu = 1.3 mmol L-1; and Mo = 0.7 mmol L-1(Cardoso et al.,2018),(Howard et al.,2021)Tomato plants were grown in miniature water-culture tanks with various substrates (perlite, coconut-fiber, coconut dust, and peat-based substrates). Humic acids (K-, Na-, and NH4-humates) in various quantities and forms were compared in numerous tests. The impact of humates on the germination of tomato seeds was also studied. The impact of humate treatments on tomatoes' ability to absorb nutrients was examined. In tanks with nutrient solution or containers with various substrates, tomato test plants were grown until they had three inflorescences and were bearing fruit. Tomato plants were grown in some tests until they reached eleven or twelve leaves (Lua & Böhme.,1999). The treatment trough with cocopeat, gravel, and silex stone yielded the most (4.9 kg/plant). 245.3 t/ha was the maximum production attained after the treatment (Joseph & Muthuchamy.,2014).

Conclusion

We observed that, when the two systems were compared, the aeroponics system was significantly more productive than the hydroponics system because it consumes less water and gives plant roots more aeration. The aeroponics system was 70% bigger than the hydroponics system in terms of potato tuber production. The hydroponic system had a fantastic size, but the aeroponic system weighed 33% less .

In tomato cultivation we have grown in both the system but in the aeroponics cultivation system the production is just double than hydroponics that seems aeroponics is such a good cultivation system than the hydroponics. We have used both techniques to produce tomatoes, however the productivity from the aeroponic system is only slightly higher than that from the hydroponic system. In comparison to hydroponics, it appears that aeroponics is a much better method of cultivation .

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