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Aeroponics incorporation with the production of strawberries

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Introduction

Aeroponics, a technique for cultivating plants, involves suspending the roots in the air and spraying them with a nutrient-rich solution. Unlike traditional soil-based farming or hydroponics, which use water as the growing medium, aeroponics delivers nutrients directly through the mist, promoting optimal oxygenation and nutrient absorption for faster growth and higher yields.

Aeroponics reduces water usage by up to 95% compared to traditional soil-based farming, as the closed-loop system recycles water, minimizing waste and conserving resources. When grown aeroponically, strawberries benefit from improved access to oxygen and nutrients, leading to accelerated growth and increased yields. This method is well-suited for vertical farming and urban agriculture, as stacking plants vertically maximizes space usage. Furthermore, the absence of soil decreases the risk of soil-borne diseases and pests, simplifying plant maintenance. Aeroponics enables precise control over the nutrients provided to plants, ensuring optimal growth conditions.

Material And Methods

Before you start growing aeroponic strawberries, you need to set up your system. Here are the key components:

1. Root Chamber is where the strawberry roots will be suspended. It should be a dark, enclosed space to prevent algae growth and keep the roots moist.

2. Mist Nozzles: These nozzles spray a fine mist of nutrient solution onto the roots at regular intervals.

3. Nutrient Solution: A mixture of water and essential nutrients that is sprayed onto the roots. This solution should be carefully balanced to provide all the nutrients the strawberries need.

4. Pump and Timer: The pump delivers the nutrient solution to the mist nozzles, and the timer controls the frequency and duration of the misting.

5. Lighting: LED grow lights are ideal for providing the necessary light for photosynthesis. Ensure that the light spectrum and intensity are suitable for strawberry growth.

Choosing the Right Strawberry Varieties

Not all strawberry varieties are suitable for aeroponic systems. Here are a few recommended varieties:

1. Ever-bearing Strawberries: Varieties like ‘Albion’ and ‘Seascape’ produce fruit continuously throughout the growing season, making them ideal for aeroponic systems.

2. June-bearing Strawberries: Varieties such as ‘Chandler’ and ‘Camarosa’ produce a large crop in a short period, which can be advantageous for maximizing yield in aeroponics.

3. Day-neutral Strawberries: Varieties like ‘Tribute’ and ‘Tristar’ produce fruit throughout the growing season, regardless of day length, making them well-suited for indoor aeroponic systems.

Systems Installation and Experimental Treatments

The study utilized a randomized complete block design with 12 treatments. Throughout the plant growth period, all treatments experienced consistent average temperatures, irrigation periods of 15 minutes per hour, and humidity levels. Three different soilless culture systems were employed in the experiment: a suspended NFT system, a pyramidal aeroponic system, and a tower aeroponic system. Additionally, four different irrigation water treatments were used, including normal water and magnetic water with three different magnetic levels: magnetic water level 1 (MWL 1) at 3800 Gauss, magnetic water level 2 (MWL 2) at 5250 Gauss, and magnetic water level 3 (MWL 3) at 6300 Gauss. Each system was designed to accommodate an average of 64 plants per square meter. An environmentally controlled greenhouse was constructed using an iron frame wrapped with a 2.0-meter wide, 3.5-meter long polyethylene sheet, and reaching a height of 2.5 meters. The NFT system, a suspended shape system, consisted of 1.5-meter-high iron stands and 2.5-meter-long pipes with a 4-inch diameter, which were perforated with 5-centimeter diameter holes. The plants were placed in the same gullies of plastic hydroponic cups with a 20-centimeter gap between them. This system comprised six pipes and 72 plants.

Assessment Criteria

The measurement of flow rate utilized an Arduino flow meter, specifically designed and manufactured for hydroponic systems due to its ability to calculate water flow through pipes without requiring high pressure. The water flow sensor comprises a plastic valve body, a water rotor, and a hall-effect sensor. As water flows through the rotor, its speed changes, causing the hall-effect sensor to output a corresponding pulse signal. Prior to use, the flow meter underwent evaluation to determine water volume using a scaling tester.

The flow meter's circuit consists of two sections. The first section is analog, utilizing signals represented by a continuously variable physical quantity to program the Arduino microcontroller. The second section is digital, receiving the signal from the flow rate sensor and transferring it to the microcontroller for storage on the memory card.

Components of the Arduino flow meter include a flow rate sensor (model: FS300AG3/4”, flow range: 1–30 L min^{-1}, working pressure < 1.2 Mpa (Sea), YF-21, made in Italy), Arduino microcontroller (model: tutorial—Uno R3, made in Italy), pull-up resistor (10K ohm), wires, memory card (32 GB), and battery (Zinc Carbon, made in China, 9 V).

Weekly assessments of the pH and total dissolved solids (TDS) of the fertigation solutions for each treatment group were conducted using a digital pH meter (ATC, China, with 0.1 pH resolution) and a 3in1 TDS device (Water World Company, Missouri City, TX, USA) with 2% accuracy for TDS measurement. After five months of transplanting, three plants from each condition were randomly selected for nutrient absorption (N.P.K.) measurement using the Kjeldahel digestion technique to determine the total nitrogen (N) content.

Total phosphorous (P) concentration was determined using automated colorimetry (molybdovanadate technique), and total potassium (K) content was assessed using a flame photometric method. During the harvest stage, three plants from each treatment were randomly selected to assess plant growth metrics, including the number of leaves per plant, stem diameter, leaf area, plant height, fruit number, fruit volume, and fresh weight of fruits. Stem diameter and plant height were measured using an electronic digital caliper with 0.02 mm accuracy. To estimate the total leaf area per plant, three plants from each treatment were chosen at random and analyzed using digital image processing with ImageJ software, following the method reported by O'Neal, Landis.

An HP Scanjet G4010 desktop scanner was used to digitize and store individual leaves. The volume of fruit was calculated by measuring the water displaced in the tester when the fruit was placed in it. A computerized balance (Chyo balance corp., Japan, accuracy of 0.01 g) was used to weigh the fruits. The total fruit weight for each system was collected and reported as (g plant−1) and (kg m−2). Titratable acidity was determined by titrating fruit sap samples with NaOH (0.1 N) until the pH reached 8.2. Equation (5) was then used to calculate the citric acid content.

Acidity (%)=0.064×Used NaOH×NaOH factor / Sample weight×10

Conclusion

The use of soilless culture systems such as NFT, tower aeroponics, and pyramidal aeroponics can significantly enhance agricultural productivity and water efficiency through the recycling of fertigation. Magnetic treatment applied to irrigation water has been found to enhance the effectiveness of soilless cultivation techniques. Specifically, applying magnetic treatment at level 3 (MWL 3) in NFT, tower aeroponic, and pyramidal aeroponic systems resulted in substantial increases in strawberry yield and water productivity. Compared to non-treated irrigation water solutions, the application of magnetic treatment led to significant improvements in yield and water productivity in all three systems. Furthermore, the use of magnetic water treatment in soilless cultivation resulted in improved plant characteristics, including the number of leaves, stem diameter, and leaf area, as well as enhanced fruit quality. These findings suggest that the use of magnetic water treatment in soilless culture systems can lead to the production of higher-quality agricultural products that meet customer expectations. As a result, further evaluation of additional soilless culture systems is necessary to fully assess the potential benefits of magnetic treatment of irrigation water in crop yield generation. This technology holds promise for farmers utilizing soilless culture techniques and should be more widely implemented to achieve increased yields and reduced water consumption, thereby supporting eco-agriculture.

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