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Development of aeroponics system suitable in urban farming

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Abstract
This study aimed to develop an aeroponics system suitable for urban farming. The system's design and performance were evaluated for growing basil. The aeroponics system, featuring a nutrient tank, net pots, and a misting fertigation setup, showed promising results. The pH and EC levels were monitored and maintained within optimal ranges, ensuring satisfactory plant growth. The system's efficiency in nutrient delivery and water usage highlighted its potential for urban agriculture. The findings suggest that aeroponics can be a viable solution for sustainable farming in urban areas, offering improved growth rates and resource efficiency.

Keywords: Aeroponics, urban farming, nutrient solution, basil growth, sustainable agriculture

Introduction
Due to the growing population, agricultural land is reducing day by day. Feeding such a large population is a problem. The crops that are cultivated are insufficient by traditional farming. The use of chemicals has been increased by farmers to increase the production. There is an increase in the production due to the intake of chemicals but on the other hand, the nutritious value of the food is gradually decreased. The entire food chain is disturbed due to the chemicals, causing the problems like skin diseases in human beings (Kaur and Kumar 2014) [4]. When implementing the new way of agriculture, it is important to take into consideration factors like climate change, decreased soil productivity, depleted soil nutrients, and fertigation availability (Mir *et al.* 2022a) [6]. The soil is not always essential for plant growth; macro and micronutrients are required for plant growth and development. Different methods of soilless farming are hydroponics, aeroponics, and aquaponics. Soilless farming can be accessed on various kinds of places such as balconies, roofs, greenhouses, and land unsuitable for cultivation. Aeroponics is the process of growing plants in an air or moist environment without the use of soil or an aggregate medium. Aeroponics plants require nutrients from a nutrient-rich water solution that is sprayed onto their dangling roots. The main advantage of nutrient delivery using the aeroponics system is that the plant is kept in a relatively closed environment, so diseases are not spread rapidly. Another advantage of aeroponics is that the suspended plants receive a hundred percent of the available oxygen and carbon dioxide to the root zone, stems, and leaves, thus accelerating growth and reducing misting frequency. Plants grown in air always show proper root hair development due to the highly aerated environment surrounding the root system.
Aeroponics gained popularity through the NASA initiative. Today Siccssor tail Farms in Tulsa, Oklahoma is one of the world's largest aeroponics farms with a capacity of 62,000 plants. It saves up to 95% less water and 90% less land than conventional farming (Barkavi *et al.*, 2019a) [1].
Hence to solve the problems related to traditional farming practices, the aeroponics system was developed. The study was undertaken on “Development of Aeroponics Suitable in Urban Farming” with the following objectives:
1. To design and develop a suitable aeroponics system for greens in urban farming.
2. To evaluate the performance of the aeroponics system.

Aeroponics system
Hayden *et al*. (2004) developed an aeroponics system for the production of root crops used

in the herbal and phyto-pharmaceutical industries. It was concluded that the higher biomass yield of aerial parts from the aeroponics treatment indicated that this production technique should not be limited to root crops, but should be considered for other types of crops. Surmani *et al.* (2013) [9] studied an aeroponics cultivation system for obtaining quality potato seeds in tropical lowlands. The size of the aeroponics chamber used was 1.5 m in length, 1.0 m in width, and 1.0 m in height. The outer wall of the aeroponics chamber was made of a plywood material 12 mm thick. The inside part of the wall was insulated with Styrofoam of 2.0 cm thickness. It was concluded that air temperature simulated by using CFD agreed well with that of air temperature measured inside the aeroponics chamber. Salachas *et al*. (2015) [7] studied the effect of the available root zone volume on yield and quality characteristics of aeroponically cultivated sweet basil (*Ocimum basilicum,* L.) plants. At a fully automated glasshouse aeroponics growing system, plants were cultivated in canals. Essential oil content was determined at 0.83%, 0.79%, and 0.80% weight per volume (v/w) for the three growing canals (0.15 m, 0.30 m, and 0.70 m depth) respectively, characterized by high linalool content (63.85%, 67.02% and 66.58% respectively). It was concluded that the basil plants grown in air are of superior nutritional quality characteristics.

Nutrient solution

Prastowo *et al*. (2007) studied the evaluation of the fertigation efficiency and coefficient of uniformity (CU) of the existing aeroponics system which has been conducted for one growing season of petsai. The evaluation covers the CU of the spray discharge, pH, temperature, and electrical conductivity (EC) of the nutrient solution. It was concluded that the CU of spray discharge, pH, and temperature of the nutrient solution was relatively high, but the CU of EC of the nutrient solution was relatively low. Conveyance efficiency and water-use efficiency were about 84.38% and 40.09%, respectively. The average crop water requirement was about 1,457 cc/crop/season or equal to 16,870 cc per Kg of petsai produced. Trejo-Tellez and Gomez-Merino (2012) studied the nutrient solution used for the plant's growth. The study revealed that for the essential growth of the plants all 17 nutrients are necessary. It was observed that the intake of the nutrient will be less due to a continuous supply of nutrient solution. It was concluded that if the supply of the nutrient solution is appropriate then plants can be grown healthier and richer in soilless culture.

Development of Aeroponics system

Material Used

The working of an aeroponics system is usually based on the misting of water- based nutrient solution directly onto the roots of the plants as shown in Fig 1. The cultivation of the plant is divided into two sections;

1. Which grows inside the growth chamber.
2. Which grows above the growth chamber.

The growth chamber holds the plant's weight and supports the fertigation system. This growth chamber was sufficient for growing 36 plants. The nutrient tank was made of plastic material having a capacity of 20 litre. It was used for holding the water and nutrient solution. The availability of storage is important for delivering the nutrient solution and water through pipes and pump. Net pots were used for efficient plant growth providing abundant aeration. The plants are held in net pots through supporting media. Hydro tons were used as supporting media for the cultivation of plants in the aeroponics system. Its size was ranging between 15-30 mm. An 18-watt submersible pump will typically have a flow rate of around 100 to 300 liters per hour (L/h). This is enough for a small aeroponics tower with a few plants. The tank holding the water-based nutrient solution was having a capacity of 30 Liter.

Methodology

As the crop height was increasing every week, the proportion of the solution supplied to the plants was also increased by 120 ml for supplying additional nutrient quantity to the plants. The leafy part A and part B nutrient solutions were mixed in the water tank. Daily pH and E.C. of the nutrient solution were checked in the morning. The nutrient solution was drained from the tank and it was filled with clean water when the potential of hydrogen (pH) and electric conductivity (E.C) of the nutrient solution were above 7 and 2.2 respectively. The next morning, the clean water was drained off and the nutrient tank was again filled with clean water, and the nutrient solution was added to it. After the mixture of water-based nutrient solution the pH and E.C. was checked. Such work was supported by Sardare and Admane (2011).

Determination of potential of Hydrogen (pH) and electric conductivity (E.C) of the water based nutrient solution

The water-based nutrient solution was used for the growth of plants in an aeroponics system. The pH, E.C and TDS of the nutrient solution were daily checked in the morning. The results of the pH, E.C and TDS measured are given in Chapter IV Section 4.

Assembling the Aeroponics tower

Working of an Aeroponics System

In this experiment, Green Warrior Aeroponics tower was used for the cultivation of plants. There were 36 holes on the growth chamber and each hole was acquainted with one net pot. With the help of these net pots, the roots could grow in the growth chamber and get nutritional mist regularly. The roots dangling in the air with the support of the net-pots find the best condition regarding oxygenation and moisture. The plant grown in the aeroponics system was basil and it was planted in these net pots. The plant roots were dangling inside the growth chamber and hydro tons as a growing media was used for protecting the plant from getting dry and helping them to create a moist surface around it. A nutrient tank was placed below the growth chamber having a capacity of 20 L, Because of these conditions, it allowed for better plant nutrition absorption, resulting in faster development of the cultivated plant. The water-based nutrient solution falling from the roots was collected in the growth chamber and dribbled back to the nutrient tank.

The work of the motor was to draw the water-based nutrient solution from the nutrient tank and delivered it to the growth chamber through the means of a fertigation system the water-based nutrient solution was supplied in the mist through the flood jet nozzles. By this setup, the loss of the nutrient solution was further reduced and it helped. To recycle the nutrient by making it reuse again the water droplet size was enough to carry the nutrients to the roots in sufficient quantity.

Results and Discussion

Assembling of the Aeroponics System

The aeroponics system of size 30.48 cm x 30.48 cm x 152.4 cm was erected. The components of the aeroponics system were a growth chamber, net pots, fertigation system, nutrient tank, pressure gauge, motor pump. The pH and E.C. on the 7th day were found to be 7 and 2.2 respectively. Hence, water-based nutrient solution utilized till the 7th day was drained off and it was replaced with a new water-based nutrient solution.

Fig 1: Aeroponics Tower

The aeroponics system were having different components like a motor pump, growth chamber, net pots, hydro tons, pressure gauge, nutrient tank, and digital timer. The specification of each component is given in Table 1.

Table 1: Specification of the aeroponics system

Sr. No.	Components	Specification	Material
1.	Growth chamber (tower section)	Length = 0.305 m Width = 0.305 m Height = 1.524 m	Food Grade Plastic
2.	Net pots	Width = 3.8 cm Length = 5.5 cm Height = 5 cm	Food Grade Plastic
3.	Hydro tons	Size = 15 to 30 mm	Lightweight Expanded-Clay Aggregate (LECA)
4.	PVC pipes	Length – 2 m Outside diameter = 21mm Inside diameter = 16 mm Pressure = 28.14 kg/cm^2 Flow rate = 0.13 – 0.25 lps	Polyvinyl Chloride
5.	Submersible pump	Delivery Up to 33 m Power = 18W / 0.0241 hp Rated Voltage = 220 V Capacity = 100 to 300 lph	Food Grade Plastic
6.	Nutrient tank	Capacity = 20 L Height = 0.2 m Diameter = 0.35 m	Food Grade Plastic

Testing of pH and E.C and TDS of the water-based nutrient solution

The observation of the pH and E.C. are shown in Table 2 In all Twelve (12) observations were taken from 05/07/2024 to 16/07/2024.

Table 2: Measurement of pH and E.C and TDS.

Sr. No.	Dates	Potential of Hydrogen (pH)	Electric conductivity (E.C.) (dSm-1)	Total Dissolved Solids (TDS) (ppm)
1.	05/07/2024	6.5	1.1	620
2.	06/07/2024	5.9	1.1	625

3.	07/07/2024	6.2	1.4	630
4.	08/07/2024	6.1	1.3	634
5.	09/07/2024	6.2	1.2	634
6.	10/07/2024	6.2	1.4	632
7.	11/07/2024	6.3	1.5	630
8.	12/07/2024	6.1	1.4	634
9.	13/07/2024	6.1	1.5	634
10.	14/07/2024	6.1	1.5	634
11.	15/07/2024	6.2	1.5	629
12.	16/07/2024	6.3	1.5	720

The Table 2 shows the results of measurements of the pH, EC, and TDS of a water-based nutrient solution. The pH is a measure of how acidic or basic a solution is, the EC is a measure of the electrical conductivity of the solution, and the TDS is a measure of the total dissolved solids in the solution.

The table shows that the pH of the nutrient solution ranged from 5.9 to 6.5, with an average of 6.2. The EC ranged from 1.1 to 1.5 dS/m, with an average of 1.3 dS/m. The TDS ranged from 620 to 720 ppm, with an average of 631 ppm.

These values are all within the normal range for hydroponic nutrient solutions. The ideal pH for Aeroponics is generally between 5.5 and 6.5, so the pH of the nutrient solution in the table is well within this range. The EC and TDS of the nutrient solution will vary depending on the specific nutrients that are used, but the values in the table are typical for a general Aeroponics nutrient solution.

Overall, the results of the measurements in the table show that the water-based nutrient solution is within the normal range for Aeroponics. (Fig. 2)

Fig 2: Basil Grown in aeroponics tower

Conclusions

1. The suitable pH and E.C. was maintained for the basil crop in aeroponics system.
2. The performance of aeroponics system was found to be satisfactory.
3. The growth of plants in system was found satisfactory.

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