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The Relevance and Prospects of Using Hydroponic Technologies in Modern Conditions

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Abstract: This article is devoted to analyzing the results of growing plants using hydroponic technology. It examines the essence of the hydroponics method and describes the process of cultivating berry plants using strawberries as an example. It also compares traditional, modern soil-based, and soil-less methods of growing plants. Currently, hydroponics is widely used both by amateurs and in professional plant growing. Thanks to the control of pH, electrical conductivity, and nutrient solution composition, plants receive the necessary elements in a timely manner at all stages of development — from the initial stage of growth to the formation of the crop. The advantages of the hydroponic method include the absence of the need for pesticides and herbicides, since plants in optimal conditions demonstrate high resistance to diseases and provide higher productivity compared to soil cultivation.

Keywords: hydroponics, water, air, expanded clay, nutrient medium, strawberries.

Introduction

Hydroponics is a method of growing plants in artificial media without soil. In the hydroponic growing method, mineral nutrients are dissolved in water, and the plant absorbs them without the use of soil. In hydroponic cultivation, the plant receives nourishment not from soil but from a moist, highly aerated aquatic or solid but porous, water- and air-retaining medium that promotes root respiration and requires relatively frequent (or continuously dripped) irrigation with a nutrient solution made according to the plant's needs. Substitutes such as gravel, crushed stone, and some porous materials like expanded clay or vermiculite can be used [1].

Advantages of Hydroponics Over Soil-Based Growing Technology

Nutrient Regulation

The first and most important advantage is that plant nutrition is under your full control. Only the elements that you add to the water reach the root zone, and they are in the proportions you set. At any given time, you can control the quality and quantity of nutrients dissolved in the water. It is worth noting that over the past 200 years, plant cultivation has made significant progress thanks to hydroponic technologies, especially in plant nutrition. Today, hydroponics is used in most plant research. Despite any debates, it is also applied in genetic research and gene transfer [2]

To maintain healthy growth, a plant must transpire a certain amount of water. Rapid, lush growth in hydroponics means the plant consumes a large amount of water. However, the plant transpires all the water used. Nothing disappears into the soil or evaporates. Water conservation compared to plants grown in soil is quite impressive. Recent irrigation improvements—switching from field-wide watering to water delivery at the plant's base—have significantly increased water use efficiency in horticulture. However, hydroponics is still much more efficient in this respect [3].

Nutrient Conservation

Similarly, plants fully absorb all the nutrients they consume. Nothing goes into the ground, groundwater is not polluted, and there is no impact on microbial life in the soil. Thanks to improved health and accelerated growth, the need for pesticides is reduced [4]. The term "pesticide" itself is a misnomer! These substances should be called "biocides," as they kill all living organisms. Many people think pesticides only kill pests, but their action is non-selective, and they also destroy beneficial organisms. The fact that plants grown hydroponically, with proper care, grow rapidly and remain disease-free allows them to outgrow pests or at least resist them. This does not mean that you will never need to fight pests, but the need will be less, and you can tackle problems using milder solutions without destroying all life around the plant [5].

A plant originally grown using hydroponic methods is more viable. If a mother plant is grown hydroponically for the purpose of cloning, and the seedlings are later transplanted into soil, they will be more viable than those grown from a mother plant in soil.

Larger Size and Higher Quality

It is clear: when plant health is strengthened, productivity and yield increase. Hydroponically grown crops are noticeably larger than their soil-grown counterparts. In the field of nutrition, numerous analyses have shown significant, often double increases in the amounts of vitamins and mineral salts. This also applies to active compounds in medicinal plants. Regularly checking the roots is very beneficial. In most hydroponic systems, access is available to inspect and address possible pathogen issues; early intervention allows for easy treatment. The use of hydroponics is especially beneficial when the main product obtained from the plant is the root. For most medicinal plants, active compounds are found (or also found) in the roots [6].

Production of a Large Amount of Biomass

High nitrate content in the nutrient solution promotes explosive vegetative growth in plants. If you need a lot of green mass, this is advantageous. Hydroponic pools can be used to clean heavily polluted wastewater. The byproduct will be a large amount of green mass, which can be processed into fuel [7].

Experimental Part

The goal of our work is to create a hydroponic system, prepare the substrate, properly select and prepare the nutrient solution, and plant strawberry seedlings in the hydroponic installation, as well as in soil, and compare the obtained results. To evaluate the effectiveness of growing plants in a hydroponic system, we decided to plant the crops simultaneously in both the hydroponic system and the soil. For the hydroponic system, we chose a 6-liter dark-colored container, 5 mm diameter conductors, an air aerator with a capacity of 6 liters per minute, and a connecting diffuser between two aerators. The diffuser is placed inside the container, connected by conductors from both sides, with the other ends connected to the aerator. Three pots with water and air entry holes were installed on the container's lid after trimming its surface. The aerator was continuously connected to a 220V power source until the end of the experiment.

For seedlings in the hydroponic system, we selected young strawberry plants from the genus *Fragaria* × *ananassa*.

For the substrate, we chose expanded clay—light-density stones of medium size, for supporting the root and plant body, and for allowing the nutrient solution to penetrate the plant's root system. The composition of our nutrient solution includes the following components: Iron sulfate – 0.15 g, KNO3 – 3.3 g, NH4NO3 – 0.3 g, MgSO4 – 1.52 g, CaHPO4 (K2HPO4) – 0.25–1.5 g, ZnSO4*7H2O – 0.006 g.

This recipe is prepared in 6 liters of distilled water, as the volume of our hydroponic system is 6 liters. The plants were grown on the sunny side of a windowsill. Artificial lighting was not used. The solution in the hydroponic system was changed every 10 days. During the intervals, the solution level was monitored, and if necessary, distilled water was added to maintain the proper level. Watering the plants in the soil was done based on the soil's moisture content.

Results

Over 24 days, from February 2 to February 27, strawberries were grown both in the hydroponic system and in the soil substrate. In the first days after planting, no significant differences in growth and development were observed. However, after the plants were transferred to the full nutrient solution, those cultivated hydroponically showed a noticeable advantage over those grown in soil. New leaves formed, and the old ones grew larger. In the hydroponic system, stem elongation was more intense, while this process was slower in the soil method.

The results can be seen in the table below (Table 1).

Date	Strawberry Stem Length (Hydroponics)	Strawberry Stem Length (Soil)
2-4 February	-	-
5-7 February	1.5	0.7
8-10 February	3.2	1.3
11-12 February	4.5	2.5
13-15 February	6	3.2
16-18 February	7.5	4
19-20 February	8.3	5.3
21-23 February	9.5	6
24-26 February	10.5	7.2

Based on the data in the table, plants grown using the hydroponic system are noticeably taller than those grown in soil.

Conclusion

The primary goal of this study was to investigate hydroponic cultivation technology and compare the soilless method with traditional soil-based cultivation. Based on the results obtained, it can be concluded that hydroponics demonstrates higher effectiveness compared to classical soil cultivation. Thus, the research goal was fully achieved, and the hypothesis was confirmed. In the context of the growing world population, there is an ongoing reduction in natural land resources. If the current pace of growth continues, traditional food production methods may not meet the future needs of humanity and the animal world.

The technologies used in hydroponics are eco-oriented. Unlike traditional agriculture, soilless cultivation does not negatively impact the atmosphere, underground water, or soil cover, nor does it contribute to the accumulation of toxic substances in the environment. Plants grown hydroponically—green crops, vegetables, and fruits—are safe and beneficial for both humans and animals and can be considered a promising alternative to modern food sources.

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