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CULTIVATING MEDICINAL PLANTS USING HYDROPONICS TECHNOLOGY

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ABSTRACT

Background: Hydroponics is a method of cultivating plants without soil by using a nutrient-rich water solution. The method chosen in this study is the Nutrient Film Technique (NFT), which enables cultivation by supplying a continuous, thin film of nutrient-rich water directly to the plant roots. The drugs selected were Coriander, Spinach and Fenugreek. **Objectives:** To make rare medicinal plants available and reduce market deficit, to increase productivity and produce high-quality, uniform crops through controlled conditions, and to minimize water and nutrient use. **Materials and Methods:** The study focuses on the design, preparation and efficiency of an NFT hydroponic system developed using simple and cost-effective materials such as PVC pipes, end caps, connectors, flexible tubing, a submersible pump, net pots, a reservoir tank, and biodegradable growing media like coco peat and sponges.

Result: Among the three medicinal plants, Fenugreek demonstrated the most vigorous growth performance, followed by Spinach, which showed uniform and healthy vegetative development. Coriander exhibited slower but stable growth throughout the observation period. **Conclusion:** The NFT hydroponic system proved to be an effective and sustainable method for cultivating medicinal plants under controlled conditions. It ensured efficient use of water and nutrients, supported healthy plant growth, and demonstrated successful adaptation of Fenugreek, Spinach and Coriander in a soilless cultivation system.

KEYWORDS: Hydroponics, NFT, Methika, Palak, Dhanyaka, Medicinal Plants, Soilless Cultivation.

INTRODUCTION

Hydroponics is a method of cultivating plants without soil by using a nutrient-rich water solution. The term hydroponics is derived from the Greek word's "hydro" meaning water and "ponos" meaning labour. Although hydroponics has gained significant attention in recent years, the concept of soilless cultivation is not new. In 1860, the German botanist Julius von Sachs demonstrated that soil is not essential for plant growth and concluded that plants can grow successfully with only a nutrient-rich solution. Later, in 1937, William Frederick Gericke introduced the term "hydroponics". The nutrients used in hydroponic systems may originate from fish waste, manure, chemical fertilizers, or other artificial nutrient solutions, and these systems can be established indoors or outdoors depending on resource availability and cultivation requirements. At present, agriculture is facing serious problems due to water unavailability, climate change, urbanization, pest problems and shrinkage of agricultural land with increase in population growth. Hydroponics offers a solution to a high extent to these problems, as it enables growers to grow any plant at anytime, anywhere irrespective of edapho-climatic conditions. It provides higher growth and yield with less resources, requires less water as water is recycled and reused, and is less affected by seasonal variations. A wide variety of crops can be successfully cultivated using hydroponics, including tomato, green beans, cabbage, cauliflower, broccoli, peas, palak, raspberry, basil, dhanyaka, mint, sage, rosemary, beetroot, cucumber, pepper, strawberry, lettuce, celery, herbs and fodder crops. Hence, hydroponics is a suitable alternative to the traditional method of growing crops, and it can meet food and medicinal plant demand to an extent in a sustainable way.

AIM AND OBJECTIVES

- To make availability of the rare medicinal plants and reduce the market deficit.
- To enable plant growth regardless of seasonal and climatic variations through Hydroponics.
- To increase productivity and produce high-quality, uniform crops through controlled conditions.
- To minimize the use of water and nutrients by delivering them directly to plant roots in controlled quantities.

REVIEW OF LITERATURE

Hydroponics is a method of growing plants without soil by supplying nutrients directly through water. These systems are designed to provide an optimal balance of water, nutrients and oxygen to plant roots, resulting in faster growth and higher efficiency compared to traditional agriculture. Hydroponics is widely used in modern agriculture, particularly in controlled systems and urban farming, where soil availability is limited. It also plays an important role in Controlled Environment Agriculture and supports innovations like Vertical Farming.

In urban areas, where water resources are often limited, the viability of hydroponic systems, particularly NFT, has been explored by Butt et al. and Kumar et al. Their studies concluded that these systems can provide higher yields with efficient water management, making them ideal for densely populated regions where conventional farming is less feasible. The adaptability of hydroponics to urban environments has made it a promising option for addressing food security in cities. Modern agriculture is increasingly adopting advanced technologies such as sensors, robotics, GPS, aerial imaging and satellite photography to enhance the agricultural value chain and improve profitability, efficiency, safety and environmental sustainability. In this context, hydroponics aligns well with modern agricultural practices. Many leading companies are utilizing innovations in indoor vertical farming, artificial intelligence and plant biology to cultivate a wide variety of crops efficiently.

Advantages of Hydroponics: Hydroponic techniques help in producing healthy crops with higher yield while reducing the risk of soil-borne insects, pests and diseases. Soilless cultivation produces cleaner and safer food with very limited use of pesticides and harmful chemicals. It requires less space because plants with small root systems can be cultivated closely together, and plants grow faster and provide greater yield. Water conservation is a major advantage, as water is recycled and reused. It requires less labour, as spraying, weeding, watering and tilling are greatly reduced. It is less affected by changing climatic conditions, allowing crops to be cultivated throughout the year, and is an eco-friendly method that minimizes abiotic stress on plants.

Limitations of Hydroponic System: Tall plants and plants with deep tap root system cannot be grown. Only certain plant species can thrive for long in water before they become water-logged. Irrespective of the aerator, water contains very less amount of air. There is high

installation charge, it depends on electricity and is susceptible to power fluctuations, and it requires regular monitoring and maintenance.

Drug Review

Sl No	Drug	Botanical Name	Family	Useful Part
1.	Palak	Spinacia oleracea	Amaranthaceae	Leaves
2.	Dhanyaka	Coriandrum sativum	Apiaceae	Leaves, Seeds
3.	Methika	Trigonella foenum-graecum	Fabaceae	Leaves, Seeds

Palak -Annual leafy vegetable with shallow taproot, short stem, simple alternate leaves varying from ovate to triangular. Rich in flavonoids, carotenoids, vitamins and minerals, with antioxidant, anti-inflammatory, antidiabetic, anticancer and neuroprotective activities.

Dhanyaka - Annual herb with slender taproot, erect branched stem, broad lobed lower leaves and finely divided feathery upper leaves, small white or pink flowers in compound umbels. Rich in essential oil linalool, flavonoids and polyphenols, with antioxidant, antimicrobial, antidiabetic, hypolipidemic, digestive and anxiolytic properties.

Methika - Annual leguminous herb with nitrogen-fixing nodules, erect branched slightly hairy stem, trifoliate leaves, small pale yellow or white flowers, long slender pods. Rich in trigonelline, diosgenin and galactomannan fiber, with antidiabetic, hypocholesterolemic, anti-inflammatory, antioxidant, antimicrobial, hepatoprotective and galactagogue effects.

MATERIALS AND METHODS

Source of Data: Literary aspect was collected from Ayurvedic and modern texts, updated with recent medical journals and internet. Seeds of Dhanyaka, Methika and Palak were collected from the market of Chikodi, authenticated by botanist and stored at Dravyaguna Department, KLE AMC. Compost and coco peat were purchased from market of Chikodi.

Place of Experiment: Herbal Garden of KLE AMC, Chikodi.

Type of Study: Experimental Study.

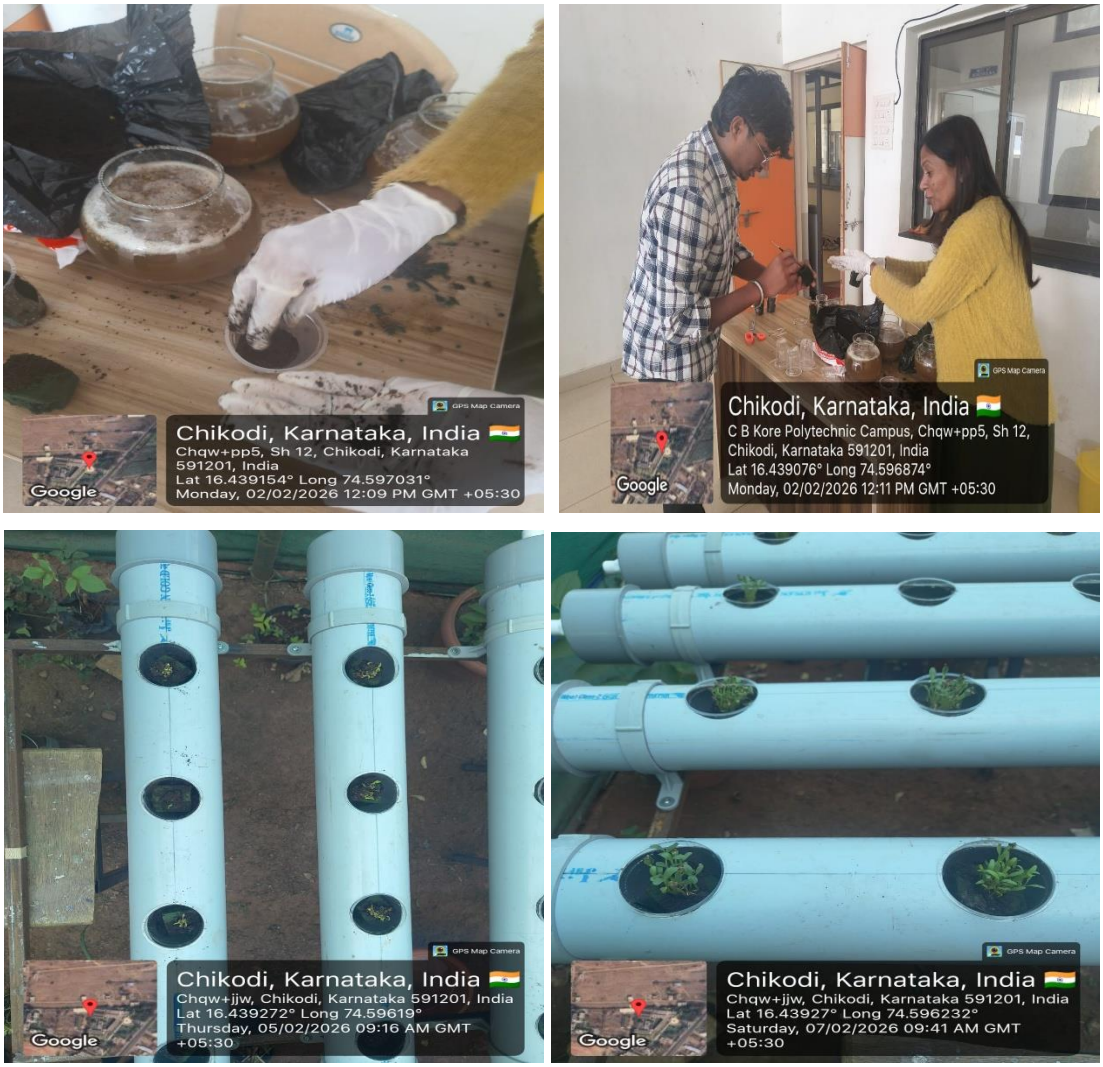
Materials Used: 20 ft 5-inch PVC pipe (3–4-inch diameter), 40W submersible water pump, end caps, PVC connectors (elbows and T-joints), flexible tubing, net pots / disposable plastic cups, reservoir tank, growing media like coco peat or sponges, nutrient solution and supporting frame.

Selection of Plants: Dhanyaka, Methika and Palak were selected because they adapt well to hydroponic systems. Plants with short growth cycles and soft stems perform better in hydroponics.

Choice of System - NFT: Nutrient Film Technique was chosen. In this method, water and nutrients circulate continuously and are delivered to the growing tray with the help of a water pump. This system consists of a slightly inclined channel through which the nutrient solution continuously flows over the plant roots before returning to the main reservoir. Plants are placed in channels with their roots suspended in the solution. NFT is particularly suitable for growing leafy vegetables and is widely used commercially for lettuce cultivation because of its economic efficiency.

Procedure

PVC pipes were cut into equal lengths and holes of 5-7 cm diameter were drilled along the top surface to accommodate plant cups, ensuring edges were smoothed to prevent damage to roots. Pipes were then assembled by fixing end caps on both ends and connecting them in series using elbows and joints to facilitate flow, maintaining a slight slope of about 2-5° to enable gravity-assisted movement. A stable support structure was used to hold the pipes securely. A reservoir was filled with nutrient solution and equipped with a submersible pump, connected to the inlet of the first pipe using flexible tubing. The system was designed in a closed loop, where the outlet of the final pipe returns the solution back to the reservoir for recirculation. Growing media such as coco peat or sponge was placed into net pots, and germinated seedlings were inserted before positioning them into the pipe openings. The system was then tested by switching on the pump to ensure uniform nutrient flow, proper circulation and absence of leaks. Regular maintenance was carried out by monitoring pH levels (5.5-6.5), checking nutrient concentration, and cleaning the system periodically to prevent clogging.



OBSERVATIONS AND RESULTS

During operation, distinct growth patterns were observed. The nutrient solution flowed uniformly as a thin film through the sloped PVC pipes, ensuring continuous contact with plant roots. Adequate aeration was maintained, and no water stagnation occurred, supporting proper root respiration. In the initial stage, all seedlings established well in coco peat or sponge and were firmly supported in net pots. Methika exhibited the fastest germination and early growth. Its roots elongated rapidly into the nutrient stream and appeared dense, fibrous and well-branched, indicating efficient nutrient uptake. Palak showed moderate growth, developing broad green leaves gradually, with roots thicker, fewer in number, but healthy and elongated. Dhanyaka showed comparatively slower germination and growth, with fine, delicate roots that took more time to reach the nutrient film but adapted steadily. As the system progressed, all plants showed healthy vegetative growth without visible symptoms of nutrient deficiency such as chlorosis or necrosis. Methika developed trifoliate leaves quickly

and showed vigorous shoot growth. Palak produced lush, turgid leaves, while Dhanyaka gradually formed its characteristic feathery foliage. The roots of all plants remained moist, white, fresh and well-aerated, preventing root rot. The recirculating system maintained consistent nutrient supply, and pH remained within 5.5-6.5. No clogging or flow obstruction was observed. Overall, Methika showed the most vigorous growth, followed by Palak, while Dhanyaka exhibited slower but stable adaptation in the NFT system.

DISCUSSION

The present study showed that Methika, Palak and Dhanyaka can be successfully grown under controlled soilless conditions with efficient nutrient delivery. The continuous thin film of nutrient solution flowing through PVC channels ensured proper supply of water, minerals and oxygen to the root zone, which is essential for healthy plant growth in NFT systems. The roots of all plants remained healthy, white and well-aerated, confirming adequate oxygen supply and absence of root rot. The maintained pH range and balanced nutrient solution supported normal growth without any visible deficiency symptoms. The recirculating system also ensured efficient use of water and nutrients, reducing wastage and improving sustainability. Differences in growth performance were due to plant nature. Methika showed fastest germination and most vigorous growth, likely due to its strong adaptability and rapid root development. Palak exhibited steady and moderate growth, indicating good compatibility with hydroponic conditions. Dhanyaka showed slower germination and delayed establishment, which may be due to its sensitive root system and slower initial nutrient uptake. In conclusion, the study indicates that NFT hydroponics is an effective method for cultivating medicinal plants, supporting healthy growth, efficient resource use and consistent plant development under controlled environmental conditions.

CONCLUSION

The achievements of this study highlight that NFT hydroponics ensures efficient water utilization through a closed-loop recirculation system, significantly reducing water wastage. It also provides controlled growth conditions, including optimal pH and nutrient balance, which contribute to uniform plant development and higher productivity. Another important outcome is the system's ability to maintain consistent crop performance regardless of seasonal and climatic variations, making it suitable for urban agriculture and areas with limited arable land. The integration of biodegradable media further enhances sustainability and reduces environmental impact. Despite these advantages, challenges such as initial setup

cost, requirement of technical knowledge, and regular monitoring of nutrient levels and system maintenance were observed. Future work may focus on automating NFT systems using sensors for real-time monitoring of pH, nutrient concentration and water flow, exploring energy-efficient pumping systems, scalability for commercial production, and integration with smart farming technologies such as IoT. Additionally, further studies on crop-specific optimization and low-cost system designs can help in wider adoption of NFT hydroponics, contributing to sustainable food production and resource conservation.

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