COMPARATIVE ANALYSIS OF SOIL BASED FARMING AND HYDROPONIC FARMING USING EICHHORNIA CRASSIPES (WATER HYACINTH)

Dissertation submitted in partial fulfillment of the requirements for award of the degree of Bachelor of Science in

BOTANY

By

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2023

CERTIFICATE

This is to certify that the dissertation entitled "Comparative Analysis of Soil Based Farming and hydroponic farming" is an authentic work carried out by Vismaya Wilson (AB20BOT033) under my supervision and guidance in the Department of Botany, Teresa's College (Autonomous), Ernakulum, in partial fulfilment of the requirements for the award of the Degree of Bachelor of Science in Botany. I further certify that no part of this work embodied in the project has been submitted for the award of any degree or diploma.

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ACKNOWLEDGEMENT

I wholeheartedly express my gratitude to Dr. Arya P. Mohan, Assistant Professor, St.Teresa's College, Botany department for suggesting the topic and guiding and inspiring me through the period of this work.

I am thankful to all the faculty members of the department of botany for their extended support and constant upliftment throughout the course of study.

I do thank all the non -teaching staff, Department of Botany and the workers of science block for all the help rendered during our work.

I thank my fellow project coworkers Prathyusha Pramod, Anie Aleena and Vismaya Wilson for the invigorating discussion and coordination we had throughout the course of study.

I express my gratitude to my classmates who played an excellent role in showering their love, friendship and generosity.

I convey my ardent gratitude to my parents for their reckless support and guidance directly and indirectly. Finally I thank god almighty for guiding me through the right path.

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ABSTRACT

Hydroponics is a method of growing plants using a nutrient-rich water solution, without the use of soil. The plants are typically grown in a container or floating structure, which allows them to be raised in environments where traditional agriculture is not feasible. Hydroponics can be particularly useful in countries with poor soil quality, limited arable land, and water scarcity. The productivity of soil-based agriculture can be limited by factors such as soil fertility depletion, frequent droughts, and unpredictable weather patterns. This project deals with a comparison between soil-less and soil-based system. Two Amaranthaceae members, *Amaranthus viridis* and *Amaranthus cruentus* were used. In soil based system pots were filled with potting mixture and planted with the Amaranthus seeds and in the soil-less system bamboo logs were tied together and a raft was made which was spread with water hyacinth, and cocopeat on which the seedlings was transferred. The growth pattern of the plants were analysed for seven week .The plants exhibited sufficient growth in a soil less system. This result achieves the aim of the study that plants can also be grown in the soil-less system.

INTRODUCTION

Hydroponics is a method of growing plants using a nutrient-rich water solution, without the use of soil. It is a subcategory of hydro culture and is a useful technique for growing plants in a controlled environment. In this method, the roots absorb the necessary nutrients from the water, allowing the plants to grow and mature. Hydroponics can be used to grow plants in various media such as liquid, sand, or gravel, as long as the necessary nutrients are provided. It has gained popularity in recent years for commercial production and horticulture, as well as for home gardening in urban areas with limited space. Hydroponics offers several advantages over traditional soil-based agriculture, including efficient use of resources, reduced water usage, and greater control over plant growth. As a result, it has become an increasingly popular method of cultivation in various fields.

Advantages of Hydroponics

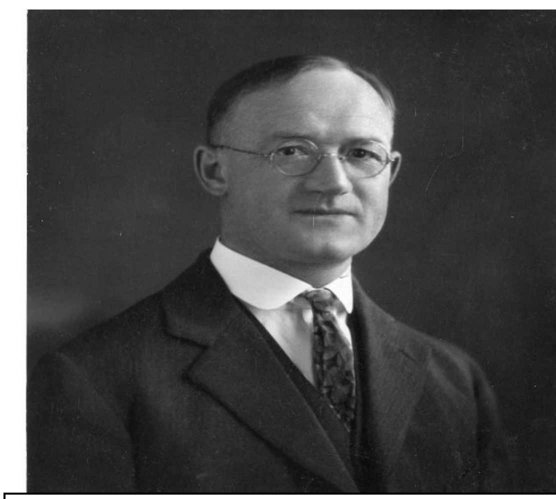
- Higher yield.
- Controlled level of nutrition.
- Plants are healthier, and they mature faster
- Weeds can be easily eliminated
- Susceptibility to pests and diseases is negligible.
- Automation is possible.
- Water present in the system can be reused, which facilitates water conservation.
- Ease of harvesting.
- Crops produced are fitter for consumption.

➢ Small production space can be optimised effectively.

Nutrients in hydroponics can come from various sources, including organic and inorganic materials such as fish and duck manure nutrient solutions. Instead of soil, some hydroponic systems use a soil-less medium like rock wool, coconut fibers (coir), or clay pellets to anchor the plants. Other systems don't have a solid growing medium, and the roots are submerged directly in the nutrient solution. Regardless of the method used, the plants receive their nutrients from the liquid solution instead of soil.

William Frederick Gericke is credited with making the earliest modern reference to hydroponics in 1937. He grew tomato vines that were over 7.6 meters tall in his backyard using a mineral nutrient solution. Since then, hydroponics has become an increasingly popular method of cultivation for commercial growers, home gardeners, and researchers alike.

Dr. Gericks, standing on a ladder, harvesting tomato plants grown in hydroponics.



William Frederick Gericke

Hydroponics is a promising solution to face the challenges of climate change and improve production system management, which can help mitigate malnutrition. This method has the potential to utilize water lands that have poor soil quality, allowing for efficient utilization of natural resources.

The success or failure of hydroponics primarily depends on nutrient management programs, as highlighted by Sankhalkar et al. (2019). Moreover, in metropolitan areas and other locations, the availability of fertile cultivable land can be limited due to unfavorable geographic or topographic conditions. In some cases, soil is not available for crop growing at all. In such situations, hydroponics can provide an efficient and effective way to grow crops without relying on soil. Another problem is that it is difficult to hire labor for conventional open-field agriculture. Under such circumstances, soil-less culture can be introduced successfully.

OBJECTIVES

- Develop an economically viable soil-less farming system that can provide an efficient and sustainable alternative to traditional soil-based agriculture.

- Evaluate the efficiency and effectiveness of *Eichhornia crassipes* (water hyacinth) as a substitute for soil in soil-less farming systems, including its ability to provide necessary nutrients and support plant growth.

- Investigate the adaptability of soil-less farming systems in urban areas and for farmers during floods, with a focus on identifying key factors that contribute to successful implementation and addressing potential challenges.

- Compare the performance of soil-less farming systems with traditional soil-based methods, specifically looking at the Amaranthaceae family members *Amaranthus viridis* and *Amaranthus cruentus*.

Literature Review

Many studies have been conducted to investigate the opportunities for implementing hydroponics systems and their possible applications, as well as to determine suitable designs and functionalities. Hydroponics is the science of growing plants in a soil-less medium, where plants can absorb and consume essential minerals in tap water and absorb ions directly from nutrient-rich solutions. Automation reduces the actual time it takes to maintain plant growth requirements in an automated system without soil, where a mix of water and nutrient solution is supplied from a storage tank and regularly recirculated. Soil is the default source for nutrient supplements, but when these same nutrients are provided artificially into a plant's water source, soil is no longer needed for plant growth.

Studies have compared the growth of plants in soil-based (traditional) and hydroponic systems, with the latter showing a higher growth rate. Kratky (2009) utilized a non-circulating hydroponics concept for growing lettuce, while Maeva (2014) found that hydroponics plants germinated and grew faster than soil plants. Crops grown in soilless culture are healthier and more reliable than crops grown in soil (Sardare et al., 2013). Hydroponics cereals are an effective solution for fodder scarcity, with nutrient increase in crude protein, fiber, ether extract, vitamins, and minerals consistently observed. Fodder feeding improves milk yield and composition of dairy cows through increased intake and digestibility of nutrients (Salo, 2019). Hydroponics is a preferable alternative to conventional systems due to conservation of water, precise use of space, reduced carbon footprints, increased cereals yield, reduced time growth, etc. (Nonigobal, 2019).

Hydroponics is a potential technique for barley cereals production with less water consumption, particularly in areas where water is a limiting factor for agricultural production. Tertiary treated sewage wastewater is a feasible source for irrigation of hydroponically produced barley cereals (AI-Karaki, 2011). Bakshi et al. (2017) critically assessed hydroponic fodder production, concluding that it is best suited to semi-arid, arid, and drought-prone regions of the world suffering from chronic water shortage or in areas where irrigation infrastructure does not exist.

Sangeeta Sankhalkar and co-workers (2019) conducted a study comparing physiological and biochemical studies in vegetable plants grown with soil and soilless cultures, finding a higher root ratio in plants grown in hydroponics than in soil, higher chlorophyll content in seedlings grown in hydroponics, and slightly higher sugar and protein content in soil-grown seedlings. Hydroponic cultures of vegetable crops with more leaf biomass are more beneficial, although hydroponically grown roots, although longer, were fragile in comparison to roots of the soil-grown seedling. Hydroponics is one of the best choices of conventional cultivation and does not require advanced equipment for cultivation.

MATERIALS AND METHODS

The first step was to choose the plant type. The selected plants belong to the Amaranthaceae family, namely *Amaranthus viridis* and *Amaranthus cruentus*, which were chosen due to their easy availability and easy germination. About 20 pots were used for this experiment.

The materials used for creating the required growth media are as follows:

For the soil-based systems, the following materials were used:

- Pots
- Potting mixture (soil, cow dung, and coco peat were mixed in the proportion)

For the soil-less systems, the following materials were used:

- Bamboo
- Coir ropes
- Water hyacinth
- Cocopeat

The seeds were soaked in normal water for 12 hours to facilitate easy germination. Then, the soaked seeds were transferred to a wet tissue and covered for faster germination. The next day, the seeds were transferred to the growth medium. In a soil-based system, soil was used as the rooting medium. In the soil-less system, water hyacinth was used as a rooting medium. After 3 days, the seeds germinated.

In the soil-based system, the germinated seeds were watered twice a day. In the soil-less system, with water hyacinth, water was sprayed once a day until the root developed.

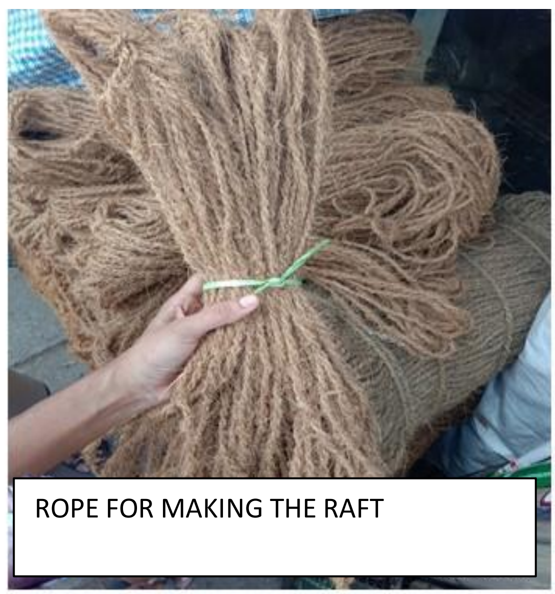
For the soil-less system, bamboo was tied together closely with rope and filled with water hyacinth. On top of the water hyacinth, coco peat was also used, and it was made wet before transferring the germinated seeds to this medium. Water was sprayed once a day, which retained the water holding capacity around the roots, while preventing it from rotting.

In the soil-less system, with water hyacinth as a rooting medium, bamboo was tied closely, and a raft was made and filled with water hyacinth. The germinated seeds were transferred to the raft and watered once until the root developed. After the development of roots, the bamboo raft was transferred to water, and watering of seeds was not done as the roots were completely dipped in water.

In the soil-based systems, a pot with holes was filled with potting mixture. The germinated seeds were transferred to the soil and watered twice a day. The height of the plants was measured using a scale every week for seven weeks and recorded. The average height was calculated for growth analysis. Photographs of the growing phases of plants were also taken every week for future reference.

COLLECTION OF RAW MATERIALS


20 POTS FOR PLANTING THE SEEDLINGS


ROPE FOR MAKING THE RAFT


COLLECTED BAMBOO FOR THE RAFT

EICHHORNIA

COLLECTION OF EICHHORNIA

COLLECTED EICHHORNIA

CUTTED PIECES OF EICHHORNIA

METHODS IMPLEMENTED

DRAINING OF EICHHORNIA

DRIED EICHHORNIA

PREPARATION OF POTTING MIXTURE
ADDITION OF COCOPEAT

PREPARATION OF POTTING MIXTURE
ADDITION OF COWDUNG

OBSERVATION AND RESULTS

FILLING THE POT WITH THE POTTING MIXTURE

SOWING OF THE SEEDS

RAFT FOR THE SOIL LESS STRUCTURE

SPREADING THE RAFT WITH COCOPEAT AND WATER

The comparative analysis of growth patterns of Amaranthaceae family in soil based and in hydroponics method of cultivation for seven weeks. After 7 weeks the experiment was concluded and the data was tabulated.

The observations are as given below:

<u>CONTROL</u>

Weeks	Length in cm	No.of leaves
1st week	0.5 cm	2
2nd week	3 cm	4
3rd week	5.5 cm	4
4th week	8 cm	6
5th week	12 cm	8
6th week	13 cm	9
7th week	15 cm	9

EXPERIMENT

Weeks	Length in cm	No. of leaves
1st week	1 cm	2
2nd week	4 cm	4
3rd week	6 cm	6
4th week	9 cm	8
5th week	13 cm	9
6th week	16cm	10
7th week	18 cm	11

Graphical Representation

NO. OF LEAVES

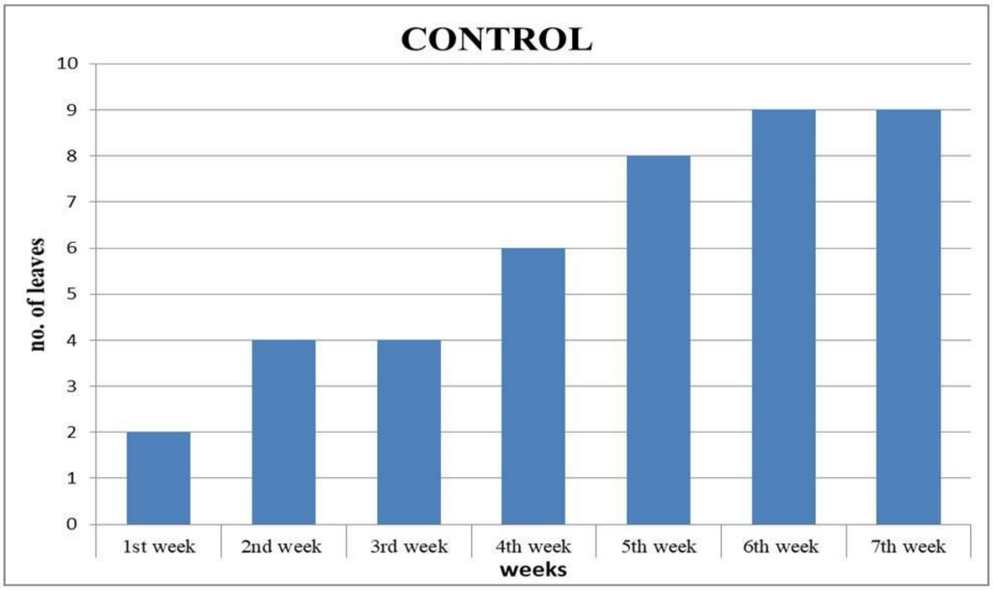


Fig .1. Number of leaves

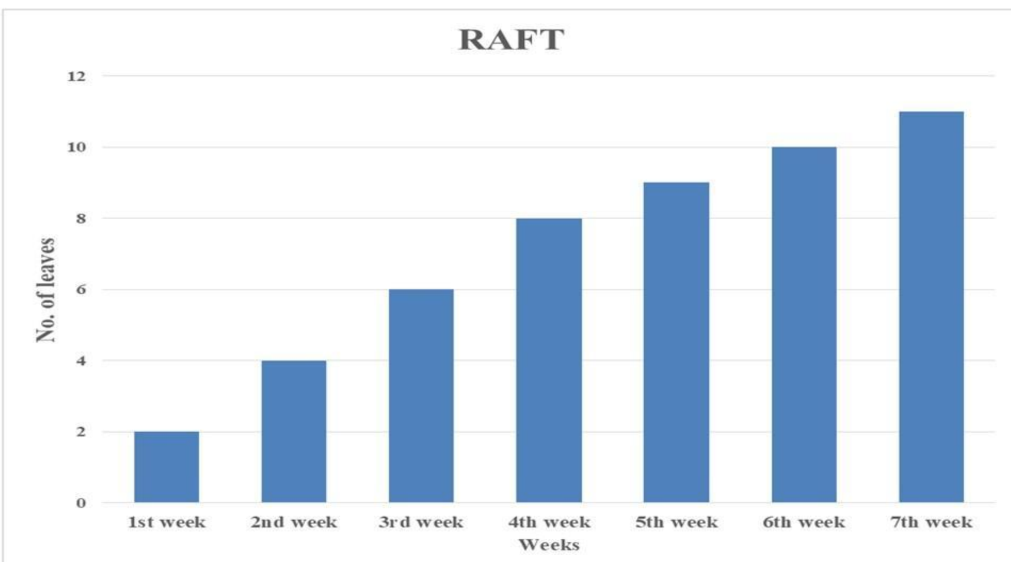


Fig .2.Number of leaves

LENGTH OF THE PLANT (in cm)

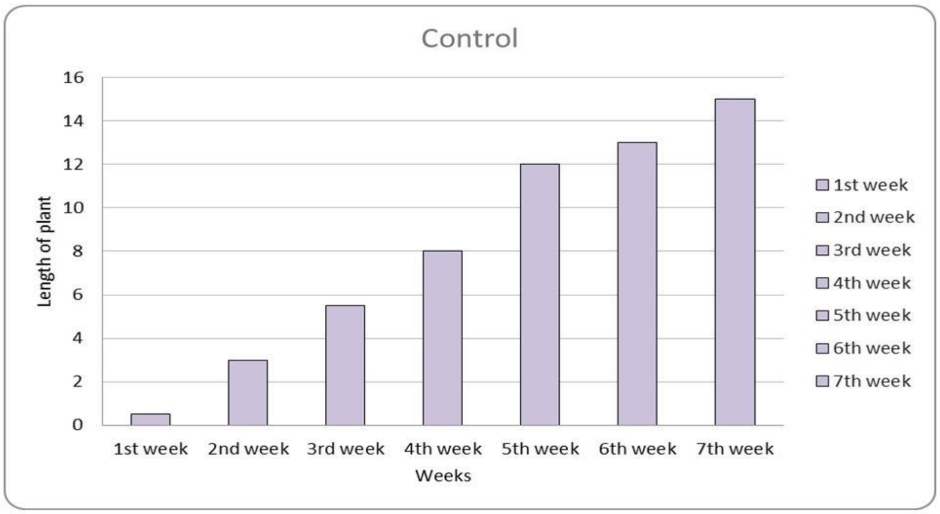


Fig.3. Length of the plant in control

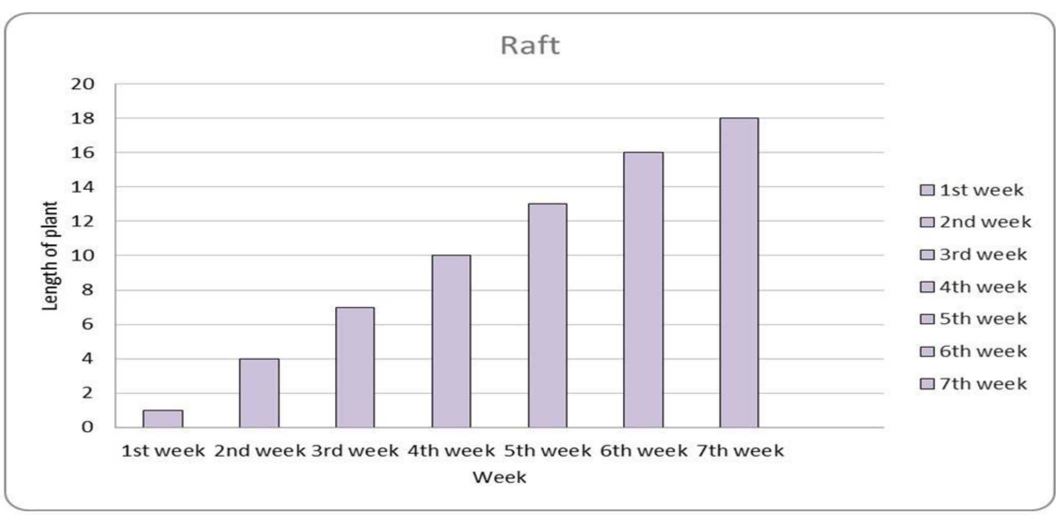


Fig.4.Length of the plant in the raft

RESULTS

The results of the comparative analysis showed promising outcomes for plants grown in hydroponic rafts. This suggests that modern cultivation methods such as hydroponics can be useful for initial germination and growth, especially in urban areas. It was observed that the roots of hydroponically grown plants were stronger and the stems were stiff and strong compared to those grown in soil. Additionally, hydroponically grown plants grew faster and taller than soil-grown plants, and their leaves were greenish in color and not destroyed by insects. Overall, the plants grown in the hydroponic raft exhibited rapid growth in comparison to those grown in pots.

PLANT GROWTH IN CONTROL

Image .1

IMAGE 1 A) Plant growth in first week

B) Plant growth in second week

C) and D) Plant growth in third week

On the 1st week the length of the plants is about 1cm and it had two leaves. During this period, only a less amount of sunlight was provided . Proper irrigation is maintained throughout it's growth. In the second week plants reached at a height of 3cm and had 4leaves. During this week, the pots were placed in direct sunlight. At 3rd week the plants were grown up-to the height of 5.5 cm. There were no particular difference in the number of leaves as compared to the second week .On the 4th week, the plants size was increased to about 8cm and it had 6 leaves.

IMAGE 2

IMAGE 2. E) Plant growth in fourth week

F) Plant growth in fifth week

G) Plant growth in sixth week

H) Plant growth in seventh week

During the 5th week, plants had the length of about 12 cm and 8 leaves were produced by it. Gomutra was also sprayed to the plants. On the sixth week,it's length increased by 1cm as compared to the previous week and had 9 leaves.At the last week of observation, the total height of the plant was about 15 cm and there was no changes in the number of leaves, but there is an increase in the size of the leaves .

PLANT GROWTH IN RAFT

IMAGE .3.

IMAGE 3 A) First week of plant growth in raft

B) Second week of plant growth in raft

C) Third week of plant growth in raft

D) Fourth week of plant growth in raft

At the first week, its growth is similar to the plants that are planted on the pots. Initially small mud balls were prepared to plant the seedlings in it. But the mud balls became stiff during the period of growth and the roots was unable to penetrate through it. So it was well moisturized with sufficient water. And was kept in the raft spreaded with water hyacinth and cocopeat. It had a length of about 3cm and 4 leaves were present. On the 3rd week, the Plant height increased to about 7cm and had 6 leaves. Proper irrigation and sunlight was also provided. On 4th week, plant height was increased it's length was about 10 cm and had 8 leaves on it. Cocopeat and water hyacinth were added as manures during its period of growth .

IMAGE .4.

IMAGE 4. E) Fifth week of plant growth in raft

F) Sixth week of plant growth in raft

G)and H) Seventh week of plant growth in raft

On the fifth week, The plants had the length of about 12 cm and had 9 leaves. The plants in the raft is more healthier and stronger than the plants in the pot. In sixth week, It's length is about 13 cm. and finally, last week of the plant growth in raft, the growth of the plant is more in the raft than the plants in pot. It's height was about 15cm. It had stronger stem and root as compared to the plants in the pot also the attack by insects was comparatively less than that planted in the pot.

Due to the use of a constant feeding of nutrients and water, the hydroponic plants have grown much taller and produced more leaves quicker than the plants growing in normal soil. Because of the use of water hyacinth (Eichhornia crassipes) in the raft, it makes the plant growth more properly. Water hyacinth (Eichhornia crassipes) can absorb ammonia, phosphorus, oils, nitrates etc. is likely to be nutritious because of the high protein content. The plant that were grown on the raft hasn’t got any kind of pest attack as compared to the plant in the pot and its growth occurs more rapidly than the pot. The roots and the stem of the plants that were grown on the raft was more stronger and healthier than the pot hydroponic system plants are more densely spaced together compared to the size of land that would be needed to grow the same number of plants. Hydroponics is the most ideal system recommended for many growers because of the awareness placed on the environment and ecosystem. Hydroponics is fully adapted to suit the needs and outcomes as required by those investing in it. Compared to field-grown plants, hydroponically produced plants consume only 10% of the water. Hydroponics allows for complete control over the nutrients (foods) that plants require.

DISCUSSION

The use of hydroponics has become increasingly popular in recent years due to its ability to provide a controlled environment for plant growth, which can result in higher yields, improved quality, and reduced use of resources such as water and fertilizers. Hydroponics offers several advantages over traditional soil-based cultivation, including the ability to grow plants in areas with limited access to fertile soil, the ability to grow plants year-round, and the ability to produce crops with fewer pesticides and herbicides. Additionally, hydroponic systems can be tailored to suit a variety of crops and growing conditions, allowing for increased flexibility and efficiency in agricultural production.

A large number of plants and crops or vegetables can grow by hydroponics system. Quality of produce, taste and nutritive value of end products is generally higher than the natural soil based cultivation. Various experimental findings outline that leafy greens (lettuce, spinach, parsley, celery, etc) can be successfully and easily grown in a hydroponic system. Lettuce and spinach are most promising species to grow in integrated hydroponics and aquaculture systems because of its higher growth and nutrient uptake capacity.

Recently various hydroponic experiments were conducted using spinach as a model crop. Ranawade. et al. (2017) have compared spinach yield in hydroponics, aquaponics and in a traditional system in which perlite (aquaponics) and sphagnum moss(hydroponics) were used to support the plants. The results of Mwazi et al. (2010) showed that salinity has a negative impact on vegetative growth, but spinach has some tolerance to saline water with 5 ppt. When spinach growing in floating system, lack of aeration and hypoxia was not severe enough to influence yield and yield component as spinach is short duration crop but quality somehow is affected (Lenzi et al., 2011).

According to Bandara from University of Peradeniya, the experiment shows that an average of 1200 kg of natural gas would be needed annually for 1ha farm of hydroponics. The root lengths of the plants grown in the hydroponics were slightly higher than the lengths of the soil grown plants. These plants also had their roots being more resistant to growth as the initial lengths of their roots were close to that after the experiment. The hydroponically grown plants recorded higher shoot dry weights as compared to those from the soil which had high root dry weights. This is one of the best ways of determining the quality of the harvest one should expect after the plants have grown to maturity.

There is demand for food and space. To meet the food requirement there is tremendous use of pesticides and chemical fertilizers. The plants are also irrigated with contaminated water. This has affected our health. In order to overcome the said problems the current project was undertaken where by soilless cultivation was carried out using Hydroponic techniques. For the study Amaranth the leafy vegetable from family Amaranthaceae was taken, as this plant is rich in protein, calcium, vitamins etc. The Amaranth plant is also known for its therapeutic potentials in curing cancer, malaria, intestinal disorder etc. The seedlings were grown in coco peat and the saplings were transferred in to a nutrient rich container. The plants grew in short period of time and healthy too. This hydroponically grown plant was compared with the Amaranth plant grown in soil. The result obtained favoured soilless cultivation rather than the plant grown in soil. Thus the attempt to grow Amaranth using hydroponic technique was significant. It yielded safe and nutrient rich leafy vegetables even during off seasons.

The Amaranth seed took 3 days for germination. The results of this study suggest that hydroponic cultivation is a viable and promising option for cultivating Amaranth and other leafy vegetables. The benefits of this method include more efficient water and nutrient utilization, reduced use of pesticides and fertilizers, and improved yields and quality of produce. With the increasing demand for food and the growing concern over the safety and quality of our food supply, hydroponic cultivation represents a sustainable and innovative solution to meet the needs of a growing population.

CONCLUSION

Hydroponics is rapidly gaining momentum and popularity as the best way to cultivate everything from flowers and food to medicine. In Europe, hydroponics is now widely accepted by consumers and is quickly catching on in other countries around the world. Hydroponic industry is still rather small, and there aren't many local shops. Hydroponics is the most ideal system recommended for many growers because of the awareness placed on the environment and ecosystem. Hydroponics is fully adapted to suit the needs and outcomes as required by those investing in it. Proper background education is needed alongside an effective project planner, highlighting the aim, vision, goals, objectives and sources of advantage that will bring about successful production. Hydroponics help in better growth of plants in limited time. It requires only very less/no soil. It can be done on a small scale as well as on a large scale. It is affordable. It provides a promising future crop.

Hydroponics is a promising approach to cultivation that offers many advantages over traditional soil-based farming methods. The controlled environment and nutrient-rich water solutions allow for more efficient use of resources and increased yields of high-quality produce. Hydroponics can be adapted to a variety of plant species and has been shown to be effective in commercial applications. While there are initial costs associated with setting up a hydroponic system, the long-term benefits and potential for sustainable agriculture make it a worthwhile investment. As the demand for food continues to increase and concerns about soil degradation and water contamination persist, hydroponics offers a viable solution for meeting these challenges.

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