COMPARATIVE STUDY ON THE GROWTH PERFORMANCE OF *CUCUMIS SATIVUS L.* GROWN IN HYDROPONICS AND SOIL

DISSERTATION

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VYSHNAVI SATHEES

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CERTIFICATE

This is to certify that the dissertation entitled "Comparative study on the Growth Performance of *Cucumis sativus L.* grown in Hydroponics and Soil" submitted in partial fulfillment of the requirements for the award of the Degree of Bachelor of Science Botany is an authentic work carried out by VYSHNAVI SATHEES (REG NO: AB20BOT034) under the supervision and guidance of Dr. Liza Jacob.

Dr. LIZA JACOB

Associate professor and Head

Supervising Teacher

Department of Botany

St. Teresa's College (Autonomous)

Ernakulam

Examiners:

1. Dr Krishnaraj M.V 27/4/2023

2. Cyril Alexander 27/4/2023

Place: Ernakulam

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Place: Ernakulam VYSHNAVI SATHEES

Date:

CONTENTS

Introduction

In the Cucurbitaceae family, cucumber (*Cucumis sativus L.*) is a widely grown creeping vine plant that produces spherical to cylindrical fruits that are used in cooking as vegetables. The cucumber is an underground-rooted creeping vine that climbs trellises or other frames of support by twining its thin, twisting tendrils around them. The plant can also take root in a soilless medium, in which case it will spread out on the ground without a support system. Large leaves on the vine provide a canopy above the fruits.

The cucumber was first cultivated in the Himalayas in China (Yunnan, Guizhou, and Guangxi) and northern Thailand, but it now thrives on most continents and there are numerous varieties developed for commercial purposes and sold on the international market. Cucumbers are a low-maintenance vegetable that grow quickly with regular hydration and warmth. They enjoy the sun and water. In terms of fruit size, shape, and colour, the processing business has different requirements depending on the preservation method and the relevant nation. Breeders of cucumbers must therefore consider a variety of breeding objectives. The major goals of cucumber breeding are to maintain resistance in existing types, improve fruit quality, and increase fruit output. Moreover, breeding objectives such parthenocarpy, female constancy, germination, and fruit set at insufficient temperatures may be of importance in special breeding programs.

While hydroponic growing is a soil-free method that offers the nutrients in a liquid form, soil-based growth feeds the plants with nutrients through minerals in the soil. Although both techniques can result in robust plants, each has advantages and disadvantages. The plants are planted directly into the ground outdoors or into a pot indoors with soil when using the more conventional method of soil gardening. The roots of the plant absorb the essential nutrients from the soil as organic materials and minerals decompose there. During the feeding cycle, some gardeners also like to add additional synthetic fertilizers to the soil because they break down faster than natural minerals and can offer extra advantages.

In hydroponic gardening, plants are fed by liquid solutions that directly give nutrients, water, and oxygen to the roots rather than through the soil. The plants are automatically fed via a closed-tube system since the roots are submerged in water rather than soil. This more recent method calls for tools and expertise. Compared to a regular soil setting, a hydroponic growing environment gives the farmer much greater control over the production process. Plants' access to nutrients in soil is more difficult to regulate, and it can be challenging to pinpoint the precise makeup of soil nutrients.

With hydroponics, the grower can accurately control the amount and composition of the nutrients to which plants have access. Also, with hydroponics, a grower may regulate the pH of the growing environment and protect plants from pests and pollution. In a hydroponic system, water can be used more effectively because irrigation water can be reused.

Whether growing in the ground or in a garden bed, traditional soil gardening requires a sizable amount of yard space. Also, in order to get the same yield, hydroponics will require less room than growing crops in pots and planters. With hydroponics, plants may grow more in a smaller area. This is so that the plant may obtain the nutrients it needs without relying on soil. Instead, the plant is given the remedy that has been developed for it directly. Hence, the requirement for extensive roots, as in soil, is avoided. You don't require as much space because the plants don't rely on the soil to deliver nutrients to them. The plant can grow successfully as long as there is enough for both the mineral solution and the plant.

Hydroponically grown plants typically grow more swiftly than soil-grown plants because oxygen and nutrients are supplied directly and heavily to the roots of these plants. Harvesting durations are shortened as a result of the quick growth, and more growth cycles can be squeezed into a given period of time. Plants in hydroponic systems also often produce greater yields since they don't have to work as hard to receive nutrients and can devote more energy to fruit and vegetative development. Hydroponic systems can be installed practically everywhere, even in environments that are utterly unsuitable for growing plants, as they are not dependent on environmental factors. Moreover, hydroponic systems utilize available space more effectively than soil-based growing conditions. So, they are especially well-suited to use in urban environments where space is tight and areas with cultivable soil are limited. The use of artificial light in indoor environments can make hydroponics viable in environments where access to sunlight is problematic, either because of seasonal conditions or the surroundings.

When comparing soil versus hydroponics, another factor is the nutrients your plants will get. With hydroponics, you can tailor the nutritional requirements for exactly what you are growing. In soil gardening, you will need to enrich the soil and choose from different options. There is topsoil, regular soil, soil that’s amended with compost, and more. Even enriching the soil with compost and whatever else you add — potting soil, vermiculite, peat moss, manure, filler soil, composted mulch, etc.— you may not have the optimum nutrients like you can in hydroponics. The use of hydroponics for plants allows them to grow at a much faster rate. Using hydroponics will allow the plants to grow anywhere from 30% to 50% faster

Review of literature

Techniques for producing food have been the subject of many investigations. Soilless farming techniques are one of them. The roots of plants are suspended in nutrient-rich water in a hydroponics system, so they can grow naturally without the use of any chemicals. It allows commercial and residential gardeners to grow food in locations where it is not practical or cost-effective to use a typical soil system. When compared to a soil-based system, hydroponic plants can produce 20–25% more yields while being 2–5 times more productive.

According to Grillas *et al.* (2001), hydroponic systems enable flexibility and intensification while still producing high crop yields and high-quality goods.

The application of hydroponics using artificial substrates could minimise the need for chemical pest control, Polycarpou *et al.*, (2005).

Maeva Makendi's experiment investigation revealed a competitive analysis of the plant's growth in soil-based and hydroponic systems. If hydroponic plants and plants grown in soil are given the same germination and growth conditions, the hydroponic plants will perform at least as well as the plants produced in soil, if not better. For one month, various kinds of plants were used in the experiment. Compared to soil plants, hydroponic plants did germinate and grow more quickly.

Shraddha, V.A., and Mamta, D.S. (2013) entitled "A Review on Plant without Soil—Hydroponics," Plants are grown in soilless culture without the use of soil. Improving soilless culture techniques for food production have produced some encouraging outcomes globally in terms of saving space and water.

An overview of hydroponics as a cutting-edge method for growing vegetables by Sharma Nisha, Acharya Somen, Kumar Kaushal, Singh Narendra, and Chaurasia

2019) .The performance of various crops, including tomato, cucumber, pepper, and leafy greens, as well as water conservation by this method have all been discussed in this article. Different hydroponic structures, including wick, ebb and flow, drip, deep water culture, and Nutrient Film Technique (NFT) systems, have also been covered. This method has several advantages over conventional farming, including shorter crop growth cycles, year-round output, low disease and pest incidence, and the elimination of tasks like weeding, spraying, and watering.

Salvatore Gaetano Verdoliva *et al.* (2020), in their article -Controlled comparisons between soil and hydroponic systems reveal increased water use efficiency and higher lycopene and β-carotene contents in hydroponically grown tomatoes. Plants cultivated in the two hydroponic systems transpired less water and used less water overall than plants grown in soil. Total soluble solids and sugar levels did not differ considerably, and fruit production was comparable.

Materials and Methods

The study was conducted to find out the growth performance of *Cucumis sativus L*. in both soil and hydroponics. The materials and methods of present study are as follows.

Plant used for study: *Cucumis sativus L.*

The first step in this experiment is to select seed or seedling of cucumber. These were chosen because they germinate quickly to speed up experimentation. A total of four seeds were used for this experiment, four cucumber seeds .Two are used for hydroponics, and the other two are for soil. Cucumbers can be grown successfully in many types of soils. The preferred soil is loose, well drained, and well supplied with organic matter and plant nutrients. The soil pH should be between 6.0 and 6.5. Soil temperature should be at least 60 degrees F before seeding for optimum germination.

A hydroponic system provides all the nutrient without involving the sunlight, soil, extra labor and produce large yields. Cucumbers prefer moderate humidity. Good air flow is essential for plant vigor. Cucumbers are prone to powdery mildew in high humidity. 80°F maximum is best for accelerated growth. Night temperatures should be no less than 65°F. pH range 5.5-6.0 for optimal results.

Hydroponic Method:

The plant selected to conduct the trial was *Cucumis sativus L.* They were chosen because of various factors such as quick germination, easy to set up etc. The materials needed for creating the hydroponic system are the following: Big plastic containers, (yoghurt containers), etc. with a big hole for the small plastic container to fix it in the middle of the big container. Drilled the lid, creating a large enough to place and hold a net pot. Next the container was filled with water (distilled water). The hydroponics nutrients used were- Nutrient solution A, which consist of calcium and iron chelate and Nutrient solution B consisting of sulfate potassium , zinc sulphide and magnesium sulfate in the form of Epsom salt to neutralize the pH. The pot was placed over the growing medium keeping the root system sunk in the nutrient solution. The plants were monitored daily for 30 days and keep them away from pests and root-rot (if roots go slimy, theplant will turn brown and die).

Control:

For this traditional soil planting methods are used

1. Enough space; A sunny spot is required to grow the plants in good condition.

2. A plastic container with a small hole in the bottom is used for this. It is inexpensive and easily available

3. Potting mixture with soil, sand and organic nutrients was prepared.

4. Seedlings used for this are *Cucumis sativus L*. High quality seeds are bought from a nearby nursery. The seeds were planted in the soil.

6. Later the potted plant was watered regularly and fed with proper nutrients and fertilizers. Normal tap water available was used for this.

8. After planting this is kept in a space where it can get bright and direct sunlight.

Growth Parameters

Various growth parameters considered for the study were:

1. MORPHOLOGICAL PARAMETER

a) General appearance
b) Shoot length
c) Number of leaves
d) Number of branch

2. PLANT BIOMASS

a) Fresh weight of leaf, stem, and root
b) Dry weight of a leaf, stem, and root

3. PLANT PIGMENTS

a) Chlorophyll a
b) Chlorophyll b
c) Total Chlorophyll
d) Carotenoid

CHLOROPHYLL AND CAROTENOID CONTENT

The method of Arnon (1949) was employed for the quantitative estimation of Chlorophyll and Carotenoid content.

80% acetone was prepared. A pre weighed (250 mg) quantity of fresh leaf Material was ground into fine paste. 10 ml of 80% acetone was added into it. The extract was centrifuged repeatedly till the leachate became colorless. The supernatant was taken together and was made up to 25 ml with 80% acetone. The extract was kept away from direct sunlight. The optical density of the extract was read at 420,490, 540, 590, 650 wavelengths. The samples were analysed in duplicates.

From the optical densities, the Chlorophyll and Carotenoid contents were calculated using the formula

1. Chlorophyll a (mg/gm) =12.7(D663)-2.69(D645) xV/1000xW

2. Chlorophyll b (mg/gm) =22.9(D645)-4.68(D663) xV/1000xW

3. Total Chlorophyll (mg/gm)=D652x1000/34.5xV/1000x W

Where D optical density

V=final volume of 80% acetone (10 ml)

W= weight of sample taken (0.25g)

The results obtained were compared with that of control.

OBSERVATION AND RESULTS

The results showed that the plants grown in hydroponics performed better.

SHOOT LENGTH (TABLE 1)

Growth of *Cucumis sativus L*. in Hydroponics

- The shoot length observed on 35th day was 27.9 cm

Growth of *Cucumis sativus L*. in Control

- The shoot length observed on 35th day was 8.9 cm

NUMBER OF LEAVES (TABLE 1)

Growth of *Cucumis sativus L*. in Hydroponics

- No.of leaves observed on 35th day was 5

Growth of *Cucumis sativus L*. in Control

- No. of leaves observed on 35th day was 5

TABLE 1: MORPHOLOGICAL FEATURES

SI. NO	FEATURES	HYDROPONICS	CONTROL
1	Shoot length	27.9 cm	8.9 cm
2	Root length	18.6 cm	14.9 cm
3	No. of branches	5	5
4	No. of leaves	5	5

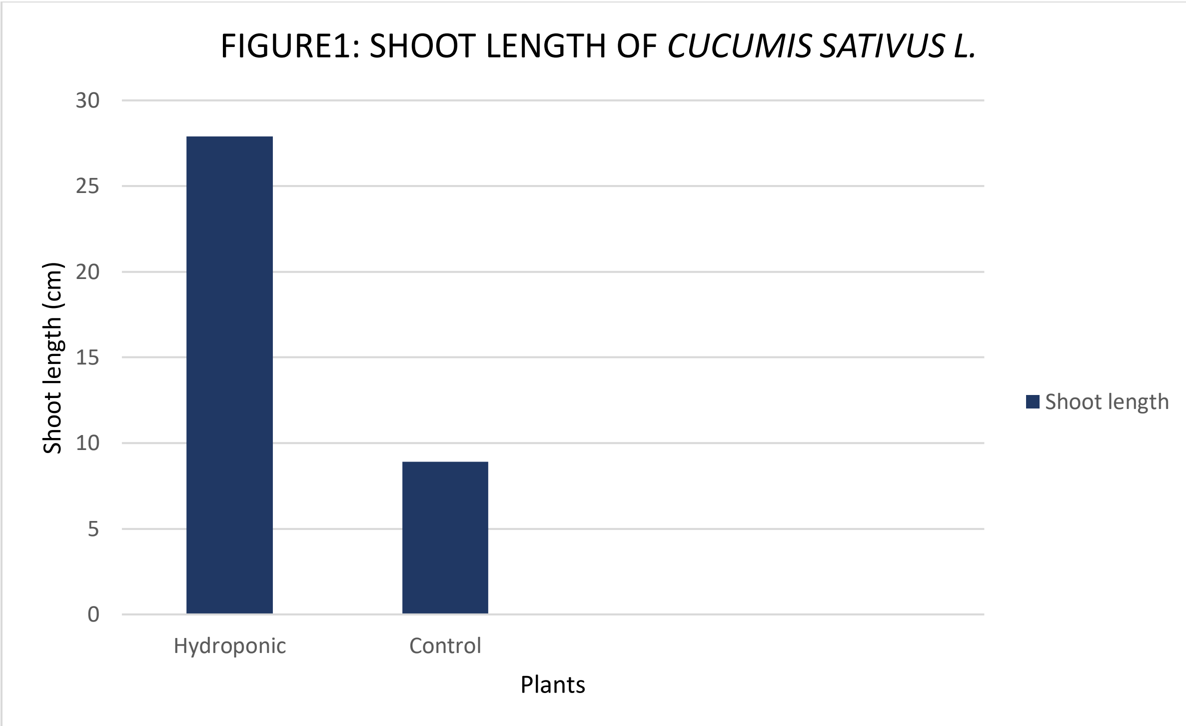


FIGURE1: SHOOT LENGTH OF *CUCUMIS SATIVUS L.*
30
25
20
15
10
5
0
Shoot length (cm)
Hydroponic
Control
Plants
Shoot length

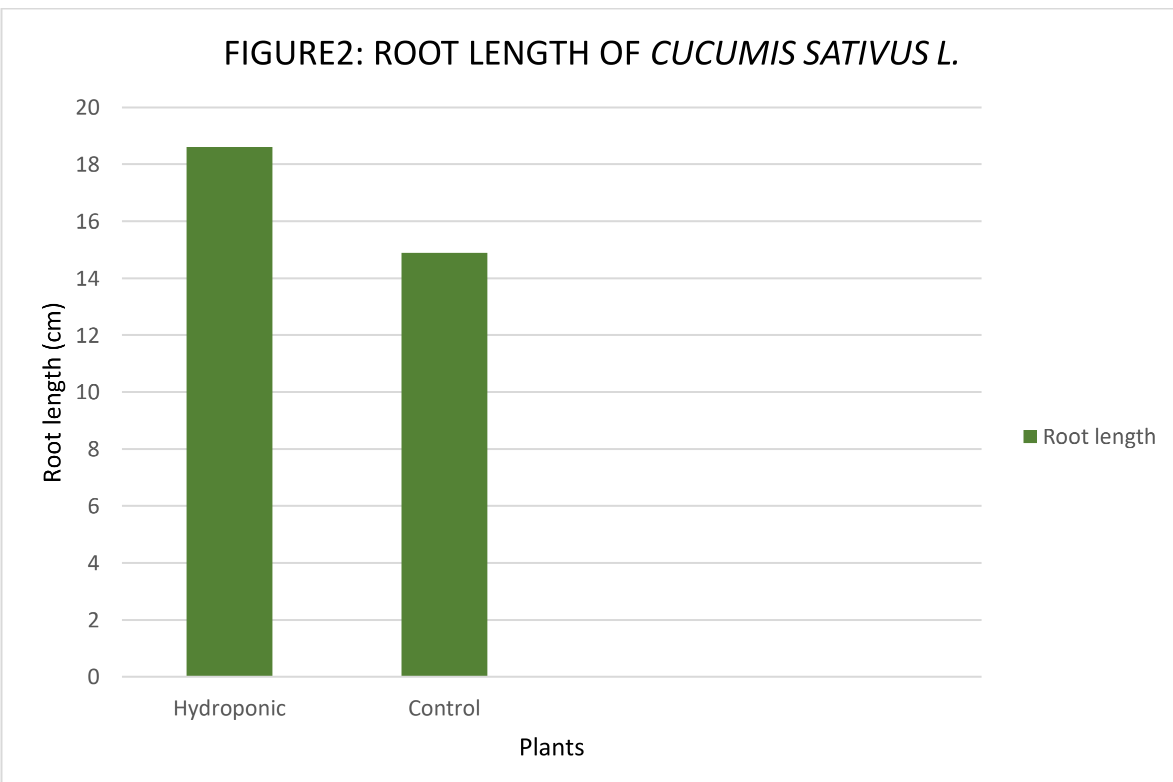


FIGURE2: ROOT LENGTH OF *CUCUMIS SATIVUS L.*
20
18
16
14
12
10
8
6
4
2
0
Root length (cm)
Hydroponic
Control
Plants
Root length

WET WEIGHT OF *CUCUMIS SATIVUS L.* TAKEN ON 35^{TH} DAY
(TABLE 2)

Growth of *Cucumis sativus L*. in Hydroponics

- Weight of whole plant observed was 4.93gm
- Weight of shoot observed was 4.49gm
- Weight of root observed was 0.12gm

Growth of *Cucumis sativus L* in Control

- Weight of whole plant observed was 2.27gm
- Weight of shoot observed was 1.65gm
- Weight of root observed was 0.12gm

TABLE 2: WET WEIGHT

	PLANT PART	HYDROPONICS	CONTROL
1	Whole plant	4.93gm	2.27gm
2	Shoot	4.49gm	1.65gm
3	Root	0.12gm	0.12gm

DRY WEIGHT OF *CUCUMIS SATIVUS L*. ON 35TH DAY (TABLE 3)

Growth of *Cucumis sativus L*. in Hydroponics

- Weight of shoot observed was 0.36gm
- Weight of root observed was 0.02gm

Growth of *Cucumis sativus L.* in Control

- Weight of shoot observed was 0.15gm
- Weight of root observed was 0.01gm

TABLE 3: DRY WEIGHT

SI. NO.	PLANT PART	HYDROPONICS	CONTROL
1	Shoot	0.36gm	0.15gm
2	Root	0.02gm	0.01gm

CHLOROPHYLL AND CAROTENOID CONTENT (TABLE 4)

Leaf pigment content of *Cucumis sativus L*. grown in hydroponics and control in 35th day

Cucumis sativa L. grown in hydroponics

- Chlorophyll a content on 35th day was 3.832 mg/gm
- Chlorophyll b content on 35th day was 3.521 mg/gm
- Total Chlorophyll content on 35th day was 7.321 mg/gm
- Carotenoid content on 35th day was 2.51 mg/gm

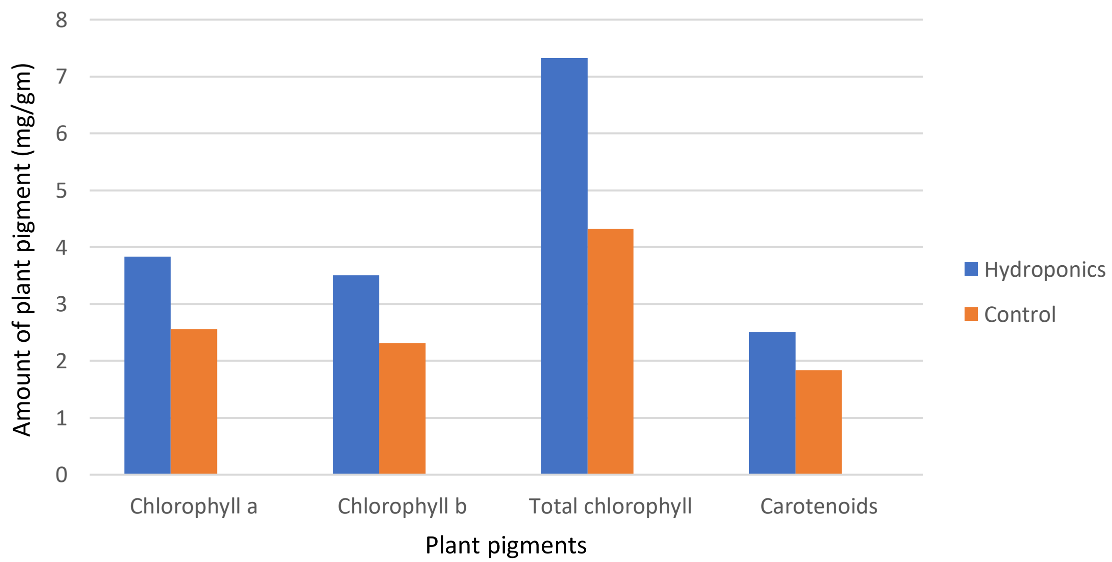
Cucumis sativa L. grown in control

- Chlorophyll a content on 35th day was 2.561 mg/gm
- Chlorophyll b content on 35th day was 2.31 mg/gm
- Total Chlorophyll content on 35th day was 4.32 mg/gm
- Carotenoid content on 35th day was 1.831 mg/gm

TABLE 4: PLANT PIGMENT CONTENT OF *CUCUMIS SATIVUS L.*

SI. NO.	PIGMENTS	HYDROPONICS	CONTROL
1	Chlorophyll a (mg /gm)	3.832	2.561
2	Chlorophyll b (mg /gm)	3.521	2.31
3	Total chlorophyll (mg /gm)	7.321	4.32
4	Carotenoids (mg /gm)	2.51	1.831

FIGURE 3: PIGMENT CONTENT IN *CUCUMIS SATIVUS L.*



***Cucumis sativus L*. grown in Control**

***Cucumis sativus L*. grown in Hydroponics**

PLATE: 1

DISCUSSION

The present work was carried out to compare the growth performance of *Cucumis sativus L*. grown in hydroponics and soil.

Cucumber cultivation can be done using hydroponics or traditional soil-based methods, and there have been numerous experiments conducted to compare the growth and yield of cucumber plants in both systems. Several studies have shown that hydroponic cultivation of cucumber can lead to higher yields compared to traditional soil cultivation. For instance, a study by Maboko *et al.* (2011) demonstrated that foliar fertilizer in combination with reduced nutrient concentrations can significantly increase cucumber yield in hydroponic systems. Additionally, hydroponic systems allow for precise control of nutrient and water uptake, leading to more efficient use of resources.

In a study conducted by Pomoni and *et al.* (2023), Hydroponics as a production method is advanced and promotes large-scale cultivation in the absence of soil, ensuring the increased production of many crops at significantly higher yields through vertically accumulated trays to provide more space. Hydroponic systems are efficient, industrial-type vegetable production systems. A plant's growth rate in hydroponic cultivation is 30–50% faster than in soil cultivation .Similarly, cucumber cultivated on hydroponics showed faster results than grown in soil.

Food production is facing many global challenges such as adapting to climate change and the resulting extremes of weather, the increasing and increasingly urbanised human population, challenges to the supply of macronutrients such as phosphorus and the need to reduce the impact of agrochemicals on the environment. These challenges occur at a time when there is a potential slowdown in improvements in yield per unit area for some crops and large-scale degradation of land used for food production for example from irrigation and the increase in saline land Brekke *et al.* (2011). There are many possible solutions to specific challenges, one is to produce more food within controlled environments Jensen (1999). Controlled environment agriculture (CEA)

A study conducted by Verdoliva *et al. (*2020), reveal increased water use efficiency and higher lycopene and β-carotene contents in hydroponically grown tomatoes. Plants cultivated in the two hydroponic systems transpired less water and used less water overall than plants grown in soil. Similarly the plants grown in hydroponic has carotene content more compared to the soil.

In the present study all the growth parameters considered exhibited better performance in hydroponics system. Hydroponics can be a better choice over traditional plant cultivation especially where there is space constrains for traditional cultivation methods. Even in urban living condition a small kitchen garden can be raised in constrained spaces like balcony. It can be concluded that, though traditional soil cultivation is recommended for plants, hydroponics can be adopted where there is lack of enough space to adopt traditional plant cultivation practices.

SUMMARY AND CONCLUSION

The present work was carried out to compare the growth performance of *Cucumis sativus L*. grown in hydroponics and soil. In hydroponic systems, plant roots are suspended in nutrient-rich water so they can develop except the want for chemicals. Hydroponically grown plants typically grow more swiftly than soil-grown plants because oxygen and nutrients are supplied directly and heavily to the roots of these plants. If hydroponic plants and plants grown in soil are given the same germination and growth conditions, the hydroponic plants will perform at least as well as the plants produced in soil, if not better.

While hydroponic growing is a soil-free method that offers the nutrients in a liquid form, soil-based growth feeds the plants with nutrients through minerals in the soil.

In the present study all the growth parameters considered exhibited better performance in hydroponics system. Hydroponics can be a better choice over traditional plant cultivation especially where there is space constrains for traditional cultivation methods. Even in urban living condition a small kitchen garden can be raised in constrained spaces like balcony. It can be concluded that, though traditional soil cultivation is recommended for plants, hydroponics can be adopted where there is lack of enough space to adopt traditional plant cultivation practices.

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