Comparative Analysis of Fenugreek Plant: Hydroponic System vs Soil based system

AMRUTA N. AVALASKAR[1], YASH KUCHEKAR[2], AISHWARYA SUL[3], OMKAR JAJURNE[4], KALYANI DHANOKAR[5], AJAY BHANGARE[6]

[1, 2, 3, 4, 5, 6] *Department of Pharmaconosy, All India Shivaji Memorial college of Pharmacy Pune*

Abstract- ***Fenugreek (Trigonella foenum-graecum) is an annual herbaceous plant valued for its culinary, medicinal, and agronomic significance. It is a multipurpose crop that can be used as a leafy vegetable, fodder, or condiment in one or more of its forms [1]. As a versatile crop, fenugreek is cultivated worldwide for its seeds, leaves, and other plant parts, which are utilized in various cuisines and traditional medicines. In recent years, there has been a growing interest in exploring alternative cultivation methods to enhance fenugreek production and optimize its growth conditions. One such method is hydroponics, a soilless culture technique that involves growing plants in nutrient-rich water solutions. Contrasting with traditional soil cultivation, hydroponics offers precise control over nutrient levels, water availability, and environmental conditions. This study aims to compare the growth, development, and yield of fenugreek plants cultivated through soil-based methods with those grown hydroponically. By examining the differences between these two cultivation approaches, valuable insights can be gained into optimizing fenugreek production systems, potentially leading to increased efficiency, sustainability, and crop yields in agricultural practices.***

I. INTRODUCTION

Fenugreek (*Trigonella foenum-graecum*) is an annual herbaceous plant valued for its culinary, medicinal, and agronomic significance. It is a multipurpose crop that can be used as a leafy vegetable, fodder, or condiment in one or more of its forms [1]. As a versatile crop, fenugreek is cultivated worldwide for its seeds, leaves, and other plant parts, which are utilized in various cuisines and traditional medicines. In recent years, there has been a growing interest in exploring alternative cultivation methods to enhance fenugreek production and optimize its growth conditions. One such method is hydroponics, a soilless culture technique that involves growing plants in nutrient-rich water solutions. Contrasting with traditional soil cultivation, hydroponics offers precise control over nutrient levels, water availability, and environmental conditions. This study aims to compare the growth, development, and yield of fenugreek plants cultivated through soil-based methods with those grown hydroponically. By examining the differences between these two cultivation approaches, valuable insights can be gained into optimizing fenugreek production systems, potentially leading to increased efficiency, sustainability, and crop yields in agricultural practices.

Hydroponic method: Hydroponics is a method of growing plants that takes advantage of this fact by providing all of the nutrients, in their inorganic form, in a liquid solution. Hydroponic systems allow for easy separation of root tissue and precise control of nutrient availability. It is the soilless culture of plants, but in the presence of artificial supporting medium [2]. Hydroponics is a viable alternative method for growing leafy vegetables [3].

Hydroponics offers several advantages over soil-based systems. When removed from soil, root tissue is often mechanically sheared causing loss of tissue or damage. This is particularly true for fine root structures such as lateral roots and root hairs. Hydroponic systems that do not utilize an inert particulate media allow a less invasive separation of root and shoot tissues.

Objective: The aim of study is to efficiently and effectively grow the plant in a controlled environment without the use of soil. The main objectives include:

1) Conservation of resources: Hydroponic systems typically use less water compared to traditional soil-based farming, making them more environmentally sustainable, especially in regions where water is scarce or expensive.

2) Enhancement of nutrient uptake: Fenugreek, like many plants, requires specific nutrients for healthy growth. Hydroponic systems can deliver these

nutrients directly to the plant roots in a readily available form, potentially leading to faster growth and better nutrient absorption.

3) Increasing Yield and Harvest Frequency: Hydroponic systems often result in higher yields compared to traditional farming methods, as they provide an optimal environment for plant growth. Additionally, fenugreek grown hydroponically may have shorter growth cycles, allowing for more frequent harvesting.

II. MATERIAL AND METHODS

The soil grown method for Fenugreek is as follows:

1) Soil method: procedure

1) Preparation of Soil: Use well-draining soil rich in organic matter. Ensure pH is around 6.0 to 7.0.

2) Sowing of Seeds: Plant fenugreek seeds directly into the soil, spacing them 2 inches apart in rows.

3) Watering: Keep soil consistently moist but not waterlogged. Water regularly.

4) Sunlight: Place in a sunny location; fenugreek thrives in full sun.

5) Fertilization:

Apply a balanced fertilizer once a month to encourage growth. Fertilizers play a crucial role in the soil-grown cultivation of fenugreek by providing essential nutrients that support healthy growth and development. Here's how fertilizers contribute:

Nutrient Supply:

Fenugreek requires specific nutrients like nitrogen (N), phosphorus (P), and potassium (K) for optimal growth. Fertilizers supply these nutrients to the soil, ensuring the plant has what it needs to thrive.

Promoting Growth:

Nitrogen-rich fertilizers support vigorous leafy growth in fenugreek, which is important for developing lush foliage and a good harvest of tender leaves.

Enhancing Yield:

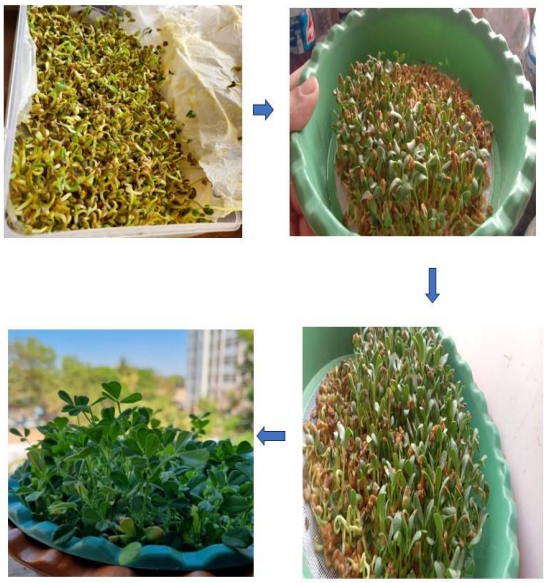
Properly balanced fertilization can lead to increased yields of fenugreek. Phosphorus aids in root

development and flowering, while potassium supports overall plant health and disease resistance.

Correcting Soil Deficiencies:
Fertilizers can address deficiencies in the soil, ensuring that fenugreek has access to all necessary nutrients for optimal growth and productivity.

Regular Application:
Regular application of fertilizers throughout the growing season replenishes nutrients that may be depleted as the plants grow and develop.
6) Weeding:
Remove weeds regularly to prevent competition for nutrients.
7) Harvesting:
Fenugreek leaves can be harvested when young, around 3-4 weeks after sowing.

2) Hydrophonics



The hydroponic method for fenugreek includes:
Hydroponic method: procedure

Hydroponic Setup: Use a hydroponic system like deep water culture (DWC) or nutrient film technique (NFT) to grow fenugreek. Ensure the system provides ample oxygen and support for the plants.

Nutrient Solution:
The fertilizers containing the nutrients to be supplied to the crop are dissolved in the appropriate concentration in the irrigation water and the resultant solution is referred to as “nutrient solution” [4].

Prepare a balanced hydroponic nutrient solution containing essential macro and micronutrients. Fenugreek benefits from a solution rich in nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and trace elements like iron (Fe), manganese (Mn), zinc (Zn), and others. we used banana peel tea as a source of nutrient. The procedure for the banana peel is as follows:

Banana Peel Tea:
One way to utilize banana in hydroponics is by making a nutrient-rich tea from banana peels. Here's how you can do it:

- Collect banana peels (organic ones are preferable to avoid pesticide residues).
- Chop the banana peels into small pieces.
- Place the chopped peels in a container and cover them with water.
- Let the mixture steep for several days, stirring occasionally.
- Strain out the banana peel solids, leaving with a banana peel tea.

Nutrient Content:
Banana peel tea can contain various nutrients beneficial for plant growth, including potassium, phosphorus, calcium, and magnesium. Potassium, in particular, is important for flowering and fruiting plants like fenugreek.

Application in Hydroponics:
Dilute the banana peel tea with water to achieve a suitable concentration of nutrients.

- Use this diluted solution to supplement the regular hydroponic nutrient solution.
- Monitor plant growth and adjust the frequency and concentration of banana peel tea application based on plant response.
- Considerations:
- Banana peel tea is not a complete substitute for a balanced hydroponic nutrient solution. It should be used as a supplement to provide additional nutrients.
- Ensure that the banana peel tea is well-aerated during brewing to prevent anaerobic conditions and unpleasant odors.
- Monitor pH and EC levels of the hydroponic solution to ensure proper nutrient uptake by the plants.

Feeding Schedule: Monitor and adjust the nutrient solution regularly to maintain proper nutrient levels. Fenugreek generally requires higher nitrogen during vegetative growth and more phosphorus and potassium during flowering.

pH and EC Control: Regularly check and adjust the pH (acidity/alkalinity) and electrical conductivity (EC) of the nutrient solution to ensure optimal nutrient uptake by the plants.

Light and Temperature: Provide suitable light conditions (full spectrum LED or fluorescent lights) and maintain optimal temperature and humidity levels in the laboratory for healthy fenugreek growth.

Harvesting: Fenugreek can be harvested when the leaves are young and tender, typically around 3-4 weeks after planting in a hydroponic system [2].

Chemical constituents:

Table 1. Chemical constituent of fenugreek.

Flavonoids	Quercetin
Phenolic content	Gallic acid and Tannic Acid

Procedure:

1) Extractive value (Alcohol soluble):

5 g of powdered drug + 100 ml of alcohol
↓ 24 hrs
Filter and evaporate 25 ml of filtrate and dry at 105℃
↓
Calculate percentage of alcohol soluble extract

2) Extractive value (Water soluble):

5 g of powdered drug + 100 ml of Chloroform Water
↓ 24 hrs
Filter and evaporate 25 ml of filtrate and dry at 105℃
↓
Calculate percentage of Water soluble extract

3) Total ash value:

Incinerate 2-3 gm of drug at a temperature ≤ 450℃
↓
Calculate percentage of ash with reference to air dried drug

4) Acid Insoluble ash value:

Boil total ash obtained with 25 ml dil.hcl
↓
Collect it on ashless filter paper
↓
Wash with hot water and ignite to constant weight
↓
Calculate the percentage of acid insoluble ash

5) Water soluble ash value:

Boil total ash obtained with 25 ml of Water
↓
Collect it on ashless filter paper
↓
Ignite for 15 min at a temperature ≤ 450℃
↓
Weight of Ash-Weight of Insoluble matter = Water soluble ash.

6) Total Phenolic content:

1 ml sample(1000µg/ml) +5 ml Folin CIO catechu reagent

↓ After 6 min

Add 4 ml of 7.5 % Sodium Carbonate

↓ After 15 min

Take Absorbance at 760nm and find out the unknown conc. from std. Gallic acid curve (Absorbance vs Concentration)

7) Flavonoid content:

1 ml sample + 0.2 ml Sodium nitrite

↓ After 5 min

2 ml 10 % Aluminum Chloride + 2 ml 1M NaOH

↓

Take absorbance at 510nm and find out unknown conc. from std. Gallic acid curve (Absorbance vs Concentration).

Preparations of Standards and Reagent:

Thin Layer chromatography:

Thin-layer chromatography (TLC) is a common technique used to separate and identify the components of a mixture based on their differential partitioning between a stationary phase (adsorbent) and a mobile phase (solvent). When applied to fenugreek, TLC can help identify and quantify the various phytochemical constituents present in different parts of the plant, such as seeds, leaves.

Thin layer chromatography of hydroponically fenugreek was performed using mobile phase Toluene: Ethyl acetate: Methanol: Water in the ratio 6 : 4 : 3 : 1.

Preparation of Standard Solution

- Gallic acid: 1000 µG/ml solution of gallic acid was made by using alcohol as a solvent.
- Quercetin: 1000 µG/ml solution of quercetin was made by using alcohol as a solvent.
- Rutin: 1000 µG/ml solution of Rutin was made by using alcohol as a solvent.
- Tannic acid: 1000 µG/ml solution of Tannic acid was made by using alcohol

Preparation of Sample:

10000 µG/ml of fenugreek extract in ethanol were prepared.

Preparation of Spray reagents:

- Alcoholic Sulfuric acid: 5% alcoholic solution of sulfuric acid was prepared.
- Ferric chloride
- Aluminum chloride: 20 % alcoholic solution of aluminum chloride was prepared.

III. RESULTS AND OBSERVATIONS

1) Extractive value:

Higher extractive values indicate a greater concentration of bioactive compounds in the plant material, which may correlate with its medicinal or nutritional efficacy. Manufacturers of pharmaceutical industry use extractive value measurements to ensure consistency, potency, and adherence to regulatory standards in formulations and dietary supplements.

Table 2. Extractive Value of Fenugreek

Extractive value	Soil grown	Hydroponically grown
Water soluble	0.41	0.25
Alcohol Soluble	0.37	0.13

Inference-High extractive value of Soil grown fenugreek indicates significant amount of soluble or extractable components. Extractive value of plants grown in soil versus hydroponic systems reflects the influence of nutrient source, growing environment, and cultivation method on the composition and bioactivity of plant materials

2) Ash Value

It represents the inorganic mineral content present in the sample, which includes both essential minerals naturally occurring in the plant and extraneous matter such as sand, soil, or other contaminants. Higher ash values may indicate the presence of impurities or adulterants in the sample.

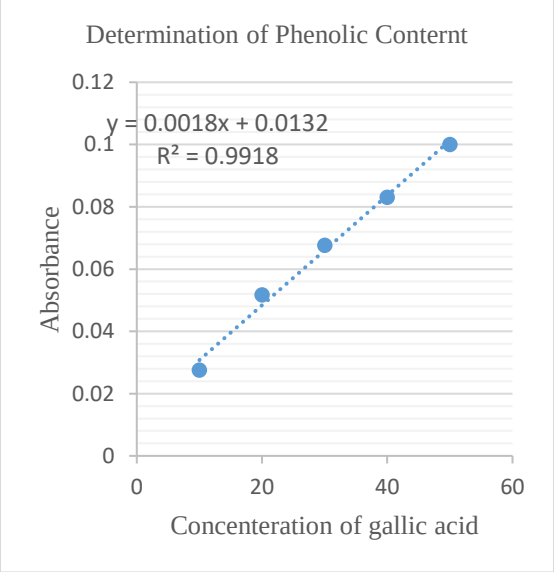
Table 3. Ash Value of Fenugreek

Ash Value (%)	Soil grown	Hydroponically grown
Total ash	0.47	0.39
Water soluble	0.15	0.10
Acid insoluble	0.41	0.35

Inference- From the above data it can be concluded that hydroponically grown fenugreek has low ash Value which indicates soil grown plants has accumulation of excess minerals from synthetic fertilizers and potential contamination from chemical residue.

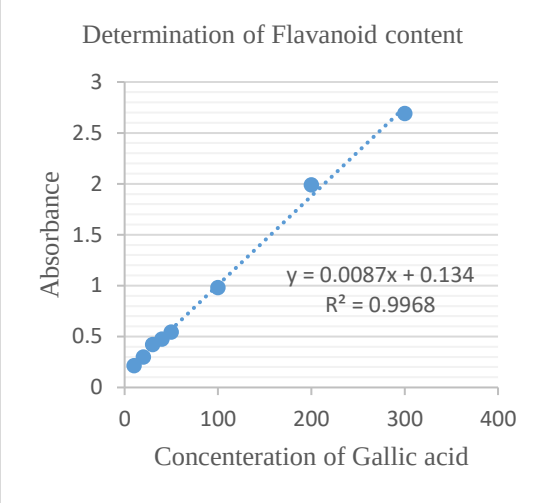
3) Total Phenolic and Flavonoid Content:
Total phenolic and flavonoid content are important indicators of the antioxidant potential, health benefits, quality, and nutritional value of plant-based materials.

For Soil grown Fenugreek



Graph 1.Total Phenolic Content for Soil grown Fenugreek

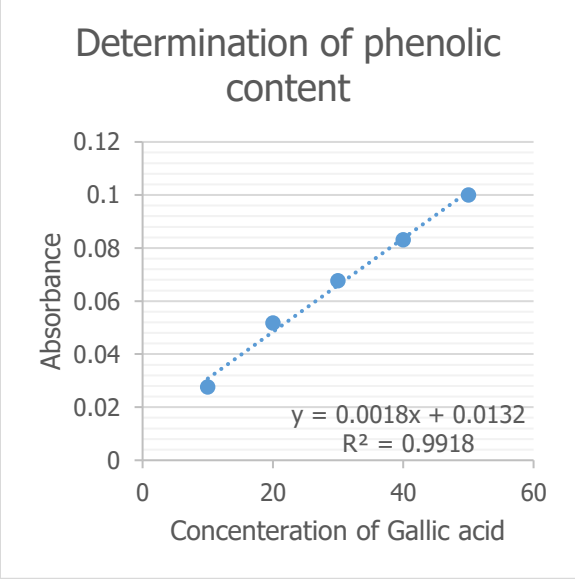
Phenol Content=124.56 µg/ml of 1000 µg/ml of extract
Absorbance=1.1365



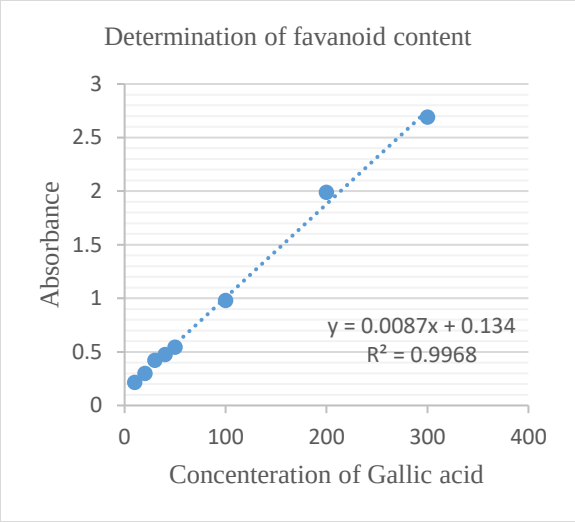
Graph 2.Total Flavanoid Content for Soil grown Fenugreek

Flavonoid content=25.3 µg/ml in 1000 µg/ml of extract

For Hydrophonically grown Fenugreek
Phenol content =122.322 µg/ml in 1000 µg/ml of extract
Flavonoid content=31.75 µg/ml in 1000 µg/ml of extract

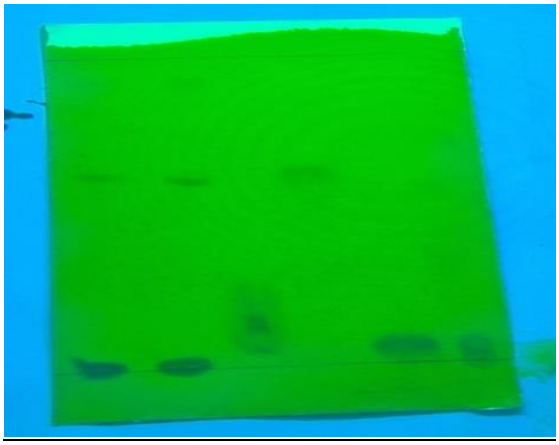


Graph 3.Total Phenolic Content for Hydrophonically grown Fenugreek



Graph 4. Total Flavonoid Content for Hydrophonically grown Fenugreek

Inference: High amount of phenolic and flavonoid content were found in hydroponically grown Fenugreek.



Thin Layer chromatography:

Plate sprayed with $Fecl_3$

R_f soil = 0.58
R_f hydroponic=0.57
R_f Quercetin=0.58
R_f tannic acid=0.54
Result- R_f soil=R_f hydroponic=R_f quercetin=R_f Tannic acid
{Presence of Tannic Acid Confirmed}

Plate sprayed with H_2SO_4

R_f soil=0.6, 0.94 ,0.57, 0.32
R_f hydroponic=0.9, 0.58, 0.3, 0.27
R_f Quercetin=0.58
Result- $R_f$soil=R_f hydroponic=R_f Quercetin

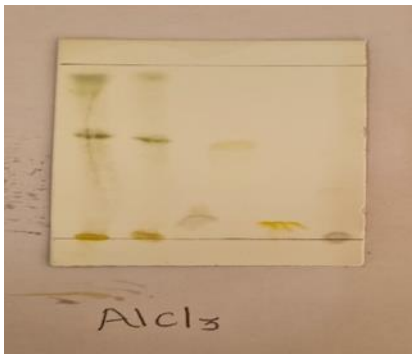


Plate sprayed with $Alcl_3$

R_f soil=0.93, 0.57
R_f Hydroponic=0.94,0.55
R_f Gallic=0.11
R_f Quercetin=0.55
R_f Tannic acid=0.11

IV. RESULTS AND DISCUSSION

1) Growth parameter

Height- The height of Soil grown Fenugreek was found to be more than that of hydroponically grown Fenugreek plant.

Root morphology- Roots of hydroponically grown Fenugreek plant found to be slightly more dense and short than that of soil grown fenugreek plant [5].

Size of leaf- Leaves of hydroponically grown fenugreek were found to be similar with soil grown fenugreek.

2) Nutritional analysis

From the TLC analysis and other evaluated parameters like ash value, Extractive value it can be concluded that both soil grown and hydroponically grown fenugreek contains same amount of Chemical constituents.

3) Water and Nutrient uptake Efficiency

Hydroponically grown fenugreek showed higher water and nutrient uptake efficiencies compared to soil-grown plants.

V.

VI.

CONCLUSION

According to the comparative analysis, there are specific benefits and drawbacks to both soil and hydroponic culture techniques for fenugreek production. For quick growth and effective fertilizer use, hydroponics may be the better option; it's perfect for confined spaces and controlled settings. On the other hand, soil-based cultivation is more suited for organic or conventional farming methods as it seems to promote higher biomass production and maybe richer secondary metabolite profiles.

REFERENCES

[1] Khiriya, K. D., & Singh, B. P. (2003). Effect of phosphorus and farmyard manure on yield, yield attributes and nitrogen, phosphorus and potassium uptake of fenugreek (Trigonellafoenum-graecum). Indian Journal ofAgronomy, 48(1), 62-65.

[2] Raj Singh1 , Sushil Kumar Upadhyay2*, Chhaya Singh3 , Neha Chauhan4 , Indu Sharma5 , Pooja Sharma6 and Anju Rani7. STUDY ON THE HYDROPONIC SYSTEM FOR SUSTAINABLE FARMING OF LEAFYVEGETABLE CROPS

[3] Kavitha R* 1 , Haripriya B2 , Femila Anugraga V3 , Janani K4 , Amala Ovia A5 and Janani P6. Comparative Analysis of Growth and Biochemical Parameters of Selected Plants in Hydroponics and Soil System

[4] S.T. Patil, U.S. Kadam, M.S. Mane, D.M. Mahale and J.S. Dhekale, "Hydroponic Growth Media (Substrate): A Review", International Research Journal of Pure Applied Chemistry, vol. 21, no. 23, pp. 106-113, 2020.

[5] To evaluate growth factors of feenugreek in hydrophonic system and soil based system

[6] Singh Gurdas1, Patil R.K2, Jindal Diksha3, Patil H.C4 Petropoulos, G. A. 1973. Agronomic, genetic and chemical studies of Trigonella foenum -graecum L. PhD diss. BathUniversity, England