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# Comparative Analysis of Growth and Biochemical Parameters of Selected Plants in Hydroponics and Soil System

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## Abstract

The need for food production is being driven by the world's expanding population. Meanwhile, conventional farming, which relies on soil-based methods, is unable to meet the world's growing food needs. Thus, developing novel planting and farming techniques is essential to averting further food crises. The purpose of this study was to investigate the hydroponics system, which is an effective alternative planting method. The growth, morphological, and biochemical characteristics of *Triticum aestivum* and *Trigonella foenum-graecum* were evaluated and compared between soil and hydroponic systems. It was noted that wheatgrass and fenugreek cultivated hydroponically have longer roots than plants grown on soil. In comparison to plants grown in soil, it is also shown improved growth in terms of plant height, leaf length, leaf breadth, and leaf area. It was discovered that plants grown in soil had higher levels of total chlorophyll than plants cultivated in hydroponic systems. The soil-grown plants exhibited a significantly higher total phenolic content and antioxidant activity in comparison to their hydroponic counterparts. The hydroponic system presents growers and customers with a plethora of new options and chances to produce crops of superior quality. Hydroponics is a viable alternative method for growing leafy vegetable seedlings.

***Key words*:** Hydroponics, Soil system, Wheat grass, Fenugreek, Alternative farming

Conventional agricultural practices have a wide range of detrimental effects on the environment in addition to the reduction of cultivable area due to the rising urbanization and industrialization. In order to feed the world's expanding population in a sustainable manner, techniques for producing sufficient food must evolve. Global food output has improved dramatically in recent years due to the adoption of hydroponics, which offers better control over climatic and pest variables, as well as more efficient use of water and fertilizers. Plants can be grown hydroponically in nutrient solutions with or without the addition of an inert medium to give mechanical support, such as sawdust, coir dust, peat moss, gravel, vermiculite, rockwool, coconut fibre, etc. Moreover, greater crop quality and productivity from hydroponic farming lead to increased competitiveness and financial earnings. Because they do not have to battle soil-borne diseases and receive all the food and water they require continuously at their roots, plants produced hydroponically can actually grow faster and healthier than plants grown in soil. Perhaps the most intensive crop-production technique used in the agricultural industry today is hydroponic culture, which is mostly employed in industrialized and developing nations to produce food in small spaces. It is extremely productive, environmentally friendly, and sparing with regard to land, water, and space.

The popularity of hydroponics has grown quickly, which has stimulated more experimentation and study in the field of indoor and outdoor hydroponic agriculture. The United States of America and the Asia-Pacific region are the next two largest markets for hydroponics, with Europe being the largest, with the top three manufacturers being France, the Netherlands, and Spain [1]. The hydroponics sector in India is anticipated to have rapid growth in the near future. Given the current circumstances, soil-less agriculture may be effectively started and explored as a substitute option for raising wholesome crops, vegetables, or food plants [2]. Hydroponics is becoming more and more popular among other soilless farming approaches due to its effective resource management and food production.

These days, soil-based agriculture faces a number of difficulties, including indiscriminate use of chemicals and pesticides that are reducing the fertility of the ground, natural disasters, and climate change. Prior hydroponic studies have mostly concentrated on tomatoes, peppers, and leafy greens [3-6]. The six types of hydroponic systems are as follows: water culture, drip system, aeroponic system, ebb and flow (flood and drain), wick system, and nutrient film technology (NFT). Additionally, plants cultivated hydroponically have greater resistance to highly salinized water. Hydroponic farming does not necessitate labor-intensive tasks like planting, cultivating, disinfecting, or watering [7]. Since the majority of water needed in traditional farming quickly passes through the root layer, hydroponic plants often require only a tenth of the water needed by plants grown in soil. Because hydroponic crops are not affected by climate change, they can be grown all year round and are referred to as off-season crops [8].

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The growing global population is driving the demand for food production. In the meanwhile, the world's expanding food needs cannot be met by conventional farming, which uses a soil-based method. Therefore, creating innovative agricultural and planting methods is necessary to prevent future food crises. The purpose of this study was to investigate the hydroponics system, which is an effective alternative planting method. *Triticum aestivum* L. (wheatgrass) and *Trigonella foenum-graecum* L. (fenugreek) were grown in both soil-based and hydroponic systems. These plants' development and biochemical characteristics were compared in two systems.

## MATERIALS AND METHODS

*Trigonella foenum-graecum* L. is an annual plant that belongs in the Fabaceae family. It is a self-pollinating crop that can be used as a condiment, fodder, and green vegetable [9]. In Asia and Africa, this plant's seeds form a regular part of food [10]. At the start of the growing season, fenugreek grows slowly and its leaf development is temperature-dependent [11]. Wheat grass, or *Triticum aestivum* L., is a plant that has a variety of phytochemical components. Vitamin-rich wheatgrass functions as an antioxidant and prevents the body's cells from ageing.

Both coco coir and coco pith were employed as growing media in the current study. While coco coir is an organic plant material, it decomposes very slowly and won't supply any nutrients to the plants that grow in it, which makes it ideal for hydroponics. In addition to being pH neutral and having excellent moisture retention capabilities, coco coir also permits the roots to receive adequate aeration. A mixture of macro and micronutrients, such as phosphorus, nitrogen, potassium, magnesium, calcium, sulphur, manganese, iron, boron, copper, zinc, chlorine and molybdenum are needed for plants to grow properly. The plants will suffer if there are too many or too few nutrients in the solution. In the current study, plants were hydroponically grown utilizing the deep-water culture method using Hoagland's nutritional media. (Table 1) listed the ingredients of the Hoagland modified nutrition solution.

Table 1 Composition of modified nutrient solution

| Compounds | | Concentration of stock solution (mM) | Vol. of stock solution per litre of final solution (ml) |
|---|---|---|---|
| Macronutrients | $KNO_3$ | 1000 | 6 |
| | $Ca(NO_3)_2.4H_2O$ | 1000 | 4 |
| | $KH_2PO_4$ | 1000 | 2 |
| | $MgSO_4.7H_2O$ | 1000 | 1 |
| Micronutrients | KCL | 25 | 2 |
| | $H_3BO_3$ | 12.5 | |
| | $MnSO_4.H_2O$ | 1 | |
| | $ZnSO_4.7H_2O$ | 1 | |
| | $CuSO_4.5H_2O$ | 0.25 | |
| | $MoO_3$ | 0.25 | |
| | Fe Na EDTA | 64 | 1 |

The most user-friendly system is the deep-water culturing system. The plants are held in place by a Styrofoam or other comparable floating platform on the nutritional solution. Aquarium air pumps supply the roots of the plants with an external supply of oxygen. A 7 L plastic tub filled with 3 L modified Hoagland's nutrient solution (original pH of 6.5 ± 0.3, electrical conductivity of 1.60 mS $cm^{-1}$) and two plastic baskets per tub was used to build the hydroponic system for fenugreek and wheat grass separately. (Plate 1). Fenugreek and wheat grass seeds weighing 20g were cleaned, immersed in water for four hours. The base of the basket held wet coco coir, which was used to hold the filter paper. On it, the seeds were scattered. The setup was shielded from the sun by shade. Every two days, the nutrient solutions were swapped out. Every hydroponic tub was aerated with Bluestone air pumps (Model: RS-180). Three days later, sprouts began to appear. After 15 days, the leaves were collected and used for additional examination.

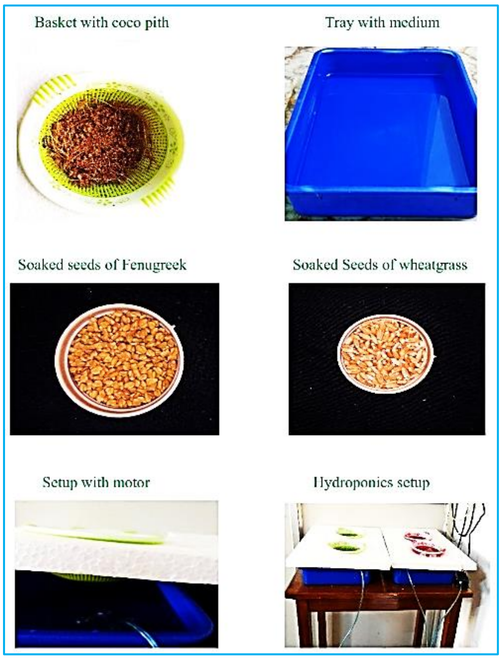


Plate 1 Hydroponics setup

Plants were grown in soil systems using 6-inch plastic pots that were filled with 500 g of soil mixture. Fenugreek and wheat grass seeds weighing 20g were cleaned, steeped in water for the entire night, and allowed to sprout. The earth was damp when the seeds were planted. Every day, the soil system received irrigation.

Fenugreek and wheatgrass plants were randomly picked from each growth system, and the following characteristics were measured: plant height, root length, leaf density (number of leaves), leaf length, leaf breadth, and fresh weight of shoots and roots. Roots and plant shoots were weighed independently. The Association of Official Analytical Chemists' Official Procedures (AOAC, 2000) were followed in the oven drying process to ascertain the moisture content. The samples were dried on an aluminium sample tray until they attained a consistent weight. The following formula was used to compute the moisture content:

$$\%\ \text{Moisture} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100$$

Using a chlorophyll meter, the total chlorophyll content of the leaves of wheat grass and fenugreek was ascertained after the leaves were taken from the plants. A 2,6-dichlorophenolindophenol (DCPIP) titrimetric method was used to measure ascorbic acid. Three percent of meta-phosphoric acid was used to grind the plants. After centrifuging the samples for 3 minutes at 12,400 ×g, the supernatant was recovered. Supernatant was titrated with 0.172 mM DCPIP solution in combination with extraction solution until a noticeable rose-pink hue lasted for ten seconds. The amount of DCPIP added was contrasted with a conventional ascorbic acid titration at a known concentration. A modified Folin-Ciocalteu method was used to determine total phenolics [12]. Using 1,1-

diphenyl-2-picrylhydrazyl, or DPPH, the free radical scavenging activity of these extracts was assessed [13]. The following formula was used to get the scavenging ability (SA).

$$\text{DPPH scavenging effect (\%)} = \frac{A_0 - A_1}{A_0} \times 100$$

Where;
$A_0$ represents the control's absorbance at 30 minutes and
$A_1$ represents the sample's absorbance at that same 30-minute mark

## RESULTS AND DISCUSSION

For soilless culture, the ideal pH range for the nutrient solution was kept between 5.8 and 6.5. Though the pH level will differ from plant to plant, most plants generally like a growing environment that is somewhat acidic, between 5.5 and 6.5 [14]. Osmotic pressure from higher electrical conductivity will hinder the absorption of nutrients, and lower levels will negatively impact plant health and productivity. Accordingly, proper EC management in hydroponics can provide a useful tool for enhancing crop yield and quality [5]. The medium's electrical conductivity was kept at 1.60 mS cm-1. Sprouts began to appear three days after seeding (Plate 2-3). After 15 days, the leaves were collected, and the growth metrics and nutritional value were examined.

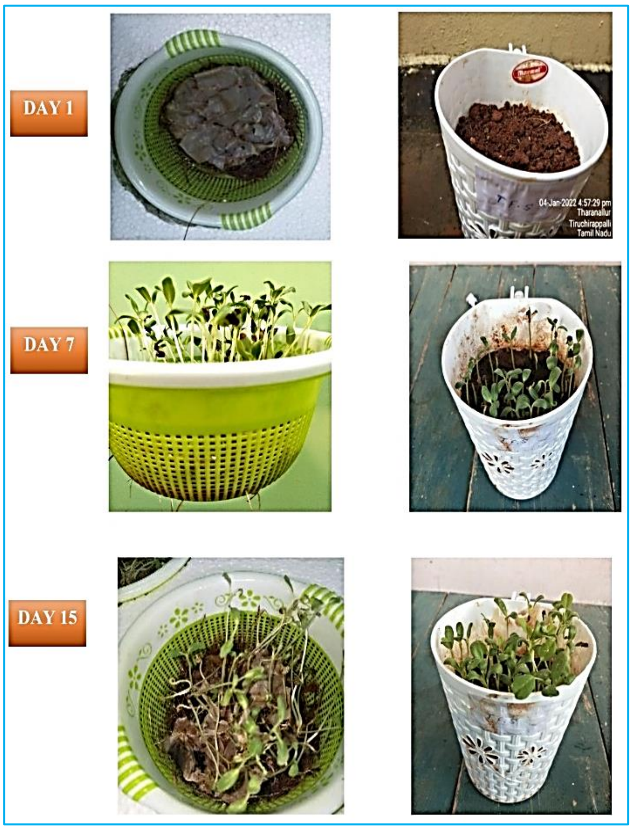


Plate 2 Cultivation of fenugreek in hydroponics and soil system


Plate 3 Cultivation of wheat grass in hydroponics and soil system


Plate 4 Comparison of growth parameters of plants grown in hydroponics and soil system

The experiment involved growing the plant using the soil culture approach as well. Twenty grammes of nutritious wheat and fenugreek seeds were taken, and they were soaked in water for the entire night. The seeds were planted in pots of garden soil. After three days, the sprouts were visible (Plates 2-3). On the fifteenth day, several growth metrics were examined and contrasted. The entire plant was utilized to gauge the length of the roots and shoots. The leaf area was calculated using the fully extended leaf. When the plants were harvested after 15 days, there was no discernible visual difference between soil-grown and hydroponically grown plants in terms of colour, size, form, or leaf size. Nonetheless, there were clear morphological differences, with wheatgrass and fenugreek cultivated hydroponically showing longer roots than plants cultivated in soil. When comparing hydroponically produced wheatgrass to hydroponically grown fenugreek, the former had significantly more root growth. This discrepancy may suggest that the hydroponic system, as opposed to the soil matrix, promoted plant root growth by keeping the roots consistently immersed in enough nutrients and water as well as free from physical obstacles. The findings of Li, Li, Tang, and Gu [15] were comparable. When compared to soil-grown plants, the plant height and leaf length of wheatgrass in a hydroponics system were much higher. In comparison to fenugreek plants grown in soil, those cultivated hydroponically demonstrated improved growth in terms of plant height, leaf length, leaf width, and leaf area (Plate -4). Table 2 displays the average plant height, plant breadth, leaf density, leaf length, and leaf width over the 15-day growth period. The density of leaves in both systems was nearly identical. Wheat grass produced hydroponically had narrower leaves than plants grown in soil was unexpected. Hydroponically grown plants may have longer leaves, which could be the reason of this.

Table 2 Comparison of growth parameters of plants between hydroponic and soil system

| Growth parameters | Fenugreek | | Wheat | |
|---|---|---|---|---|
| | Hydroponics | Soil | Hydroponics | Soil |
| Plant height | 7.5 cm | 7 cm | 25.5 cm | 11 cm |
| Root length | 1.8 cm | 1 cm | 6.5 cm | 2 cm |
| Leaf density | 3 | 3 | 2 | 2 |
| Leaf length | 1.6 cm | 0.7 cm | 15.5 cm | 6.8 cm |
| Leaf width | 0.5 cm | 0.3 cm | 0.3 cm | 0.4 cm |
| Leaf area | 1.6 $cm^2$ | 1.2 $cm^2$ | 5.6 $cm^2$ | 5.0 $cm^2$ |

*Determination of moisture content*

Plant moisture content has a significant effect on the fresh vegetable's eating quality and shelf life [16]. It may also have an effect on food safety. The plants cultivated in two distinct systems were compared with respect to their moisture content. There was no discernible change in the moisture content of the fenugreek plant between the two systems. On the other hand, wheat grass cultivated hydroponically has a higher moisture content than wheat grass grown on soil (Table 3, Fig 1). Compared to plants cultivated on soil, those grown in hydroponic systems transpired less water and used less water overall.'

Table 3 Moisture content of experimental plants

| Plants | Cultivation method | Fresh weight | Dry weight | Percent of moisture content |
|---|---|---|---|---|
| Fenugreek | Hydroponics | 0.25g | 0.04g | 84 |
| | Soil | 0.18g | 0.03g | 83 |
| Wheat | Hydroponics | 0.3g | 0.05g | 83 |
| | Soil | 0.11g | 0.03g | 73 |

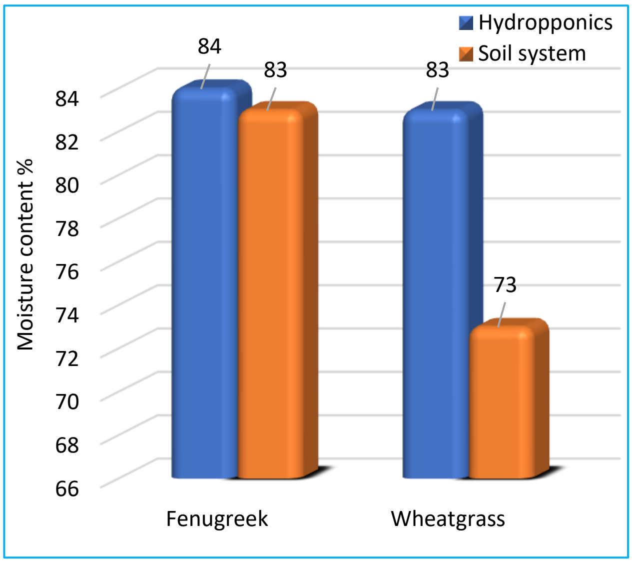


Fig 1 Moisture content of plants grown in hydroponics and soil system

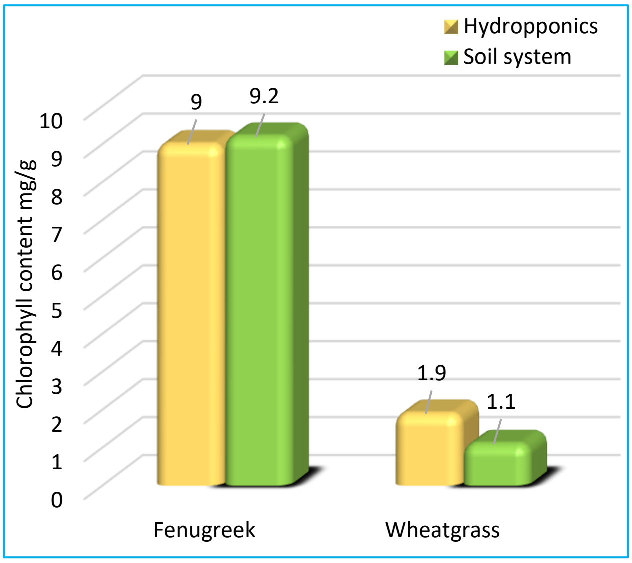


Fig 2 Chlorophyll content of plants grown in hydroponics and soil system

*Determination of total chlorophyll*

The (Fig 2) displays our findings on the total chlorophyll content of seedlings (wheatgrass and fenugreek) cultivated in soil and hydroponic systems. The wheatgrass seedlings cultivated hydroponically had a higher chlorophyll content than the ones grown in soil, according to the results. One possible explanation for wheatgrass's higher chlorophyll content could be that the roots were exposed to direct nutritional solutions; this would encourage the uptake of magnesium, which would explain the higher chlorophyll content [17]. But compared to hydroponically grown fenugreek plants, soil-grown plants had more total chlorophyll.

*Determination of ascorbic acid*

There is minimal difference in the ascorbic acid concentration of plants cultivated in soil versus plants grown hydroponically. The vitamin C content of wheatgrass and fenugreek plants is higher. (Fig 3) presents the findings.

*Determination of total phenolic content*

When compared to hydroponically grown plants, the total phenolic content of the wheatgrass and fenugreek extracts from soil-grown plants was considerably higher (Fig 4). Plant secondary metabolites are crucial in regulating both biotic stress conditions (such as temperature fluctuations, water availability, micro- and macronutrient fluctuations, and light intensity) and abiotic stress conditions (such as defence against pests, diseases, and herbivores) [18]. As a result, increased stress levels in field-grown plants may be the cause of the higher total phenol content seen in soil-grown plants, whereas reduced stress levels in hydroponic culture may be the cause of the lower phenolic content.

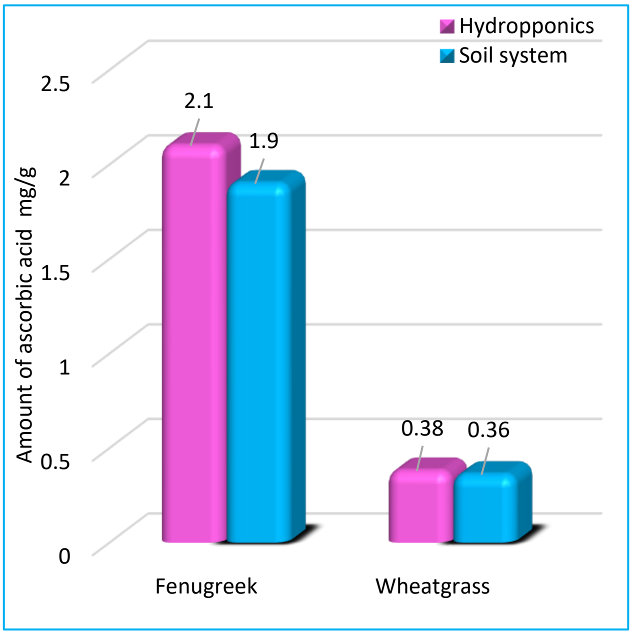


Fig 3 Ascorbic acid content of plants grown in hydroponics and soil system

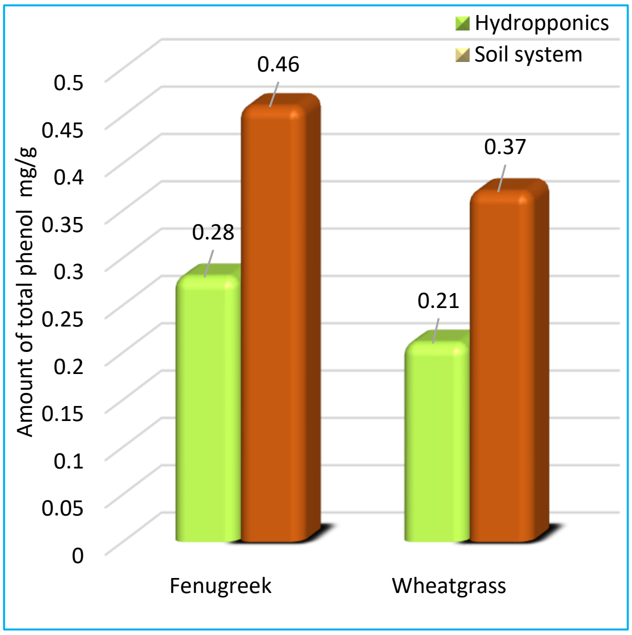


Fig 4 Total Phenolic content of plants grown in hydroponics and soil system

*Determination of antioxidant capacity*

It is commonly recognized that flavonoids derived from plants and other phenolic chemicals play a major role in radical scavenging. Their diverse antioxidant characteristics can be ascribed to their medicinal applications in various ailments. Wheatgrass and fenugreek plants cultivated in soil have greater antioxidant activity than plants maintained in hydroponic systems (Fig 5). This might be because soil-grown plants have a higher phenolic content because they have experienced a variety of environmental stresses.

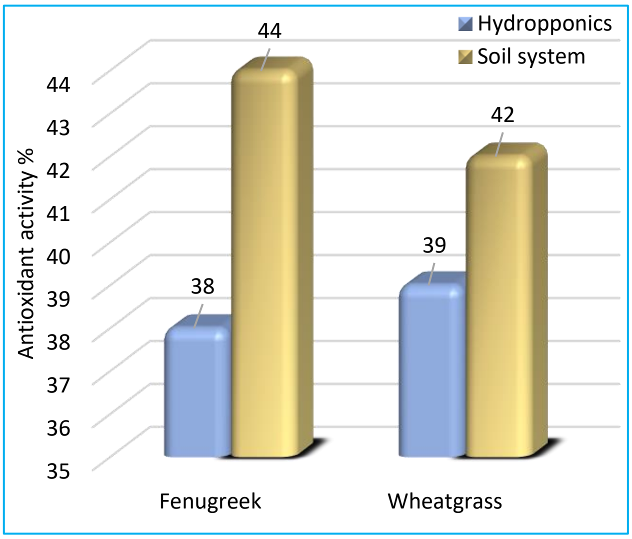


Fig 5 Antioxidant activity of plants grown in hydroponics and soil system

## CONCLUSION

The stringent nutrient management scheme determines whether a soilless culture succeeds or fails. A good soilless culture garden can be achieved by carefully adjusting the pH level, temperature, electrical conductivity (EC), and fertilizer solution—replacing it as needed. This study clearly shows that, due to its many benefits over soil systems, hydroponics is one of the best systems for growing green vegetables. It has been noted that plants produced in hydroponic systems grow far more quickly than plants cultivated on soil. This is because the nutrients are actually being bathed in the roots of the plant, making it easy for them to absorb them directly and with little effort. The hydroponics system presents growers and customers with a plethora of fresh options and chances to produce high-quality veggies. Although there are many environmental advantages to hydroponic food production, it's vital to take into account the challenges that commercial and small-scale farmers may face. Hydroponic gardening appears to be a vital tool for producing crops with excellent nutritional value. Both soil-based and hydroponic production systems, however, need to be properly controlled and implemented with due regard for the demands of the plants, the soil, water, environment, farmers, and the safety of the final product. Water, soil, air, energy, and employment may all be conserved using a hydroponics system, improving the quality of life. By utilizing scarce natural resources, hydroponics can improve the economies of both wealthy and poor nations. For shrubby and taller plants, soil seems to provide a better habitat for effective development and metabolism. A plant's shelf life can also be extended by soil by creating a natural habitat. For leafy vegetable seedlings, hydroponics is an alternate technique that works well. Hydroponic farming can be done as a hobby, takes less area, and does not require the traditional farming methods. Herbaceous seedlings are best suited for hydroponic culture. It might be useful for the astronauts to obtain food when they are in space because it doesn't require soil for plant growth. This technology could make it easier for farmers and kitchen gardeners to produce food in areas where conventional farming is not viable or profitable. It is also beneficial to conduct additional research on hydroponic production, optimize its capacity to guarantee high-quality produce, and choose the best types to generate superior hydroponic goods.

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