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The Cultivation of Crops through Hydroponics Techniques

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INTRODUCTION

The term "hydroponics" derives from the amalgamation of two Greek words: hydro, which denotes water, and ponos, which denotes labor (working water). It is the practice of growing plants in nutrient-rich solutions instead of soil. Hydroponics is used in the commercial cultivation of many greenhouse crops and is currently the fastest growing sector in agriculture. It has the potential to become the dominant source of sustainable food production in the future. Hydroponics technology is perhaps the most intensive and versatile method of growing crops production at present, as it allows for the optimal utilization of nutrient solution, water, and space, as well as a better control of climate and plant protection factors. Hydroponic technology can be used to produce food from extreme environmental ecosystems, such as deserts, mountainous regions, or arctic communities. As global population increases rapidly and arable land declines due to urbanization, hydroponics and other soilless farming technologies are anticipated to become crucial solutions for addressing food security concerns. This technique of growing without soil employs nutrient solutions to provide nutrients to plants in the absence of soil. Hydroponics possesses the potential to sustain a significant proportion of the global populace and enable third world nations to provide sustenance for their populace, even in regions with limited soil fertility and water availability. The technology has the potential to serve as a valuable resource for food production in areas with limited space. In hydroponics, non-soil growing media can be used to provide mechanical support to the roots, which will support the plants weight and keep them upright. Several types of media are commonly used in hydroponics, including sand, gravel, river rock, oasis cubes, floral foam, vermiculite, rockwool, perlite, peat moss, coir, coco-peat and sawdust. An essential component possesses a distinct physiological function, and its absence impairs the entire plant life cycle.

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At present, the majority of plants require 17 essential elements, namely carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, copper, zinc, manganese, molybdenum, boron, chlorine, and nickel. These all 17 essential elements are supplied based on different dilutions of the media.

Advantages

- It is feasible to cultivate crops in regions that lack suitable soil or are contaminated with diseases.
- The utilization of labor for tasks such as tilling, cultivating, fumigating, watering, and other traditional practices has been substantially reduced.
- The maximum yields make the system economically feasible in high-density and expensive land areas.
- The preservation of water and nutrients is a fundamental aspect of all systems. This can result in a reduction in the pollution of land and streams, as valuable chemicals need not be lost.
- Soil-borne plant diseases are more readily eradicated in closed systems that can be completely inundated with an eradicant.
- A more comprehensive management of the environment is typically a characteristic of the system (such as the root environment, timely nutrient feeding, or irrigation), and in greenhouse-type operations, it is feasible to regulate the light, temperature, humidity, and composition of the air.
- Water containing high levels of soluble salts may be utilized with extreme caution. If the concentration of soluble salt in the water supply exceeds 500 ppm, an open hydroponic system may be utilized, provided that the growing medium is regularly leached to minimize salt accumulations.

Disadvantages

- The initial construction cost per acre is substantial.
- Trained people must direct the growing operation. Knowledge of plant growth and nutrition principles holds significant importance.
- All beds on the same nutrient tank of a closed system may be affected by introduced soil-borne diseases and nematodes.
- The majority of plant varieties that have been adapted to controlled growing conditions will necessitate research and development.
- The reaction of the plant to good or poor nutrition is extremely rapid. The cultivator is required to closely monitor the plants on a daily basis.

Hydroponic Structures

Drip systems: Drip systems are fairly easy to control the moisture in. The nutrient solution from the tank or reservoir is provided to individual plant roots in the appropriate proportion with the help of a pump. Plants are usually placed in medium absorbent growing medium so that the nutrient solution drips slowly.

Wick System: This type of hydroponic system is the simplest and least used, requiring no electricity, pump, or aerators. Water or a nutrient solution is delivered to plants through capillary action. You can control the amount of water getting to the plant by using a larger or wider wick or more than one. This system is effective for small plants, herbs, and spices, however, it is not efficient for plants that require a significant amount of water.

Deep water culture system: The deep water culture system is the simplest system to use. The plants are supported on a floating platform made of Styrofoam or a similar material in the nutrient solution. The external supply of oxygen is provided to the roots of the plants through an aquarium air pump. Water culture is the most commonly used method for leafy vegetables. It is most often used for leafy vegetables.

NFT systems: In the mid 1960's in England, Dr. Alen Cooper pioneered the use of NFT, wherein a very shallow stream of water containing all the dissolved nutrients required for plant growth is recirculated past the bare roots of plants in a water-tight, thick root mat that forms at the bottom of the channel. NFT is good for growing many kinds of vegetables.

Ebb-Flow (flood and drain) systems: Flood and drain systems exhibit considerable variation in their design, and were intended to be the initial commercial hydroponic system based on the principle of flood and drain. Nutrient solution from a reservoir swamped by a water pump into the system. The system employs the principle of gravity to redirect the excess water to the reservoir for subsequent reuse.

Aeroponic systems: The aeroponic system is undoubtedly the most advanced form of hydroponic gardening. This method involves growing plants with their roots suspended in air and continuously sprayed with a nutrient solution. The misting process usually occurs every few minutes. The aeroponic system requires a brief cycle timer, compared to other systems that operate the pump for a brief duration every couple of minutes.

Nutrient Solution: For optimal growth, plants necessitate a balanced supply of both macronutrients and micronutrients. The macronutrients comprise of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S), which are required in greater quantities. Furthermore, plants necessitate essential micronutrients such as iron (Fe), manganese (Mn), boron (B), zinc (Zn), copper (Cu), molybdenum (Mo), and chlorine (Cl), which are required in lesser quantities but equally crucial for diverse physiological and metabolic processes. Within certain parameters of composition and total concentrations, there exists a considerable range of nutrient solutions that are suitable for plant growth. Typically, the insignificant amount of minerals present in the water supply can be overlooked. When nutrients are insufficient or excessively present in the solution, however, the plants will encounter difficulties.

It is important to exercise caution when choosing and adding the minerals to the nutrient solution. The importance of the purity of the nutrient materials or chemicals is paramount in the formulation of a solution. In some cases, a fertilizer grade chemical may be used, while in others, a technical-grade or food-grade chemical may be needed. The finest grades possess minimal impurities, whereas the lower or fertilizer grades may possess a greater number. The plants can sometimes make use of the contaminants. The low cost of these organic chemicals makes it imperative to employ them as often as possible. Numerous formulas have been devised to fulfill the nutrient requirements for plant growth. There are many recommendations that will give satisfactory results, but they often require less than one gram of chemicals that are not easily obtained. The process of evaporation in the solution, whether through atmospheric or plant transpiration, results in a reduction of water content and an increase in salt content. It may be detrimental to the plants to consume too much salt.

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Table 1: Composition of Modified nutrient solution

Compounds	Composition	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	
	H_3BO_3	12.5	2
	$MnSO_4.H_2O$	1.0	
	$ZnSO_4.7H_2O$	1.0	
	$CuSO_4.5H_2O$	0.25	1
	MoO_3	0.25	
	Fe Na EDTA	64	

CONCLUSION

Hydroponic culture is perhaps the most intensive method of crop production in today's agricultural industry. It is mainly used in developed and underdeveloped countries for food production in limited space. It is highly productive, conserving water, land, and space, and protecting the environment. The rapid rise in popularity of hydroponics has resulted in a significant increase in experimentation and research in the realm of indoor and outdoor hydroponic gardening. The hydroponic industry in India is anticipated to experience a rapid expansion in the near future

