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SOIL LESS CULTURE

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ABSTRACT:

The availability for cultivation of land is decreasing at an alarming rate due to urbanization and other anthropogenic activities, it leads to the increase in food production in per unit area with reduction in land availability. To overcome this issue, soil less culture leads to efficient and alternate for food production. The soilless culture is practiced during ancients' times also, it is dated in our history, when local soils were unsuitable for the specific plant, they transported mature trees from their countries of origin to the king's palace, where they were subsequently grown as soilless cultures. Various ancient civilizations have utilized soilless culture for their agricultural production. According to Egyptian hieroglyphics dating back several centuries, plants are capable of growing in water. Excellent illustration of soilless culture is the Babylonian hanging garden, in the history. Modern developments include, scientists began experimenting with water culture and hydroponics with different types.

INTRODUTION:

In recent years, the global population has been rising at a quicker pace, resulting in a decline in the availability of agricultural land per person. Consequently, there is significant pressure to boost food production per unit area despite decreasing land resources. This situation has created challenges for soil dependent agriculture, particularly with the rise of industrialization and urbanization, especially in densely populated nations such as India and China. In many urban and industrialized regions, there is a shortage of soil suitable for crop cultivation, and in some locations, the lack of fertile arable land can be attributed to unfavorable geographical or topographical factors (Beibel, 1960). Another major challenge faced is the difficulty in securing labor consistently for traditional open field farming (Butler & Oebker, 2006). To address these challenges, an alternative solution has emerged, leading to the development of innovative techniques like soilless agriculture. This approach presents a practical and effective means of cultivating high-quality vegetables, flowers, and fruits in confined spaces. Soilless culture, a modern agricultural methodology that entails growing plants without natural soil, has gained significant traction recently due to rising global issues related to food security, urban expansion, and environmental preservation. This technique encompasses hydroponics, aeroponics, and systems that utilize substrates, providing efficient use of resources, increased crop outputs, and less reliance on cultivable land.

HISTORY OF SOILESS CULTURE:

Although growing plants in aboveground containers has been attempted at different points throughout history, soilless culture is thought to be a modern practice. The earliest known instance of container-grown plants appears to be wall paintings discovered in the temple of Deir el Bahari (Naville, 1913). When local soils were unsuitable for the specific plant, they transported mature trees from their countries of origin to the king's palace, where they were subsequently grown as soilless cultures. For their agricultural output, numerous ancient societies have employed soilless culture. Plants can grow in water, according to Egyptian hieroglyphic records from several hundred years ago. The Aztecs cultivated some crops in floating gardens. Another excellent illustration of soilless culture is the Babylonian hanging garden. Francis Bacon's book Sylva Sylvarum, published in 1627, was the first published work on soilless culture. Water culture then gained popularity as a research method. John Woodward published his spearmint water culture experiments in 1699. The method of soilless cultivation was developed by 1859–1865 as a result of the discoveries made by German botanists Wilhelm Knop and Julius von Sachs. It soon established itself as a common research and teaching method, and it is still in use today as a kind of hydroponics. In 1929, William Frederick Gerick Berkeley openly advocated for the use of solution culture in the production of agricultural crops. Instead of using soil, Gerick used mineral nutrient solutions to grow tomato vines 25 feet high. Additionally, in 1937, he created the term hydroponics, which comes from the Greek words hydro-, which means "water," and ponos, which means "labor," to describe the practice of growing plants in water. The use of hydroponics to grow vegetables for the passengers on Wake Island was one of the early successes of the technique. The Nutrient film technique was created by Allen Cooper of England in the 1960s.

Numerous hydroponic methods are p rominently displayed in the Land Pavilion at W alt Disney World's EPCOT Center, which opene d in 1982.In 1938, the nutrient solution metho d was initially developed in India.

HISTORY OF SOILESS CULTURE IN INDIA:

In 1946, an English scientist named W. J. Shalto Duglas established a laboratory in the Kalimpong area of West Bengal and introduced hydroponics to India. He wrote a book on hydroponics called "The Bengal System. "Commercial hydroponic farms were later established in Abu Dhabi, Arizona, Belgium, California, Denmark, Germany, Holland, Iran, Italy, Japan, the Russian Federation, and other nations in the 1960s and 1970s.

Numerous computerized and automated hydroponics farms were set up worldwide in the 1980s.NASA has conducted a lot of hydroponic research for their Controlled Ecological Life Support System, or CELSS, in recent decades. In order to grow in a variety of colors with significantly less heat, hydroponics designed for Mars uses LED lighting.

SOILLESS CULTURE:

According to EI-Kazzaz (2017), "any method of growing plants without the use of soil as a rooting medium, in which the inorganic nutrients absorbed by the roots are supplied via the irrigation water" is known as "soilless culture." soilless culture that does not use chemically active growing media (GM) like zeolite, peat, or coir (Adams, 2002). The process of growing plants without soil by submerging their roots in a nutrient solution is known as "soilless culture" (Maharana & Koul, 2004). The term "soilless culture" refers to "any method of growing plants without the use of soil as a rooting medium, in which the irrigation water supplies the inorganic nutrients absorbed by the roots." The term "nutrient solution" refers to the mixture that is created when fertilizers that contain the nutrients that the crop needs dissolve in irrigation water at the proper concentration. The primary benefit of SCS is the crop's independence from the soil, which is a natural medium that is diverse, harbors pathogens, degrades quickly in monoculture systems, and can be infertile, saline, or sodic. Without the need for soil fumigation, SCS's independence from the soil as a rooting medium allows for more effective pathogen control as well as the optimization of the physical and chemical properties of the root environment. Consequently, it is possible to achieve greater yields at a cost-effective production level with minimal pesticide use and superior product quality. Certain cultural practices such as soil cultivation and weed control are avoided in soilless culture, and land unsuitable for soil cultivation may be utilized (Polycarpou et al., 2005). Hydroponic plants were consistently of higher quality, yielded more, were harvested more quickly, and contained more nutrients. Liquid hydroponics, solid media culture, and aeroponics are the three primary soilless systems. The term "hydroponics" was initially used in the 1930s by Dr. William F. Gericke of the University of California, who popularized the technique for producing food on a large scale after successfully growing tomato plants in nutrient solutions. American troops stationed on non-arable Pacific islands were provided with fresh produce through the use of hydroponics during World War II. Since that time, soilless culture has evolved beyond hydroponics to encompass substrate culture (using inert media such as perlite, cocopeat, or rockwool) and aeroponics (plants suspended in air with nutrient misting). Automation, LED lighting, climate control, and other technological advancements in the late 20th and early 21st centuries have further improved the effectiveness and usefulness of these systems. Soilless culture is now a key component of controlled environment agriculture (CEA) and is utilized extensively worldwide in urban farming, commercial greenhouses, and research environments.

TYPES OF SOILLESS CULTURE:

HYDROPONICS:

A nutrient-rich water solution is used in hydroponics, a technique for growing plants without soil, to supply vital minerals straight to the roots of the plants. Trays floating in nutrient solution-filled tanks are used to grow plants. It is a productive and sustainable type of farming that is frequently employed in places with inadequate soil or space. The main characteristics of hydroponics Soil-free growth using inert media such as rockwool, coconut coir, or perlite. Nutrient solutions designed for the best possible plant health are sprayed on or submerged in the roots. It offers a regulated setting. Frequently utilized in indoor farms or greenhouses to provide growing conditions all year round. In 1976, Professor Franco MAs Santini of the University of Pisa in Italy used it for the first time to grow strawberries, cardoons, and lettuce. Professor Franco MAs Santini used it for the first time in 1976 to grow strawberries, cardoons, and lettuce at the University of Pisa in Italy. These days, the technique is mostly used to grow aromatics (basil, mint, thyme, etc.) and fresh-cut leafy vegetables (lettuce, chicory, rocket, lamb's lettuce, etc.).

TYPES OF HYDROPONICS:

DEEP WATER CULTURE:

Developed in 1929 by Professor W.F. Gericke of the University of California, DWC is a hydroponic technique that was the first to be proposed for commercial use. The vegetation is upheld by a slender coating of sand (1 cm) that rests atop a container filled with a nutrient-rich liquid, which is shielded by a mesh and fabric. The plants' roots dangle in the nutrient solution. A different option would be to cover the bucket with a lid and hang the plants in net pots from the middle of the cover. DWC involves suspending roots in a nutrient solution that is highly oxygenated. When plants are suspended above a reservoir, an air pump continuously adds oxygen to the water to avoid root rot and encourage healthy growth. Netted pots, either with or without an extra growing medium, are used to secure the plants to the system. The roots hang over the reservoir, absorbing oxygen, nutrients, and water as needed. Net pots with a growing medium (such as clay pebbles) inside are used to hold plants. The net pots are suspended above a reservoir that is filled with water that has been infused with vital nutrients. The solution is aerated using an air stone and an air pump. The roots continuously absorb water and nutrients as they extend directly into the nutrient solution.

WICK SYSTEM:

Without requiring electricity, pumps, or aerators, the Wick System—known as a Passive System—is the simplest form of hydroponics. It employs absorbent materials or wicks to move the nutrient solution from a storage area to the plant roots via capillary action. This budget-friendly and easy-to-manage technique is perfect for gardening at home or for limited agricultural practices, especially in areas with insufficient electrical resources. While its restricted capacity for nutrient and water delivery renders it impractical for extensive or high-demand crops, it remains a practical choice for cultivating smaller plants such as herbs and leafy vegetables.

DRIP HYDROPONIC SYSTEM:

The two containers that make up the drip hydroponic system are positioned vertically, one at the bottom to hold the nutrient solution and the other above to support the plants. With the aid of a drip mechanism, nutrient solutions are transferred from the lower container to the plants. The system is especially appropriate for plants with extensive root systems because the addition of an aquarium stone to the bottom container improves the oxygenation of the solution.

EBB AND FLOW SYSTEM:

Despite having structural similarities to the drip system, the Ebb and Flow System functions differently. Additionally, it uses two containers: one for the solution containing nutrients and another for the vegetation. Nevertheless, in this approach, the nutrient blend mimics the natural patterns of irrigation by periodically soaking the root zone and subsequently permitting it to drain. This changing root environment encourages vigorous plant growth and the formation of strong, healthy roots.

NUTRIENT FILM TECHNIQUE (NFT):

Allan Cooper created the closed hydroponic system known as the Nutrient Film Technique (NFT) in the 1960s. A thin layer of nutrient solution is circulated through a PVC channel that slopes gently, exposing the roots of the plants. Plant health and growth are improved by this arrangement, which guarantees a consistent supply of nutrients and oxygen. In order to maintain resource efficiency, excess solution, or runoff, is gathered and put back into a holding tank. These various hydroponic methods—drip systems, ebb and flow, and NFT—emphasize the versatility and inventiveness of soilless agriculture by providing specialized solutions for various plant species and growing conditions.

AEROPONICS:

Aeroponics, a highly effective soilless cultivation technique that is especially well-suited to controlled environments like greenhouses, gets its name from the Latin words "aero" (air) and "ponic" (labor). This system guarantees ongoing moisture and oxygen supply by keeping plant roots airborne and frequently spraying them with a nutrient-infused mist. A specific pressure range (60–90 psi) is upheld using different types of nozzles, such as airless pressurized systems, high-pressure misting nozzles, and ultrasonic mist generators. Regular misting is crucial to prevent the roots from drying out. As demonstrated in Korea, aeroponics has been successfully used for a variety of crops, from leafy greens to even more substantial ones like potato seed tubers. Despite being praised for having better water and nutrient efficiency than conventional hydroponics, its widespread use is constrained by its high startup and running costs. making it more common for small horticultural crops and research applications.

Nutrient formulas are applied directly onto the hanging roots through different types of nozzles at consistent times, ensuring the root area stays sufficiently hydrated and preventing it from drying out. Several nozzle options are employed, including ultrasonic atomization foggers, high-pressure atomization nozzles, and pressurized airless nozzles. These systems maintain a static pressure typically ranging from 60 to 90 psi, meticulously controlled by automated systems (Liu et al., 2018).

AQUAPONICS:

In contrast, aquaponics is a synergistic combination of hydroponics and aquaculture that allows plants and fish to be grown simultaneously in a shared soilless environment. Water-centered cultivation of plants and fish is captured in the phrase, which merges the Latin term "aqua" meaning water and the Greek term "ponos" meaning work. The natural nutrients for plant growth in this system are derived from fish waste. Water travels through a biofilter containing the helpful bacteria Nitrobacter and Nitrosomonas as it moves from the fish tank to the plant bed. These bacteria transform the toxic ammonia from fish waste into nitrates, which are plants' useable form of nitrogen. A closed-loop system is created by reintroducing the filtered, nutrient-enriched water into the fish tank. As an environmentally friendly method of integrated food production, aquaponics has become increasingly popular throughout the world, especially in China, India, Israel, and several African countries.

BIOPONICS:

An advanced form of hydroponics, bioponics cultivates plants without the use of soil, relying on natural nutrient sources instead of synthetic chemical fertilizers. The word emphasizes its organic and environmentally friendly approach to hydroponic farming by fusing the words "bio" (life or organic) and "ponics" (cultivation). In a bioponic system, a nutrient-rich solution is produced using organic inputs like compost teas, fish emulsions, seaweed extracts, or decomposed plant materials. Similar to how it happens in soil, microbial activity breaks down these organic materials to release nutrients for plant uptake. Biofilters are frequently included to support this microbial activity, which cultivates helpful bacteria and fungi that facilitate nutrient conversion.

SUBSTRATE MEDIUM CULTURE:

A sort of soilless cultivation system known as "Substrate Medium Culture" involves growing plants in a solid medium, or "substratum," which gives the roots structural support. In contrast to hydroponic systems, which suspend roots in water or mist, substrate medium culture uses growing media that hold water, nutrients, and air for plant uptake, such as coco coir, rockwool, perlite, vermiculite, clay pellets, or peat moss.

CONCLUSION:

A revolutionary development in contemporary agriculture, soilless culture offers effective, sustainable, and space-saving substitutes for conventional soil-based farming. Systems such as hydroponics, aeroponics, aquaponics, bioponics, and substrate medium culture offer more control over nutrient delivery, quicker plant growth, and increased yields by doing away with the need for soil. These techniques are especially helpful in areas with low soil quality, little arable land, or limited water supplies. Even though every technique has unique needs, advantages, and difficulties, they all help create a more inventive and resilient agricultural future. Soilless culture has enormous potential to meet the expanding global demand for food in an environmentally responsible manner with the right management and technological assistance.

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