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Soilless cultivation: a new approach for quality horticulture crop production

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Soil is usually the most available growing medium for plants. It provides anchorage, nutrients, air, water, *etc*. for plant growth (Ellis *et al*., 1974). However, soils do pose serious limitations for plant growth too, at times. Some of them are presence of disease causing organisms and nematodes, unsuitable soil reaction, unfavorable soil compaction, poor drainage, degradation due to erosion *etc*. In addition, soil-based agriculture/open field vegetable production is somehow difficult as it involves more area, more water and more number of workers. Moreover, such areas as like; metropolitan areas where soil is not favorable to grown vegetables, in some areas, there is water scarcity for proper irrigation and due to unfavorable geographical or topographical conditions there is lack of cultivable lands. Out of these difficulties another major difficulty is to hire labour. Under such situation, soilless vegetable cultivation can be introduced successfully. (Butler & Oebker, 2006). Soilless culture is the technique of growing plants in soil-less condition with their roots immersed in nutrient solution (Maharana & Koul, 2004). In soilless culture some cultural practices like soil cultivation and weed control are avoided, and land not suitable for soil cultivation can be used (Polycarpou *et al*., 2005). Plants grown in soilless media had consistently superior quality, high yield, rapid harvest, and high nutrient content. This system will also help to face the challenges of climate change and also helps in production system management for efficient utilization of natural resources and mitigating malnutrition (Butler & Oebker, 2006). Soilless culture can provide important requirements for plant growth with equal growth and yield results compared to field soil.

Crops can be grown in soilless media:

Fruits	:	Strawberry
Vegetables	:	Tomato, chilli, capsicum, brinjal, Beans, Lettuce, Parsley, Mint, Sweet basil, *etc.*
Flower/ornamental crops	:	Marigold, Roses, Carnation, Chrysanthemum, *etc.*

Besides, production of horticulture crops, soilless culture highly utilized in raising nursery of fruits, vegetables, flower crops, and other horticulture crops. Seedlings or nursery raised through soilless culture is superior to traditional soil based nurseries as it allows for precise control over nutrient delivery, ensuring that plants receive the exact amount and balance of nutrients they need for optimal growth. Furthermore soilless culture eliminates the risk of soil-borne diseases and pests, which are common challenges in traditional soil-based nurseries. This results in healthier and more vigorous plants compared to soil-based nurseries where nutrient availability can be inconsistent.

Media for soilless culture:

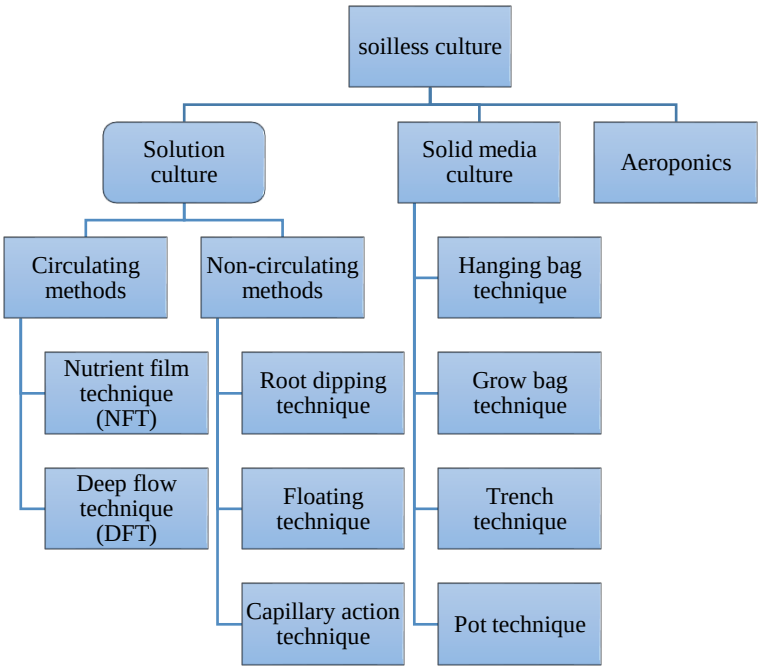
Soilless culture, also known as hydroponics, can utilize various types of growing media or substrates to support plant growth. The choice of growing media depends on factors such as the plant species, system design, water availability, and personal preferences. Here are some commonly used growing media in soilless culture:

- **Rockwool:** Rockwool is a popular and widely used growing medium. It is made from molten rock spun into fibers and compressed into cubes or slabs. Rockwool provides excellent water retention while allowing for good drainage and aeration.
- **Perlite:** Perlite is a lightweight volcanic glass that is expanded by heating. It has good drainage properties and retains some moisture. Perlite is often used in soilless mixes to improve aeration and prevent compaction.
- **Vermiculite:** Vermiculite is a mineral that expands when heated. It has excellent water-holding capacity and can improve moisture retention in soilless systems. Vermiculite is often used in combination with other media to enhance water retention. It contains minerals like potassium and magnesium.

- **Coconut coir:** Coconut coir is derived from the fibrous husk of coconut shells. It is an increasingly popular growing medium due to its sustainability and water-holding capacity. Coconut coir provides good aeration and drainage while retaining moisture. It is a pathogens free medium and access speed germination and rooting upon landfall.
- **Peat moss:** Peat moss is a partially decomposed organic material harvested from peat bogs. It has good water-holding capacity and provides a stable environment for root development. However, peat moss is not a renewable resource and has environmental concerns associated with its extraction.
- **Sphagnum moss:** Sphagnum moss is important as a growing media due to its unique characteristics. It has high water-holding capacity, provides aeration to roots, and releases nutrients slowly. Additionally, it helps maintain acidic conditions for acid-loving plants and promotes beneficial microbial activity, making it ideal for horticultural applications.
- **Sawdust:** It is made from wood, produced by sawing. It is 100% natural, eco – friendly and easily available soilless growing medium. It offers good aeration and drainage properties, which can be beneficial for plant roots.
- **Sand:** Sand can be used as a growing media for certain types of crops, especially those that prefer well-drained soil conditions. It provides excellent drainage, allowing excess water to move away from the plant roots, reducing the risk of waterlogging and root rot. However, sand has poor water and nutrient retention capacity, so it may require frequent irrigation and regular fertilization to ensure plants receive adequate moisture and nutrients.

Soilless cultures systems:

Different soil less culture of cultivation can be described according to the techniques employed. Generally it refers to ways for application of nutrient solution to the plant root system. The various soilless culture systems that are used are gen below:



A. Solution culture:

a) Circulating methods:

In circulating culture systems, plants are typically grown in containers or trays filled with an inert growing medium. The roots of the plants are suspended or supported in the medium, and the nutrient solution is continuously circulated to provide water and essential nutrients directly to the plants.

- **Nutrient Film Technique (NFT):** NFT systems involve a shallow, sloping channel where a thin film of nutrient solution flows over the plant roots, providing nutrients and water. The excess solution is then collected and recirculated.
- **Deep flow technique:** In this technique, Plants are fitted in PVC pipe with plastic net pots and the nutrient solution flow through these pipes. These pots contain nutrient solution at their bottom that flows through the pipes. The PVC pipes must have fitted in inclined manner in order to facilitate the movement of nutrient solution.

b) Non-circulating methods

It refer to systems where the nutrient solution does not continuously circulate or flow throughout the growing medium. These methods are sometimes referred to as static or passive hydroponic systems. Here are a few examples of non-circulating hydroponic methods.

- **Root dipping technique:** In this technique, plants are raised in small pots containing small amount of growing medium. The pots are arranged so that their lower 2-3 cm are buried in the nutritional solution. Due to this, some of the roots are immersed in the solution while the rest remain hanging in the the air above the solution for nutrient and air absorption, respectively. This method is very economical and easy to use.
- **Floating Technique:** In this method, about 10 cm container are used in which pots are fixed in a thin and light sheet which floats on the nutrient solution filled in the container and solution is artificially aerated.

c) **Capillary Action Technique:** this technique work on the natural property of water to move through small spaces, such as capillary tubes or porous mediums, against the force of gravity. Capillary action is employed by placing the plant's root system in contact with a wick or absorbent material, which draws up water and nutrients from a reservoir through capillary action, ensuring a continuous supply to the roots. This technique promotes efficient nutrient uptake and minimizes water wastage in soilless culture systems.

B. Solid media culture or aggregate system:

The media material selected for this culture must be flexible, friable, with water and air holding capacity and can be drained easily. In addition, it must be free of toxic substances, pests, disease causing microorganisms, nematodes, *etc*. (Hussain *et al.,* 2014). The various techniques of solid media culture are explained below:

a) **Hanging bag technique (Open system):** in this technique, UV treated thick polythene bags are used which are suspended above a nutrient solution-collecting channel. Therefore, this technique is also known as 'verti-grow' technique. The openings on the sides of the hanging bags are crammed with seedlings or other planting materials that have been put in net pots. A micro sprayer placed to each hanging bag at the top which pumps the nutrient solution to the top of each bag. Inside the hanging bag, the nutrient fluid is dispersed uniformly by the micro sprinkler. The roots of the plants and the fiber of the coconut are moistened by the nutrient solution that flows down. Through holes drilled into the bottom of the hanging bags, extra solution is collected in the channel below and flowed back to the stock tank for nutrient solution. This system is suitable for both i.e. open space and in protected structures. However, in protected structures, the hanging bags in the rows and between the rows must be positioned so that enough sunlight reaches the bags in the inner rows. This system is suitable for leafy vegetables, strawberry, and small flower plants.

b) **Grow bag technique:** In this technique 1 – 1.5 m long white colour (lack inside) polythene bags are placed horizontally in rows on the floor with walking space in between. Seedlings or other planting materials that have been planted in net pots are squished into the coir-dust through small holes drilled into the top surface of the bags. On each side of the bags, there are two tiny drainage or leaching slots. Fertigation is used, with a black capillary tube connecting the main supply line to each plant. Before depositing the bags, the entire floor is covered with white UV-resistant polythene. The plants receive reflected sunlight from this white polythene. Additionally, it decreases the frequency of fungal infections and the relative humidity between plants.

c) **Trench or trough technique:** In this open system, Plants are planted in shallow trenches excavated into the earth or in troughs built above the ground out of masonry or concrete. To keep the growing media separate from the rest of the ground, both trenches and troughs are lined with waterproof material (thick, UV-resistant polythene sheets in two layers). The width of the trench or trough can be chosen based on ease of operation. Depending on labor availability, either a drip irrigation system or hand application can supply the nutritional solution and water. To drain out extra nutritional solution, a well-perforated pipe with a 2.5 cm diameter can be inserted at the bottom of the trough or trench.

C. **Aeroponics:** Aeroponics is a method of growing plants that involves suspending the plant roots in the air and misting them with a nutrient-rich solution. It is a form of hydroponics, which is a technique of cultivating plants without soil. However, unlike other hydroponic systems where the roots are submerged in a nutrient solution, aeroponics relies on a fine mist or fog to deliver nutrients directly to the roots. In an aeroponic system, plants are typically grown in containers or growing chambers where the roots are exposed to air. A misting system sprays a nutrient solution onto the roots at regular intervals, ensuring they receive the necessary moisture and nutrients. The excess solution is then collected and recycled, making aeroponics an efficient and water-saving method of cultivation. The main advantage of aeroponics is that it provides plants with high levels of oxygen, allowing for faster growth rates and increased yields. It also enables

better nutrient absorption and reduces the risk of diseases and pests commonly associated with soil-based farming. Additionally, aeroponics systems can be set up vertically, maximizing space utilization and making them suitable for urban and indoor farming.

Advantages of soilless cultivation include:

Increased control over nutrient delivery: With soilless systems, nutrients can be precisely controlled and adjusted, ensuring plants receive optimal nutrition for growth
Efficient water usage: Soilless systems typically use less water compared to traditional soil-based cultivation, as water can be recirculated and reused in closed-loop systems.
Reduced risk of pests and diseases: By eliminating soil, the risk of soil-borne pests and diseases is minimized, reducing the need for chemical pesticides or herbicides.
Higher yields and faster growth: Soilless cultivation allows plants to access nutrients directly, resulting in faster growth rates and potentially higher yields compared to traditional soil-based methods. However, there are also challenges associated with soilless cultivation, such as the initial setup cost of equipment, maintaining the appropriate nutrient balance, and ensuring proper oxygenation for the roots. Additionally, some crops may still benefit from certain soil characteristics that can be challenging to replicate in a soilless environment. Overall, soilless cultivation offers a sustainable and efficient method of growing horticultural crops, particularly in areas with limited access to arable land or unfavorable soil conditions. It has gained popularity in commercial horticulture, urban farming, and indoor gardening due to its potential for year-round production and controlled growing conditions.

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