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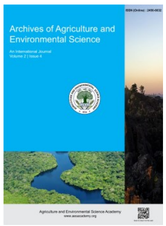

REVIEW ARTICLE

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# A review on soilless cultivation: The hope of urban agriculture

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**ABSTRACT**

The cultivation of plants without using soil as a rooting medium is known as soilless farming. Depending on the requirement and type of crop, there are several soilless systems, including hydroponic, aeroponic, vertical farming, and others. The rate at which megacities are growing is worrying. As a result, urban agriculture needs to undergo a revolution in order to address the problem of food scarcity and hunger. These significant quantitative and qualitative food concerns can be solved by soilless farming in urban environments. In greenhouses and tunnels, about 3.5% of the world's crops are produced utilizing soilless, hydroponic farming methods. People who reside in deserts, the arctic, and other difficult-to-farm places can build up hydroponic farms. Since there is no soil, there are fewer insects and weeds. Vegetables, fruits, flowers, and medicinal plants are among the crops grown in soilless or hydroponic systems. Growth media is used in soilless culture methods in place of soil. As growth media, inorganic or organic substrates (barks, coconut coir, coconut soil, fleece, marc, peat) are used. Aquaponics in Nepal has a promising future because it is still in its early phases and is expected to thrive and expand well. As a result, a variety of crops are produced year, increasing income. Soilless cultures are thought of as a recently found approach to agricultural development, yet they are extremely difficult to put into practice.



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## INTRODUCTION

A small number of the published publications on soil-based plant cultivation focus on growing plants without soil. The study that is being provided is a summary of agricultural practices that do not involve soil. The lack of the typical amount of water required to produce plants, however, can be remedied through soilless agriculture. Fertile soil is fast disappearing due to climate change and intensive farming practices as the world's population rises. The population of the world was 7.6 billion in 2011, and the UN projects that number to increase to 8.6 billion in 2030 and 9.8 billion in 2050. (UN, 2019). The world's total agricultural land increased by 3% between 1958 and 2005, mostly in tropical nations. However, there was a 0.19 percent decline in agricultural land between 2005 and 2011. (Foley *et al.*, 2011). There are now much fewer acres per person available for soil-based farming, which has led to a number of agricultural and environmental issues (Pradhan and Deo, 2019). The environment suffers when there isn't enough food to feed everyone on the planet (FAO and ITPS, 2015). According to study from October 2018, there are 820 million hungry people in the world. To address the problem of food scarcity and malnutrition, urban agriculture must undergo a revolution (Dubbeling *et al.*, 2010). But, in cities soil is hard to come by and, even when it is, it may include impurities that make it unfit for plant growth. Finding both is extremely difficult in cities because both labor and space are expensive (Sardare *et al.*, 2019). These significant quantitative and qualitative food concerns can be solved by soilless farming in urban environments. The world's agricultural areas are not only constrained but also troubled by pollution, salinization, and drought, all of which reduce crop production (Despommier, 2013). In these crucial situations, innovative technologies and procedures must be developed to withstand the current situation. Only a small number of studies on in vitro and agricultural practice have specifically addressed soilless culture.

Recent years have seen the use of several soilless agriculture systems. Soilless agricultural production (Tzortzakis *et al*., 2020) is a highly promising technique for increasing the cultivation of numerous cash crops and for growing plants without the need of soil as a rooting medium. Depending on the requirement and type of crop, there are several soilless farming methods, including hydroponic, aeroponic, vertical farming, NFT technology, and others (Despommier, 2013). Soilless agriculture could be more cost-effective than soil-based farming, resulting in larger yields and faster harvests from fewer areas of land (Grafiadellis *et al*., 2000; Raviv *et al*., 2007; Rezaei Nejad and Ismaili, 2014). Balconies, roofs, greenhouses, and other types of unfit ground are just a few of the sites where soilless agriculture can be found. These agricultural practices work under strict regulations to increase output and profits. Despite the fact that the cost of producing soilless plants has increased, this value is quickly compensated by the enormous quantity of output. Soilless culture may be a method of cultivation that is modern and sophisticated, but it also has to look for human workers who are capable of performing this work and who may be rare. In this context, a brief overview of these strategies will be given with an emphasis on the paragraphs as follows.

## Methodology

Various secondary sources of data were accessed for this research. Journals from Elsevier and springers were also reviewed. Different articles, books and review papers were accessed and secondary source of information were taken and their proper referencing was done in this study.

## Soilless agriculture

Several advancements have occurred in recent years, ranging from grow bags to net caps to a range of specific nutritional solutions for specific plants. These gardening techniques were created with soilless farming in mind (Gruda, 2012). The value of soilless culture is anticipated to grow over time due to increased soil erosion and a shortage of space in metropolitan areas. Soilless agriculture is especially suitable for urban areas because of its light weight, mobility, and ability to be maintained in terms of competency (Despommier, 2013). Cultivating crops in a system without soil is known as soilless cultivation (Savvas and Gruda, 2018). This broad description covers a wide range of plant growth systems, all of which require the container for root development of plants in a porous rooting medium known as a "substrate" or "growing medium" (Barrett *et al*., 2016b). Soilless agriculture could be more cost-effective than soil-based farming, resulting in larger yields and faster harvests from fewer areas of land (Grafiadellis *et al*., 2000; Raviv *et al*., 2007; Rezaei Nejad and Ismaili, 2014). Soilless systems are also more efficient in terms of nutrient and water utilization (Savvas and Passam, 2002; Van Os, 1999). As a result, over the last 50 years, they have become increasingly essential globally (Schmilewski, 2009).

There are two types of soilless cultivation systems: a) liquid medium systems that do not use any other media to support plant roots, and b) solid medium systems that use a substrate to support the plants. The hydroponic system is made up of two types of systems: liquid medium and inert substrate. Furthermore, soil-free substrate cultures are divided into two types: open systems (in which the nutrient solution that drains from the roots is not reused) and closed systems (in which the surplus nutrient solution is collected, rectified, and reintroduced) (Bhandari *et al*., 2016). The use of nutrients and the lack of soil (that may be replaced by the substrate in certain of its activities) are the major features that distinguish soil-less agriculture from conventional techniques (Di Lorenzo *et al*., 2013).

## The nutrient solution

All soilless production methods, whether with or without substrates, have one thing in common: the use of a nutrient solution to provide required nutrients (excluding carbon). Mineral nutrition principles for plants grown in the absence of soil are identical to those for plants grown in the presence of dirt. The fundamental distinguishing factor is the smaller amount of substrate (and/or nutrient solution) supplied to each plant, which explains the soil-less system's special nutrient solution management (Di Lorenzo *et al*., 2013). Plants do not require the same higher nutritional levels for growth as those necessary for soilless cultivation, as documented in (Martin and Marschner, 1988; Nielsen, 1984; Olday, 1972). In soilless farming, such high concentrations are employed to provide a good nutrient reserve and to facilitate the preparation, control (e.g., with a conductivity meter), and reintegration of the nutrients. The chemical composition of the nutrient solution reflects that of the cultivated plant rather than that of the soil's circulating solution. Plants use less energy to aggressively extract nutrients in these conditions. Furthermore, nutrient solutions are usually more saturated than the soil's circulating solution because lower concentrations could result in a deficiency, especially if the nutrient solution is not renewed on a regular basis (Olday, 1972). To meet the needs of the macro elements, nutrient solutions are frequently made with four or five salts, which eliminates the chance of achieving larger proportions among the concentration levels of the elements.

## Types of soilless farming

There are many different methods of soilless farming, including aeroponics, which utilizes vaporized nutrients, aquaponics, which uses fish and other marine creatures, and solid media culture, which employs both organic (sawdust, cocopeat, sphagnum moss, and so on) and inorganic media (vermiculite, gravel, sand, hydrogel, etc.).

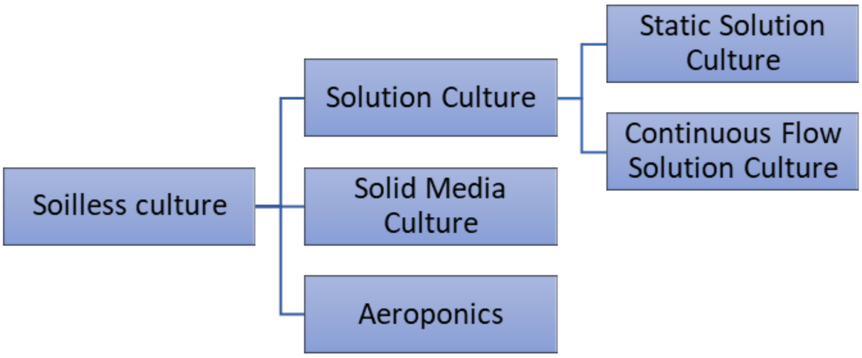


**Figure 1.** *Classification of the soilless culture (Designed by the authors).*

## Hydroponics

Hydroponic farming could be the first step toward a more sustainable lifestyle. For those unfamiliar with the term, hydroponic farming is a type of farming that does not use soil. In fact, the amount of water used is substantially less. The best thing is that this method of agriculture does not require much area, making it ideal for both apartment dwellers and garden dwellers. Currently, about 3.5 percent of the world's area is grown for vegetable production under tunnels and greenhouses using soilless agricultural techniques based on hydroponic solutions (such as floating systems, nutrient film technology (also known as NFT) (Pignata *et al.*, 2017). The extent to which plants get nutrients from the growing medium has a significant impact on the productivity and quality of crops grown in hydroponic systems, which is well known (Valentinuzzi *et al.*, 2015). This approach contributes to the management of production systems for optimal use of natural resources and the reduction of malnutrition (Butler and Oebker, 1962). There are a lot of different hydroponic techniques (Sardare *et al.*, 2019). They are:

Circulating methods (closed system) or continuous flow solution culture

a) Nutrient film technique (NFT): Roots are placed in a small-diameter PVC tube or trough, and fertilizer solution runs across the roots, creating a nutrient-dense film of water around them.
b) b) DFT (Deep Flow Technique)
c) Non-circulating method (open systems)/Static solution culture
    a) Technique for dipping roots
    b) Floating method
    (c) Capillary action technique

## Media selection in hydroponics

The plant's oxygen, moisture, nutrients, and support must all be supplied by the hydroponic medium. Particle size, shape, and porosity all have an impact on medium moisture retention. Foam gravel, perlite, rockwool, and sand are all typical media choices. The most popular hydroponic rock is rockwool, a mineral fiber generated from basaltic rock (Treftz *et al.*, 2015). In this approach, no solid substrate is utilized except when sowing vegetables, and a sponge is used to nurture seedlings.

## Hydroponics: the future of farming

The hydroponics approach opens a "new" door in science, allowing for increased crop production for both food and ornamental purposes. It has the potential to reduce greenhouse and nursery environmental impacts while also improving yield quality (Putra and Yuliando, 2015). In over-populated locations, hydroponics can provide a high yield of native crops such as green vegetables or flowers. All kinds of plants and crops can be cultivated all over the world if the hydroponics technique can be modernized (Barman *et al.*, 2016). Hydroponics has the potential to feed millions in places like Africa and Asia where water, soil, and crops are scarce. As a result, hydroponics offers a ray of hope for crop and food production management (Khan, 2018). To feed its people, Japan has begun producing rice using a hydroponics approach (De Kreij *et al.*, 2003). In the dry and arid climate of Israel, berries, citrus fruits, and bananas are grown in great quantities (Van Os, 1999). It's a good fit for biological research and for analyzing interactions between many biotic and abiotic elements that influence plant growth. Hydroponics cultivation is currently in high demand in both developing and developed countries (Trejo-Téllez and Gómez-Merino, 2012).

Traditional soil farming is less effective than hydroponically irrigated gardening. Plants receive nutrients directly from the water, which is more efficient than using soil. Only a small amount of water is wasted in a hydroponic garden because the water is recycled. It requires less area to grow and can be cultivated completely inside. Hydroponic gardens take up 90% less room than traditional gardens and can be cultivated in the home, on a rooftop, or on a balcony. Geographical location and climate have no impact on hydroponic gardens. In 2015, NASA experimented with growing lettuce in space. Hydroponic farms can be set up by people who live in deserts, the arctic, and other regions where farming is difficult. Gardening in this style allows for more predictability and consistency. They are unaffected by weather conditions. There are fewer pests and weeds since there is no soil. Because there is no soil, pesticides, or herbicides in hydroponic gardens, the produce requires minimal washing. The hydroponic farm provides a route to a more sustainable food ethic that promotes the health of our food, bodies, and environment while avoiding the use of harsh chemicals (El-Kazzaz *et al.*, 2017). As a result, the government should enact rules and provide subsidies for such cultivation systems.

### Crops grown in a soilless or hydroponic environment

Using this method, people can essentially grow any type of vegetable, fruit, herb, or crop. Hydroponically produced flowers have a better bloom and color. Because hydroponics systems are mechanized, they are more controlled and better for collecting produce. A variety of plants, including vegetables, fruits, flowers, and medicinal crops, can be grown in a soil-free or hydroponic environment (Sardare *et al.*, 2019).

### Aquaponics

Aquaponics is an aquaculture technique in which aquatic organisms such as snails, fish, crayfish, or prawns are raised in tanks using a combo of hydroponics and aquaponics (Rakocy, 2007; Rakocy *et al.*, 2006). Water from an aquaculture system is passed through a hydroponics system, where toxic by-products are decomposed by nitrifying bacteria living on the surface of the grow bed media, first into nitrites, then into nitrates, which are used as nutrients by the crops, and the water is then cleaned and returned to the aquaculture system (El-Kazzaz *et al.*, 2017). Aquaponics systems of the following types are the most popular:

Media filled beds
Nutrient Film Technique (NFT)
Deep Water Culture (DWC)

### Media selection in aquaponics

In soilless culture systems, growth media takes the place of soil. The plants are supported in this setup by a solid medium. The functions of the growth medium are to provide oxygen to the roots, to bring water and dissolved nutrients into contact with the roots via the irrigation system through the media, to allow the solution to run to waste to recirculate the solution through the system, and to stabilize the plants as supportive mediators so that they do not topple over. Organics (barks, coconut coir, coconut soil, fleece, marc, peat, ruffia bark, husks, sawdust, and wood chips) or inorganic (expanded clay, glasswool, gravel, perlite, pumice, rockwool, sand, sepiolite, vermiculite, volcanic tuff, and zeolite) substrates are utilized as growth media (Olympios, 1999).

### Suitable fish species in an aquaponics system

Various cold-water and warm-water fish species, such as Tilapia (*Oreochromis niloticus*), trout (*Oncorhynchus mykiss*), perch (*Perca*), Arctic char (*Salvelinus alpinus*), and largemouth bass (*Micropterus salmoides*), have acclimated to recirculating aquaculture systems (Diver and Rinehart, 2000; Wani *et al.*, 2010). Tilapia is one of the fish species that has been chosen for research and practice. The experimental evaluations in the outdoor barrel aquaponic system were carried out in IAAS Paklihawa (Gyawali *et al.*, 2019) with the stocking of bighead carp (*Aristichthys nobilis*) and common carp (*Cyprinus carpio*), with a significant growth and survival rate. Rohu, Naini, silver, and common carp are grown by farmers in the Syangja district (Gurung, 2016).

### Suitable plants Species in an aquaponics system

The stocking density of fish tanks and the resultant nutrient content of aquaculture effluent are related to the selection of plant species appropriate for hydroponic cultivation in aquaponic greenhouses (Diver and Rinehart, 2000). Aquaponics can produce both green crops and fruits (Azad *et al.*, 2016)). Leafy vegetables with low to moderate nutritional requirements, such as lettuce, spinach, chives, and basil, as well as cabbage, carrots, and okra (Azad *et al.*, 2016; Salam *et al.*, 2013), are viable in the aquaponic system. Fruits with high nutritional needs, such as tomatoes, bell peppers, and cucumbers, thrive in a well-stocked, well-developed aquaponics system (Diver and Rinehart, 2000). In IAAS Paklihawa, the experimental assessment in outdoor barrel aquaponics was carried out with the growing of broad-leaf mustard of various types, which produced a high yield (Gyawali *et al.*, 2019). Stone is used to grow onions, cucumbers, tomatoes, carrots, garlic, and coriander, while PVC pipes are used to grow spinach, chilly, strawberries, potatoes, and mint, and thermocol is used to grow cauliflower and broccoli (Gurung, 2016).

### Prospects for aquaponics in Nepal

Because the majority of Nepalese farmers rely on both vegetable and fruit growing for their income and livelihood, aquaponics has a bright future in Nepal. Though it is practiced in some places in Nepal, it is still in its early stages, with good growth and expansion anticipated due to its numerous advantages and adoption nature. Regarding the proper diet, food, and nutritional security, Nepal remains underprivileged. Nepal is unlikely to meet the recommended daily amount of 30 gram of fish or animal protein any time soon (Gurung, 2016). Several people are suffering from nutritional deficiencies as a result of inadequate dietary consumption. Fish are rich in omega-3 fatty acids, protein, vitamins, iron, zinc, and fat-soluble vitamin D. All are abundant in fish. In Nepal, fish output per capita was 3.10 kg in 2017/18, and fish availability per capita was 3.39 kg (CFPCC, 2018). As can be observed, there is a gap between the number of fish produced and the number of fish available, which is covered by imports from other nations. In 2017/18, a massive 10,756 metric tons of fish were imported (Subedi and Shrestha, 2020). These imported fish are of poor quality and can be harmful to one's health. Nepal must be self-sufficient in fish production to guarantee excellent health, a balanced diet, food security, and nutritional security. Similarly, veggies are high in vitamins A and C, iron, zinc, potassium, and other minerals. With the rise in healthy and conscientious eating habits in Nepal, there is a growing need for veggies. Fish and vegetable production can work together to improve the country's nutritional and economic situation.

Moreover, growing urbanization, industrialization, and various other uses have encroached on agricultural land, putting great-

**Table 1.** Concentration ranges of macronutrients (mM) in soil and soil-less crops (Buer *et al.*, 1996; Martin and Marschner, 1988; Nielsen, 1984; Olday, 1972).

| Nutrients | Soil | Soilless |
|---|---|---|
| N-NO3- | 0.5-10 (usually <1-2) | 5-20 |
| N-NH4+ | 0.02-0.05 | 0.5-2 |
| P(H2PO4-) | 0.005-0.05 | 0.5-2 |
| K+ | 0.02-2 | 5-10 |
| Ca2+ | 0.5-4 | 3-6 |
| Mg2+ | 0.2-2 | 1-2 |
| S (SO4 2-) | 0.1-2 | 1.5-4 |

**Table 2.** An example of subdivision (%) between the phases of soil and substrate (Di Lorenzo *et al.*, 2013).

| Phase of the medium | Soil | Substrate |
|---|---|---|
| Solid | 50 | 25 |
| Liquid | 25(35) | 50 |
| Gaseous | 25(15) | 25 |

**Table 3.** Crops that can be cultivated in a soil-free environment are listed below (Barman *et al.*, 2016; Hayden, 2006; Shishkin and Antipova, 2017).

| Crop varieties | Name of the crops |
|---|---|
| | *Cucumis sativus* (Cucumber), *Lycopersicon esculentum* (Tomatoes), *Capsicum frutescens* (Chillies), *Solanum melongena* (Brinjals), *Phaseolus vulgaris* (Green-beans), *Beta vulgaris* (Sugar-Beet), *Psophocarpus tetragonolobus* (Winged-beans), *Capsicum annum* (Bell-peppers), *Brassica oleracea var. capitata* (Cabbages), *Cucumis melo* (Melon), *Allium cepa* (Onions), *Raphanus sativus* (Radishes). |
| Leafy vegetables | *Ipomoea aquatica* (Kang-Kong), *Lactuca sativa* (Lettuces). |
| Cereals | *Fruits of Oryza sativa (Paddy) and Zea mays (Maize).* |
| Fruits | *Fragaria ananassa* (Strawberries) |
| Ornamental and flower crops | *Carnations (Dianthus caryophyllus), Chrysanthemum indicum (Chrysanthemum)* |
| Fodder crops | *Sorghum bicolor (Sorghum), Alfalfa Medicago sativa (Alfalfa), Hordeum vulgare (Barley), Cynodon dactylon (Bermuda grass), and Axonopus compressus (Carpet grass)* |
| Medicinal crops | *Solenostemon scutellarioides (Coleus), Anemopsis californica (Yerba mansa), Aloe vera (Indian Aloe),* |

er pressure on existing natural resources. Due to the scarcity of arable land in urban areas, innovative approaches such as rooftop farming and house gardening have emerged. This aquaponics technology has been adopted in a major city with limited land and water supplies. Since it can be done in the garden or on a rooftop, it lowers transportation costs and ensures customer satisfaction. It contributes to promoting consumer health by providing essential elements such as protein and vitamins without the use of growth hormones or hazardous chemicals. Organic food is more popular among customers, despite the fact that it costs a little more. A simple aquaponic system is estimated to grow six times more per square foot than regular farming and uses 70% less energy. Nepal's aquaculture and agricultural land are dependent on groundwater. With the passage of time, these sources are drying up, affecting Nepal's agriculture productivity to a large quantity. On the other hand, an aquaponics system with a recirculatory mechanism saves around 95% of water while utilizing only 10% (Dalsgaard *et al.*, 2012). This aquaponic technique is a blessing to the urban community in this context. Local production utilizing aquaponics could be beneficial to future generations to meet the rising demand for high-value crops and fish. Thus, the aquaponic system can produce chemical-free, fresh, nutritious crops and high -quality fish, ensuring optimal health (Azad *et al.*, 2016). This technology has the potential to help Nepal maintain a healthy and sustainable food production and security system.

## Aeroponics

Aeroponics, which relates to the closed soilless culture system, is the most advanced sort of hydroponics system (Yuvaraj and Subramanian, 2016). Aeroponics is a way of growing plants in an air or mist environment with their root systems hanging in the air. There is no need for a growing medium or soil in this technique. The mist cools the roots while also bringing oxygen into the growing chamber (Zobel *et al.*, 1976). Aeroponics can be a great way to cultivate pathogen-free food. The growth chamber's enclosure prevents initial contaminants while also isolating surrounding plants (Nir, 1982). Aeroponic culture has been effectively proven in legume-rhizobia interaction, the formation of arbuscular mycorrhizal fungi, the roots of hardwood cuttings, and ultimately the development and nodulation of *Acacia mangium* (Martin-Laurent *et al.*, 1997; Sylvia *et al.*, 1986). There have been no efforts made to use it to produce tree saplings inoculated with AM fungus for tropical reforestation (Yuvaraj and Subramanian, 2016). Only the aeroponics system is the most efficient plant cultivation technology in the current environment when compared to other soilless systems (Peterson and Krueger, 1988). The nutrient-mist system uses very little water and provides a great growing microenvironment for plants (Buer *et al.*, 1996).

Major crops grown by aeroponic farming:

Cauliflower, cabbage, broccoli, beans, tomatoes, cucumbers, potatoes, beets, carrots

Fruits: melons, strawberries

Mint, Ginger

### Solid media culture

Solid media culture includes organic media (saw dust, cocopeat, sphagnum moss, etc.) and inorganic media (vermiculite, gravel, sand, hydrogel, etc.).

**Peat:** The term "peat" refers to a variety of plant materials that have degraded partially in anaerobic, wet circumstances (Martin and Marschner, 1988). Peat has good biochemical and physiological qualities for plant growth in general (Barrett *et al.*, 2016a; Robertson, 1993; Schmilewski, 2009). These characteristics might vary greatly depending on the environment in which the peat is created (Barrett *et al.*, 2016a; Karki, 2018). Younger, less decomposed pine peats have a higher water retention capacity than older, more decomposed peats (Jackson *et al.*, 2008; Sabahy *et al.*, 2015; Schmilewski, 2009). Importantly, this intrinsic heterogeneity makes for a versatile material that may be employed in a variety of horticultural applications.

**Coir:** Coir (also known as coir pith, coir meal, coir dust, and coco peat) is a solid waste of the coconut (*Cocos nucifera*) industry (Arenas *et al.*, 2002), comprised of the dust and short fibers obtained from the mesocarp of the fruit. Coir's basic physical, chemical, and bio qualities have been extensively studied (Barrett *et al.*, 2016b; Prasad, 1997; Salah and Romanova, 2017; Schmilewski, 2009), and it provides a favorable balance of water and air to plant roots, similar to peat. Unlike peat, which can be difficult to re-wet once it has dried out (Michel, 2013), coir has a high re-wetting capability (Blok and Wever, 2008). As a result, it's been employed as a peat substitute in a variety of horticultural applications, from soft fruit cultivation to floriculture (Schmilewski, 2009). It may not always be treated and managed in ways that would make it ideal for use in growing media because it is a waste product that was not produced expressly for horticultural applications. As a result, its physical, chemical, and biological properties can all be quite different (Abad *et al.*, 2005; Evans and Stamps, 1996; Salah and Romanova, 2017; Smith, 1995).

**Fiber from wood:** In the literature, the term "wood fiber" is generally defined and applied to a wide variety of materials made both from primary (e.g., fresh pine chips) and waste (e.g., shredded pallets) wood streams (Jackson *et al.*, 2009). Wood fiber materials manufactured employing intensive secondary processing processes are the most extensively employed in commercial soilless growth media. The performance of substantially processed wood fiber in the growing medium has been extensively studied (Barrett *et al.*, 2016a; Gruda and Schnitzler, 2001; Schmilewski, 2009), and it is characterized by an increased total porosity and air holding capacity.

### Composted organic waste

Over the last 40 years, the utilization of composted organic wastes in soilless growth media has increased significantly (Beeson, 1996; Farrell and Jones, 2010; Nappi and Barberis, 1993; POOLE, 1970; Rainbow, 2009; Raviv, 2013; Sanderson, 1980). At first glance, composts appear to be an appealing idea because they are high in organic matter and nutrients (Farrell and Jones, 2010). Composting also has a great environmental benefit, as it permits many waste products that would otherwise wind up in landfills or incineration plants to be reused (Raviv, 2013). Pathogen inhibition has also been demonstrated in composts, which adds to their economic value (Hoitink *et al.*, 1997; Noble and Coventry, 2005; Ros *et al.*, 2005; van der Gaag *et al.*, 2007). As a result, a variety of decomposed organic materials generated from both plant and animal wastes have been studied for use in soilless growth media (Barrett *et al.*, 2016a).

## Soilless Cultures' Benefits and Drawbacks

### The benefits of soilless cultures

**Production augmentation:** The use of soilless culture boosts yields by precisely controlling plant development components such as nutrients, pH, oxygen, carbon dioxide, light, and temperature. Increased output from soilless cultures, on the other hand, will help alleviate the initial and any subsequent costs of the soilless cultures. Vegetables grown in a soilless culture can be of good quality and require little washing.

**Water control:** In most types of soilless culture, irrigation water is precisely managed using a very small amount of water, compared to regular irrigation in traditional soil cultures. It saves much-needed time and labor for checking, cleaning irrigation nozzles, and regular inspection of trippers that are easily blocked by calcium carbonate or other compounds that can be removed by acidification of nutrient solution or by pretreatment of irrigation water, but which require additional costs, labor, and time.

**Plant nutrition is monitored:** The nutrition elements are employed in solution form in precise amounts as the plant requires, rather than in large amounts as in a typical plantation. In soilless growing, toxic substances to plants above specified dosages can be kept within safe limits. However, nutrition element distribution homogeneity exists only for all plants in water cultures. The PH and E.C. of the nutrient solution can be adjusted to meet the needs of the crop and the surrounding environment, which is extremely difficult and costly in traditional soil cultures.

Soilless culture occurs in controlled conditions, preventing the development of weeds, illnesses, and insects, as well as the usage of pesticides, which pollute the environment when used in soil cultures, resulting in fewer laborers and lower costs.

**Inspect root surroundings:** In soilless cultivation, controlling the surroundings and root temperature, as well as feeding roots with oxygen, is simple.

**Crop diversity:** As there is no cultivation operation as there is in soil cultivation, the interval time between crops is almost minimal in soilless culture. As a result, several crops are produced per year, resulting in increased income.

**Agriculture for inappropriate land:** When no suitable ground free of diseases and salinity is available, agriculture without soil gives an idealized approach for plant cultivation.

### The disadvantages of soilless cultures

**Significant initial capital investment:** The cost of developing a soilless culture system is high at first, but the fast and large yield production quickly offsets such costs in the first 3–4 years, assuming everything goes well.

**A shortage of technicians and skilled personnel:** agriculture without soil faces a workforce problem.

**Pathological injuries are a possibility:** Morbidity is low in open soilless cultivation methods, but it is high in closed systems, which necessitates intensive care and sanitation.

## Conclusion and recommendations

Soilless cultures are regarded as a newly discovered strategy for agricultural development, but they are far from easy. In many nations, however, there is a dearth of technical knowledge of the new technique among farmers and horticulturists, and well-trained employees are required. Furthermore, because most substrates are sold worldwide, they are costly. As a result, it is preferable to search locally for reasonably priced, good substrates. Growers can customize soilless systems to meet their specific needs, as well as the location of the system and their financial resources. In any event, the system must pay close attention to and monitor the parameters necessary for plant growth, such as nutrient concentrations, light, and oxygen surrounding the root zone, water quality, pH, disinfection, solution temperature, and more.

In conclusion, the enhancement of economically viable soilless systems has recently made significant progress, and there are currently several business applications in nations that have adopted agricultural advancements.

## Conflict of interest

The authors declare that there is no conflict of interest for the publication of the manuscript.



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