

An Examination of the Science of Soilless Culture: A New Approach to Crop Production

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ABSTRACT:

As civilisation spreads around the globe, soil-based agriculture faces many significant obstacles, including a decline in the amount of land available per person. In addition, land agriculture will continue to face difficult challenges as a result of the fast urbanisation and industrialisation, as well as the concerns posed by climate change and its associated negative effects. In the near future, it will be difficult to feed everyone utilising a soil field system due to these conditions. In order to address these issues, soil-less cultivation is, of course, becoming more important. The cultivation of plants that mimic soil-based gardening utilising a variety of growth medium, such as inorganic, organic, and synthetic substrates, is known as "soilless culture." The fastest-growing area of agriculture is soilless cultivation, which may spur future food production. As soil growing conditions become more challenging, the sector is anticipated to increase rapidly in the future. Utilising artificial substrates in a soilless cultivation system would minimise the need for pesticides to manage pests and diseases while maximising the usage of water and fertilisers. Superior quality, high yield, quick harvest, and high nutritional content are all characteristics of plants cultivated in soil-free culture. However, there is a lack of customary familiarity and inadequate transmission of its accessible technology in undeveloped nations.

Keywords: Soilless culture, Hydroponics, Solution Culture, Aeroponics, Nutrients.

INTRODUCTION

The most accessible growth medium for plants is often soil. For plant development, it offers anchoring, nutrients, air, water, etc. (Ellis et al., 1974). Soils do, however, sometimes provide significant obstacles to plant development. These include the existence of nematodes and disease-causing organisms, inappropriate soil reactions, unfavourable soil compaction, inadequate drainage, deterioration from erosion, etc. (Beibel, 1960). Furthermore, open field agriculture is challenging since it requires a lot of land, labour, and water (Beibel, 1960). Due to

unfavourable topographical or geographical characteristics, most urban and industrial regions have less soil accessible for agricultural growth, or in other cases, there are few fertile cultivable arable lands (Beibel, 1960). Hiring workers on a regular basis for traditional open-field farming is another significant issue (Butler & Oebker, 2006). Soil-less culture may be effectively introduced in such situations (Butler & Oebker, 2006). Growing plants without soil while submerging their roots in a nourishing solution is known as soilless cultivation (Maharana & Koul, 2004). Systems of soilless culturing may be categorised based on the methods used. It provides fresh veggies to both small, populous nations and those with little arable land. In nations where tourism is an important part of the economy, it might be helpful to provide enough fresh veggies for both the local people and visitors. Hawaii and the West Indies are two common examples of such areas, both with a sizable tourism sector and limited land used for growing vegetables (Resh, 1993). Certain cultural activities, such as weed management and soil cultivation, are avoided in soilless culture, and area unsuitable for soil cultivation may be used (Polycarpou et al., 2005). Hydroponically grown plants were consistently of higher quality, had a high yield, were harvested quickly, and had a high nutritional content. The crucial elements.

Figure 1 provides information for improved soilless culture development. Some popular local commodities might be grown using soilless culture at a fair price while adhering to food safety regulations (Paul, 2000). In addition to managing the production system for effective use of natural resources and reducing hunger, this approach will assist in addressing the issues posed by climate change (Butler & Oebker, 2006). When compared to field soil, soilless culture may provide crucial conditions for plant development with comparable growth and yield outcomes. The roots of terrestrial plants may be cultivated in an inert media or only in the mineral nutrition solution. Plant roots may absorb the mineral nutrients in the soil when they dissolve in water. Soil is no longer necessary for a plant to flourish when the necessary mineral nutrients are artificially added to the water supply. The most basic and traditional soilless cultivation technique involves dissolving inorganic chemicals in a container of water to provide the nutrients that plants need. Pure-solution culture has seen a number of changes in the past. Vermiculite, bark chips, or sphagnum peat may be used to further enhance the retention of water and nutrients. These are the most often used materials, however additional materials including sawdust, rice hulls, bagasse (sugarcane waste), and sedge peat are

sometimes used as ingredients in soilless mixtures. In Europe, rockwool (porous stone fibre) is used as a growth medium, whereas straw bales have been utilised in Canada and England.

Figure 1. Key factors of soilless culture or hydroponics production

History

Although growing plants in containers above ground has been attempted at different points throughout history, soilless cultivation is thought to be a recent method. The earliest known example of plants growing in containers seems to be wall murals discovered in the temple of Deir el Bahari (Naville, 1913). When local soils were unsuitable for the specific species, they brought mature trees from their home nations to the king's palace and grew them as a soilless culture. Soilless culture has been employed for agricultural production by several ancient civilisations. The growth of plants in water is shown in Egyptian hieroglyphic documents that date back several hundred years B.C. The Aztecs cultivated several crops in floating gardens. Another excellent illustration of soilless cultivation is the hanging garden of Babylon. Following Francis Bacon's 1627 book *Sylva Sylvarum*, which was the first published study on soilless cultivation, water culture gained popularity as a research method. John Woodward reported his spearmint water cultivation research in 1699. The German botanists Julius von Sachs and Wilhelm Knop made findings that led to the creation of soilless agriculture around 1859–1865. It is still commonly used today and is generally regarded as a kind of hydroponics. It swiftly

became a regular research and teaching method. William Frederick Gerick Berkeley openly advocated for the use of solution culture in agricultural crop production in 1929. Instead of using dirt, Gerick used mineral nutrition solutions to create 25-foot-tall tomato plants. In 1937, he also created the word hydroponics (from the Greek hydro-, "water," and ponos, "labour") to describe the cultivation of plants in water. Hydroponics was first successful on Wake Island, where it was utilised to produce vegetables for the guests. The Nutrient film method was created in the 1960s by Englishman Allen Cooper. A range of hydroponic methods are prominently shown at the Land Pavilion at Walt Disney World's EPCOT Center, which debuted in 1982. English scientist W. J. Shalto Douglas brought hydroponics to India in 1946 and set up a facility in the West Bengal region of Kalimpong. His book, *Hydroponics The Bengal System*, is on hydroponics. Table 1 lists India's vegetable output under soil-less cultivation. Commercial hydroponic farms were subsequently established in Abu Dhabi, Arizona, Belgium, California, Denmark, Germany, Holland, Iran, Italy, Japan, the Russian Federation, and other nations throughout the 1960s and 1970s. The 1980s saw the establishment of several computerised and automated hydroponic farms all over the globe. NASA has conducted a great deal of hydroponic research in the last several decades for its Controlled Ecological Life Support System, or CELSS. LED illumination is used in hydroponics that are meant to be used on Mars in order to grow in a variety of colours with much less heat.

Table1. Vegetable production under soil-less culture in India.

Vegetables	Production (g/m ² /day)
Carrot	56.5
Cucumber	226
Garlic	57
Ginger	57
Leek	57
Green Bean	113
Lettuce	226
Onion	56.5
Peapod	113
Potato	56.5
Salad greens	226
Tomato	113
Greens	113

Source: Source: Singh and Singh (2012)

Crops Which Can Be Grown In Soil-Less Culture

Almost every plant can theoretically be grown in soilless culture. This technique has been used so far mostly in the cultivation of vegetables and garden plants, it can also be used in other plant cultivation. Below is a list of certain crops that have successfully been grown in soilless conditions in table 2.

Table 2. List of crops that can be grown on commercial level using soil-less culture

Type of crops	Name of the crops
Cereals	Oryza sativa (Rice), Zea mays (Maize)
Fruits	Fragaria ananassa (Strawberry)
Vegetables	Lycopersicon esculentum (Tomato), Capsicum frutescens (Chilli), Solanum melongena (Brinjal), Phaseolus vulgaris (Green bean), Beta vulgaris (Beet), Psophocarpus tetragonolobus (Winged bean), Capsicum annum (Bell pepper), Brassica oleracea var. capitata (Cabbage), Brassica oleracea var. botrytis (Cauliflower), Cucumis sativus (Cucumbers), Cucumis melo (Melons), Raphanus sativus (Radish), Allium cepa (Onion)
Leafy vegetables	Lactuca sativa (Lettuce), Ipomoea aquatica (Kang Kong)
Condiments	Petroselinum crispum (Parsley), Mentha spicata (Mint), Ocimum basilicum (Sweet basil), Origanum vulgare (Oregano)
Flower/Ornamental crops	Tagetes patula (Marigold), Rosa berberifolia (Roses), Dianthus caryophyllus (Carnations), Chrysanthemum indicum (Chrysanthemum)
Medicinal crops	Aloe vera (Indian Aloe), Solenostemon scutellarioides (Coleus)
Fodder crops	Sorghum bicolor (Sorghum), Medicago sativa (Alfalfa), Hordeum vulgare (Barley), Cynodon dactylon (Bermuda grass), Axonopus compressus (Carpet grass)

Source: Singh and Singh (2012)

Media Of Soil-Less Culture

Soil-free growth media are mostly used in soilless culture gardens to start seeds and root cuttings. A system is simpler and less costly to run when it uses less medium. The concentration of water and air in a perfect medium is almost equal. Table 3 lists the different crops cultivated in different soilless culture medium.

Table 3. Various Soilless Culture media and Crops Grown

Country	Year	Area (ha)	Media/System	Major Crop Grown	Reference
Netherlands	2001	10,000	Rockwool	Tomato, Lettuce, Cucumber, Muskmelons, Cauliflower, Gerbera, Carnation, Chrysanthemum, Strawberry	Hassall et al. (2001)
Spain	2001	4000	Perlite, Sand, Rockwool	Tomato, Lettuce, Cucumber, Capsicum	Hassall et al. (2001)
Canada	2001	2000	Perlite, and Rockwool	Tomato, Cucumber, Capsicum	Bradley et al. (2001)
China	2005	1250	NFT, DFT, Rockwool	Tomato, Cucumber, Lettuce, Roses, Chrysanthemum, Carnation	Jiang et al. (2007)
France	1996	1000	Rockwool	Tomato, Cucumber, Capsicum, Cut flowers	Donnan, (1998)

Perlite

Perlite is the most popular kind of medium used in containerised soilless culture systems (Boodley & Sheldrake, 1977). The silicone material that occurs in volcanoes is the source of perlite grains, which are very light. Merchants sell this medium in small to big bags that may be added to growth media to improve soil aeration and drainage.

Coconut Coir

It goes under many trade names, including Ultrapeat, Cocopeat, and Coco-tek. It blends the air retention of perlite with the water retention of vermiculite. Shredded coconut husks are used to make this entirely organic material. The coconut husk protects the seed from the sun and salt as it floats in the ocean. (2) A hormone-rich, fungus-free media to accelerate roots and germination after landing. Coconut coir, when finely shredded and steam-sterilized, provides plants with the perfect rooting medium while also protecting them from fungal and root diseases. Additionally, coir is entirely renewable, in contrast to peat moss, which is quickly running

out due to abuse.

Vermiculite

Magnesium and potassium are both present in this molecule. Although it is less durable than certain other media, like sand and perlite, it retains a lot of water and helps with soil drainage and aeration.

Peat Moss

In growth media, peat moss holds onto moisture. For container plants that need more moisture, peat moss is a common ingredient in readymade potting soil products. To grow and thrive, tropical plants need more moisture and warmth.

Sphagnum Moss

Because of its qualities, it may be used extensively to repair both excessively dry and wet soil. Sphagnum moss helps aerate and drain heavy soils like clay so that more water may run off and the clay doesn't collect as much water. Sphagnum moss helps light sandy soils retain moisture and nutrients by preventing water from running off.

Table 4. Bulk density and porosity of some growing media

Substrate	Bulk density (kg/m ³)		Total porosity (%v/v)
Light peat	60-100		90-95
Dark peat		100-150	85-90
Vermiculite	90-150		90-95
Perlite	80-120		85-90
Rockwool	80-90		94-97
Expanded clay		600-900	85-90
Pumice		650-900	65-75
Ideal		190-700	50-85

Source: Pardossi et al., 2011

Sand

Sand is a good growth medium for plants that need loose soil and a dry atmosphere. Instead of soaking into sand like it would in clay, too much water will create runoff. Because sand is lightweight, simple to expand in, and does not retain too much moisture, root plants like potatoes and carrots produce more vegetables in it. The properties of some growing media widely used are given in table 4.

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Classification Of Soil-Less Culture

Originally, nutrient solution culture without a supportive medium was referred to as "soilless culture." But it also includes employing a nutrient solution to grow plants in solid medium for anchoring. We refer to this method as the aggregate system. Hydroponics systems are further divided into two categories: closed (surplus solution is collected, refilled, and recycled) and open (nutrient solution is not reused after it is provided to the plant roots). The methods used in current hydroponic farming systems may be categorised. Applying a fertiliser solution to plant roots is known as a hydroponic technique. Table 5 lists the many soilless cultivation techniques utilised in certain nations to produce crops. A) Liquid hydroponics or solution culture Circulating techniques (closed system) NFT, or nutrient film technology Deep flow methodology (DFT) Non-circulating approach (open systems) The method of rootdipping Capillary action method and floating technique

B. Aggregate systems, or solid media culture, may be either closed or open. The hanging bag method Techniques for growing bags and trenches or troughs Pot method

C). Aeroponics

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The nutrient solution is pumped through the plant root system and excess solution is collected, replenished and reused. The various salient findings of solution culture are given in Table 6.

N.F.T. (Nutrient Film Technique)

The plant roots in NFT are immediately exposed to the nutrient solution, making it a real hydroponics system. There is no need for a timer for the submersible pump since N.F.T. systems provide a steady supply of nutritional solution. After being injected into the growth tray—typically a tube—the fertiliser solution passes over the plant roots before emptying back into the reservoir. Air is often the only growth media utilised, saving money on refilling the growing medium after each harvest. The roots of the plant often hang into the nutritional solution while it is supported in a little plastic basket. N.F.T. systems are particularly vulnerable to pump failures and power outages. When the nutritional solution supply is cut off, the roots dry out extremely quickly.

Deep flow technique (DFT)/ pipe system

Using this method, a nutritional solution that is two to three centimetres thick passes via PVC pipes with a diameter of ten centimetres, to which plastic net pots containing plants are attached. The bottoms of the plastic pots, which hold planting supplies, come into contact with the nutritional solution flowing via the pipes. Plants are placed in plastic net pots and fastened to the PVC pipe holes. The net pots may be filled with planting material made of carbonised rice husk, old coir dust, or a combination of the two. To keep the planting material from dropping into the nutrient solution, a little piece of net is lined within the net pots. The nutrient solution becomes aerated when the recycled solution falls into the stock tank solution. To make the flow of nutritional solution easier, the PVC pipes have a slope of drop of 1 in 30 to 40. The nutrition solution will heat up less if the PVC pipes are painted white.

Non-Circulating Methods (Open System)

The nutrient solution is not circulated but used only once. When its nutrient concentration decreases or pH or Ec changes, it is replaced. This system is of following types:

Root dipping technique

Using this method, plants are cultivated in tiny pots with

little growth media. The pots are positioned so that the bottom two to three centimetres of each pot are immersed in the nutrient solution. For the purpose of absorbing nutrients and air, some roots are submerged in the solution, while others are suspended above it. This "low tech" growth technique requires minimal upkeep and is cheap to build. Crucially, this method doesn't need costly components like pipelines, water pumps, power, etc.

Floating Technique

Although small containers (10 cm deep) may be utilised, this approach is comparable to the box technique. Plants grown in tiny pots are affixed to a Styrofoam sheet or any other light plate, and they are let to float on the artificially aerated nutritional solution within the container.

Capillary Action Technique

Planting pots with holes at the bottom come in a variety of forms and sizes. Seedlings and seeds are planted in the pots that have been filled with inert media. The nutrition solution is poured into shallow containers containing these pots. Through capillary action, the nutrient solution enters the inert medium. In this method, aeration is crucial. Thus, it is possible to utilise old coir dust combined with gravel or sand. This method works well for indoor, floral, and decorative plants.

B). Solid media culture or aggregate system

The chosen media material ought to be readily drained, flexible, friable, and capable of holding air and water. It must also be devoid of harmful materials, pests, microbes that cause illness, nematodes, etc. Prior to usage, the medium must be completely sterilised. Locally accessible materials may be used to practise the following inert solid media methods. Table 7 lists the different noteworthy findings in the aggregate system.

Hanging bag technique (Open system)

Sterilised coconut fibre is placed inside thick, white (with a black inside) UV-treated polythene bags that are about one metre long. These bags are attached to a little PVC pipe at the top and sealed at the bottom. Above a canal that collects nutritional solutions, these bags are hung vertically from an overhead support. Consequently, this method is sometimes referred to as the "verti-grow" method. The openings on the sides of the hanging bags are filled with seedlings or other planting materials that have been put in net pots. Each hanging bag has a tiny sprayer connected to it that pumps

the nutrient solution to the top of the bag. The nutritional solution within the hanging bag is dispersed uniformly by this micro sprinkler. The plant roots and coconut fibre are moistened by the dripping nutrient solution. Through perforations in the bottom of the hanging bags, extra solution is collected in the channel below and returned to the nutritional solution stock tank. Both protected buildings and open areas may be used to set up this system. The hanging bags in the rows and between the rows in shielded buildings must be spaced such that the bags in the inner rows get enough sunshine. Strawberries, green vegetables, and little flower plants may all benefit from this method. To stop mould from growing within, nutrition solutions must be delivered in black tubes.

Grow bag technique

Depending on the crop to be grown, the bags may be arranged in paired rows. Squeeze seedlings or other planting materials placed in net pots into the coir-dust by making tiny holes on the top surface of the bags. Each bag may support two to three plants. Each plant is fertilised using a black capillary tube that runs from the main supply line. Before the bags are placed, the whole floor is coated with white, UV-resistant polythene. The sunshine is reflected to the plants by this white polythene.

Trench or trough technique

In this open method, plants are cultivated in above-ground troughs made of concrete blocks or bricks, or in small trenches in the ground. To keep the growth medium apart from the surrounding soil, both trenches and troughs are coated with waterproof material (thick, UV-resistant polythene sheets in two layers). Depending on how simple it is to operate, the trench or trough's width may be chosen. Two rows of plants may be planted in wider ditches or troughs. Depending on the plants to be grown, a minimum depth of 30 cm may be required. The medium for this culture may be made from old sawdust, sand or gravel, peat,

vermiculite, perlite, or a combination of these materials. A drip irrigation system is used to provide the water and fertiliser solution; hand application is also an option, depending on labour availability. To remove extra nutritional solution, a well-perforated pipe with a diameter of 2.5 cm might be positioned at the bottom of the trench or trough. Cucumber, tomato, and other tall-growing vine plants need extra support to bear the weight of the fruits.

Pot technique

Similar to trench or trough culture, the pot method involves filling clay or plastic pots with growth medium. Crop growth needs determine the container's volume and growing medium. Typically, the capacity falls between 01 and 10 litres. Trough or trench culture is comparable in terms of growing substrate, nutritional solution delivery, plant support, etc.

Aeroponic

Plants are grown aeroponically by anchoring them in holes in Styrofoam panels and suspending their roots in the air underneath the panel. In order to promote root development and inhibit the formation of algae, the panels form a sealed box. The roots are sprayed with a thin mist of the nutrition solution. Every two to three minutes, a few seconds of misting are performed. This is enough to keep the fertiliser solution aerated and the roots hydrated. The solution film that sticks to the roots provides the plants with water and nutrients. Lettuce, spinach, and other low-leafy crops may be grown using aeroponic culture, which is often done in enclosed spaces. Making the most use of available space is this technique's main benefit. Compared to previous methods, this method can support twice as many plants per unit floor space. The most advanced kind of hydroponic farming is likely the aeroponic system. Similar to the NFT method, air makes up the majority of the growth medium above. The roots are misted with nutritional solution while hanging in midair. If the misting cycles are stopped, the roots will quickly dry up since they are exposed to the air, much as with the N.F.T. system.

Table 5. Soilless culture systems for crop production in some countries

Countries	NFT	DRFT	DFT	Aeroponic	Substrate culture
Thailand	√	√	√	√	√
Singapore	√	√	-	√	√
China	√	-	√	√	√
Korea	√	-	√	√	√
Japan	√	-	√	√	√
New Zealand	√	-	-	-	√
Australia	√	-	-	-	√

NFT = Nutrient film techniques, DRFT = Dynamic root floating techniques, DFT = Deep flow techniques.

Table 7. Salient Finding in Aggregate System

Crop	Place	Salient finding	Reference
Tomato	Iran	Stem diameter of tomato with sawdust higher than in those supplemented with perlite.	Delshad, (2006)
Anthurium	Italy	Cheers the longest (averaging 72 cm) and Choco the shortest (56 cm on average).	Cristiano et al. (2007)
Rose	Netherlands	Red France and Dallas gave the highest cut flower yield i.e. 24.8 and 24.1 flowers per plant, respectively.	Fascella et al. (2007)
Grape	Italy	Higher quality, berry yields, 20 days earlier harvesting and extended the harvesting compared to conventional greenhouse culture.	Lorenzo et al. (2005)

Nutrient Solution For Soilless Culture

For plants to grow and flourish, they need seventeen basic ingredients. Plants cannot complete their life cycles without these nutrients, and no other element can take their place in the development of plants. Soilless culture plants get all necessary nutrients in the form of nutrient solution, which is made up of fertiliser salts dissolved in water. The key to successful soilless culture gardening is managing plant nutrition via nutrient solution management, therefore the grower must have a solid understanding of plant nutrients. By modifying the nutrient solution to fit the plant development stage and provide them in regulated proportions, soilless culture

Nutrient Solution Management

Although achieving optimal nutrition in soilless culture is simple, improper nutrient solution management might harm the plants and result in total failure. Therefore, the rigorous nutrient management program is the main factor that determines whether a soilless culture garden succeeds or fails. A successful soilless culture garden will result from carefully adjusting the pH level, temperature, and electrical conductivity of the nutrient solution and refilling it as needed.

Ph Level

The pH is a measure of acidity or alkalinity on a scale of 1 to 14. In a nutrient solution, pH determines the availability of essential plant elements. The optimum pH range for soilless culture nutrient solution is between 5.8 and 6.5. The further the pH of a nutrient solution from recommended pH range, the greater the odds against the success. Nutrient deficiencies will become apparent or toxicity symptoms will develop if the pH is higher or lower than the recommended range for individual crops. The pH values for different soilless crops are given in Table 8.

Table 8. pH values for different soilless culture crops

Plant	pH Range	Plant	pH Range
Beans	6.0-6.5	Onions Peas	6.5-7.0
Broccoli	6.0-6.5	Pineapple	6.0-6.8
Cabbage	6.5-7.5	Pumpkin	5.0-5.5
Carrots	5.8-6.4	Radish	5.0-6.5
Cucumbers	5.8-6.0	Strawberries	6.0-7.0
Garlic Lettuce	6.0-6.5	Tomatoes	5.5-6.5
	6.0-6.5		5.5-6.5

Source: Hydroponic Food Production by Howard M. Resh Woodbridge Press, 1987

Electrical Conductivity (Ec)

An Ec meter's measurement of electrical conductivity reveals the nutrition solution's strength. Ec is measured in dS/m. Ec has the drawback of simply showing the solution's overall concentration rather than the specific nutritional components. For hydroponics, an Ec range of 1.5 to 2.5 dS/m is appropriate. Because of osmotic pressure, higher Ec will hinder nutrient absorption, whereas lower Ec will negatively impact plant health and productivity. The total salt concentration, or Ec, of the solution varies as plants absorb water and nutrients from it. Fresh water must be added to lower the Ec if it exceeds the prescribed range. If it is lower, boost it by adding nutrients.

Advantage Of Soil-Less Culture

Growing plants in soilless culture has many benefits over soil-based culture (Savvas, 2004). Compared to open field agriculture, soilless culture gives potential to create ideal circumstances for plant development, resulting in better yields; gardening is also very simple and clean, requiring very little work (Silberbush & Ben-Asher, 2001). Table 9 shows the average yields from soilless cultures compared to those from regular soil. In the tropics, where the life cycles of these organisms continue unabated and the possibility of infestation persists, soilless culture, also known as soil-less culture, provides a method of controlling soil-borne illnesses and pests. Additionally, it works well in areas of the world where there is a lack of fertile or arable land for farming (Sonneveld, 2000). It saves money and time on a number of duties that are avoided in soilless agriculture. It provides a hygienic

workplace, making labour recruiting simple.

Table 9. Soilless culture averages compared with ordinary soil yields

Name of crop	Hydroponic equivalent per acre	Agricultural average per acre
Wheat	5,000 lb.	600 lb.
Oats	3,000 lb.	850 lb.
Rice	12,000 lb.	750-900 lb.
Maize	8,000 lb.	1,500 lb.
Soybean	1,500 lb.	600 lb.
Potato	70 tons	8 tons lb.
Beet root	20,000 lb.	9,000 lb.
Cabbage	18,000 lb.	13,000 lb.
Peas	14,000 lb.	2,000 lb.
Tomato	180 tonnes	5-10 tonnes
Cauliflower	30,000 lb.	10-15,000 lb.
French bean	42,000 lb. of pods for eating	-
Lettuce	21,000 lb.	9,000 lb.
Cucumber	28,000 lb.	7,000 lb.

Source: Singh and Singh (2012)

Limitation Of Soilless Culture

Soilless cultivation has many drawbacks despite its numerous benefits (Sonneveld, 2000). Technical expertise and a larger initial financial investment are necessary for commercial use. If controlled environment agriculture is integrated with soilless cultivation, this will be much higher (Sonneveld, 2000). Preparing solutions, maintaining pH and Ec, assessing and correcting nutritional deficiencies, guaranteeing aeration, maintaining favourable conditions within protected structures, etc. all need a high level of management abilities. Controlling the health of plants requires extreme caution. Lastly, the system requires energy inputs to function (Van Os et al., 2002). The soil-less culture is restricted to high-value crops in the cultivation region due to its very high cost.

CONCLUSION

The fastest-growing area of agriculture is soilless cultivation, which is gaining appeal and pace. In some nations, soilless cultivation is more widely recognised, particularly in the commercial production of vegetables, and it is rapidly spreading to other regions of the globe. Future food production may be dominated by soilless cultivation. People will use new technology, such as soilless crop cultivation, when the population grows and the amount of arable land decreases as a result of bad land management. The possibility of using soilless cultivation in third-world nations with restricted water supply has already generated a lot of interest in the scientific community. Although the initial capital expenses of establishing soilless culture are still a barrier, with time, as with any technologies, prices will decrease, making this alternative far more viable. This method has not yet gained favour among gardeners in poorer nations. Lack of standard knowledge and inadequate distribution of its accessible technologies are the primary causes of this. Even if there is increasing material on soilless cultivation, there is still a dearth of reliable, accurate, and standard information. Further research and development

might result in new cultivars that are better suited to regulated environments, more affordable buildings and materials, and a decrease in the amount of energy that must be bought. settings and automated systems; to better manage pests and diseases, including enhanced plant resistance.

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