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Soil-less vegetable cultivation: A review

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Abstract
Soil-less cultivation is a new advanced method for improving cultivation of different vegetable crops. It is a method of growing vegetables without the using soil as a rooting medium, in which the inorganic nutrients absorbed by the roots are supplied through irrigation water. It includes hydroponics, aeroponics and aquaponics. Hydroponics is the growing of vegetables in an fed with a solution containing a mixture of macro and micro-nutrients. Aquaponics is the technique in which, aquatic animals such as snails, fish, crayfish, prawns, etc., are grown in tanks with combination of hydroponics with vegetables are grown in water in a symbiotic environment. In aeroponics system, sealed root chamber is used as reservoir for nutrient solution where the plants above the reservoir cover with polystyrene/other material. It must be supported or hanged through holes in the expanded cover and are misted with nutrient solution to keep it always moist. Soil- less cultivation has been followed in number of vegetables such as, tomato, chilli, brinjal, green bean, bell pepper, cauliflower, cucumber, melons, radish, onion, lettuce, beet, winged beans, water spinach, spinach, coriander, and so on. Soil-less cultivation helps in early nursery raising and easy management, production of healthy vegetable seedlings free from disease, insects and pest. It has various benefits like; year-round production and off season, higher productivity and uniform quality, management of insect-pests, diseases and weeds is easier which helps in more efficient and less use of resources. Soil less cultivation has huge potential to become popular in upcoming future generation. This advance technologies and techniques involved in soilless vegetable cultivation can be said as next-generation crop science hence, it can open a doorway to establish a new civilization in outer space.

Keywords: Soilless cultivation, hydroponics, aquaponics, aeroponics

Introduction
Soil is easily available crucial growing medium for vegetables that provides nutrients, mechanical support, water, air, etc, for plant proper growth and development. Soil has also serious limitations for plant growth too, at times, due to presence of various disease-causing organisms and nematodes, unfavourable soil compaction, unsuitable soil reaction, poor drainage, degradation due to erosion, etc. [12]. 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 favourable to grown vegetables, in some areas, there is water scarcity for proper irrigation and due to unfavourable geographical or topographical conditions there is lack of cultivable/arable lands. Out of these difficulties another major difficulty is to hire labour. Under situation, soil-less vegetable cultivation can be introduced successfully.

Soil-less culture mainly refers to the techniques of Hydroponics, Aeroponics and Aquaponics. The term Hydroponics was derived from two Greek word's *hydro* means water and *ponos* means labour. Simply it is known as growing vegetables using mineral nutrient solutions, without soil in which their roots are in mineral nutrient solution only/in an inert medium, such as coco peat, perlite, gravel, mineral wool, etc. [18]. This cultivation technique helps to face the challenges of adverse climatic condition and also helps in production system management for efficient use of natural resources and reduction of malnutrition. Aeroponics is another technique, somehow similar to hydroponics with only difference that under aeroponics plants are grown with fine drops/ a mist of nutrient solution [30]. Aquaponics vegetable cultivation technique is the combination of recirculating aquaculture and hydroponics that is used for fish and vegetable production. It has been gaining attention [11] as it serves as abio-integrated model for sustainable vegetable production [13]. In this related topic, it will be reviewed these new and advanced techniques are briefly focus on the following paragraphs.

Historical steps of soilless agriculture
Soil-less cultivation was followed in many years ago and recorded in several ancient civilizations but there is no proper information was recorded.

However, in 1627 the book, Sylva Sylvarum was published by Sir Francis Bacon, the father of the scientific method, work on growing terrestrial plants without soil which he nominated it "water culture". In 1666 Robert Boyle (Irish scientist), conducted first experiments on growing plants/vegetables with their roots submerged in water. John Woodward has published his water culture experiments with spearmint in 1699 and also, he found that plants/vegetables grown in less-pure water grew better than in distilled water. In 1860, the German botanist first perfected, mineral nutrient solutions for soilless cultivation through experiments conducted at 1842 and 1895 by Julius von Sachs and Wilhelm Knop respectively. In 1929, Professor William Frederick Gericke of the University of California at Berkeley made first proposal for commercial water culture technique. The word ''hydroponics'' was proposed by Gericke in 1937 to describe the growing of crops/ vegetables with their roots in a nutrient solution. In 1940 Gericke wrote the book, Complete Guide to Soilless Gardening. Since, 1938 two others of plant nutritionists at the University of California named Dennis R. Hoagland and Daniel I. Arnon had developed nutrition solution known as Hoagland solution used for hydroponics till now. Moreover, in 1930, the Pacific Ocean used hydroponics technique to grow vegetables to feed the fresh vegetables to the passengers travelling in the ship because there was no soil to grow vegetables. In 1946, Hydroponics technique was introduced in India by an English scientist, W. J. Shalto Duglas and on the same year he also established a laboratory in Kalimpong area, West Bengal and has written a book on Hydroponics, named called as Hydroponics-The Bengal System. The Nutrient Film Technique was developed in the 1960 by Allen Cooper. During 1960-1970, in countries like; Abu Dhabi, Ariz ona, Belgium, California, Denmark, German, Holland, Iran, Italy, Japan, Russian Federation and other countries were developed commercial hydroponics farms. During late 1970s and early 1980s researchers adopted aquaponics technique (from the New Alchemy Institute North Carolina State University). In 1980, the University of the Virgin Islands adopted Aquaponics technique. Many computerized and self-automated hydroponics farms were established during 1980 around the world. During 1990, home hydroponics kits became popular worldwide.

Furthermore, in 2007, NASA has done extensive research related to hydroponics in Arizona, Euro fresh Farms in Willcox for their Controlled Ecological Life Support System, and during that time, researcher sol hydroponically grown tomatoes more than 200 million pounds. Commercially Euro fresh has established hydroponic greenhouse/glass under 318 acres land [3]. The tomatoes grown in Euro fresh were free from pesticide. In Canada it has hundreds of acres of land following commercial hydroponic greenhouses, producing tomatoes, peppers cucumbers and many more vegetables. Due to modernization in technology in cultivation system and numerous economic factors, in globe hydroponics market is predicted as to increase from US$226.45 million in 2016 to US$724.87 million by 2023 [2].

Future scope

Hydroponics is the rapidly following technique of agriculture specially for the production of vegetable crops in the upcoming future. Due to over population and modern civilization, arable land is decreasing day by day, to coop-up such a situation new technology like hydroponics and aeroponics are additional channels of vegetable cultivation. To get knowledge about these techniques we need to study on some of the early adopters of related matter which plays crucial role in future for the production of vegetable crops.

Hydroponics also have been using successfully in Israel (arid dry climate). A company Organitech, growing vegetables and other crops successfully by using hydroponic technique in shipping containers having size of 12.19m. It gives better yield that is 1,000 times more than the equal area of land could produce [27]. It has been done deal to use hydroponics in 3rd world countries where water supplies are limited for normal cultivation. Soilless cultivation has the ability to feed millions of people in areas where both crops and water are scarce like; Asia and Africa.

Soilless farming especially hydroponic technique will be crucial in future related to the space program for the vegetable production. NASA has been made many hydroponics researches plans in place, this will benefit in current as well as future space exploration, which will also benefit in the Moon or long-term colonization of Mars. As we know that there is no soil to support cultivation in space, and it is too difficult to transport soil through the space shuttles. So, soilless could be main key to the future of space exploration for the any crop production. It offers the potential for a larger variety of crop which will provides a bio-regenerative life support system in space. In soilless farming, the vegetables are grown in nutrient solution which is essential for proper plant growth and development process, they will absorb carbon dioxide and provide renewed oxygen through the plant's natural photosynthesis process. Hence, in this way we can predict that there is possible for long-range habitation of both the space stations and other planets where can produce crop without soil.

Types of soilless cultivation [19]

There are two types of soilless vegetable cultivation system (closed soilless vegetable cultivation and open soilless vegetable cultivation). In brief both the types are discussed in below;

Open soilless vegetable cultivation: In open soilless vegetable cultivation, dissolved nutrient solution are normally supplied to the plants through dripping framework. In this system of vegetable production frameworks, a sufficient keep run-off must be kept up with a specific end aim to keep supply adjust in the root zone of the plant which help easy to uptake sufficient nutrient required for plant growth. It just uses the substrates and dribble frameworks. Moreover, there is a drip system used as closed system in case of use reservoir recirculating nutrient solution that essential for crops. It is further divided into following types;

i) Root dipping technique: In this technique, vegetables are cultivated in pots having small holes at the bottom and are filled with substrate medium/soilless medium like coco peat and are placed in a container having required nutrient solution. The lower portion of the pots (minimum 1–3 cm) remain in close contact with the nutrient solution [31]. Plant roots are partially deep in the nutrient media and some roots are just hanging in the air. This is a simple, easy and cost-effective system to cultivate small leafy vegetables like coriander, celery, etc [9].

ii) Hanging bag technique: In this technique, long cylinder-shaped polythene bags are used which are closed at the lower end and connected to PVC pipes at the upper portion. Above a nutrient supplement tank bags are hanged vertically. Planting

materials such as seeds, seedlings, etc. sown in netted pots and are softly pressed into holes in order to generate compactness. A micro sprinkler is used to circulate the nutrient solution. At the bottom of the bag for collection of excess nutrient solution there is placed solution tank. By using this technique, vegetables like; lettuce, bread leaf mustard, coriander, celery, etc. are successfully growing in recent days.

iii) Trench technique: In this technique, vegetables are grown on trenches constructed using concrete blocks above ground. To prevent the growth media from direct contact with the ground the inner linings of trenches are covered by thick polythene sheets. The size and shape of the trenches is constructed according to cropping nature. All required nutrient with water are circulated through the dripping system with the help of water pump. Vegetables like; lettuce, coriander, spinach, etc are successfully growing in this system.

Closed soilless vegetable cultivation: In closed soilless vegetable cultivation frameworks, the dissolved nutrient solution are recycled and are observed and balanced in like manner. The dissolved nutrient solution must be test/observed and dissected in any event once every week to keeping the supplement adjustment. If there is no proper supervision of nutrient supplement it may escape of the balance which can cause the death of the plant. Furthermore, it includes following types which are mention in following paragraph;

i) Hydroponics system: In this system, vegetables are growing without soil. Simply, it is defined as growing of vegetables in water. Plants need vitamins and minerals that soil can provide for them with light, H_2O, Co_2 and O_2 for proper crop growth and development. Inert medium like; rocks or coco coir fiber, peat moss, vermiculite, etc are used as a growing medium and they are feed a solution containing macro and micro-nutrients. Almost all vegetables can be grown successfully trough hydroponically. It is world widely used by farmers and growers because of various advantages like; their roots do not need to reach for nutrients and crops can grow closer together which means more production from small area. [6]. The nutrient solution also keeps the constant amount of nutrients available all the time which results in proper growth of crop. Due to these all things combination making hydroponics crops are more productive than soil growing crops [28]. Hence, many farmers in various countries are beginning hydroponics vegetable production. One of the major reasons to use hydroponics is about concern water use only use 10% whereas soil-based cultivation used more than 80% so, becoming more popular day to day- it significantly conserves water. This technique is further divided into following types [20];

a) Wick system: It is the most simplest of all types of hydroponic systems, traditionally it doesn't have any moving part, it doesn't use any water circulating pumps and electricity. It can useful in places where is no facility of electricity. But the wick is the connecting part between the potted plant and food solution which helps to circulate the nutrient solution to the crop root zone. Due to easy type of system to build, this type of hydroponic system is also teachers often used in classrooms as experiments for kids [3].

b) Nutrient film technique (NFT): This technique is recirculated framework to run highly oxygenated dissolved nutrients solution continuously over the roots zone of crop through a set of channels and vegetables are grown in baskets hanging in a PVC pipe [1, 29]. The nutrient solution is circulated from a holding tank. The excess water returned back to the tank through irrigators at the top of every sloping pipe which is connected to the bottom of the channels. So, the nutrient solution is continuously recycled [23]. Due to the solution remains in a continuous flow, there will be changes in the nutrient solution salinity in comparison to the soil where vegetables can be grown in much higher salinity than soil-based cultivation like lettuce [21].

c) Water culture or deep-water culture (DWC): In this technique of hydroponics system plants are floating by float platform on a bath of nutrient medium in which Oxygen is supplied by an air pump that runs continuously to the root zone of the crop. It can easily be set up in glass basins, ice boxes, plastic boxes, fish ponds, Concrete basins and in engraved basins covered with polypropylene sheets [4]. In this system, there is no risk of damage to plants in the event of a power outage and even stop the air pump because plants are floating contact with the nutrient solution. The most common vegetables grown in this framework are Lettuce, Chinese cabbage, spinach, etc [32].

d) Drip system: In this technique it is set up with using two containers, one at the top and another at the bottom. In the top container vegetables are grown, while in the bottom container contains nutrient solution. The water pump is used to circulate the nutrient solution and an aquarium air stone is used to oxygenate the water where, water and air pumps run continuously. A timer controls the nutrient pump. To cover all area around the root with nutrient solution is passed in misting form and the excessive nutrients solution is passed back to the bottom container with filter down to the plant roots. The misting is usually done every few minutes around the hanged roots to keep it always moist [24]. If the misting cycle is disturbed the roots will dry out rapidly due to, the roots are exposed to the air. Normally vegetables are grown in supportive mediators with nutrient solution found in the reservoir by electrical water pump. Almost all vegetable crops can grow using this technique. However, crops with large root balls like potatoes are particularly suited.

e) Ebb and flow systems: This technique is closely similar to the drip system, because in this system also set of with two containers, one at top containing crops and one at the bottom containing the nutrient solution. The nutrient solution is passed to drippers at the stem of each plant by using water pump to the top container where crop is growing [24]. The excess water is being back to the bottom container and recirculated. The pump is switched on for 30 minutes and off for 15 minutes, to flood the grow tray accordingly. All nutrients are siphoned out of the crop growing tray through the pump line if the pump is switched off. For oxygen supply to the roots zone of the crop, the empty period allows, thus, air stone is not required for these systems. As win drip systems, almost all vegetables can grow and also suited for crops having with large root balls.

ii) Aeroponic systems: This system is a type of closed soilless vegetable cultivation system. Simply, vegetables are grown in air and the roots of the crops are hanging in air. For nutrient solution reservoir, sealed root chambers are used which are covered with polystyrene or other material. Usually

nutrient solution misting is done every few minutes around the root zone of the plant with the help of water pump [22]. It needs a short cycle timer that runs the pump for a few seconds every couple of minutes so, at the side of tank a timer is fitted to controls the nutrient pump much like other types of hydroponic technique. If the misting cycles are interrupted, roots will dry out rapidly because the roots are hang out to the air. This system consist three types of frameworks, the first framework is high pressure which don't generally used a water pump. The second framework is low pressure framework known as soakaponics. The water and nutrient solution is simply stream out of the sprinkler i.e. mister heads (more water pressure) by using standard submersible water pumps. The third framework is ultrasonic foggers that make a fog. A little water bead measure while, they do make a fog /mist [21]. All most all vegetable crops can be grown easily in this system

iii) Aquaponic system: This system is the integration of recirculating aquaculture and hydroponics systems which is used for double harvest purpose that is fish and vegetable production in a symbiotic environment. Water pump is used to pumped water from the fish tank to the plants. It do not need to add external nutrient to the crop because fish excreta is sufficient for plant growth and development. Fish excreta is rich in ammonia so, bacteria convert ammonia and nitrite to nitrate. Excess water is returned to the fish tank.

It serves as a bio-integrated model for sustainable fresh and healthy vegetable production [5] due to this has been gaining more attention in present days [11]. Increasing popularity of this technique is the interlinking of aqua cultural and hydroponic procedures [14]. It can also ensure food security in urban area where normal vegetable cultivation cannot follow [7]. Likewise, resource scarcities such as decreasing fertile land, soil degradation, lack of freshwater supplies for the crop, and soil nutrient depletion add an extra challenge for soil-based vegetable farming [16, 17]. For mitigation of such a challenges review studies shows that aquaponic systems can be good solutions [10]. In recent days the leading countries in aquaponics are Israel, India, China and Africa

Growing Medium and its types

It is a medium other than soil which is inert and non-organic material. It has good water holding capacity, porosity and many other properties. It provides support for the plants to hold up them. There are different types of growing medium and they are as follows [26];

i) **Coco coir:** This medium has excellent moisture holding ability and inert characteristics. It is made from a brown husk of coconut shell. It is sold in small compressed packets which expand 6 to 8 times in volume when water is added. Though it has good aeration property however, it has disadvantage too that is, it breaks down after several use and cannot drain out excess water quickly.

ii) **Hydroton:** It is most versatile growing mediums in soilless crop production. It is an expanded clay product and has a porous structure which makes it easy to absorb water and other nutrient solution, easy in exchange of Oxygen with roots. It is a pH neutral product in which it is good to grow crop.

iii) **Perlite:** It is inert material having light weight inexpensive growing media. It is made by heating it expands like popcorn. It is porous and has good water-retention properties so keeps plants more open to air. It cannot be used alone for ebb & flow because, it float away or move during the flooding cycle.

iv) **Vermiculite:** It is natural mineral having lightweight which is used as growing media in soilless cultivation. It is rot resistant growing medium. Through soil aeration which helps to improves soil structure, also increases water and nutrient retention.

v) **Peat Moss:** Peat moss is made from sphagnum moss that is decomposed in peat bogs over thousands of years. It is dark brown fibrous product of and other organic materials. It can holds moisture several times its weight in and releases slowly to the plants roots as required amount.

vi) **Sawdust:** It is made from wood, produced by sawing. It is 100% natural, eco – friendly and easily available soilless growing medium.

vii) **Rockwool:** It is inorganic material soilless growing media which is made into matted fiber. It is used especially for insulation and soundproofing. It can withstand extremely high temperatures since; it is fire resistant as well as noise resistant. It is more expensive than other medium and different from other insulating materials.

viii) **Coarse Sand:** It is a sand particle having a diameter of 0.5- 1 mm. It is used in soilless mixes. It doesn't retain water however; it improves drainage and aeration.

ix) **Pea Gravel:** It is a small piece of stone having size of the size of a pea about 1*8 inch – 3*8 inch. It improves drainage, prevents weed growth and controls erosion as well.

Raising seedlings of different vegetable crops in soilless media using portrays

To produce disease free, vigorous and off-season seedlings under protected environment the pro tray nursery raising technology has been developed. Normally three ingredients; vermiculite, cocopeat and perlite are used as rooting medium for raising the nursery. The required containers are filling with ingredients mixing in the ratio of 3:1:1. It promotes better root development of transplants also provides better drainage and aeration [32]. Following are some reasons why pro-tray vegetable seedling;

- ✓ It promotes proper germination.
- ✓ Provides independent area for each seed to germinate where is no any completion for place.
- ✓ Reduce mortality rate due to proper care and less infestation of disease insect and pest.
- ✓ Maintain uniform and healthy growth of seedlings because of proper nutrient distribution.
- ✓ Pro-trays are easy to handle and store in a small area.
- ✓ Reliable and economical in transportation of seedling.

Advantages and Disadvantages of Soilless Vegetable cultivation

There are various merits and demerits of this techniques some of the major points are described in following brief points [24, 25].

Advantages of soilless vegetable cultivation

i) **Production augmentation:** Increase in the yield using soilless vegetable cultivation will help the offset the initial and any additional costs of the soilless vegetable production. The application of soilless media increases the yield of vegetables as the result of the precise control of the growth elements to the plants such as nutrition,

carbon dioxide, light, pH, oxygen and temperatures which helps to produce high quality vegetables and need little washing.

ii) **Water control:** In soilless vegetable cultivation the uses of irrigation water are accurately controlled with extremely less amount (only 10%) as compared with soil-based vegetable cultivation. It saves much required labor and time for checking, cleaning irrigation nozzles and frequent supervision of trippers which easily can be blocked by calcium carbonate and other compounds.

iii) **Monitor of plant nutrition:** In soilless vegetable production, the harmful elements to plants above certain dosages can be kept within safe dosages otherwise it may leads to plant death. The essential nutrient elements are used as solution forms in appropriate amounts as the plant required. PH and E.C. of the nutrient solution can be controlled according to the requirement of the crop however it is strongly difficult and expensive in the case of normal soil-based cultivation.

iv) **Purge practices:** Soilless vegetable is occurred under controlled environment. It helps to avoid spreading of diseases, insects and weeds hence, no need for using the pesticides which pollute the environments as used in soil-based vegetable production, mean less labor, less costs with vegetables less chemicals.

v) **Monitor root surroundings:** It is easy to control the surrounding environmental and root temperature due to having no soil.

vi) **Crop diversity:** In small place we can grow various types of vegetables. The interval time between crops is nearly null set because the absence of cultivation operation as in normal cultivation therefore, multiple vegetable crops can be cultivated which increase income.

vii) **Agriculture of land inappropriate:** Vegetables can be grown in any place like; roof of the building, balcony, ocean, room of house, stores, etc where there is no appropriate land empty of pathogens and salinity is available.

viii) **Alleviation of labor requirements:** For the soilless vegetable production, all cultural practices of soil cultivation such as weed, control soil solarization and others can be excluded because there is no weeds, no insect pest incidence which directly save the labor input and the needed time of work.

ix) **No soils needed:** It don't require soil for vegetable production, it means can grow vegetables in places where the land is not suitable for normal cultivation. Hydroponics was successfully used to grow fresh vegetables for military in Wake Island, a refueling stop for Pan American airlines during 1940. Also, Hydroponics has been considered as the cultivation of the future to grow vegetables for space traveler in the space by NASA.

x) **Climate control:** In this technique the climate is completely control like in greenhouses, (temperature, light intensification, humidity, composition of the air) it means can grow vegetables all year round regardless of the season. Farmers can produce fresh vegetables at the appropriate time to maximize their income.

xi) **Water-saving:** In this vegetable cultivation system, water is re-circulated and crop will take up the necessary water, excess water will be captured and return to the system. Water loss only occurs in evaporation and leaks from the system. So, crop grown in this system use only about 10% of water whereas, it is estimated that soil-based farming uses up to 80-90% water (ground and surface water).

xii) **Effective use of nutrients:** There is 100% control of the nutrients that plants need so, growers can check and the specific amounts of nutrients needed at particular stages (what plants require).

xiii) **pH control of the solution:** All minerals require for crop are contained in the water, in which the pH levels of water mixture can measure and maintain easily compared to the soils. This enhance the plants to uptake optimal nutrients.

xiv) **Better growth rate:** Due to control environment for plants' growth (lights, moisture, temperature, and especially nutrients) it directly leads towards better growth and development xv) No weeds: There is lot of weed infestation in soil in soil-based vegetable cultivation. So, one of the most important way to grow crops without weed is soilless cultivation.

xv) **Fewer pests & diseases:** Due to protected and control environment the crops are less vulnerable to soil-borne pests and diseases.

xvi) **Less use of insecticide, and herbicides:** There are fewer chemicals used due to no use soils and while the weeds, pests, and plant diseases are heavily reduced. This helps to grow cleaner and healthier vegetables.

xvii) **Labor and time savers:** It helps to saves labor and time due to fewer works on cultivating, tilling, watering, and fumigating weeds and pests.

Disadvantages

i) **High capital investment:** The initial capital investment is high for the set-up of this system of vegetable cultivation.

ii) **The shortage of technicians and skilled labor:** It is modern and advance technology for the vegetable production which require skilled manpower due to lack of specific skill there is shortage of workers and skilled labor.

iii) **The risk of Pathological Injuries:** The nutrient solution is circulated continuously to all the plant and excess water is again back to the same tank so, if there is any disease in a single plant it may be transmit immediately to another plants too.

iv) **Requires time and commitment:** In this vegetable production system proper care and time to time caring is required. The plant may die out, if there is problem in nutrient solution supply time to time.

v) **Experiences and technical knowledge:** It is a technical based vegetable cultivation system so, which requires necessary specific skilled manpower to run the system. The expert should have good knowledge on what vegetables can grow and how they can survive in a soilless environment.

vi) **Water and electricity risks:** Water and electricity is mostly use in a soilless system. Beware of electricity in a combination of water in close proximity. Always put safety first when working with the water systems and electric equipment, especially in commercial greenhouses.

vii) **System failure threats:** Electricity is required to manage the whole system, if there is power outage, the system will stop working immediately, and plants may dry out quickly and will die out. Hence, a backup power source and plan should always be planned, especially for great scale systems.

viii) **Initial expenses:** The initial expense is high to build systems, due to need of containers, lights, a pump, a timer, growing media, nutrients and so on. Once the system build, the cost will be reduced to only nutrients and electricity (to keep the water system running, and lighting).

ix) **Long return per investment:** The initial expenses high and the long, uncertain return on investment due to expensive in set up the system.

Conclusion

Soilless vegetable farming may not seem significant at current situation but it has huge potential in the coming generation. It has many pros and cons however, with the gradual decline of fertile land around the world due to advent unmanaged human civilization it becomes necessary to search new alternate technologies and techniques for mass production of vegetable to feed the entire rapidly growing population of the world. If, the advanced new technologies and techniques are applied and inspect properly it will open a doorway to produce different vegetables crops in outer space. Hence, it can be the next-generation vegetable cultivation science.

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