International Journal of Horticultural & Crop Science Research.
ISSN 2249-4243 Volume 11, Number 1 (2021), pp. 1-7
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Soilless Agriculture: a modern and advanced method for Agriculture development

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Abstract

In recent years, due to a rapid increase in world population, many challenges have come to lime light. Although several works were carried out on cultivation of plants in soil and in vitro, few of these are concentrated on soilless cultures. Soilless agriculture is a new promising method for improving cultivation of different cash crops. Besides reservation and restoration of cultivation lands, soilless farming, especially close-loop system has various advantages. It utilizes recycled fixed amount of water, saves 85–90% of irrigation water and can be implemented in areas unfavorable for ordinary farming almost zero environmental pollution and better yield than conventional cultivation. In the present study, various techniques of soilless farming are elaborated and a basic design of eco-friendly soilless farming unit is proposed.

Keywords: Hydroponic, land conservation, nutrient, soilless culture

INTRODUCTION

Soil is not necessarily required for plant growth. It only provides all the essential macro and micronutrients for growth and development of plants. Fertile soil is disappearing fast because of climate change and intensive farming, just as the world needs to feed more people. Soilless farming may change the face of agriculture by providing a more sustainable and productive alternative to traditional cultivation. Soilless culture is an artificial means of providing plants with support and reservoir for nutrients and water (Nagaraj *et al*. 2015). Soilless production system can improve

water use efficiency, as well as water and fertilizer management in crop production (Mazahreh *et al*. 2015). Characteristics of media include holding water and nutrient, providing good aeration to root system, light, free from pathogens and substances that are toxic to plants. Choosing the medium should be based on its physical characteristics as well as availability and its cost (Asghari, 2014). A good growing media should have some characteristics as to provide aeration and water, allow for maximum root growth and support physically to the plant (Aktas *et al*. 2013).

Soilless culture contributes to the improvement of plant growth earliness, yield and increase crop quality, which results in higher competitiveness and economic incomes (EI-Sayed *et al*. 2015). Replacing soils by soilless growing media is to overcome plant protection problems, soil borne pathogens and environmental regulations against ground water pollution with nitrate pesticides (Nagaraj *et al*. 2015). Soilless media resulted in better control of plant nutrition and elimination of plant diseases that are caused by soil (Mazahreh *et al*. 2015). Soilless growing media are easier to handle and may provide a better growing environment compared to soil (Aktas *et al*. 2013). There are various techniques of soilless agriculture have being recently used. Such techniques are including Hydroponics, Aquaponics, Aeroponics as well as agriculture using supportive mediators. The soilless agriculture can be accessed on various kinds of places such as balconies, roofs, greenhouses and lands unsuitable for cultivation. Agriculture outside of soil is including hydro agriculture (Hydroponics), aqua agriculture (Aquaponics), aerobic agriculture (Aeroponics) as well as agriculture using supportive mediators. However, in soilless culture plants did not need soil but they need to be supplied with minerals Nitrogen (N), Potassium (K), Phosphorous (P), Calcium (Ca), Magnesium (Mg), Sulphur (S), Iron (Fe), Manganese (Mn), Copper (Cu), Zinc (Zn), Molybdenum (Mo), Boron (B), Chlorine (Cl) and vitamins also they need water, light, carbon dioxide, oxygen at their root zone. Soilless culture could be a technique of cultivation of recent and advanced needs to go looking for human cadres have the power to qualify for this work and could be a rare. In this regard, it will be reviewed these techniques briefly focus on the following paragraphs.

CATEGORIES OF SOILLESS FARMING

Two types of soilless farming methods are widely used *i.e.* closed soilless culture and open soilless culture.

Open farming culture

In this method, diluted nutrients are utilized for every irrigation pattern. The plants uptake nutrient solutions which are usually delivered by dripping system. Through this method adequate amount of nutrients are synchronized in the root zone. Few techniques of open soilless culture are given below.

Root dipping technique: Under this process, plants are cultured in pots having small holes at the bottom. These are filled with substrate medium like coconut fibre and are placed in a container having nutrient solution. Minimum 1–3 cm of the lower portion of the pots remain in close contact with the nutrient medium. Only few roots are

partly submerged in the nutrient media and some just hang in the air. This is a simple and cost-effective system to cultivate small herbs or flowering plants.

Hanging bag technique: In this technique, long cylinder shaped polythene bags are utilized. These are closed at the lower end and connected to PVC pipes at the upper portion. These are hanged vertically above a nutrient supplement tank. Planting materials such as seeds, fruits *etc* acclimatized in netted pots are firmly pressed into holes on the hanging bags. A micro sprinkler is used to circulate the nutrient medium to the top of each hanging bag. The nutrient solution is proportionately spread inside the hanging bag by the sprinkler. The solution stock tank is placed at the bottom of the bag for collection of excess nutrient solution. Tubes that contain the nutrient solution should be black in color to prevent mould growth inside. Using this technique, vegetables such as lettuce, climbers, small flowering plants *etc.* are grown.

Trench method: In this method, small herbs and shrubs are grown on trenches constructed using bricks or concrete blocks on or above ground. To prevent the growth media from direct contact with the ground the inner linings of trenches are covered with thick polythene sheets. The shape and size of the trenches vary from crop to crop grown in them. All nutrient supplements along with water are delivered through the dripping process. This system is suitable for growing herbs as well as tall vine plants (Bohme, 1995).

Closed farming culture

In this technique, the diluted concentrations of nutrients are marked and balanced for reuse. It is difficult to maintain the calibration of nutrients in a hydroponic system as the dissolved supplements must be tested in a regular time interval to obtain better results. Closed farming models incorporate both primary as well as modern culture frameworks. Few techniques of closed soilless culture are given below.

Hydroponics technique: Vegetables, herbs, climbers and flowers are grown hydroponically. For growing plants hydroponically, inert media such as coconut fibre, rock pieces, etc. are used. The plants are fed with nutrient solution containing all minerals and nutrients. This system has a wide range of advantages which include high yielding capacity, less pollution, better nutrient and water efficiency *etc*. This method is highly beneficial which varies from simple set ups to modern type.

Nutrient film technique (NFT): This technique was developed by A. Cooper in England during 1960. NFT is an example of hydroponics system where the plant roots remain in contact with the nutrient solution. In NFT, continuous supply of nutrient solution is maintained by submerged motor pump inside the culture vessel. Only air is used as a growing medium and plants are cultured inside containers with their roots hanging inside the nutrient media. As the solution remains in a continuous flow, there may be changes in the nutrient solution's salinity in comparison to the soil. One of its advantages is that plants can be grown in much higher salinity than soil-based cultivation.

Aeroponic technique: The aeroponic system is one of the most advanced types of hydroponics system. In this technique, the supplement solution is sprayed to create a fine mist around the root system inside the chamber. For growth of the plants, expanded polystyrene or other inert materials with holes are used. The roots of plants growing in the chamber are suspended in midair just below the panel and enclosed inside a spraying box. Just like other methods of hydroponics, a timer regulates the nutrient pump. However, in the case of aeroponics system, a short cycle timer is used to run the pump for 5– 10 sec for every 2–3 min time interval. Mostly leafy vegetables like lettuce, spinach *etc.* are grown through aeroponic culture. The most important advantage of this system is the utilization of minimum space. Through this culture, plants can be grown on per unit floor area twice as compared to other systems. The major disadvantage of this process is that, if the nutrient spreading cycles are not working properly the roots will dry out rapidly causing death of the plant.

Aqua agriculture (Aquaponics): In this technique aquatic animals like fish, prawns *etc.* are grown in water tanks in a symbiotic environment with combination of plants which are grown in hydroponics. The water from the tank gets cleaned and recycled back to the aquaculture system while moving through hydroponics system, whereas the byproducts are broken down by micro-organisms which live on the surface of the culture media and utilized by plants as nutrients.

Water Quality

One of the main elements of the success of farming systems without soil is water availability and quality. There are many sources for water availability from lakes, rain water, rivers and underground reservoirs or from other treatments. However, water must be of high quality free of pathogens as determinant factors for the success of agriculture without soil, Van *et al.* 1991.

WATER DISINFECTION

One of the disadvantages of the closed systems is the risk of a rapid dispersal of soil-borne pathogens by the recirculating nutrient solution. To eliminate these pathogens several disinfection methods can be used and the followings are some of them:

Ozone treatment

Ozone treatment can be used to disinfect the drain water. Ozone is the second most powerful sterilants in the world and its function is to destroy bacteria, viruses and odors. An ozone supply of 10 g/h/m^3 water with an exposure time of 1h is sufficient to kill all pathogens.

UV disinfection

Another way to disinfect the drain water is the use of UV radiation. Ultra-violet radiation (or UV) is a proven process for disinfecting water, air or solid surfaces that are microbiologically contaminated. For eliminating bacteria and fungi an energy dose is recommended of 100mJ/cm^2. For viruses a dose of 250 mJ/ cm^2 is recommended. The advised dosage of 100mJ/cm^2 to control Fusarium gave adequate control at 14% transparency. However, at 8% transparency 110mJ/sq.cm was needed and at 4% transparency more than 174mJ/sq.cm was required. For Fusarium control, the grower has the option of diluting the water, or increasing the UV radiation.

Heat treatment

When heat treatment is applied, a solution is heated for about 30 seconds to a temperature of 95˚C. At this temperature all pathogens are killed. A disadvantage of heat treatment is the consumption of gas. Also warm drain water contains less oxygen.

Slow sand filtration

For several years commercial growers have used a slow sand filtration installation to eliminate pathogens. Sand filtration is frequently used and a very robust method to remove suspended solids from water. The filtration medium consists of a multiple layer of sand with a variety in size and specific gravity. Sand filters can be supplied in different sizes and materials both hand operated or fully automatically.

ADVANTAGES OF SOILLESS CULTURE

a. Crops can be grown where no suitable soil exists or where the soil is contaminated with disease.

b. Labor for tilling, cultivating, fumigating, watering, and other traditional practices is largely eliminated.

c. Maximum yields are possible making the system economically feasible in high-density and expensive land areas.

d. Conservation of water and nutrients is a feature of all systems. This can lead to a reduction in pollution of land and streams because valuable chemicals need not be lost.

e. Soil borne plant diseases are more readily eradicated in closed systems which can be totally flooded with an eradicant.

f. More complete control of the environment is generally a feature of the system (*i.e.* root environment, timely nutrient feeding or irrigation) and in greenhouse-type operations like: light, temperature, humidity and composition

of the air can be manipulated.

g. Water carrying high soluble salts may be used if done with extreme care. If the soluble salt concentrations in the water supply are over 500 ppm, an open system of hydroponics may be used if care is given to frequent leaching of the growing medium to reduce the salt accumulations.

h. The amateur horticulturist can adapt a hydroponic system to home and patio-type gardens even in high-rise buildings. A hydroponic system can be clean, light weight, and mechanized.

DISADVANTAGES

a. The original construction cost per acre is very high.

b. Trained personnel must direct the growing operation. Knowledge of how plants grow and of the principles of nutrition is important.

c. Introduced soil borne diseases and nematodes may be spread quickly to all beds on the same nutrient tank of a closed system.

d. Most available plant varieties adapted to controlled growing conditions will require research and development.

e. The reaction of the plant to good or poor nutrition is unbelievably fast.

CONCLUSION

Soilless cultivation has many advantages and disadvantages, but with the gradual decline of arable land all around the world it becomes necessary to seek new alternate technologies for mass production of crop. Soilless farming may not seem significant at present but it has tremendous potential in the coming future. The technologies and techniques involved in soilless culture can be called as next-generation crop science because if it is explored and evaluated properly it will open a doorway to establish a new civilization in outer space.

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