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HYDROPONICS – CHANGING PLANTATION ZONES

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Abstract

The agriculture sector is facing challenges from the growing population, which is expected to be about 10 billion by 2050 globally. Besides, the changing diets are driving up the demand for food all over world. To meet the demands, intensive and modernized agricultural practices have been adopted which depend heavily on the use of fertilizers, pesticides and irrigation. Mechanized farming has made soil salty and dried out water bodies. The food security challenge will only become more difficult, as 70 percent more food will be required by 2050 to feed an estimated ten billion people. The challenge is intensified by the extreme vulnerability of traditional agriculture to climate change. The unpredictable rains, rising temperatures and pests have already started showing effects. On farms, climate change is reducing crop yields, the nutritional quality of major cereals, and lowering livestock productivity.

There is, however, another side to the coin. Agriculture is a significant contributor to global warming. It currently generates 19-29% of total greenhouse gas (GHG) emissions. Furthermore, 1/3 of all food produced globally is either lost or wasted. In the context of climate change, addressing food security challenges is crucial to achieve climate goals and reducing environmental stress. Hydroponics, the soil-less agriculture holds solutions to problems arising from soil-based agriculture. The review highlights various facets of hydroponics, which has picked up fast.

Keywords: Agriculture, Climate Change, Nutrient Media, Soil-Less, Sustainable

INTRODUCTION

Hydroponics is a practice that does away with soil and in its place uses water enriched with nutrients. The system among other alternatives uses support media such as **hydrocorn, puffed rock, expanded clay pellets, rockwool, coir, growstones, grow rocks or perlite.** By using few resources and being soil-less technique, it is seen as an option which is more sustainable than traditional soil-based agriculture. Furthermore, the water used can be recovered and recycled, and the nutrients can be obtained from a variety of organic sources, such as bat guano, manure, compost, gypsum, fish meal, and bone meal making the system environment friendly. Hydroponics is the latest trend among the urban population and is referred to as 'smart farming'. It is also known as vertical and indoor farming and is occasionally, also referred to as Controlled Environment Agriculture (CEA) when done for commercial purposes.

This method is not only adopted for increasing the crop yield through sustainable options but has become a necessity in places like Holland where soil and sunlight are limited. Hydroponics which uses shades, LED lights, fans and water pumps, can deal with hotter and wetter conditions of climate change. The risks of invasion of weeds and infection by bugs and insects are minimized, making the process simple and clean. Hydroponics also offers the possibility of growing crops all twelve months of the year. With impacts of climate change predicted in all sectors of life, agriculture faces new challenges from rising temperatures. The pollinator behaviour will change and so will the crop yield. It is time to look for unconventional food production systems and hydroponics is one such promising practice (Grayson, 2020).

HISTORY

The concept of growing plants in water without the soil is not new. The first mention of hydroponics appears in a work by Francis Bacon that got published after his death (1627), Sylva Sylvarium (Rawley et al., 1667) Hydroponics has a long history spanning from the practice of ancient civilizations to raising vertical farms that provide veggies all-round the year. The hanging gardens of Babylon are an example of ancient civilization with knowledge of growing plants without soil where the garden was irrigated with water flowing down the slope. Egyptians are also known to have grown plants without soil along the river Nile while the Roman emperor, Tiberius grew cucumbers out of season via water culture. In India, the soil-less practice was carried out in Kashmir (NOFA, 2022). In 1699, John Woodward, a fellow of the Royal Society of England, practised hydroponics with some soil added for nutrient supply. The search went on in various places for various options as sources of nutrients in water when finally at the end of the 19th century, Julius von Sachs and Wilhelm Knop described the list of elements that the nutrient solution had to contain to sustain plant growth. Knop is also therefore known as the father of water culture. Later in the 1920s, Dr William F Gericke extended his work with water culture to

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the field and called it hydroponics. The term is derived from Greek words – hydro meaning water and ponos meaning water-working or labour.

In recent years, hydroponics has **become an important agri- industry, a way to produce food with a higher yield and less use of land, water and energy.** Currently, NASA uses hydroponic farming to provide food for space travellers. Commercialized and automated hydroponics farms have been developed during 1980s in Abu Dhabi, Arizona, Belgium, California, Denmark, German, Holland, Iran, Italy, Japan, Russian Federation and other countries. Home hydroponics kits became popular during 1990s and now AI (Artificial Intelligence) is introduced to run the hydroponic farms.

A SUSTAINABLE OPTION

Modernized intensive traditional agriculture, food production and food distribution to far-off places are considered some of the significant contributors to greenhouse gases. As more and more people migrate to urban areas, there is an increasing distance between the place of food production and food consumption. A high cost is incurred on producing a lot of food, followed by packing and shipping it across sometimes great distances, before storing and finally selling it to people. From start to finish a long chain of events happens that requires resources to be deployed at every step – fuel, labour, land, buildings, and much more leaving a huge footprint. This increase in food miles and food transportation negatively impacts the goals of sustainable farming. The agriculture industry is directly responsible for 14 per cent of total greenhouse gas emissions (CGIAR consortium, 2012). In addition, about 476 billion tonnes of carbon emission have occurred from farmland soils due to inappropriate farming and grazing practices, which is much higher compared with 'only' 270 gigatonnes, emitted from fossil fuel burning. Also responsible are broader rural land-use decisions with an even larger impact. It is believed that by 2025, about 593 million hectares of land will be put under agriculture in order to feed the global population which will be nearly 10 billion by 2050 (UN, 2019).

The United Nations Food and Agriculture Organisation (FAO) has indicated traditional agriculture as one of the most common anthropogenic causes of soil pollution among other sectors such as the use of fertilizers (Figure 1). Deforestation occurred largely by soil conservation for agricultural use, and the greenhouse gases emissions produced by the farms, themselves raise the sustainability issue to the forefront. The awareness amongst people about health risks arising due to greenhouse gases and climate change has made the agriculture industry explore alternative forms in an effort to combat these issues.

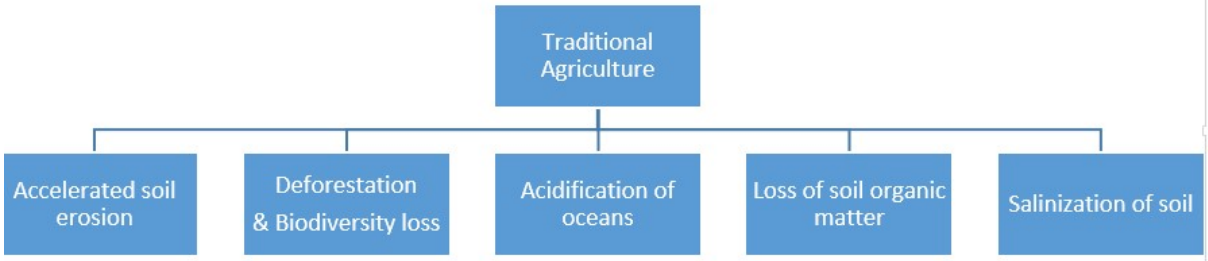

Figure 1. Some of the adverse effects of traditional agriculture which is soil-based that depends heavily on synthetic fertilizers.

The recent pandemic left people indoors with little to keep themselves busy. Digital platforms became boring and to get away from the mundane schedule, many households developed green fingers. Post pandemic people are still raising vegetables and herbs on rooftops and in backyards. The demand for organically grown produce has accelerated and several workshops are being organized to give hands-on to the 'amateur gardeners. The sale of seeds and seedlings on Amazon and Flipkart has shown a rising trend (Kaur, 2021). Gardening has become a necessity for many who wish to consume organic and self-grown vegetables. Unfortunately, the urban set-ups leave people with little space to indulge in this hobby. Hydroponics is a great relief in space crunch common to urban lifestyle and has gained a sizeable ground globally. The possibility of making vertical farms (Figure 2A) has given impetus to the hydroponic market which caters to the demand for lettuce, basil, spinach, cherry tomatoes, snack cucumbers, bell peppers and mint (Aggarwal, 2019)

GET STARTED

Setting up hydroponic system is easy. The system to be fully operational requires a water pump which moves water and allows fresh air to pass into it (Figure 2B). To hold plants in netted pot, marbles can be used (Figure 2C). All one has to remember is that the trays or the containers should be perforated for roots to emerge and grow into the nutritive medium (Figure 2D). The most important component, is the nutrient medium which one can buy from a hydroponic products supplier. The medium can be prepared at home from

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basic ingredients such as manure, compost and litter supplemented with foliar sprays. Different media can be standardised to grow different plant species using hydroponics. The nutrient composition to grow tomatoes in soil-less culture can be prepared from a sterile stock solution of salts and can be kept at room temperature. The composition of macronutrients in one litre of deionised water is KNO_3 (184g), Ca $(NO_3)_2.4H_2O$ (653 g), $MgSO_4.7H_2O$ (399g), $FeSO_4.7H_2O$ (in 10g add 72ml of 500mM EDTA pH 8.0) and composition of micronutrients in one-litre solution is H_3BO_3 (2.86g), $MnCl_2.4H_2O$ (1.81g), $CuSO_4.5H_2O$ (0.1g), $ZnSO_4.7H_2O$ (0.22g), $Na_2M_OO_4.2H_20$ (0.02g) (Lambert et al., 1992). In either case, pH must be checked with a portable handy pH meter. The salt solution is to be changed after every week. Another important component in the hydroponic set-up is the substitute of soil. Potting mix is available in the market in various forms such as sand, vermiculite, perlite, coco peat, and leaf litter. **Perlite** is used to improve drainage and help the plant roots during temperature fluctuations. **Vermiculite** is light in weight and improves drainage by retaining more water and is a better option for plants that need more moisture.

Figure 2A-D. A. Vertical farm (source: Author – Valcenteu; creative commons)

B. Improvised set-up for kitchen garden. C. Net pots filled with marbles to support the plants. D. Tomato plant established can be seen with roots that immerse in the nutrient medium.

ADVANTAGES OF HYDROPONICS

As the growth of the plants is greatly associated with the root system, special net pots are required to raise the plants. The roots get enough space in these pots to grow and reach the nutrient medium, thus making nutrients available to the plants.

- The system provides enough food in a sustainable manner and frees up large tracks of land under cultivation which reverts to the natural landscape, restoring functions and services of the natural ecosystem.
- Hydroponics is a budding sector and is fast becoming a start-up business in metropolitans like Bangalore, Chennai and Hyderabad.
- The practice has become popular because it is soil-less and can be easily carried out in compact spaces.
- The herbs and the vegetables can be grown throughout the year.
- The hydro-culture conserves about 80% of water content and the customized nature helps consumer get vegetables free of chemicals.
- To begin with the PVC pipes can be used to build up the system. It can be carried out with less expertise and one can easily manage a small hydroponic greenhouse.
- Hydroponic gardening is a rapidly growing choice for people in coastal areas and desert areas where the soil is unsuitable for growing plants.
- In addition, studies related to mineral nutrition and effect of different hormones on growth and development of the plants can be easily done under lab conditions using

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hydroponic system (Figure 3).

Figure 3: Hydroponics used in understanding growth and development of plant under laboratory conditions. (A) The seedlings used as explants to study the effect of auxin on rooting (B) profuse rooting of the seedling explant after four days.

LIMITATIONS

As hydroponics gives us options to grow vegetables and plants all year round, it has additional costs incurred in monitoring the controlled light and temperature conditions. The cost soars as LED lights, monitoring temperature and nutrient status of the medium all call for a big investment. The hydroponics system is bulky, requires more space, is time-consuming and as compared to the soil-based cropping system, the growth percentage of plants and yield is occasionally lower in hydroponics. The improper concentrations of salts in nutrient solutions can affect the growth of plants in hydroponics. Protecting the plants from pests is highly crucial as plants are growing in a nutrient-rich medium. The changes in any controlled condition such as light, temperature, and oxygenation for plants can severely affect the plant growth in hydroponics, many times, plants fail to establish in a hydroponics system. Therefore, for the commercial set-up, skilled labour should be employed and to achieve appropriate production targets, the initial number of plants to be used in hydroponics should be maintained accordingly (Pandey et al., 2009).

CONCLUDING REMARKS

As the world moves on from traditional soil-based agriculture toward a more sustainable model, there is a strong emphasis on vertical farming. If one is to believe the Forecasts from Research and Markets claim the vertical farming industry could be worth as much as $3 billion by 2024. The use of AI to manage and run such farms is making it easier for farmers to adopt this technology. If the fact is to be considered that all crops cannot be grown through hydroponics and that there is initially a handsome investment involved, hydroponics also has its limitations. If such limitations are overcome, the future of hydroponic farming is both exciting and challenging.

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