JUST AGRICULTURE
multidisciplinary e-Newsletter

# Hydroponics: An Alternate Technique of Urban and Vegetable Farming

**[1]Charan K, [2]Akshata Hattiholi and [3]Madhushudhan MR**
[1]M.Sc. Horticulture Vegetable Science College of Horticulture, Mudigree Keladi Shivappa [2]Nayaka, University of Agricultural and Horticultural Sciences, Shivmogga
[3]PhD Scholar, University of Agricultural Sciences, GKVK, Bengaluru

**ARTICLE ID: 25**

**Abstract**

Plants may be grown in water without soil using a technique called hydroponics. It is a subset of hydro farming and a sort of horticulture. The plants require some sort of passive medium for sustaining the root system, and the water must be supplied with nutrients. The basis of hydroponic farming is a technique that, among other things, replaces soil with a solution of nutrient-rich water are seen as a far more sustainable method than traditional agriculture since they use so few resources. Furthermore, hydroponic plants may be grown inside. Growing plants don't always need soil. It alone offers all the macronutrients and micronutrients required for plant growth and development. The disadvantages of soil-based traditional agriculture include soil deterioration, excessive use of chemical fertilizers, waste of irrigation water, high land requirements, etc. The need for a significant amount of nutrient-dense food to meet the huge demand of the global population warrants the introduction of new and sophisticated technologies and practices in agriculture that synchronize water and nutrient requirements to produce the highest yield.

**Keywords:** Hydroponic Farming, Sustainable Farming, Soilless Farming, Traditional Farming, Hydroponic Farming, Sustainable Alternative

## Introduction

With rising population and purchasing power, demand for food and changing consumer preferences are building pressure on natural resources. According to United Nations World Food Programme, nearly 1 billion people worldwide are undernourished (FAO 2014). About 42% of these chronically hungry people live in India and China. Until 2050 the number of people living in urban areas are estimated to rise to more than 6 billion (UN, 2013) and our growing population will require 60% more food than we produce today (Alexandratos and Bruinsma, 2012; Tilman *et al.*, 2002; Green *et al.*, 2005). All this while 1.3 billion tons of

JUST AGRICULTURE
multidisciplinary e-Newsletter

global food production is lost or wasted annually (Gustavsson *et al*., 2011). Arable land is also finite (FAOSTAT, 2012), and water is a scarce resource too (Gleick, 1993). Therefore, there is a need to find agricultural technologies that have neutral or positive impact on our environment. Use of hydroponics as an alternate urban farming method in populated urban areas on large scale holds the promise of addressing these issues by enabling more food to be produced with less resource use and sale of these crops directly in city community, reducing transportation as opposed to the standard rural farming methods. The crop grown in hydroponic system uses small land, less water gives more yield than the conventional agricultural methods (Barbosa *et al*., 2015) and hydroponically grown produce is high in nutritional quality (Buchanan *et al*., 2013). This system can help to face the challenge of climate change and also helps in mitigating malnutrition. In country like India, where urban conglomerate is growing each day, there is no option but adopting soil less culture to help improve the yield and quality of produce to ensure

**Hydroponics:**

The science of growing plants in a medium other than soil, using essential plant nutrient elements dissolved in water. A successful hydroponic system depends upon the media used for planting and nutrient solutions used to supply nutrients to the plants in a hydroponic system. Different types of media used are Coco Coir, Rockwool, Perlite, Gravel whereas nutrient solutions include all the macro and micro elements which are dissolved in water and supplied to the plant.

**Historical Evolution of Hydroponic:**

Hydroponics, a method dating back thousands of years, has been utilized by numerous civilizations throughout history. One of the earliest records of hydroponics dates back to around 600 BC in Babylon, where the renowned hanging gardens featured plants irrigated from the Euphrates River on terraces. Similarly, around 40 AD, the Aztecs created an island city in Tenochtitlan, where plants floated over water with direct contact with roots, a precursor to modern hydroponic techniques (González Carmona and Torres Valladares, 2014). Chinampas, a type of ancient Mesoamerican agriculture utilizing hydroponic principles, continues to thrive today, producing approximately 40,000 tons of vegetables and flowers annually (Arano, 2007). Recognized as an important agricultural heritage system, Chinampas highlight the enduring efficacy and sustainability of hydroponic practices (Aquastat, 1999). Even in the early modern era, hydroponics garnered attention. In 1627, Sir Francis Bacon, renowned as the father of the

JUST AGRICULTURE
multidisciplinary e-Newsletter

scientific method, published "Sylva Sylvarum," which included insights into growing terrestrial plants without soil. Bacon termed this method "Water Culture," laying the groundwork for modern hydroponic techniques. In 1666, Robert Boyle conducted his experiment on plants having roots submerged in water. Similarly, John Woodward's work in 1699 on a soilless system in spearmint revealed that plants have performed better in distilled water than impure water. In the early 20th century, Professor William Frederick Gericke proposed a commercial water culture system, coining the term "hydroponics" in 1937. Hydroponics was introduced to India in 1946 by English scientist W.J. Shalto Duglas, who established a laboratory in Kalimpong, West Bengal, and authored the book "Hydroponics: The Bengal System." These milestones mark the evolution of hydroponics into the advanced agricultural technique it is today.

**Concept of Urban Farming:**

United Nations defines urban agriculture as “an industry that produces, processes and markets food and fuel, largely in response to the daily demands of consumers within a town, city or metropolis, applying intensive production methods, using and reusing natural resources and urban wastes to yield a diversity of crops and livestock”. Urban farming is often confused with community gardening, home gardening, but what distinguishes urban agriculture is that in urban farming the element of commerce also becomesits major part which means that the vegetables or fruits that are grown in towns are not only used for personal consumption but large part of total produce is sold in the market for money.

**Need of Urban Farming:**

1. **Depleting Fresh Water Resources:**
    a. World contains estimated 1,400 million cubic km of water out of which only 0.003% are what is called “fresh water resources”.
    b. In-fact only about 9,000-14,000 cubic km are economically available for human use. Agriculture is by far biggest user of water accounting for almost 70% of all withdrawals.
    c. Under developed and developing countries Asian countries are the largest user of fresh water resources for agriculture accounting for about 87.6% of total water use. India comes under water stress conditions in terms of withdrawals for agriculture as a percentage of total renewable water resources.

JUST AGRICULTURE
multidisciplinary e-Newsletter

2. **Food loss:**
    a. Edible harvest is wasted at each stage in the food chain starting from the harvest stage to the consumption stage.
    b. Most of the harvest, processing losses are in Europe, post- harvest losses are high in South and SE Asia whereas consumption losses are highest in North America and Oceania regions. (UN FAO).
3. **Population growth and limited arable land:**
    a. World population is projected to reach about 11.2 billion until 2100. Growing food raising livestock for 6.8 billion people require land equal to the size of South America.
    b. By 2050 another Brazil's worth of area will be needed using traditional farming and that much arable land does not exist.
4. **Negative effects of Agriculture:**
    a. Conventional agriculture involves use of various pesticides, chemicals and fertilizers which on one hand increases the yield of produce but on the other hand also leads to soil pollution, soil degradation, agricultural runoff and ocean acidification which in return reduces the availability of nutrients from soil and degrades the quality of water making it unfit for human use.

**Selection, Suitability, and Applications of Hydroponics for Vegetable Farming:**

The choice of crop species in hydroponic systems has a significant impact on nutrient uptake as well as the acceptance of the technology in urban settings. Vegetables suitable to grow on a commercial scale using soilless culture have been presented in Table 1. Because ornamentals like tomatoes, cucumbers, lettuce, and cut flowers have short growth cycles and allow for greater cultivation control, studies primarily focus on these types of crops or vegetables (Prazeres et al., 2016). Crop selection is also determined by market demand and consumer expectations, which place a premium on qualities like flavor, color, nutrition, firmness, shelf life, and pathogen resistance. Although the use of treated wastewater in hydroponic vegetable farming has been investigated, worries regarding decreased crop quality and shelf life endure. Because there is less interaction between irrigation water and edible plant portions, soilless farming dramatically lowers the danger of microbial contamination in fresh produce, according to commercial research. There are still issues, though, such as the high infection rates found in small-scale hydroponic systems that use treated gray water (Tangahu

JUST AGRICULTURE
multidisciplinary e-Newsletter

et al., 2011). Despite these difficulties, there are no clear guidelines for crop selection in the literature; instead, species or varieties with better growth performance are usually found through pilot research. While permitting water and nutrients to flow freely, an inert medium such as pine needles, rock wool, farmyard manure, perlite, coco coir, or sugarcane bagasse serves as a physical support for plant roots (Alam et al., 2022). Vegetables can be grown successfully under a soilless culture farming system. The commonly cultivated vegetables under the hydroponic system include spinach, lettuce, and kale, which grow well in hydroponic culture owing to their shallow root systems and quick growth cycle (Jones, 2014). Moreover, tomatoes (Balashova et al., 2019), cucumbers, peppers, and strawberries also can be grown effectively in hydroponic culture (Jones, 2014). Vegetable production through a hydroponic system depends on delivering the essential nutrients to roots directly via nutrient solution. Commercially, hydroponic culture is employed by farmers to cultivate valuable vegetables on a large scale (Croft et al., 2017). Farms produce various types of vegetables around the year that ensure consistent and better quality to fulfill the demands of the growing population (Hochmuth & Cantliffe, 2021). Due to limited land in urban areas, hydroponic cultivation is very well-suited. In compactly populated areas farmers can cultivate different vegetables through using rooftop and vertical hydroponic culture, which decreases food distance, increases food security, and supports food production locally (Payen et al., 2022). Under greenhouse conditions hydroponic system is used to expand agricultural production and environmental management. Through this system, better quality vegetables can be produced around the year because in this system vegetables are less prone to pests, and disease (Bisbis et al., 2018). This system can be implemented in various fields of study like educational and research institutions to undertake studies on plant growth, nutrition, and sustainability of the environment (Sambo et al., 2019). In educational institutions, hydroponics can be used to teach the youth about the production of food, the biology of plants, and sustainable agricultural practices. Urban agriculture and community gardening are the key indicators of enhancing the number of projects related to hydroponics. According to Ben-Othmen et al. (2023), This system supports the self-sufficiency of food and ensures fresh, nutritious vegetable availability in ignored groups. Farmers can harvest various crops through hydroponic production which is difficult to manage in orthodox systems based on soil (Ampim et al., 2022). Using hydroponic culture growers can grow rare types of vegetables, flowers, microgreens, and herbs. Small growers and

JUST AGRICULTURE
multidisciplinary e-Newsletter

home gardeners looking at easy and space-saving methods for vegetable production are increasingly attracted to hydroponic systems (Caputo et al., 2020). Installation of hydroponics in homes enables the public to enjoy fresh vegetables around the year irrespective of the exterior growth factors and this system ranges from modest systems to countertop gardens. Furthermore, these systems can be applied for environmental remediations, particularly in programs related to phytoremediation that removes contaminations from soils (Kumar et al., 2024). Yan et al. (2020) have shown that certain Plants cultivated in hydroponic systems can absorb and detoxify the contaminations, viz., heavy metals and organic chemicals. This method can thus reduce pollution and restore ecosystems.

**Advantages of Hydroponics:**

Vegetable Production The advantages of hydroponic farming over traditional methods are extensive and varied, as illustrated in Table 3. Plants grow more quickly and develop smaller root systems when nutrients are delivered directly to the roots; this enables denser planting (Kumar et al., 2012). These systems provide good substitutes by providing better yield per acre, enhanced fertilizer control, better plant density, and improved quality of output (Sardare et al., 2013). It is more suitable, particularly in those areas where arable land is limited. Hydroponic agriculture produces significantly higher crop growth and yield compared to soil-based farming as it controls nutrients precisely, water, and conditions of the surroundings (Kannan et al., 2022). It is particularly beneficial to increase crop production on a small piece of land. Hydroponic cultivation is the most suitable choice in arid areas as it could save around 90% water used compared to orthodox methods (Michelon et al., 2020). Water resources conservation importance is further emphasized by using recycled water in hydroponic culture, which decreases freshwater needs. Contrasting conventional farming, farms of hydroponic are not affected by the seasons and crops may be produced around the year under controlled conditions (Mitchell, 2022). Due to the shrinkage of fertile soil more sustainable ways to grow vegetables are being encouraged, which reduces the transmission of pests and disease incidence from soil and decreases pesticide use (National Research Council, 1996; Kumar & Akhtar, 2018). Additionally, vegetables grown hydroponically commonly have more shelf life and higher nutrient contents, which reduces wastage and rotting (Manzocco et al., 2011; Aires, 2018).

JUST AGRICULTURE
multidisciplinary e-Newsletter

**Disadvantages of Hydroponics:**

Hydroponic vegetable cultivation has many advantages, but it also has some drawbacks and difficulties. A hydroponic system may require more initial setup costs than traditional soil-based farming. Hydroponic systems also require frequent maintenance and a thorough understanding of plant nutrition in order to operate at their best. Electricitydependent pumps and environmental control systems could be problematic, especially in places with unstable power sources. Since diseases like powdery mildew and root rot can affect hydroponic crops, it's imperative to employ efficient disease management techniques to keep the plants healthy and productive. Commercial hydroponic culture growth needs a higher initial investment along with technical knowledge. Since the shared solution of fertilizer in the hydroponics culture, infections caused by waterborne spread rapidly among the plants. Lower O2 levels and higher temperatures cause crop growth reduction and ultimately decrease yield. For ideal plant growth, various factors like the pH of a solution, its EC, and balanced nutrient contents must be maintained. Furthermore, to run the system more effectively, an adequate supply of energy and lighting is also required. Despite popular growth, hydroponics system has many disadvantages, viz., few crops can accumulate a higher quantity of nitrate-N (NO3-N) from the system (Guo et al., 2019). The hydroponic system must support around 40 plants, such as tomatoes, and 72 small plants like strawberries and spinach, etc. (Tyson et al., 2004). To maximize hydroponic production under greenhouse conditions various parameters, viz., temperature, intensity of light, humidity, and CO2 concentration should be checked regularly. To check and control these parameters the most useful method is the use of systems like temperature control on Arduino based (Hochmuth & Hochmuth, 2021). During the installation of these systems, the factors that need to be considered are availability, transportation costs, effectiveness, and initial expenditure (Taig, 2012). For commercial hydroponic culture, an Arduino-based control system costs around US$500-US$2000 (Takakura and Hashimoto, 2014; Khan et al., 2018; Manju et al., 2020).

**Conclusion:**

One of the numerous advantages of this technology is its ability to yield a large quantity of high-quality vegetables in a small space with minimal labor. By promoting farming entrepreneurship, hydroponics has the potential to help destitute and landless communities while simultaneously promoting economic prosperity. The hydroponics sector is expected to

JUST AGRICULTURE
multidisciplinary e-Newsletter

grow significantly, but low-cost technologies and government support are required to sustain commercial hydroponic farms. In recent years hydroponics is seen as a promising strategy for growing different crops. As it is possible to grow short duration crop like vegetables round the year in very limited spaces with low labour, so hydroponics can play a great contribution in areas with limitation of soil and water and for the poorer and landless people. In India, the hydroponic industry is expected to grow exponentially in near future. To encourage commercial hydroponic farm, it is important to develop low-cost hydroponic technologies that reduce dependence on human labour and lower overall startup and operational costs.

**References**

Adrover, M., Moyà, G., & Vadell, J. (2013). Use of hydroponics culture to assess nutrient supply by treated wastewater. Journal of Environmental Management, 127, 162-165.

Ahmed, H. A., Yu-Xin, T., & Qi-Chang, Y. (2020). Optimal control of environmental conditions affecting lettuce plant growth in a controlled environment with artificial lighting: A review. South African Journal of Botany, 130, 75-89.

Alexandratos, N., &Bruinsma, J. 2012. World Agriculture towards 2030/2050: The 2012. ESA Working Paper No. 12-03. Rome, FAO.

Asaduzzaman, M., Niu, G., & Asao, T. (2022). Nutrients recycling in hydroponics: opportunities and challenges toward sustainable crop production under controlled environment agriculture. Frontiers in Plant Science, 13, 845472.

Barbosa GL, Kublik Natalya, Weissinger Emily. 2015. Comparison of land water and energy requirements of lettuce grown using hydroponic vs conventional agricultural methods. International Journal of Environment 12: 879-91.

Dubey, N., & Nain, V. (2020). Hydroponic—the future of farming. International Journal of Environment, Agriculture and Biotechnology, 5(4).

Hochmuth, R., & Cantliffe, D. (2021). Alternative Greenhouse Crops-Florida Greenhouse Vegetable Production Handbook, Vol 31.

Khan, F. A. (2018). A review on hydroponic greenhouse cultivation for sustainable agriculture. International Journal of Agriculture Environment and Food Sciences, 2(2), 59-66.

Mugandhan, Murali R. 2011. "Hydroponics" A Novel Alternative for Geoponic Cultivation of Food Crops. International Journal of Pharma and Bio Sciences 2.2: 286-289

UN 2013. World Population Prospects: Available: http://esa.un.org/unpd/wpp/index.html.