



International Journal of Research in Agronomy

E-ISSN: 2618-0618

P-ISSN: 2618-060X

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www.agronomyjournals.com

2024; 7(11): 255-258

Received: 06-09-2024

Accepted: 10-10-2024

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Urban horticulture for sustainable living

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DOI: <https://doi.org/10.33545/2618060X.2024.v7.i11d.1972>

Abstract

Urban horticulture is essential for sustainable living, tackling food security, urban growth, and environmental issues. This review examines techniques such as vertical gardening (hydroponics, aquaponics, aeroponics), rooftop gardens, protected cultivation, and Dutch grow buckets, which optimize space, reduce resource use, and enhance crop yields. These methods conserve water, increase biodiversity, enable year-round production, and improve nutrient delivery. Overall, urban horticulture enhances food production, lowers carbon footprints, and fosters healthier urban ecosystems, underscoring its significance for sustainability.

Keywords: Urban horticulture, population, urbanization, sustainable living, protected cultivation

Introduction

As urban populations surged during the Industrial Revolution early in the 18th century, the significance of urban gardens in enhancing dietary options became increasingly recognized. The rising populations in urban areas, combined with the decreasing availability of land, present considerable challenges to sustainable agricultural practices within and around cities. Worldwide, a significant number of people experience food insecurity and poor nutrition ^[1]. Urban horticulture, which includes the cultivation of vegetables, herbs, medicinal, and ornamental plants in city environments, offers a potential remedy to these challenges ^[2]. The value of urban gardening is highlighted by its ability to enhance food security and strengthen community ties. A notable aspect of this practice is the conversion of neglected areas into green spaces and promotes environmental sustainability, enabling urban dwellers to reconnect with nature ^[1]. Additionally, seasonal temperature fluctuations across the globe further complicate the tasks of urban growers, who frequently face challenges maintaining stable production levels due to insufficient yields and crop losses. As a result, urban horticulturists may need to implement innovative techniques and tools to improve their agricultural practices. However, many of these advancements necessitate financial investment, access to specialized information, and the prerequisite knowledge and resources to refine their skills in the production, processing, and marketing of their crops. Recent innovations in urban horticulture, including various types and methodologies such as vertical farming systems (hydroponics, aeroponics, and protected cultivation), have contributed as a solution to the success of sustainable living initiatives ^[2].

Components of Urban Gardening

- Vertical gardening [Hydroponics, Aquaponics, Aeroponics]
- Roof Top Garden
- Protected Cultivation
- Dutch Grow Bucket

Vertical Gardening

Living walls or vertical gardens are known for their eco approach, in allowing plants to grow vertically on a wall without relying on soil for nutrients and water. Vertical farming structures provide resources for the plants to thrive and create green systems that optimize resource usage while providing ample space, for plant growth and root development ^[3].

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Hydroponics

In hydroponic systems (Figure 1), plant roots are submerged in nutrient-rich water, promoting growth without the need for chemicals. This method allows both home gardeners and commercial farmers to grow food in areas unsuitable for traditional soil farming. Hydroponically grown plants can yield 20-25% more than those cultivated in soil, with productivity levels that can be two to five times higher [4].



Fig 1: Crop production through hydroponics system

NFT [Nutrient Film Technique]

NFT hydroponics, developed in the 1960s by Australian horticultural scientist Dr. Allen Cooper, aims to improve crop production in confined areas. Known as the Nutrient Film Technique, this method allows for soil-free plant cultivation by maintaining a thin stream of nutrient-rich water over the roots. This continuous flow provides essential water, nutrients, and oxygen, promoting robust growth and higher yields while preventing waterlogging. NFT hydroponics has gained popularity in both commercial agriculture and home gardening [5].

Aquaponics

Aquaponic systems combine recirculating aquaculture with hydroponics to address the major challenges associated with each method. They make efficient use of nutrient-rich fish waste from aquaculture, providing nutrient-laden water for hydroponic plants. This sustainable method uses fish effluent to irrigate hydroponic beds, fertilizing the crops while converting ammonia into usable nutrients through denitrifying bacteria. Essentially, the hydroponic bed acts as a bio filter for fish wastewater before it is returned to the fish tank [6].

Aeroponics

Aeroponic farming is a vertical agriculture method that uses a spray system to deliver nutrients to roots suspended in the air, eliminating the need for soil. This technique can be implemented

in semi-closed or closed environments, allowing for precise control of temperature, humidity, and pH levels. Its popularity is growing due to pesticide-free cultivation and improved crop yield and quality. An effective monitoring system is crucial for optimizing water and nutrient distribution, tracking environmental conditions, and automating controls, with real-time data displayed on an LCD and sent to a computer for efficient management [7].

Roof Top Garden

Rooftop gardening, often known as rooftop farming or green roofs, represents a sustainable approach to cultivating plants on the rooftops of buildings. This practice transforms otherwise unused spaces into valuable green areas. The increasing trend of urbanization poses challenges in meeting the food demands of city populations, leading to a decline in agricultural land and green spaces. Rooftop gardening presents a viable solution to bridge the gap between food production and consumption. Rooftop gardens act as natural insulators, reducing heat absorption and radiation, thereby lowering energy consumption and enhancing urban microclimates. Additionally, green roofs have the potential to create private, semi-public, or fully public recreational spaces in densely populated urban areas [8].

Protected Cultivation-

Protective cultivation practices refer to agricultural techniques that manage the microclimate around plants, either partially or completely, according to the specific needs of the plant species during their growth phase. Different types of protective cultivation methods have been implemented based on the existing climatic conditions. Notably, greenhouse and polyhouse systems are particularly beneficial for year-round vegetable production in temperate climates. This form of protected cultivation, also referred to as controlled environment agriculture (CEA), is characterized by high productivity, efficient use of water and land resources, and environmental sustainability [9].

Dutch Grow Bucket

A Dutch bucket hydroponic system (Figure2), represents a form of container gardening that employs inert growing media and nutrient reservoirs to cultivate plants in buckets or pots, eliminating the need for soil. This system presents several benefits when compared to other hydroponic and traditional soil-based cultivation methods. The enclosed nature of the buckets safeguards the plant roots while facilitating the regulation of aeration and nutrient concentrations. Consequently, this results in accelerated growth rates and more reliable, higher yields. Additionally, Dutch bucket systems are more efficient in their use of water and fertilizers than conventional soil gardening practices [10].

Table 1: Illustrating the various crops that can be cultivated using different components of urban gardening

S. No.	Types of plants	Name of Plants	Techniques used	References
1.	Leafy Greens	Spinach, Lettuce	Hydroponics, Aquaponics, Aeroponics, Roof Top Gardens, Protected Cultivation,	[10-14]
2.	Herbs	Basil, Kale	Hydroponics, Aquaponics, Aeroponic, Roof Top Gardens, Protected Cultivation,	[10-4]
3.	Edible Flowers	Sunflower, Marigold, Rose, Gerbera	Aquaponics, Protected Cultivation	[11-14]
4.	Fruits	Strawberry, Tomato	Aquaponics, Aeroponics, Roof Top Gardens, Protected Cultivation, Dutch Grow Bucket.	[11, 15]
5.	Vegetables	Carrot, Radish, Cabbage, Cauliflower, Potato	Aquaponics, Aeroponics, Roof Top Gardens, Protected Cultivation, Dutch Grow Bucket.	[11-15]



Fig 2: Dutch Grow Bucket

Conclusion

Urban horticulture represents a forward-thinking strategy for sustainable living in crowded urban areas. By leveraging contemporary technologies and gardening techniques, it enables individuals and communities to maximize space, conserve resources, and lessen their environmental impact. Methods like hydroponics, aquaponics, and aeroponics facilitate effective plant growth in confined areas, reducing land usage while ensuring optimal management of water and nutrients. These systems support year-round cultivation, decrease reliance on pesticides, and bolster food security in cities. Rooftop gardens convert underutilized spaces into productive environments, helping to mitigate urban heat, enhance air quality, and support biodiversity. They also offer recreational areas and encourage community involvement while managing storm water runoff. Protected cultivation techniques, such as greenhouses, provide ideal growing conditions by shielding crops from harsh weather and pests, thereby stabilizing production in unpredictable climates and reinforcing local food systems. The Dutch grow bucket system enhances water efficiency and root management, making it particularly suitable for urban agriculture. Its modular design can be tailored to various scales, from small balconies to expansive urban farms. In summary, urban horticulture promotes sustainable living by shortening food transportation distances, encouraging local production, and fostering greener urban spaces, all of which are vital for developing resilient cities.

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