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Growing Beyond Ground: Unravelling the potential of Dutch Bucket Hydroponics

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Abstract

Protected cultivation, such as greenhouse farming, has emerged as a critical tool in addressing the global demand for fresh produce while prioritizing sustainability. It provides a controlled environment that shield crops from external factors like harsh weather, pests and diseases, resulting in improved crop quality, increased yields and reduced resource consumption. Soilless growing techniques, like Dutch Bucket technology, have played a transformative role in this paradigm shift. Dutch Bucket hydroponics, originating in the Netherlands during the 1960s, offers a space-efficient and highly efficient method for cultivating high-value crops, particularly indeterminate vine crops such as tomatoes, cucumbers and peppers. This system utilizes individual containers filled with inert growing mediums like clay balls, ensuring stability and aeration. Drip irrigation delivers precise amounts of water and nutrient solutions directly to plant roots, with excess solutions being re-circulated to minimize waste. Regular monitoring of nutrient solutions, pH and electrical conductivity helps maintain optimal plant growth. The article underscores the significance of water quality, sanitation, and temperature control within the Dutch Bucket system, along with the need for proper training for operators and growers. Dutch Bucket hydroponics represents a promising solution in addressing the world's agricultural challenges and advancing sustainable food production.

Key words: Protected cultivation, Soilless growing, Dutch bucket, Hydroponics

Introduction

Protected cultivation technology, commonly known as greenhouse farming, has heralded a remarkable shift in modern agriculture. In an era where the sustainability of food production is of paramount concern, protected cultivation techniques have emerged as a crucial component in meeting the world's growing demand for fresh produce. This method facilitates optimal growth conditions, leading to improved crop quality, higher yields, and reduced resource consumption.

One pivotal facet of protected cultivation is the integration of soilless growing techniques. Traditional soil-based farming, while time-tested, has its limitations, including susceptibility to soil-borne diseases and the inability to fully control nutrient delivery. Soilless growing techniques, like hydroponics and aeroponics, overcome these challenges by cultivating plants without soil, instead, relying on nutrient-rich water solutions to provide essential elements for plant growth. In contrast to field farming, protected soilless cultivation can achieve yields that are 2 to 5 times greater, consume 10 times less water, allow for year-round harvesting, result in improved flavour, and offer enhanced nutritional value **(Asaduzzaman et al., 2015; Chu and Brown, 2021).**

Among these innovative soilless growing techniques, Dutch Bucket technology has emerged as a highly efficient and space-saving method. The Dutch Bucket system consists of a series of individual containers, usually square or rectangular. It operates as a hydroponic system, utilizing containers typically loaded with perlite as the growing medium **(Yang et al., 2023).** These buckets are connected in a recirculating system, ensuring that no water or nutrients go to waste. An advantage of this system is its ability to maintain optimal root humidity since the roots are consistently submerged in the water contained within the bucket **(Helmy et al., 2023).**

Genesis of Dutch bucket

The genesis of Dutch Bucket technology is a testament to human ingenuity and the on-going quest to improve crop cultivation methods. The origin of the Dutch Bucket system can be traced back to the 20th century when the Netherlands, sought innovative ways to maximize crop production in limited space. Dutch farmers faced the challenge of cultivating high-value crops in a region with unpredictable weather and limited arable land. This droves them to experiment with various hydroponic and soilless growing techniques. The Dutch Bucket system itself was developed in the 1960s and gained widespread adoption in the Netherlands during the following decades.

Technical Design and Operation:

Dutch Buckets

The core of the Dutch Bucket system consists of individual containers or buckets made from materials like plastic or PVC (food grade). These buckets are typically square or rectangular in shape as show in **Fig.1.**

Fig 1. Bucket

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Growing medium: The growing medium supports the plant and provides stability and aeration. Common materials are clay balls, rockwool, perlite, coconut coir, or a mixture of both. It leads to the increased water retention and organic content of media. Numerous research studies have demonstrated that high-wire crops exhibit superior yields in peat and coir compared to perlite **(Ayipio et al., 2021).** Clay balls as media is shown in **Fig. 2.**

Fig 2. Growing media

Drip Irrigation: Each Dutch Bucket is equipped with a drip irrigation system as shown in **Fig. 3.** This system supplies a carefully measured amount of water and nutrient solution directly to the plant's root zone. Excess nutrient solution and runoff are collected and re-circulated, minimizing water and nutrient waste.

Fig 3. Micro tube

Nutrient Reservoir: The nutrient solution, typically including essential macro- and micro-nutrients, is prepared in a separate reservoir. The pH and electrical conductivity (EC) of the solution are regularly monitored and adjusted to ensure optimal nutrient uptake by the plants. A typical reservoir is shown in **Fig. 4.**

Fig 4. Reservoir

Common Nutrient Recipes: Several nutrient recipes are commonly used worldwide in Dutch Bucket systems. These recipes are adjusted based on the specific needs of the crop being grown and the stage of growth. Common nutrient components include Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg) and trace Elements like Iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), boron (B), and molybdenum (Mo).

Crops suitable: The Dutch Bucket technology is well-suited for a range of high-value crops, particularly indeterminate vine crops like tomatoes, cucumbers, and peppers. Cucumber crop grown in such system is shown in the **Fig. 5.**

Fig 5. Cucumber grown in Dutch bucket system

Precautions:

1. **Monitor Nutrient Levels:** Regularly test and adjust the nutrient solution's pH and EC to maintain optimal nutrient uptake by the plants. The commonly used

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EC range is 0.8 to 1.5 dS/m and pH range of 5.5 to 6.5. The decrease in EC value indicates the uptake of nutrients by plants. The optimum range of pH value ensue better nutrient uptake.

2. **Water Quality:** Use good quality water to prepare the nutrient solution. Toxicity of water should be evaluated by measuring elements like Na and solution should be replaced if the value crosses 50 ppm. Contaminated water can lead to nutrient imbalances.
3. **Sanitation:** Maintain cleanliness within the system to prevent the growth of algae, fungi, and harmful microorganisms. Chemigation with chemicals like H_2O_2 (100 ppm) after each growing cycle is recommended.
4. **Temperature Control:** Ensure that the root zone temperature is within the optimal range for the specific crop. Root zone heating or cooling may be necessary.
5. **Plant Health Monitoring:** Keep a close eye on plant health and look for signs of nutrient deficiencies, pests, or diseases. Address any issues promptly.
6. **Reservoir Management:** Regularly clean and sanitize the nutrient reservoir to prevent the build-up of salts and contaminants.
7. **Proper Training:** Ensure that operators and growers are adequately trained in the operation of Dutch Bucket systems and hydroponic crop management.

Conclusion

Dutch Bucket technology is a key component of protected cultivation, offering efficient soilless cultivation of high value crops. It employs individual containers filled with materials like clay balls, providing stability and aeration. Drip irrigation delivers water and nutrients to plant roots, with excess solution being re-circulated. This technology offers opportunities for customization of nutrient recipes, along with monitoring of pH and EC levels. Maintenance, water quality, and sanitation is crucial. This system maximizes crop production, making it suitable for limited spaces, while maintaining high yields and quality produce.

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