

Assessment of the Feasibility and Sustainability of Vertical Farming in Compact Urban Spaces

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INTRODUCTION

Urban space limitations and the need for sustainable food systems have highlighted vertical farming as a promising alternative to traditional horizontal cultivation. This study compares both systems using parsley (*Petroselinum crispum*) and butterhead lettuce (*Lactuca sativa*) grown in a controlled environment. Growth rate, leaf pigmentation, and water-use efficiency were measured to assess productivity and sustainability, with results suggesting significant advantages in vertical setups for urban agricultural applications.

OBJECTIVES

To evaluate the technical and environmental feasibility of vertical farming in space-constrained environments.
To compare vertical and horizontal farming systems in terms of plant growth rate and water-use efficiency.
To promote the incorporation of plants into human diets, encouraging healthier and more sustainable eating habits.

MATERIALS

Empty milk cartons
Inverted graduated tubes
Ruler
Substrate
Certified seeds
Artificial light (horticultural LED)
Precision balance
Camera / Mobile phone
Auxiliary containers (e.g. seed trays)
Data analysis software (Excel)



Between October and December, various horticultural species were sown in germination trays with commercial substrate and grown under controlled conditions. After initial growth, *Lactuca sativa* and *Petroselinum crispum* were selected. Seedlings were transplanted into halved 1L milk cartons filled with equal substrate mass. Weekly irrigation, growth monitoring, and photographic documentation were performed. Inverted graduated tubes measured water uptake. All containers were exposed to uniform sunlight. Seedlings with similar development stages were used to minimise variability. Data were collected according to defined parameters, organised in Excel®, and prepared for subsequent statistical analysis.

METHODS



Figure 1 Photographs of the experimental sowings carried out between October and December, as part of the first phase of the investigation, involving various plant species.

Figure 2 Photographic record of the weekly plant measurement and system watering process carried out during the experimental period.



Data	Plant Height (cm)	Changes in leaf colour	Water Consumption (mL/week)	Observations
12/02/2025	2,1	Light green	120	Germination started
19/02/2025	4,5	Light green	110	Steady growth
26/02/2025	7,2	Green	115	Leaves widened
05/03/2025	9,8	Deep green	130	Good light exposure
12/03/2025	12,0	Deep green	125	Consistent development
19/03/2025	14,5	Deep green	130	Height stabilised
26/03/2025	15,2	Green	120	First leaves harvested
02/04/2025	15,5	Green	115	System maintenance
09/04/2025	15,7	Slightly pale green	110	End of harvest cycle

Figure 4 Table displaying the experimental results of *Lactuca sativa*. Data presented in the table were collected during the investigation to assess the performance of the plants within the vertical growing system.

RESULTS

Data presented in the table were collected during the investigation to assess the performance of the plants within the growing systems

Data	Plant Height (cm)	Changes in leaf colour	Water Consumption (mL/week)	Observations	Data	Plant Height (cm)	Changes in leaf colour	Water Consumption (mL/week)	Observations	Data	Plant Height (cm)	Changes in leaf colour	Water Consumption (mL/week)	Observations
12/02/2025	1,8	Light green	140	Initial germination	12/02/2025	1,5	Light green	110	Recent germination	12/02/2025	1,5	Light green	110	Recent germination
19/02/2025	3,9	Light green	135	Slow growth	19/02/2025	3,2	Yellowish green	120	Slow growth	19/02/2025	3,2	Yellowish green	120	Slow growth
26/02/2025	6,5	Yellowish green	130	Reduced sunlight exposure	26/02/2025	5,0	Light green	125	Plants still young	26/02/2025	5,0	Light green	125	Plants still young
05/03/2025	8,2	Green	145	Improved ventilation	05/03/2025	7,1	Green	130	Increased leaf density	05/03/2025	7,1	Green	130	Increased leaf density
12/03/2025	10,5	Deep green	150	More uniform growth	12/03/2025	10,8	Deep green	120	Potential for partial harvesting	12/03/2025	9,3	Green	130	More robust leaves
19/03/2025	12,1	Deep green	150	Good substrate adaptation	19/03/2025	11,0	Deep green	135	Good response to irrigation	19/03/2025	11,0	Deep green	135	Good response to irrigation
26/03/2025	13,0	Green	140	First leaves harvested	26/03/2025	12,4	Deep green	130	Possible start of partial harvest	26/03/2025	12,4	Deep green	130	Possible start of partial harvest
02/04/2025	13,3	Slightly pale green	135	Irrigation system adjusted	02/04/2025	13,1	Green	125	Regular maintenance	02/04/2025	13,1	Green	125	Regular maintenance
09/04/2025	13,5	Pale green	130	Signs of substrate depletion	09/04/2025	14,5	Slightly pale green	105	Plants ready for full harvest	09/04/2025	13,5	Slightly pale green	120	Reduced growth rate

Figure 5 Table displaying the experimental results of Butterhead lettuce (*Lactuca sativa*) grown in a horizontal system.

Figure 6 Table displaying the experimental results of Parsley (*Petroselinum crispum*) grown in a vertical system

Figure 7 Table displaying the experimental results of Parsley (*Petroselinum crispum*) grown in a horizontal system

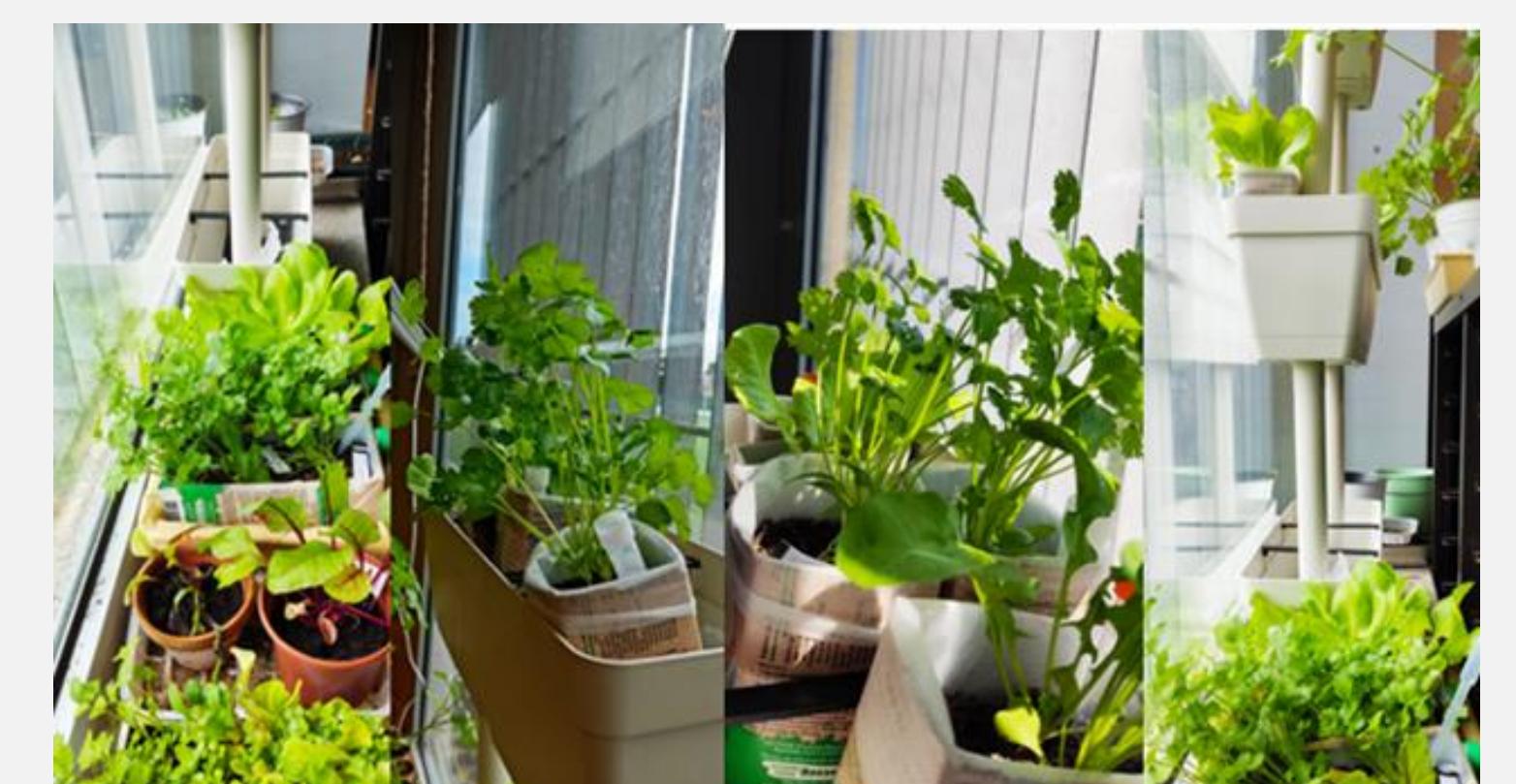
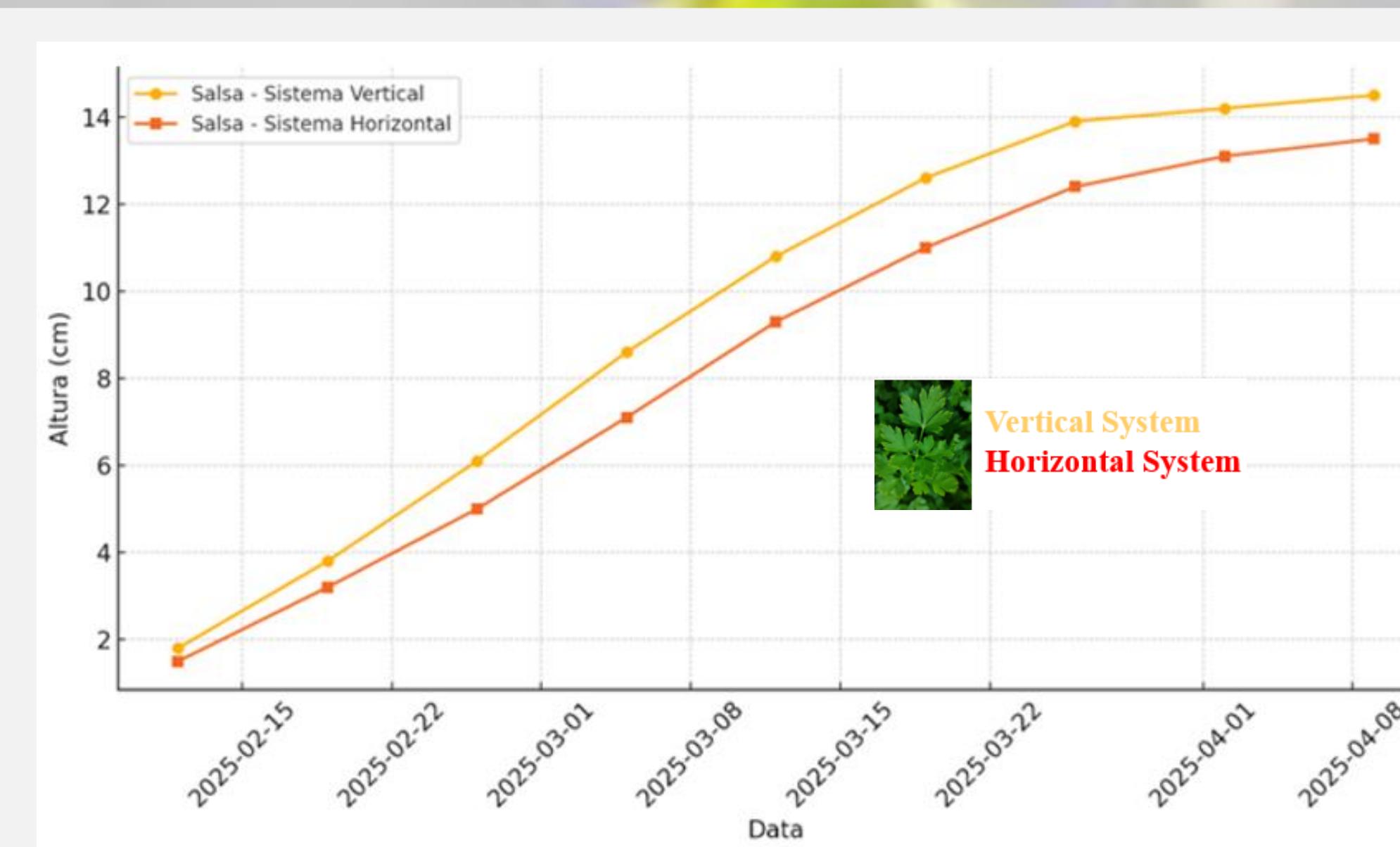


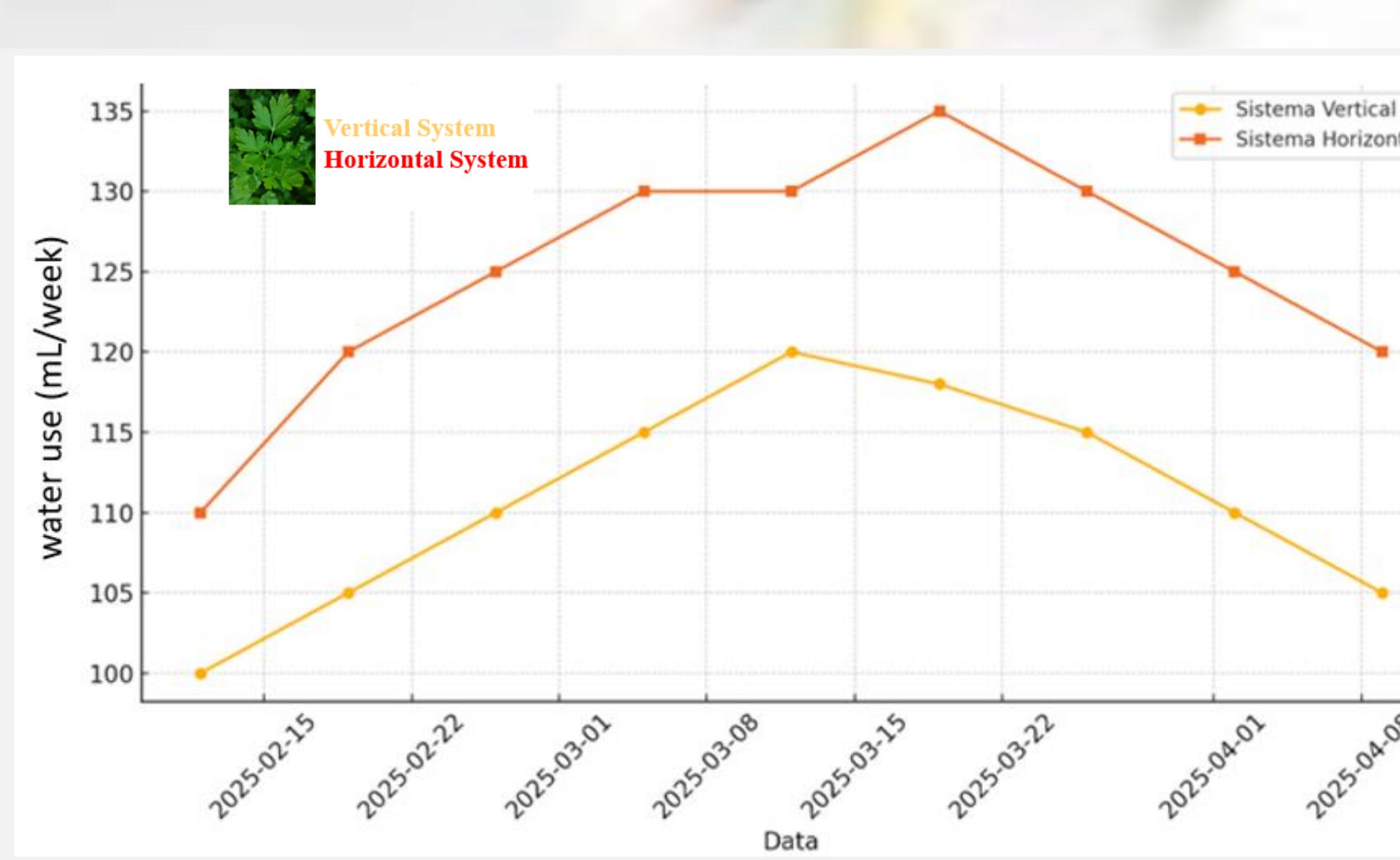
Figure 8 Photographs depicting plant growth at the conclusion of the investigation in both cultivation systems.



Graph 1, which compares the growth rate (cm/week) of parsley (*Petroselinum crispum*) in the vertical and horizontal systems.



Graph 2, which compares the growth rate (cm/week) of butterhead lettuce (*Lactuca sativa*) in the vertical and horizontal systems.



Graph 3, which shows the comparison of water use (mL/week) of parsley (*Petroselinum crispum*) between the vertical and horizontal systems.



Graph 4, which compares the water use (mL/week) of butterhead lettuce (*Lactuca sativa*) between the vertical and horizontal systems.

DISCUSSION

In the vertical system, water consumption was slightly lower and average plant height higher, consistent with the theoretical benefits described by Despommier (2010).

The results reveal statistically significant differences between systems, with a clear advantage for the vertical setup, particularly in water-use efficiency.

This system outperformed across all parameters: greater growth, lower consumption per unit, larger leaves, more intense coloration (suggesting higher chlorophyll content), and greater total length, indicating more favourable conditions for vegetative development.

CONCLUSIONS

The investigation demonstrated that vertical farming is a viable and sustainable solution for plant production in limited spaces. The results highlight significant advantages over horizontal cultivation, particularly in terms of water-use efficiency and productivity.

It is therefore recommended that educational programmes and financial incentives be developed to support citizens who wish to integrate vertical agriculture into their urban living spaces.

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