Optimizing Microgreen Cultivation for Urban Vertical Farming Systems

How can controlled environmental conditions optimize microgreen yield and quality?

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Introduction

- Controlled Environmental Agriculture (CEA) is the science of cultivating crops indoors in an enclosed environment under artificial lighting and controlled atmospheric conditions.
- CEA is reliant on technology to monitor and control abiotic growth factors using networked sensors. These values can be used to precisely control these setpoints to achieve consistent germination, minimize disease, and maximize crop yield.
- While CEA is well-studied for traditional crops, research on microgreens is limited. There is potential to explore how manipulating environmental variables—such as light, temperature, humidity, and CO2— can ultimately improve growth and nutritional content in vertical farming systems.

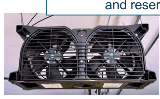
Objective

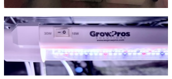
- Evaluate the feasibility of using CEA methods in an urban microgreen farm at Cal Poly Pomona.
- Assess how environmental conditions (humidity, air circulation, light) impact microgreen yield and quality.

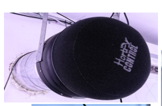
Materials and Methods

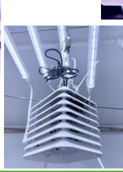
- **Experimental Setup:** Shipping container modified for hydroponic microgreen cultivation.
- **Environmental Controls:** Sensor, LED lights, ventilation, CO_2 injection and filter, dehumidifier, reversed osmosis watering system, air conditioner, exhaust, and NPK 17-5-10 fertilizer.
- **Growth Conditions Tested:** Light intensity, humidity, airflow, heat mats, seed density.
- **Data Collection:** Yield measurements, mold assessment, growth rate tracking.

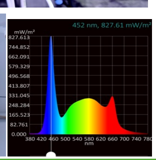
Growing racks with flooding tables, LED lights, heat mats, and reservoir.











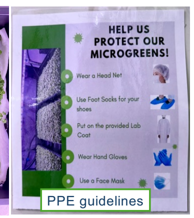
Results

Light spectrometer reading,

35 gr Micro Radish at Day 8

Harvest: micro basil, micro kale, and confetti mix clamshells.

60 gr Micro Basil at Day 14



PPE guidelines

35 gr Micro Confetti Mix at Day 10

40 gr Micro Mustard at Day 13

- The **seed density** per tray was kept between 35-50gr depending on their size, higher count for smaller seeds. On average, the **final yield per tray** was two 4oz clamshells of microgreens, allowing the seedlings to grow their first true leaves, with the cotyledons still attached. The average height was between 1–2". It was discovered that radish and kale are the fastest growing crops with the highest yields; basil and mustard are the slowest growing crops, prone to mold and uneven growth. For the Confetti mix, the average yield was about 1.5 clamshells per tray, and the germination was uneven.
- **Various treatments, including seed priming, density, layout, watering schedules, and nutrient supplementation, were implemented to assess their effects on germination, growth, and yield:** it was discovered that simulating the conditions a seed would normally experience when sowed in soil increase the germination rate and evenness. This was accomplished by placing a tray over the seeds that were sowed on the bamboo sheets (to simulate pressure), leaving them in the dark, applying an even mist of water on top, and providing constant heat using heat mats under the flooding tables. The overhead tray is removed once the seeds start sprouting and they are exposed to the LED lights, and regular bottom watering schedules are followed.
- Results revealed that **stable temperatures** (20–25°C), **optimal light intensity** (200–300 µmol/m²/s), and **moderate humidity levels** (50–60%) significantly improved growth and minimized mold development. Conversely, overcrowded trays, overwatering, and excessive humidity (above 80%) led to reduced yields and wilting.

Final yield of kale after 14 days, showcasing PPE and sanitation practices

Discussion

- Since the target of the project is to be able to grow several commercial cash crops, the variability in seed mixes needs to be accounted for, and more testing is required. The more iteration and approaches texted, the higher quality data generated for successfully establishing resource-efficient protocols for microgreen cultivation that can be applied as production strategies for CEA to achieve the highest yield and profit.
- ×Because microgreens are planted in high density environments, they are prone to diseases like mold and damping off, as well as uneven germination or unsuccessful rooting. Although sanitization guidelines and air flow were maintained, some crops were lost. Further research in better ventilation equipment could help reduce the incidence of disease.
- Due to inconsistent performance and low yields from commercially available seed mixes, we aim to explore developing our own custom mixes with a better understanding of nutrient requirements, germination and growth rates.

Mold on a confetti mix tray

Summary and Conclusions

- Microgreens grown in the CEA facility demonstrated strong potential as a sustainable, resource-efficient crop with the ability for year-round production.
- Enforcing PPE requirements and upholding food-grade standards will allow the project to increase the offerings of microgreen blends and potential vendors/partners.
- Establishing a strict cleaning and sanitizing protocol of all tools and equipment is paramount to minimize the risk of contamination and crop loss.
- Achieving an even distribution of the seeds on the growing media, as well as constant moisture using a spray bottle has offered the greatest results.
- Consistent monitoring of slow-growing varieties, as well as continued iteration and experimentation, could reduce the potential for disease and crop loss.
- Exploring seed treatments such as the under-the-ground simulation trial when using soilless media has provided the fastest germination rate thus far.

Future Work

- Explore alternative growing substrates (e.g., coconut coir vs. peat moss).
- Test the effects of automated humidity control on mold prevention.
- Explore alternatives such as installing fans closer or directly on the growing racks and investing on better ventilation equipment could help reduce the incidence of mold on the microgreens.
- Develop our own CPP seed mixes could bring potential new customers and offer more data for future research.
- Investigate how light spectrum variations impact microgreen development.

Selected References

Acknowledgements

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