University of California, Davis 2021 Station Report NCERA-101: Committee on Controlled Environment Technology & Use

Reporting Period: November 2020-September 2021

Md Shamim Ahamed, Department of Biological and Agricultural Engineering, UC Davis. Email: mahamed@ucdavis.edu

Jackson Gross, Cooperative Extension Aquaculture Specialist, Department of Animal Science, UC Davis, email: jagross@ucdavis.edu

New Equipment and Facilities

The college of agricultural and environmental sciences (CAES) at the University of California, Davis (UC Davis), has 162 greenhouses facilities with about 155,00 sq. ft of spaces. A new shipping container-type facility has recently been added for teaching and research. The controlled environment engineering lab for plants and animals (CELPA) is currently working with the vendor to add a walk-in type indoor vertical farming facility to study the energy use efficiency for indoor growing spaces. CELPA is also working on designing a lab-scale autonomous vertical aquaponic growing system. This research facility would study the energy efficiency aspects and life-cycle assessment of vertical aquaponic systems for indoor application.

Accomplishment Summaries

The following are the summary of the accomplishments related to the research in controlled environment agriculture (CEA) at UC Davis:

- A new research laboratory named Controlled Environment Engineering Lab for Plants and Animals (CELPA) was initiated at UC Davis for studying the energy-efficient design and optimization and integration of renewable energy for the operation of HVAC systems for CEA.
- The senior undergraduate students work on the energy-efficient greenhouse shape and orientation design for three different locations (Bridgeport, Santa Rosa, Imperial) in California. The study used the GREENHEAT model with the integration of a ventilation sub-model to analyze the heating and cooling costs for six different greenhouse shapes and the orientation at 15° intervals. The results indicate the quonset shape is more energy efficient for the freestanding greenhouses, but the modified arch shape is energy efficient for the gutter-connected multi-span option for all three selected study locations. The lab also collaborates with experts in CEA to review the opportunities for implementing solar energy technologies in agricultural greenhouses. We also

analyzed the heating cost for Chinese-style solar greenhouses in cold regions and their energy efficiency compared with conventional greenhouses.

- A new course named Controlled Environment for Plants and Animal was offered for the first time in fall 2021 at UC Davis.
- We are currently participating in the third urban greenhouse competition, and the autonomous greenhouse challenges 3rd edition. These two competitions are organized by the University of Wageningen from the Netherlands.

Impact Statement

Energy requirements for a greenhouse with different shapes and orientations could be significantly different depending on the location. A recent study from CELPA shows that the energy demand for the uneven span is about 18.5% higher than the quonset shape greenhouse in California. The energy demand for the even span shape and modified arch shapes is about 16% and 11.0% higher than the quonset shape, but no significant effect for changing the orientation. Regarding location, the total energy demand in Imperial (hot) is about 1.5 times higher than the greenhouse located in Bridgeport (relatively cold).

Dr. Gross lab at UC Davis produced 3 YouTube videos on Aquaponic plant production: What is the difference between coupled and decoupled aquaponics https://youtu.be/JkeMIQXRLis, Aquaponics USDA Speciality Crops https://youtu.be/_iZ0YmMLVbY, Top Aquaponic Systems, and Hydroponics https://youtu.be/xrpHNurpVIw

Published written works (arrange alphabetically)

Refereed Journal Articles

1) Ahamed, M. S.; Guo, H.; and Tanino, K. (2021). Cloud cover-based solar radiation models: A review and case study. Submitted to the International Journal of Green Energy. `
2) Dong, S.; Ahamed, M. S.; Ma, C., Guo, H. (2021). A time-dependent model for predicting thermal environment of mono-slope solar greenhouses in cold regions. Energies, 14(18),5956.
3) Gorjian, S., Calise, F., Kant, K., Ahamed, M. S., Copertaro, B., Najafi, G., ... & Shamshiri, R. R. (2020). A review on opportunities for implementation of solar energy technologies in agricultural greenhouses. Journal of Cleaner Production, 124807.

Symposium Proceedings and Oral Presentation

1. Gracely, B. Josifek, H.; Tarver, K.; Ahamed, M. S. (2021). Effect of Shape and Orientation on the Thermal Performance of Greenhouses in the Western USA. In: American Society of Agricultural and Biological Engineers (ASABE) Annual International Meeting 2021 (Virtual).
2. Gross JA and Victor Fernández-Cabanás (2021). Aquaponics: Growing Vertical, Presented at the Annual Aquaponics Association Conference (Virtual)