RETASTE Conference Abstracts
Vol. 3 RETASTE-RAC-537-Poster
Athens, Greece, 27-29 September, 2023

rethink food resources, losses, and waste 2023 retaste

Controlled Environment Agriculture: Innovations, Challenges, and Directions for a Sustainable and Circular Future

Jan Skvaril and Monica Odlare

Future Energy Center, School of Business, Society and Engineering, Mälardalen University, 721 23, Västerås, Sweden

Abstract

This study focuses on the rapidly growing field of controlled environment agriculture (CEA), a modern and technology-driven approach that typically uses artificial lighting, climate control and soilless cultivation in fully enclosed structures such as greenhouses and plant factories. CEA allows for continuous crop production throughout the year and is resilient to climatic extremes and disease risks. CEA represents a dynamic intersection of various disciplines, including plant science, data science, automation, artificial intelligence, robotics, logistics, architecture and elements of the circular economy. Such an interdisciplinary environment boost innovation and development and pushes the boundaries of traditional agriculture. From a sustainability and circular economy perspective, CEA systems are characterised by high efficiency in the use of resources, especially water. Compared to traditional farming methods, they also rely significantly less on the use of chemicals. Despite the promising opportunities CEA, there are many challenges, such as substantial investment costs combined with high energy consumption, which represent economic hurdles that need to be overcome. The relatively high energy demand requires targeted development and innovation to improve energy efficiency and further strengthen the sustainability and circularity of CEA systems. CEA offers significant advantages in regions where traditional farming methods face difficulties due to environmental or logistical constraints. It provides a viable alternative for consistent food production, enabling communities to address food insecurity and support local economies. Furthermore, the selection of crops for CEA is determined by several factors, including market value, shelf-life, growth density, light utilization efficiency for photosynthesis and suitability for automation. Several plants have been identified as particularly suitable for the controlled environment conditions. Future CEA research efforts should focus primarily on reducing energy consumption and optimising light distribution. Special attention should be paid to improving the efficiency of LED light sources and refining the precision of climate control systems. Moreover, the development of sophisticated plant sensors and further advances in automation and robotics will play an important role. From a plant science perspective, there is an urgent need to deepen our understanding of plant responses to various environmental factors.

Optimal control of these factors can then help to increase both yield and quality further. In addition to technical improvements, effective public engagement and policy reforms are also crucial. These initiatives are key to integrating CEA into urban planning, global supply chains, local and global regulatory frameworks and the wider circular economy. These efforts will help strengthen public support for CEA and establish it as an important component of future agriculture.

Although CEA does not aim to replace traditional agriculture in the near future completely, it is capable of playing an important role in the broader framework of agriculture. With escalating environmental problems and the urgent need to secure food supplies, CEA is proving to be an innovative and effective solution. Developing and applying CEA will play a crucial role in shaping the future of global agriculture as we address the complex challenges of the 21st century.

Keywords: Controlled Environment Agriculture (CEA), Interdisciplinary innovation, Sustainability and circularity, Energy efficiency, Crop selection, Yield optimization, Public engagement and policy, Future research

Acknowledgments: This work is supported by Richertska stiftelsen and Sweco under project Aqua2Farm - Boosting sustainable urban farming by near-infrared spectroscopy with aquaphotomics and by Vinnova under project Trace4Value - Traceability for sustainable value chain: Nutrient reuse and food production in circularity