Abstract

of a Doctoral Dissertation titled

“The application and contribution of innovative semi-transparent photovoltaics in the field of greenhouse systems”

This dissertation investigates the application and contribution of innovative semi-transparent photovoltaics in greenhouse systems, a promising solution to address the dual challenge of food and energy production.

The study begins by addressing the critical balance between the demands qualitative and quantitative food production and the need for effective energy management in greenhouse environments. To this end, a Multilayer Perceptron Neural Network is proposed to accurately model temperature and relative humidity within the greenhouse, achieving maximum errors of 0,877 K and 2,838 %, respectively, with a coefficient of determination of 0.999 for both parameters. The high accuracy offered by this model allows a decision support system to effectively control the conditions within a greenhouse.

The integration of photovoltaic modules into greenhouse roofs is an innovative solution to the high energy costs of production. However, the shading effect of these modules can affect crop growth, necessitating a detailed analysis of the shading dynamics. Considering this, an algorithm is developed to calculate the shading caused by photovoltaic modules based on sun’s position and the geometry of the greenhouse/photovoltaic system. This algorithm is validated using the coefficient of variation for the difference between external and internal radiation.

Furthermore, this research presents the improvements and modifications to the above algorithm for determining the shading from the solar cells of semi-transparent photovoltaics and studying the radiation passing through the modules. The findings demonstrate significant reductions in Global Horizontal Irradiance and Photosynthetically Active Radiation, by approximately 52 % and 60 %, respectively.

The study also examines the effects of shading from semi-transparent photovoltaics on strawberry cultivation (Fragaria × ananassa Duch.), revealing that while unshaded plants exhibited greater growth, shading improved certain fruit quality characteristics, such as total phenolic content and antioxidant capacity. This research highlights the potential of semi-transparent photovoltaics to harmonize energy production with agricultural production, highlighting their role in sustainable greenhouse systems.

Overall, the findings contribute valuable insights for optimizing agrivoltaics in greenhouses for photovoltaic designers and greenhouse managers, promoting innovative strategies for food and energy sustainability in the face of increasing global demands.