Local optimization of thermal storage for greenhouses: reduction of energy input and improvement of greenhouse climate

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Keywords: heat buffer, mild winter regions, extreme temperatures

Abstract

Greenhouses have a year-round energy surplus even at the latitude of Holland (52º). In temperate regions, such as the Mediterranean basin, there is a diurnal excess of energy nearly every day of the year, which is usually dissipated through natural ventilation. However, since suboptimal nighttime temperatures limit productivity of unheated greenhouses for several months a year, extracting the daytime excess energy and reusing it to heat the greenhouse during the night would increase productivity, or reduce energy consumption of the greenhouses that are heated. This would have the additional advantage of reducing ventilation requirement thereby reducing pest pressure and increasing the scope for carbon dioxide fertilization. To achieve this, the performance of the greenhouse as a solar collector has to be maximized by efficient heat exchanging and heat buffering systems. The aim of this research was to define the optimum combination of capacity and heat exchange rate of a diurnal heat storage buffer in a commercial greenhouse in the Mediterranean region (Sicily, Italy, 37 ºN), the cost function being represented by the dose (duration × intensity) of extreme temperature events (both too cold and too hot). The greenhouse temperature was calculated through a previously validated greenhouse climate simulation model, applied to one-year of real local data. The effect of the buffer on the cost-function was then calculated for each node of a pre-selected grid of the two defining parameters of the buffer. In this paper we analyze the trend of the cost function with respect to each parameter of the buffer and how this is affected by the preset tolerance of extreme temperatures. Finally we discuss a simple method to find an "optimal" configuration of the buffer.