INTELLIGENT GREENHOUSE DESIGN DECREASES WATER USE FOR EVAPORATIVE COOLING IN ARID REGIONS

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ABSTRACT

Production of fresh vegetables for consumption in arid regions usually takes place in greenhouses with evaporative cooling, mainly during the warm months of the year. In this period, water use for cooling noticeably exceeds irrigation water use in normal climate conditions. The purpose of this paper is to investigate how far water use for evaporative cooling can be lowered by adapting design elements of the greenhouse and the evaporative cooling system. In a greenhouse trial in a desert environment, in Riyadh (Saudi Arabia), two different greenhouses: one traditional and one modified, both equipped with a pad and fan system, have been compared in terms of productivity and water use; with special focus on water use for cooling. The modified greenhouse design resulted in about 14% higher in fresh production weight. As well, more than 40% water saving was achieved on evaporative cooling. The climate and water use data recorded during the trial were used to validate a greenhouse climate simulation model, including pad and fan cooling. Then, we used the validated model in a scenario study and we quantified the effect of each one of three design elements on use of cooling water. It was shown that the extracted air temperature had a major influence on water use for cooling. Increasing the extracted air temperature with 4 K resulted in about 27% saving in water use for cooling. The latter was done by repositioning the exhaust fans in order to take advantage of the vertical air temperature gradient in the greenhouse. Additionally, a 5 % higher cooling efficiency of the pad wall could yield an extra 12% water saving for evaporative cooling. Finally, the greenhouse cover-to-ground area ratio was also found to affect the water use for cooling.

In brief, the project has shown that there is much scope for saving water use for evaporative cooling by improving design of both greenhouses and the cooling system, and that a good greenhouse climate model would be a useful tool in this process. The findings of the current research provide clear guidelines for the construction of more water-efficient evaporatively cooled greenhouses.

KEYWORDS: Evaporative Cooling, Water Use Efficiency, Greenhouse Design, Pad and Fan, Water Saving, Greenhouse Climate Simulation.