The Effect of the Screen on the Mass, Momentum, and Energy Exchange Rates of a Uniform Crop Situated in an Extensive Screenhouse

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The area of crops cultivated in extensive screenhouses is rapidly growing, especially in semi-arid and arid regions. Water vapour, carbon dioxide, and sensible heat released or taken up by crops within such protected environments can substantially alter the immediate micro-environment, which in turn, affects these fluxes. This amplified interaction between plants and their microclimate challenges simple assessments on how partially covering the crop by a screen modifies plant water uptake and photosynthesis. Via a newly proposed higher-order closure model, the effects of a screen on the mean flow field, turbulent stresses, radiative and energy fluxes, as well as scalar sources, sinks, fluxes, and mean scalar concentration within screenhouses are explored. As a starting point, an extensive screenhouse is assumed thereby reducing the sensitivity of the model results to the precise geometric configuration of the screenhouse. The model findings for the screenhouse are presented and referenced against their open field counterpart. The radiation modulation and changes to turbulent transport due to the presence of the screen are investigated. In general, the presence of a screen results in a warmer and more humid environment inside the screenhouse, promoting reductions in both canopy photosynthesis and transpiration. However, the overall effect of the screen is to enhance water-use efficiency thereby resulting in water savings for the same amount of gross primary production.