Airflow, Turbulence and Evapotranspiration in a Banana Screenhouse

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Shading banana and other orchard crops with screens is increasing in popularity due to decreased water use, improved fruit quality and other reasons. This study focused on airflow, turbulence, and energy balance in a large commercial flat-roof banana screenhouse in northern Israel. House dimensions were 352 × 228 × 6 m high with average plant height 4.2 m. Measurements were made during 14 days. Screens were of clear 0.3 mm diameter polyethylene monofilaments, and screen solidity was approximately 15%. An eddy covariance system, consisting of a one dimensional sonic anemometer, a fine-wire thermocouple and a Krypton hygrometer, was deployed at 5 m height, in a location allowing a minimum fetch of 100 m in all directions. Net radiation, soil heat flux and storage, soil evaporation, air temperature and humidity and turbulent airflow characteristics were also measured. Comparison between wind speed inside and outside of the screenhouse suggests that the logarithmic wind profile model is approximately valid within the screenhouse. Airflow direction inside the screenhouse was usually the same as that of the external wind. With increasing external wind speed, the azimuth difference between inside and outside decreased. Friction velocity scaled with the mean horizontal wind speed inside the screenhouse. Integral length scale calculations showed that eddies were always narrow and long and high air velocities caused eddies to become even narrower, as expected. Average turbulence intensity within the screenhouse for all data was 0.49±0.12 (± standard deviation). Spectral energy density depended on frequency to the power of about -5/3, typical of the inertial sublayer in turbulent boundary layers. Results suggest that the flow above the canopy top (within the screenhouse) resembles that of a surface layer rather than a mixing layer as would have been anticipated according to the mixing layer analogy for roughness sublayers in canopy flows. This may be due to the effect of the screen deployed above the canopy. Evapotranspiration measured by the eddy covariance technique averaged 5.6 ± 0.47 mm day^{-1}, which is compatible with the 7-8 mm day^{-1} irrigation. Analysis of energy balance closure resulted in a slope of 0.94 and an intercept of 2.4 Wm^{-2}. We conclude that the eddy covariance technique is appropriate for measurement of evapotranspiration in this type of structures.