A COMPUTATIONAL FLUID DYNAMICS STUDY OF NATURAL VENTILATION IN ARID REGION GREENHOUSES

By

Ibrahim M. Al-helal, Ph.D.

The Ohio State University, 1998

Professor Ted H. Short, Adviser

A computational fluid dynamics (CFD) model was used to study natural ventilation in arid region greenhouses. Airflow, temperature and moisture distributions for naturally and fan-ventilated greenhouses, and greenhouses cooled by evaporative systems were simulated numerically and graphically. Predicted effects of inside and outside shade systems, and plant transpiration on inside conditions and ventilation rates were studied.

The CFD model results were compared with energy balance and mass balance models. Also, the CFD model was tested against experimental measurements. Measured and simulated results indicated that plants along with shade could reduce air temperature inside the greenhouse below outside air temperature, and increase inside relative humidity above outside relative humidity.

Wind speed had a strong and linear effect on predicted natural ventilation rates. The predicted maximum ventilation rates were found with the combined use of a side vent and roof vents for all wind speeds. The predicted minimum ventilation rates were obtained

when the windward side vent was closed. It was also found that as ventilation rate increased, predicted averages of inside air temperature increased and predicted averages of relative humidity decreased.

The inside shade screen had the same influence on predicted ventilation rates as outside shading for shading levels of 50%, 66%, 75%, 83%, and 87%. The inside shade screen also had the same effect on predicted inside air temperatures as outside shading for cases where the air entered the side vent and traveled up through the screen carrying the heat out the roof vents (Case #4 and #7). At low wind speeds, closing the side vent in Case #5 had the lowest predicted averages of inside air temperatures and highest predicted averages of relative humidity. At high wind speeds, reducing the side vent size in Case #4 by one third was the best design. It was predicted that an evaporative cooling system could be eliminated when shading level and predicted inside design temperature were 50% and 42ºC, 60 % and 37.1ºC, and 70% and 36.5ºC, respectively.