Web site: http://aesop.rutgers.edu/~horteng

CCEA Newsletter

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CCEA is a research organization dedicated to the improvement and vitality of the Controlled Environment Agriculture Industry. CCEA is funded by Industrial and Grower Partners who contribute a yearly partnership fee. Satellite partnership is also available to growers. Information about **CCEA** is available from:

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C C E A

Vision Statement
CCEA, The Center for Controlled Environment Agriculture of NJAES of Rutgers University, a partnership among growers, industry, and researchers, will devote itself to research and transferring information required for an economically viable and environmentally aware controlled environment agriculture industry. We will particularly strive to identify future trends, critical issues, appropriate emerging technologies and provide leadership for opportunities which challenge world-wide controlled environment agriculture in the 21st century.

Dr. David Fleisher joins Bioresource Engineering

Dr. David Fleisher will officially join the faculty of Bioresource Engineering on September 1, 2001. Dr. Fleisher completed his Ph.D. dissertation in early July under the direction of Dr. K.C. Ting. David's dissertation is titled "Modeling for multiple crop production and control in advanced life support systems". His work was part of the NJ-NSCORT project, which was funded by a five-year grant from NASA. David also received a prestigious NASA Graduate Student Researchers Program Fellowship. David's appointment has a major teaching component, while his research will focus on instrumentation and sensor technology for greenhouse production. Welcome aboard David!

Dr. K.C. Ting inducted as ASAE Fellow

Dr. K.C. Ting (former chair and faculty member of Bioresource Engineering at Rutgers University and now chair of the Department of Food, Agricultural and Biological Engineering at Ohio State University) was inducted as an ASAE fellow at the annual international ASAE (society for engineering in agricultural, food, and biological systems) meeting in Sacramento, CA. Among Dr. Ting's many contributions to our profession are his dedication to teaching and mentoring, technical writing, and international collaborations. Congratulations to Dr. K.C. Ting!

Blue Ribbon Award

The Horticultural Engineering Web site (for the correct address see the top of this page) received a Blue Ribbon Award in this year's ASAE Educational Aids Competition in the category Web Pages.

Department Name Change

As you recall, Bioresource Engineering was merged with the Plant Science Department on July 1, 2000. This Spring, the Plant Science Department was merged with the Plant Pathology Department and a new name was selected for this newly formed department: **Department of Plant Biology and Pathology**. Professor William Meyer (research interests: turfgrass breeding and disease resistant germplasm) was elected to serve as interim chair for the period of one year (starting July 1, 2001).

Continuation of the article by Eugene Reiss et al., from the CCEA Newsletter Volume 10 No. 3, July 2001.

Preliminary results

Shortly after the re-glazing of the greenhouse sidewalls was completed, measurements of the greenhouse and outside environment conditions were collected over a period of approximately 2.5 months (April 2–June 19, 2001, with the exception of some data on June 6). The environment control system recorded 15-minute averages of most relevant environment parameters. Figure 5 shows the daily light integrals, which were calculated from 15-minute averaged instantaneous light intensity readings. In addition to the daily inside and outside light integrals, the ratio of the daily light integrals is shown in Figure 5. Due to the fact that, usually around solar noon and during some time period of the day, the inside light sensor received direct sunlight (without passage through the glazing), this ratio cannot be defined as the greenhouse light transmission.

Figure 6 shows the set point temperature during the data collection period: 18.3ºC or 65ºF. In addition, Figure 6 shows the average daytime greenhouse temperature (calculated from 15-minute average temperature readings and for the duration of the natural daylength). Finally, Figure 6 shows the average daytime roof opening (0% is fully closed, 100% is fully opened, i.e., in an almost vertical upright position). Note that the control system operated the position of the roof based on the temperature deviation from the temperature set point (18.3ºC or 65ºF), and to a lesser extend based on the outside temperature and solar radiation.

Figure 7 shows a correlation between the ratio of the inside and outside light integral and the average daytime roof opening. The calculated regression equation has an R^2 value of 0.60.

Figure 8 shows a "snapshot" of some of the greenhouse conditions (15-minute averages) during a 4-day period (June 15-June 18). The indoor (1.2 m or 4 ft above the floor) and outdoor (at the weather station) temperatures closely follow each other in the range from approximately 18 to 31ºC (65-88ºF). In addition, Figure 8 shows the roof position (0 is fully closed and 10 is fully opened), rainfall (in minutes per 15-minute time interval), and wind speed (in m s^{-1}). Significant time periods with rain were recorded during June 16 and 17, resulting in complete closure of the roof, and simultaneous opening of the side vents (data not shown). High wind speeds during the morning hours of June 16 also resulted in (some) roof closure. Cooler temperatures during the very early hours of June 18 caused the roof to be closed from a fully open position to approximately 60% open.

Figures 9, 10, 11, and 12 show 15-minute averages of inside and outside instantaneous light intensities (PAR) and their ratio. May 21 (Figure 9) was a very cloudy day with a low light integral (only 3.8 mol m^{-2} d^{-1} inside the greenhouse). The heavy cloud cover resulted in mostly diffuse radiation and a constant instantaneous PAR ratio of approximately 54%. June 8 (Figure 10) was a sunny day with few clouds. The large amount of direct radiation caused clear shadow patterns (from the greenhouse structure, e.g., the gutters) inside the greenhouse and resulted in large fluctuations of the inside instantaneous light intensity. Interestingly, the light intensity inside the greenhouse, during several time periods, was higher than the outside intensities. This is caused by light reflection off the fully opened roof segments. For the entire day, the result was that the ratio of inside and outside light intensity (PAR) fluctuated significantly (the average ratio was 71% with an inside light integral of 41.3 mol m^2 d^{-1}). On June 16 (Figure 11) the weather conditions were windy and cloudy, and the solar radiation was mostly diffuse. The light integral was 14.3 mol m^{-2} d^{-1}, with a particular dark period around solar noon (13:00 hr), and (partial) roof closing before and after solar noon due to high wind speeds and/or rain (Figure 8). Additional data were collected on July 3 (Figure 12), a day during which the roof was kept closed on purpose. Ventilation occurred by opening the side vents only. The light integral was 32.1 mol m^{-2} d^{-1}. Comparing Figures 8 and 12 shows the different greenhouse light conditions for a sunny day (with mostly direct radiation) when the roof is fully opened (June 8) and when the roof is fully closed (July 3).

On July 3, the average ratio of inside and outside light intensity (PAR) was 60% and it fluctuated significantly until later in the day, when cloud cover resulted in mostly diffuse solar radiation.

Discussion and conclusions

All results presented in this paper were collected from an empty greenhouse (without a crop). In addition, no greenhouse heating was required during any of the measurements conducted.

Although the data collected over the 2.5 month period are preliminary, they show that, on average, the greenhouse structure blocks a significant amount of light from reaching the crop despite the crop receiving several hours of unobstructed sunlight when the roof is opened. However, under (high) light conditions, the instantaneous light intensity can be higher inside the greenhouse compared to outside due to light reflection off the opened roof segments. Whether this additional light is useful for crop photosynthesis is questionable, especially when the crop already experiences light saturation conditions.

In order to evaluate the greenhouse light environment, the ratios of inside and outside light integral and instantaneous PAR intensity were calculated. The amount of roof opening was determined by the computer control system from the indoor temperature deviation from the set point (18.3ºC or 65ºF) and/or by rainfall or wind speed), and to a lesser extend determined by the outside temperature and solar radiation. On warm(er) and cloudy days, the greenhouse roof can be fully opened, while the solar radiation is mostly diffuse with a lower intensity (and integral). On such days, the PAR ratio is constant during the day, while on sunny days (with lots of direct solar radiation), the PAR ratio fluctuates considerably due to the shadow patterns created by the greenhouse structure. These different responses due to different light conditions make it more challenging to evaluate the light environment in an open-roof greenhouse. Ideally, these light data should be simultaneously collected in a conventional greenhouse design in order for a more meaningful comparison.

Future research will continue to investigate the benefits and potential drawbacks of open-roof greenhouses as well as floor heating systems in combination with ebb and flood floor irrigation.

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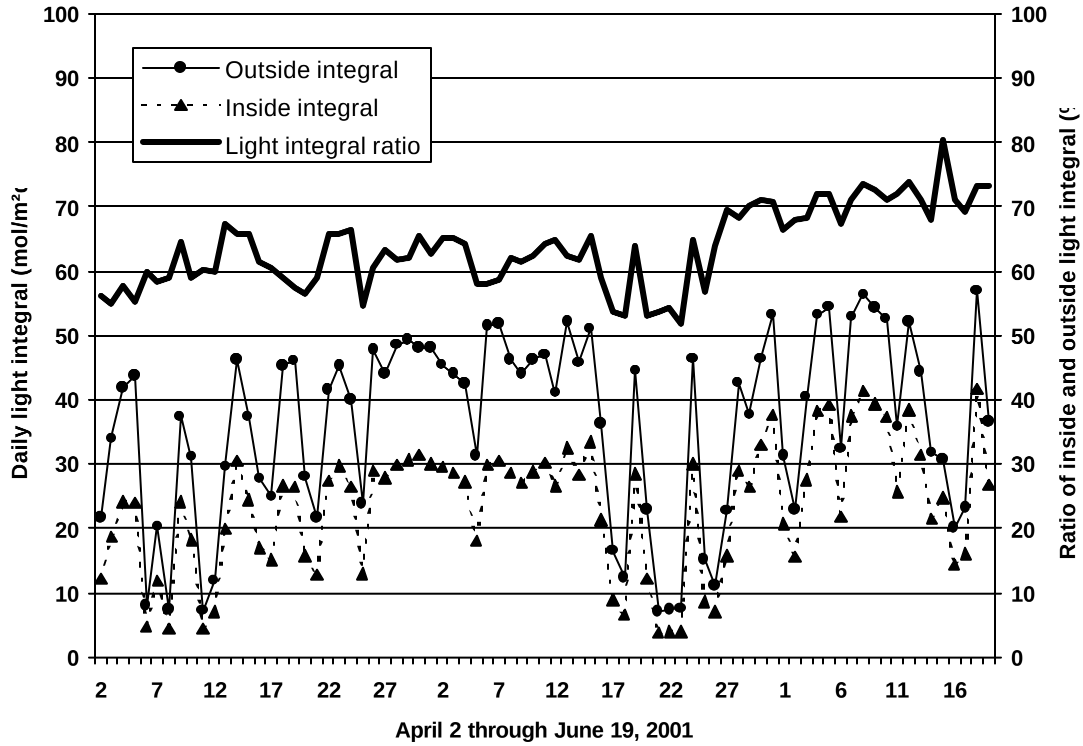

Figure 5. Daily inside and outside light integral and their ratio for a 2.5-month period.

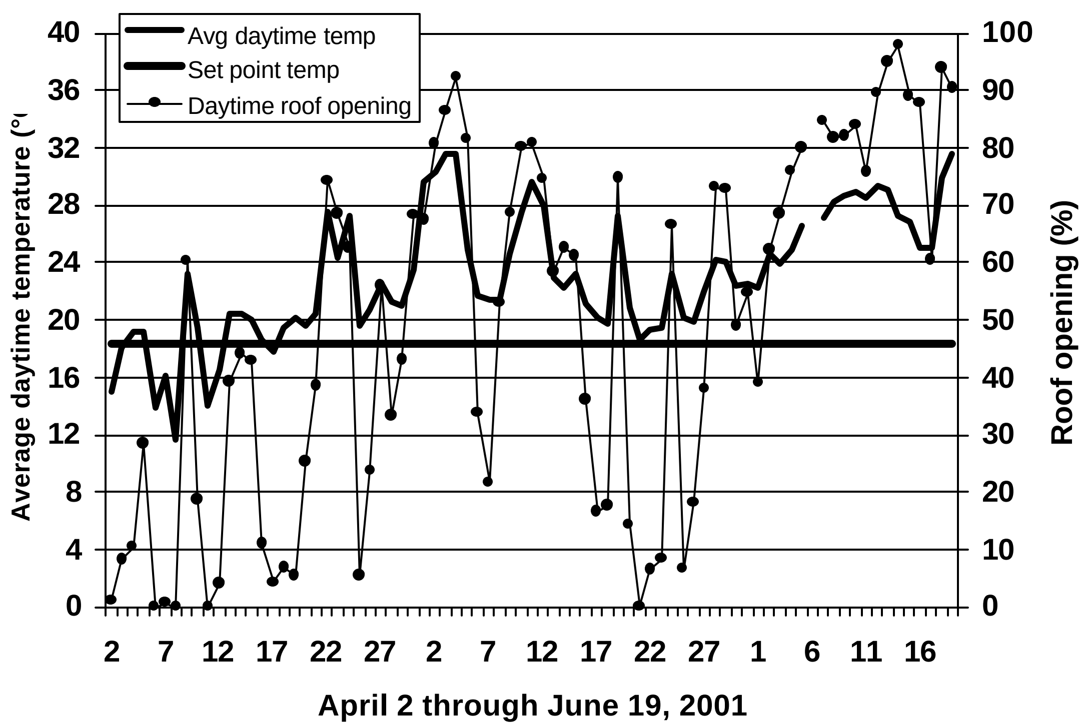

Figure 6. Average daytime temperature, temperature set point and roof opening for a 2.5-month period.

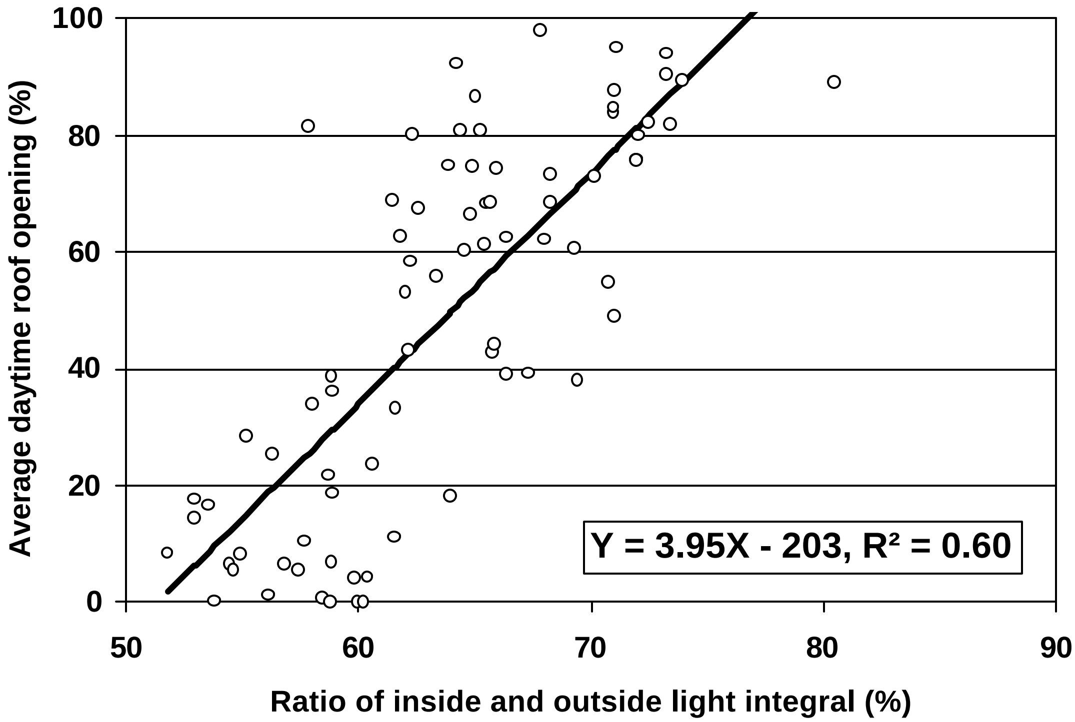

Figure 7. Correlation between the ratios of inside and outside light integrals and the average daytime roof opening.

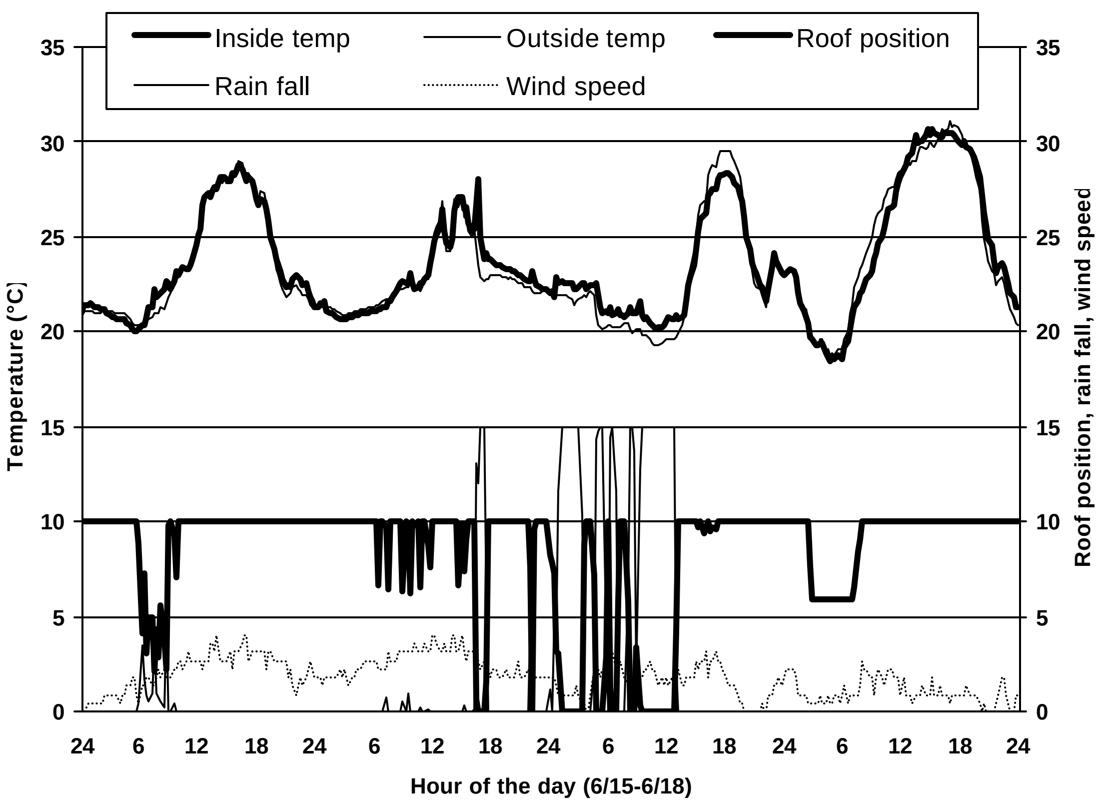

Figure 8. Inside and outside environment conditions for a 4-day measuring period.

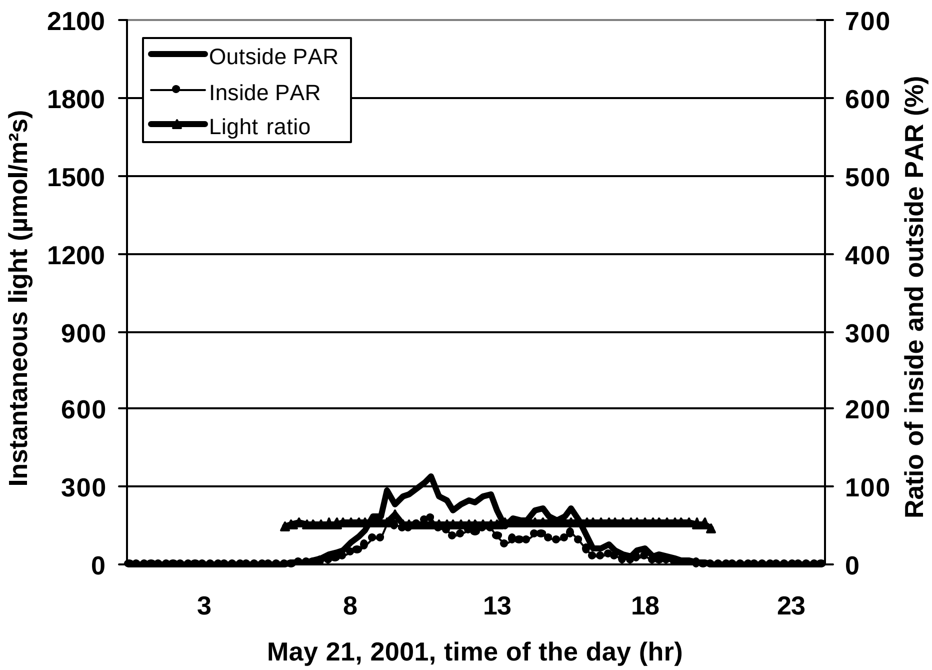

Figure 9. Instantaneous (15 minute averages) inside and outside light conditions and their ratios for May 21, 2001 (very cloudy day).

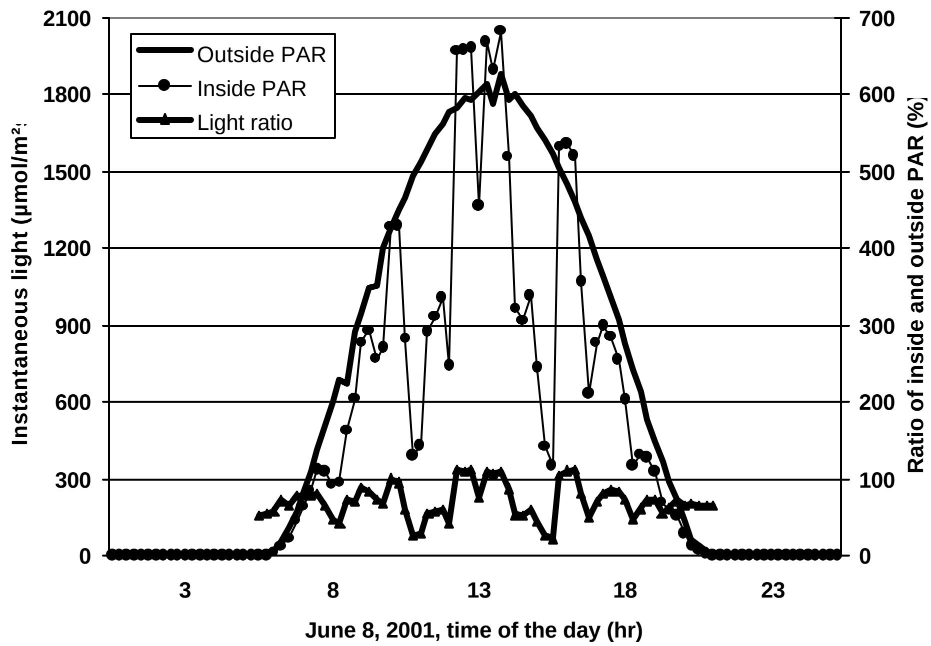

Figure 10. Instantaneous (15 minute averages) inside and outside light conditions and their ratios for June 8, 2001 (very sunny day).

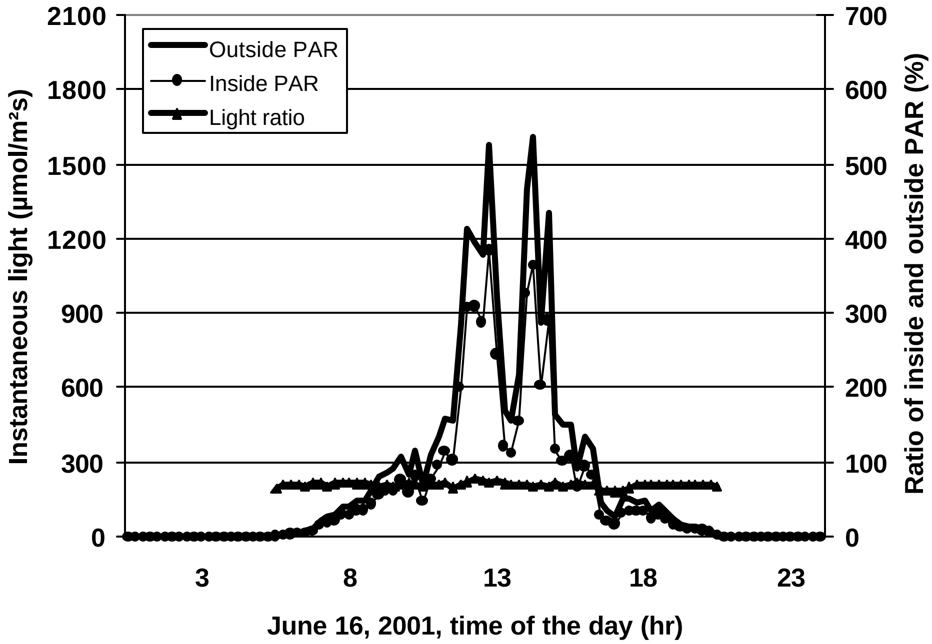

Figure 11. Instantaneous (15 minute averages) inside and outside light conditions and their ratios for June 16, 2001 (very cloudy day).

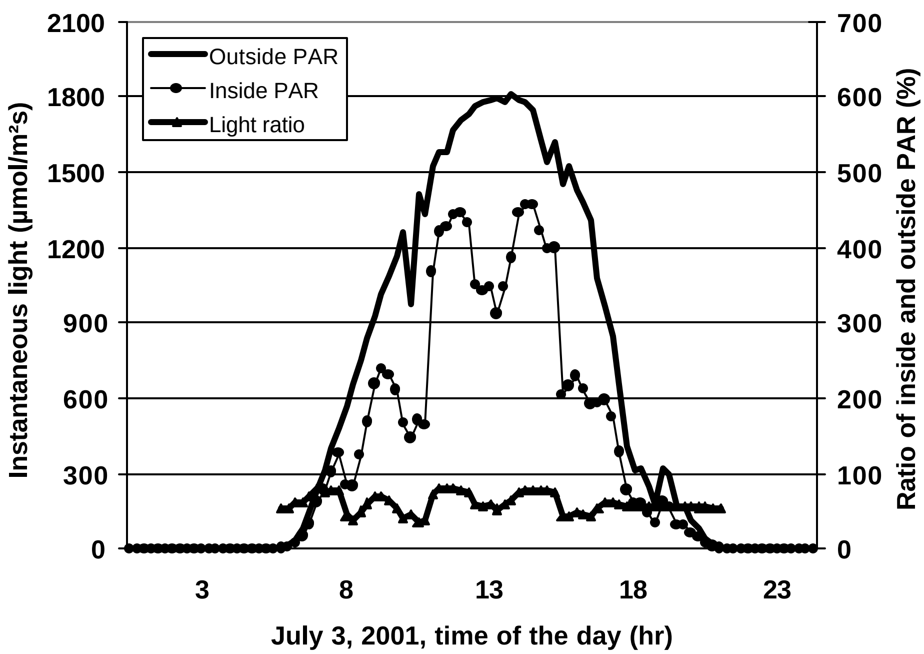

Figure 12. Instantaneous (15 minute averages) inside and outside light conditions and their ratios for July 3, 2001 (sunny day, with roof closed on purpose).






Commercial open-roof greenhouses in New Jersey (from left to right and top to bottom): Photographs 1 and 2: De Groot and Sons Greenhouses, Pompton Plains; Photographs 3 and 4: Van Vugt Greenhouses, Pompton Plains; Photographs 5 and 6: Millstone Valley Nursery, Belle Maid. These pictures were taken during very warm (around 100°F or 38° C) weather conditions on August 8 and 9, 2001. The open-roof greenhouse temperatures were within a few degrees of the outside temperature while the temperature in traditional mechanically ventilated closed-roof greenhouses was considerably higher.