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Microclimate in a Quonset Shaped Greenhouse - An Experimental Study

P. CHANDRA, R. SHRIVASTAVA, A.K. DOGRA, S. PANWAR AND ASHWANI KUMAR SINGH
Division of Agricultural Engineering,
Indian Agricultural Research Institute, New Delhi 110 012

ABSTRACT

Preliminary observations on greenhouse thermal environment as compared to the open field conditions have been presented. Carbon-di-oxide concentration in the greenhouse before sunrise was measured to be above 500 ppm, which decreased to ambient level soon after sunrise. The greenhouse transmitted about 60% sunlight in the visible and infra-red range. However, transmission in the UV range was below 36%. Relative humidity in the greenhouse was 10% to 20% higher than the ambient values during the period of measurement. Air temperatures in the unheated greenhouse were measured to be up to 8^0C higher than the ambient values during winter months.

Introduction

Greenhouse technology has a major role to play in increasing the production of high quality horticultural crops. Greenhouse technology implies cultivation under protected environment. Greenhouse is a framed or inflated structure covered with a transparent or translucent material in which crops could be grown under atleast partially controlled environment. The manipulation of environment in the greenhouse is on the basis of the requirement of a particular crop. The components of microclimate responsible for productivity are light, temperature, air composition and the nature of the root medium.

Knowledge of microclimate in a greenhouse is essential for the determination of crop responses, levels of abiotic and biotic stresses, requirements of environmental control and automation of equipment operation. It is, consequently, necessary to have a database on microclimatic parameters in different greenhouses.

Materials and Methods

The greenhouse used for the microclimatic study was situated in the Division of Agricultural Engineering at IARI, Pusa, New Delhi. The greenhouse was of quonset shape covering a floor area of 5 m x 15 m with a height of 2.5 m. The greenhouse was framed with G.I. pipe (class B) of 15 mm bore. The greenhouse had a single layer covering of U.V. stabilized polyethylene of 200 microns (800 gauge) thickness. Two exhaust fans of 60 cm diameter were used for ventilation. The exhaust fans were thermostatically controlled. Cooling pad was used for cooling the greenhouse. The cooling pad had an area of 3.7 m^2 and thickness of 2 cm. Greenhouse frame and glazing material have a life span of about 20 and 2 years, respectively.

Four climatic parameters namely, temperature, relative humidity, solar radiation and CO_2 concentration were studied. The temperature and relative humidity were measured by Humidity - Temperature meter (HM 34 C). The data were recorded three times a day, i.e., 9 a.m., 1 p.m. and 4 p.m. The solar radiation values were measured at 12 noon every day with the help of LI-1000 Data Logger. Recording of data was started in the month of January and taken upto May, 1997. The same data were also recorded for open conditions.

Results and Discussion

Carbon dioxide

CO_2 had been measured inside and outside the greenhouse at different levels as well as at different times of the day. The different levels were base, middle and top of the plant. The CO_2 concentrations were also measured in the air above the plant canopy. The data were recorded four times a day for eight different plots of a greenhouse. The average mean values were calculated to determine the CO_2 concentration of the greenhouse.

As shown in Fig 1 the CO_2 concentration was high in the morning and then it started decreasing as sunlight increased. Later on, it became constant after 11 a.m. With the increase in the light intensity, the rate of photosynthesis increases. As the rate

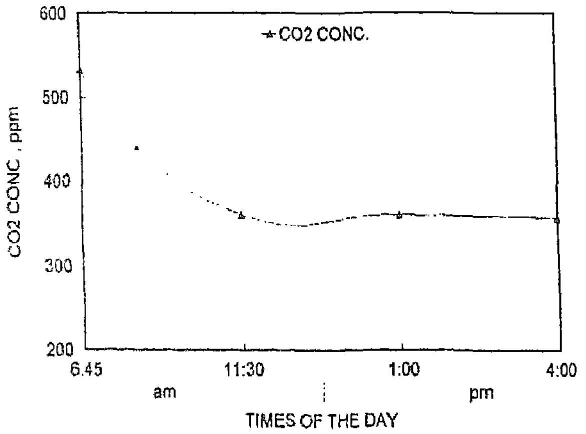

Fig. 1. Variation of CO_2 conc. at different times of the day inside the greenhouse

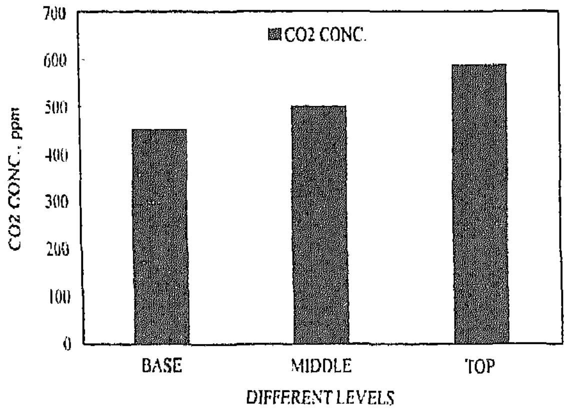

Fig. 2. Variation of CO_2 conc. at different levels inside a greenhouse

of photosynthesis increases, the consumption of CO_2 by the plants also increases and this results in depleting the CO_2 in the greenhouse. After 10 a.m. the ventilation in the greenhouse started. Therefore, due to ventilation the greenhouse air was replaced by the outside air and CO_2 concentration almost became equal to CO_2 in atmosphere.

As shown in Fig. 2 there is trend of increasing CO_2 concentration as we move from base to the top of the crop canopy. The leaf area is more at the top of the plant and so the CO_2 production is high at the top due to respiration as CO_2 is heavier than air it tends to settle down at the base level.

Solar radiation

Solar radiation data for the month of February 1997 is shown in Fig. 3. The experimental data indicate that the average mid-day solar transmission coefficient is 0.68 for the months of January to May.

Fig. 4 compares the solar spectrum in the range of 400 to 1100 nm, whereas Fig. 5 compares the solar spectrum in the UV range of 300 to 400 nm. Fig. 4 clearly indicates that the transmission coefficients for the greenhouse glazing in the visible and infra-red range of the solar radiation is nearly constant. The precise value of transmission coefficient would depend, however, on the time of the day because of the incidence angles. The fig. for the UV range indicates that the greenhouse glazing has a tendency to absorb strongly in the UV range. The maximum transmission co-efficient has been observed to be only 0.36 at 400 nm. At the lower end of the spectrum the transmission is practically zero. This information on transmission co-efficient suggests that the solar radiation environment within a greenhouse has negligible UV component, which in turn promotes plant growth as compared to open field conditions.

Relative humidity

The average RH values inside the greenhouse higher than the average RH values of ambient air (Fig. 6). For 9. a.m. the RH values for the months of January and February were above 50% for ambient air and above 60% inside the greenhouse. The RH values decreased in March and were above 25% for ambient air and above 40% inside the greenhouse.

Increase in temperature unaccompanied by a change in the amount of water vapour present in the air results in a decrease in the RH of atmosphere because of the increase in the saturation vapour pressure. While decrease in temperature of atmosphere, without any accompanying change in water vapour content, results in an increase in relative humidity.

The comparison between the greenhouse RH values for 9 a.m. and 1 p.m. indicates that RH value at the 1 p.m. was less than that at 9 a.m. This is because the temperature starts increasing towards noontime and RH becomes low. In the month of March the cooling pad was used after 10 a.m. to increase the RH inside the greenhouse. Again at 4 p.m. the values started increasing in

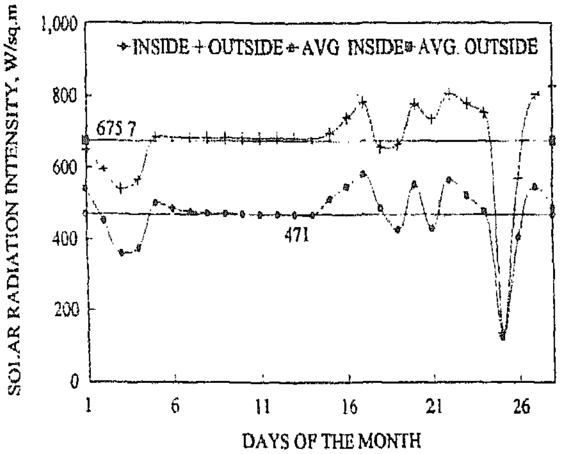

Fig. 3. Variation of solar radiation intensity at 12.00 noon and outside tomato greenhouse

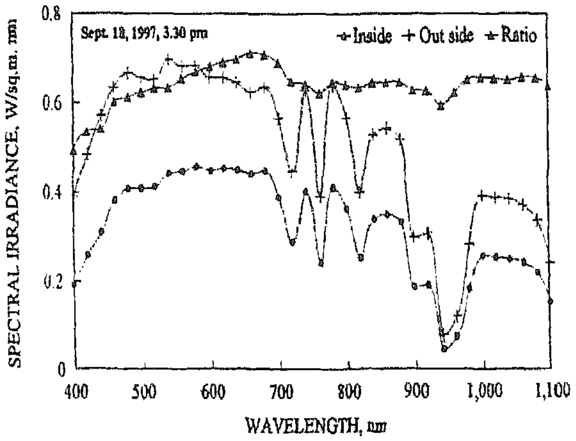

Fig. 4. Comparison of solar energy spectrum in and outside a PE glazed greenhouse (400 to 1100 nm wavelength)

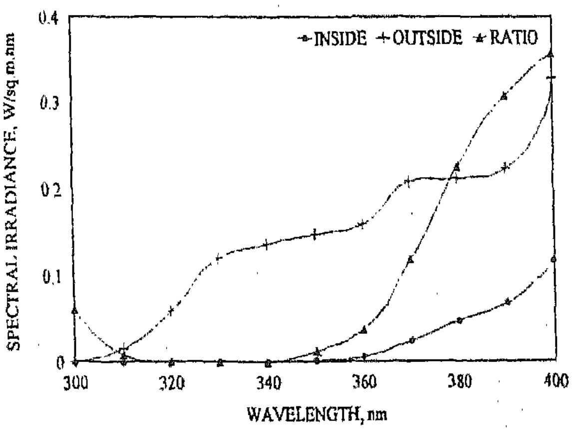

Fig. 5. Comparison of solar energy spectrum in and outside a PE glazed greenhouse (300 to 400 nm wave length)

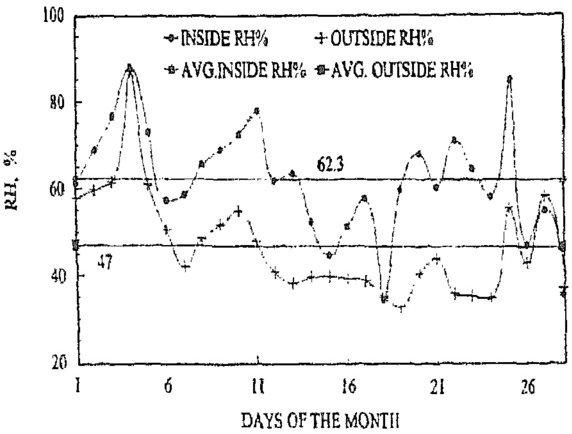

Fig. 6. Variation of the inside and outside air relative humidity for tomato greenhouse at 9.00 A.M. Feb. 97'

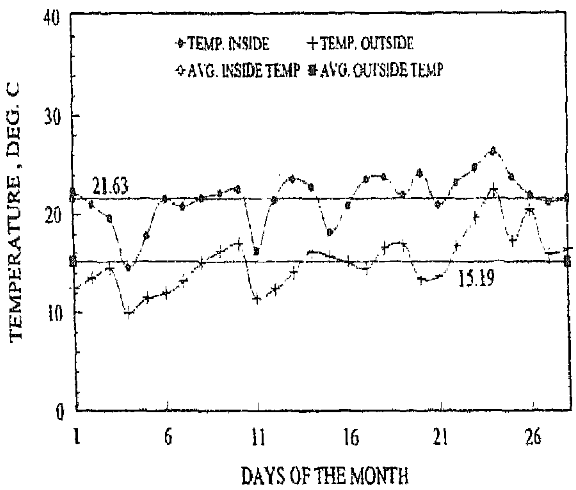

Fig. 7. Variation of the inside and outside air temperature for tomato greenhouse at 9.00 A.M. Feb. 97'

comparison to 1 p.m. because temperature started decreasing after 3 p.m.

Temperature

For 9 a.m. the average temperature value inside the greenhouse was greater (6-8°C) than the average value of temperature for outside during January and February (Fig. 7). In the month of March the difference between average value of temperature for inside and outside the greenhouse was 4°C. To bring down the greenhouse temperature ventilation by exhaust fans was performed. These exhaust fans were thermostatically controlled and greenhouse temperature was maintained between 25-30^{0}C. The maintenance of temperature was according to the crop requirement. In this case the greenhouse temperature was maintained for tomato crop.

By studying the graphs for 1 p.m. we see that the difference between the average values of temperature for inside and outside the greenhouse is 6-8^{0}C for January and February months. This difference decreased to 2^{0}C for the month of March. After 10 a.m. cooling pad along with exhaust fans were operated to bring down the greenhouse temperature during March. Again at 4 p.m. the temperature started decreasing as compared to 1 p.m. for inside and outside the greenhouse. For 4 p.m. the difference in air temperature was less than the difference of 6-8^{0}C for 9 a.m. and 1 p.m.

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