Structural Property and Microclimate Environment of Chinese Style Greenhouse in Yan'an city

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1. INTRODUCTION

The purpose of greenhouse is to modify the environment for plants and improve growth during periods of unfavorable outdoor climatic conditions. Microclimate parameters inside a greenhouse such as air temperature, relative humidity and soil temperature influence the growth of the plants. Therefore, the microclimate environment of greenhouse is considerable important and several studies have been performed in order to understand it (Avissor and Mahrer, 1982).

A Chinese style greenhouse (CSG) is a typical energy-saving greenhouse widely used in the northern China. It enables cultivation in winter without any heating facilities. The direct on-site microclimate monitoring can provide the most useful data but because of the high cost and sophistication of the measuring equipment, most greenhouse growers are reluctant to monitor the elements themselves (Zhang et al., 1997). The purpose of this study is to clarify unique structural property of CSG and monitor microclimate environment over a long continuous period in order to provide valuable data for the development of horticultural agriculture. Yan'an district was selected as a research site in this study.

2. OUTLINE OF RESEARCH SITE

Yan'an city (N 35°21' ~ 37°31', E 107°41' ~ 110°31') is located in the south part of the Loess Plateau, near the Xi'an city of Shaanxi province. It belongs to semi-arid region with a frost-free period of 150-195 days, warm and dry climate. Mean temperature is less than 0 ℃ in December, January and February. The traditional cropping system in this area involves sowing in the spring and harvesting in the fall. The introduction of CSG enables the cultivation of crops in winter as well as of the year of 1992 (Du and Bai, 2002).

3. STRUCTURAL PROPERTY OF CSG AND EXPERIMENTS

Fig.1 shows a cross sectional view of CSG. It has a wall in north, east and west, a back roof, a cold proof ditch, a steel tube frame and a front roof. The internal dimensions of greenhouses measure 8 meters wide, 62 meters long and 3.3 meters high at the ridge. The east/west side walls (which are not shown in Fig.1) and north-facing rear wall are made of loess soil. The rear wall is 0.8 meter thick and 2.6 meters high. The PVC hydrophobic film lies on the top of the steel tube frame. The earth walls are especially well adapted due to the abundance of loess soils throughout China and the unique ability of earth to act as both an effective thermal insulator and thermal mass. The back roof is shown in Fig.1, which is a loess/straw composite supported by wooden beams and steel wires, is not completely clear. It provides a flat area on which to stow the straw mats in the daytime. Each evening farmer unroll straw mats to cover the roof and provide night insulation. Each

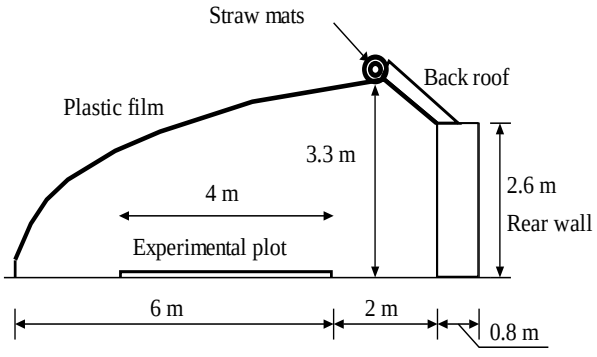

Fig.1 Cross sectional view of Chinese Style Greenhouse geometry

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morning the mats are rolled up and parked on top of the rear wall for the day.

The experiments were conducted from October, 2003 to March, 2006. Air temperature, film temperature, slant roof temperature, wall temperature, relative humidity, global solar radiation, soil temperature of up to 30 cm in depth were measured. All experiments were monitored every one hour.

4. MICROCLIMATE ENVIRONMENT CONDITIONS

The short-term comparison of solar radiation inside and outside greenhouse was shown in Fig.2. The daily mean solar radiation inside greenhouse was 133 W/m², outside was 218.6 W/m². The average solar radiation transmissivity is approximate 60% during the daytime.

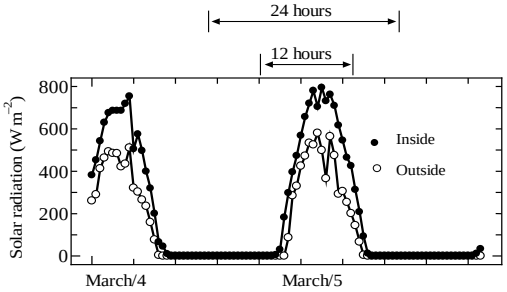

Fig.2 Comparison of inside and outside solar radiation

Inside, minimum air temperature were 2.0 ℃ at 8:00 on January 18, 2004 and 0.3 ℃ at 6:00 on January 6, 2006. At same time, outside air temperature were -16.0 ℃ and -21.0 ℃ respectively. The maximum air temperature were 46.9 ℃ at 14:00 on October 23, 2003 and 42.9 ℃ at 15:00 pm on November 4, 2005.At same time, outside air temperature were 22.9 ℃ and 20.2 ℃ respectively. From December to February, it is the coldest season in Yan'an district. However, the average inside air temperature can be maintained at about 14 ℃. There was about 15 ℃ average difference between inside and outside without supplement heating at night. This is a typical energy saving feature of the Chinese style greenhouse.

The north wall temperature, film temperature, and roof temperature, they reached to peak temperature almost at same time. At night, north wall temperature is higher than inside air temperature. The average difference between them is about 3 ℃. Soil temperature is also higher than inside air temperature at night. The average difference between them is about 4 ℃. Such difference shows that heat flux occur from the surface of north wall and soil to inside air temperature. Those heat flux are the energy source keeping the inside air temperature at the proper level to produce the vegetables in winter.

The relative humidity ranged from around 17.0 to 100% in the daytime. When the top and bottom parts of the film were manually opened for ventilation from 10:00, the relative humidity started to decrease. At night, it ranged from around 72 to 99%.The mean difference between the inside and outside relative humidity was around 27%, indicating that inside conditions were kept excess damp.

5. CONCLUSIONS

In this study, the unique structure property of CSG was been definite and microclimate environmental parameters were monitored over a long continuous period and provide the most useful data for the development of sustainable agriculture in Yan'an city.

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