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RESEARCH ARTICLE

Mathematical modeling for cooling by water evaporation over roof of a greenhouse

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ABSTRACT : A mathematical model with moving water film over the roof of even span model greenhouse has been developed to study the effectiveness of cooling in the greenhouse. Analytical expressions for flowing water temperature in south and north roof along with greenhouse room air temperature have been derived in terms of design and climatic parameters for summer period. The analysis is based on steady state mode. Flow of thin film of water is maintained over the jute cloth stretched on the roofs of greenhouse. The effects of relative humidity, flow rate of water, absorptivity of shading material (jute cloth) and length of roof on the cooling performance of greenhouse room air temperature are discussed thoroughly with the help of this model.

KEY WORDS : Solar energy, Greenhouse, Evaporative cooling, Thermal modeling

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INTRODUCTION

The conventional method for reduction of heat flux into the greenhouse through roof is by the use of movable canvas (shading material) (Al-Arifi *et al.*, 1999). The stretching of canvas over the roof during the daytime and removal of it in nighttime is the effective and economical technique for protecting greenhouse from peak summer period. The heat flux through the roof of any structure can also be decreased substantially if water is evaporated on the surface of the roof (Cooper, 1973) as roof surface receives maximum amount of solar radiation (about 50 per cent of the total radiation) in summer and hence, contributes the maximum of cooling load (Duffie and Backman, 1991). Thus, evaporation of water can be achieved by maintaining a thin film of water over the surface of the roof. If water temperature is below that of shading cloth, energy is transferred from the cloth to the water raising the water temperature and lowering the cloth temperature. Also if the relative humidity is below 100 per cent, evaporation of water transfers a large amount of energy (2300 KJ/kg. of water evaporated) from cloth to atmosphere resulting in increase of convective heat transfer coefficient between them. Morris *et al.* (1958) found that internal air temperature was reduced when using a water film over the glass surface of the greenhouse due to the lowering of the temperature of the glass surface. Recently Willits and Peet (2000) conducted an experiment with intermittent application of water to an externally mounted greenhouse shade cloth and found that the rise of greenhouse air temperature was reduced by 41 per cent under wet cloth as compared to 18 per cent under dry cloth. Hence considering the efficacy of evaporative cooling system in reducing the heat flux into the greenhouse through the roof, an attempt was made to develop a thermal model to simulate the performance for cooling of greenhouse with moving water film in the roof.

MEMBERS OF RESEARCH FORUM

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EXPERIMENTAL PROCEDURE

Working principle and description of even span model greenhouse :

By keeping the exterior surface of the roof wet, the