APPLICATION OF GREENHOUSE
FOR
CROP PRODUCTION AND DRYING

by

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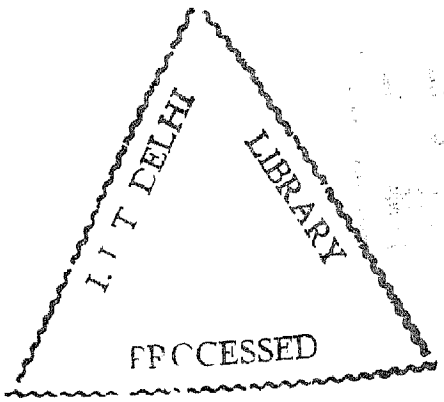

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Certificate

This is certified that the thesis entitled **"Application of Greenhouse for Crop Production and Drying"** being submitted by **Dilip Jain** to the Indian Institute of Technology Delhi, is worthy of consideration for the award of the degree of **'Doctor of Philosophy'** and is a record of the original bonafide research work carried out by him under my guidance and supervision.

The results contained in the thesis have not been submitted in part or full, to any other University or Institute for the award of any degree or diploma.

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Abstract

In tropical countries like India the application of greenhouses is limited because of prevailing extreme weather conditions in summer and winter. Heating and cooling of greenhouses are therefore important aspects for their efficient use and wide applicability. Crop drying is another important process, where the applicability of greenhouses can be extended, since the greenhouses are the effective solar energy collector. Very limited work on crop drying in greenhouses has so far been attempted in India.

The experimental studies have been conducted to optimize the parameters of one of the heating and cooling systems in a greenhouse, and also to evaluate the convective mass transfer coefficient for drying of cabbage and peas in the greenhouse. Appropriate mathematical models have been developed to study the thermal behavior of the greenhouse during these processes. An even-span greenhouse has been considered for experimental purposes and thermal modeling. A ground air collector was used for heating of greenhouse in winter. A fan and pad type evaporative cooling system was provided for cooling the greenhouse in summer. A simulated study of crop drying has been attempted with the smaller size of even-span greenhouse.

For heating of the greenhouse, parameters such as area of ground air collector; mass flow rate and heat capacity have been optimized against behavior of the plant and room air temperature and thermal load leveling. The stored thermal energy of ground collector proved useful in increasing the temperature by 7 °C from the ambient temperature during night. The optimum area of ground air collector, mass flow rate and heat capacity were obtained as 17.55 m^2, 200 kg/hr and 20950 kJ/°C, respectively for the even-span greenhouse (ridge height 3m and walls height 2m with floor area 6x4 m^2).

The cooling system (fan and pad) parameters like length of greenhouse (for effect of cooling length), height of cooling pad and mass flow rate have been optimized against the maximum temperature and thermal load leveling by dividing the greenhouse into two zones- zone-I and zone-II. The average temperature drop in greenhouse was 5 °C from the ambient temperature during daytime in summer. The temperature was lowest near the cooling pad and increased while going away from the cooling pad (along the length of greenhouse) as expected. The optimum parameters of cooling system were found to be (i) 6 m length of the greenhouse, (ii) mass flow rate as 0.6 kg/s, and (iii) 1.5 m height of cooling pad (width 3 m) o the given greenhouse.

For cabbage and peas, the convective mass transfer coefficient in greenhouse drying under forced mode doubled over the natural convection in the initial stage of drying. Its value ranged from 38 W/m^2 °C to 1 W/m^2 °C from the beginning towards the end of the drying period. The behavior of convective mass transfer coefficient in the beginning of drying was like that of a wetted surface and at the end of the drying like of dry surface. The convective mass transfer coefficient as a function of drying time has been established with the help of a two-term exponential curve model. For drying of crop produce, three simple mathematical models were developed to predict the crop temperature, greenhouse room air temperature and moisture evaporation for open sun drying (natural convection), greenhouse drying under natural and forced convection. These models were validated with experimental observations for drying of cabbage and peas with each mode of drying. The predicted values showed good agreement with experimental observations with positive coefficient of correlation for crop temperature (r =0.96), greenhouse air temperature (r =0.97), and rate of moisture evaporation (r =0.99) for all the three drying methods.

The present studies amply indicated that greenhouse can be efficiently used for crop production providing moderate heating (ground air collector) and cooling (fan and pad evaporative cooling) systems. Such greenhouses can also be used for effective crop drying under forced convection to enhance the drying.

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