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Development of greenhouse dryer for forage conservation in temperate climate

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Introduction

Greenhouse dryer implies drying of crops in covered structure that allows rapid harvesting of solar radiation and modification of agro climatic conditions conducive for proper drying. The environmental factors which affects plant growth includes air temperature, relative humidity, light, carbon dioxide concentration, soil temperature and moisture content of soil. The greenhouse may have heating, cooling and ventilating equipments for control over microclimates. Control over microclimate results in several fold increase in crop photosynthesis, and optimum thermal energy for forage conservation in the form of hay.

Chandra *et al*. (2002) have proposed the design of a naturally ventilated greenhouse. Several other single and multispan greenhouses for use in various regions of India have been developed (N.C.P.A.H., 2001). Tiwari (1984) analyzed winter greenhouse. Effect of various parameters *viz*. ventilation/ infiltration, relative humidity, movable insulation etc. have been incorporated in the analysis and their effect on the performance of greenhouse was studied. He reported that temperature rise of the plant and room air is increased upto about 3-5 ºC by covering the system with movable insulation. The performance of the greenhouse is improved by concrete north wall. It reduces the heat losses during the night.

Tiwari and Dhiman (1986) presented a design and mathematical model for a winter greenhouse at Leh, Jammu and Kashmir in India. In this part of the country, the ambient air temperature, in winter, dips down to –30 ºC and goes upto a maximum of about 25 ºC in summer. Here, greenhouses are possible because solar isolation is available for almost 11 months of the year. Numerical calculations show that a glass wall on the south side and an insulated wall and roof on the north side give good results.

Coffin *et al*. (1988) measured the transmittance of solar radiation into scale models of multispan greenhouses for a complete year, under a wide variety of climatic conditions. Models of conventional greenhouses, which were oriented East-West or North-South, and glazed with clear or diffuse glass, and models of two prototype multispan insulated greenhouses, oriented East-West with the north-facing roof sections insulated were tested. The East-West greenhouse models had higher overall light levels than the North-South ones during the winter months. The insulated greenhouses had moderate reductions in light levels during the winter as compared to the conventional models.

Materials and Methods

Greenhouse structure: A greenhouse is attempted to be made as transparent to sunlight as possible to admit the maximum sunlight during the periods of least sunshine.

Site selection and orientation of greenhouse: Ground slope for drainage is an important factor. Adequate provision should be made to divert surface water away from the greenhouse. It should be located at a place where unwanted shading from the surroundings is not present. Orientation of the greenhouse is another important factor for proper radiation environment and energy efficiency. An east-west oriented free standing greenhouse maintains better winter light as compared to a north-south oriented greenhouse. A greenhouse attached to a building in northern hemisphere must be located on the south facing side of the building to get the maximum sun light.

Greenhouse Glazing: Glass has been the traditional glazing material. Other rigid materials include fibre glass reinforced plastics, plexy glass, polycarbonate, etc. Flexible materials include polyethylene, Poly vinyl chloride, EVA, PVF, etc.

The criteria for the selection of a glazing material are quantity and quality of transmitted light, long wave radiation transmission, strength, weather ability, surface condensation properties and the cost. While total solar energy transmissivities are important from the standpoint of heating and cooling requirements, it is the transmission of photosynthetically active radiation (PAR, in the range of 400 nm – 700 nm) which is important for crop growth. The ratios of different segments of light, e.g., red to far-red ratio, are also important. The selected glazing material is adequately treated so that it does not get degraded fast by the ultra-violet rays in the terrestrial solar energy.

Greenhouse frames: The greenhouse frame is the most important component of a greenhouse system. It provides support for glazing material and a place for fitting of environmental control equipment. Commonly used structural shapes are gable, quonset, lean- to and gothic arch with minor changes to suit local conditions. Greenhouse frames are designed to withstand wind, snow and crop loads with minimum obstruction to sunlight. Wind and snowfall data are available from meteorology departments for every part of India. For most of the locations a frame designed to withstand 100 km/h wind speed is sufficient with the option to use heavier sections in regions of exceptionally high wind speeds.

Tubular/square steel sections are the most preferred structural members for greenhouse frames. Wood, bamboo and aluminium are other common materials. Steel pipes provide required strength at a competitive price and also an assured service life of over 20 years.

It has been agreed that the frame should constitute about 5% to 10% of the total surface area of the greenhouse. Most of the transparent greenhouses have 60% to 75% overall solar transmission coefficient.

Greenhouse Heating

There are essentially three main categories of efforts needed to maintain desirable greenhouse temperature during winter:
1. Design of energy efficient greenhouses with passive solar heating components
1. Design of active heating systems based on renewable energy sources such as solar and biogas.
3. Design of active heating system based on conventional fuels.
While the conventional fuel based heating systems are many and dependable, the other two categories of efforts are still evolving.

Results and Discussion

Design and development of greenhouse dryer for temperate climate: Suitable design of greenhouse dryer (8m x 4m) as shown in figure with specification has been developed to establish at Regional Research Station, IGFRI, K D Farm, Srinagar. The features of this dryer includes: Side height :2.30m on north side and 2.0m of south side above ground level; Central height i.e. of ridge line: 3.0m above the brick wall; Orientation: East-west direction: Dryer frame: 1.5” GI square pipes; Glazing material: 200µ UV stabilized LDPE (150 gsm) fixed by zig-zag profile; Skirt wall: Brick wall 30 cm above and 30 cm below the ground level plastered from both the sides; Inlet opening for air: 25 cm wide inlet of insect proof iron net throughout the length just above the brick wall on south wall and covered with plastics film with the rolling system; Outlet openings for removing humid air: 3 Nos. window each of 30 cm width and 90 cm length, and two exhaust fans each of 100 W placed on the north wall; North wall: above brick wall and upto a height of 1.7m sun dried brick wall; Foundation pipes: by digging holes to 50 cm depth at each foundation pipes and pouring cement concrete mixture (1:3:6) around foundation pipes (1.5” GI square) such that the lower 15-20 cm pipe ends are covered in concrete; Door: provided on east face of 1.0m width and 1.75m height. The design aspects of the greenhouse have been given in figures 1, 2 and 3.

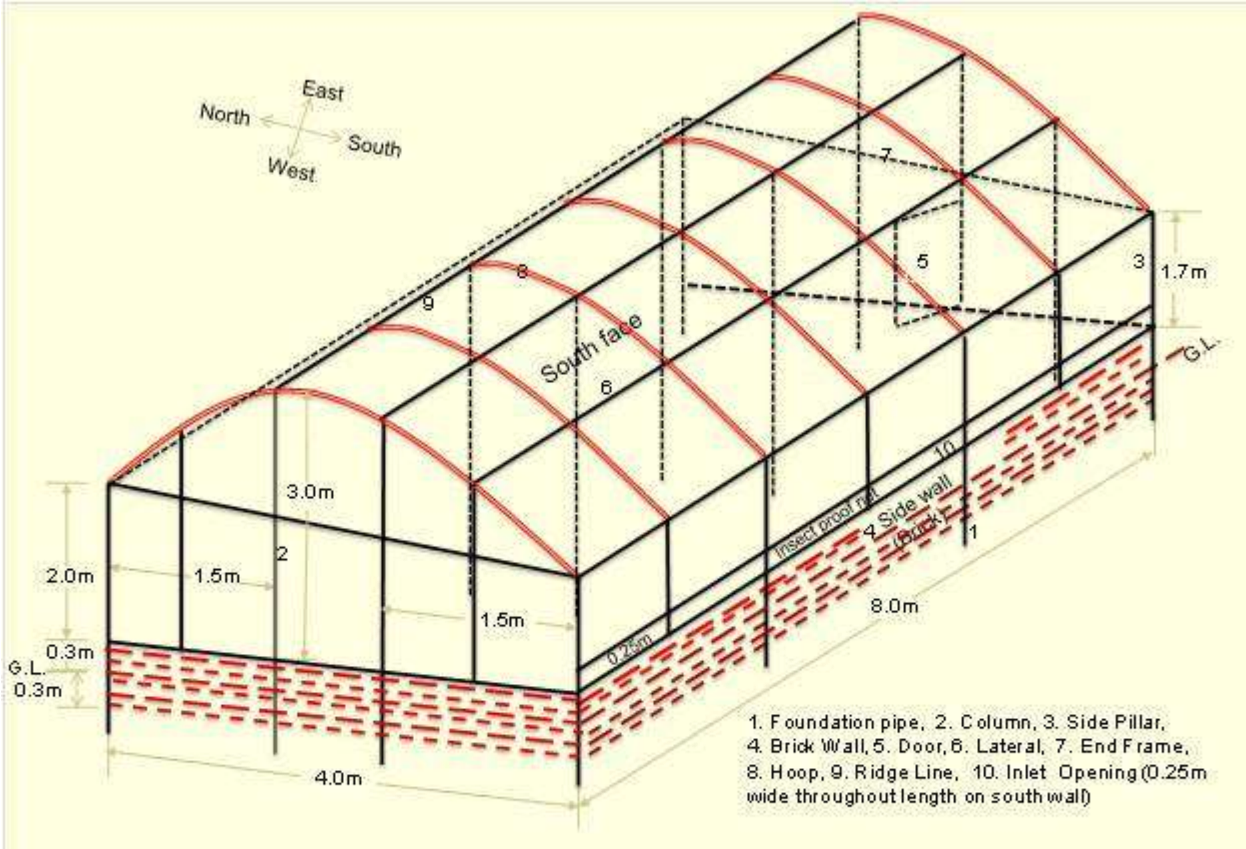

Fig. 1. Design of Greenhouse Dryer (8.0 m x 4.0 m)

Conclusion

Efforts have been made to design a low cost structure for drying of fodder crops.In temperate climatic condition, and there is no availability of fodder from December to April due to unfavorable climatic conditions for cultivation. Agricultural activities are confined to short summer season of 6 to 7 months only. By adopting greenhouse dryer, fodders can be dried and their availability time can be extended for non-availability period (lean period) also, as well as to add value to the products.

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