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Effect of Height of Naturally Ventilated Greenhouse on Light Transmission

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Three low cost greenhouses of size 8x4 m each with ridge heights of 3m, 3.75m and 4.5m were designed and constructed with a side and roof ventilation of 30% and 6% respectively. The light intensity inside the greenhouses were found to be much lower than that of outside. The rate of reduction of light intensity inside the greenhouses was found to increase with increase in light intensity. It was observed that, during peak hours (at which light intensity was maximum), lower amount of light intensity was received by the 4.5 m height greenhouse and it was found to increase with decrease in height of the greenhouse. The 3 m and 3.75 m and also 3.75 m and 4.5 m greenhouses were on par in respect of light intensity even at 10% level. But, there was a significant reduction ($P < 0.01$) of light intensity in 4.5 m greenhouse compared to the 3 m greenhouse.

Key words: Greenhouse, height, temperature, light intensity

The distinctive feature of greenhouse cultivation as compared to outside cultivation is the presence of a barrier between the crop and the environment. The presence of a cover, characteristic of greenhouses, causes a change in the climatic condition as compared to outside by reducing radiation and air velocity; increasing or decreasing the temperature and vapor pressure of air and by making the fluctuations in CO_2 concentrations. Each of these changes has its own impact on growth, production and quality of the greenhouse crop, some of them being detrimental.

Light is the most important environmental factor in the green house culture, as it influences a wide range of processes related to photosynthesis, energy balances including transpiration, phase transitions and morphology. The light is the solar radiation filtered by the atmosphere and reaching the ground. In order to attain good growth of plants, inside the greenhouse, there should be sunshine of desired quantity and intensity. The greenhouse crops were subjected to light intensities varying from 129.6 Klux on clear summer days to 3.2Klux on cloudy winter days (Radha Manohar and Igathinathane, 2000). Photosynthetic activity depends upon the light intensity and strongly increases with increase of luminosity (below the 14 lux the activity decreases). But, beyond a certain point, any further increase of luminosity does not make the photosynthetic activity increase any more (Zenon, 1990) .For most of the crops, neither of the extreme conditions were ideal. Many crops became light saturated. In other words, rate of photosynthesis was not increased at light intensities beyond 32.3 Klux (Radha Manohar and Igathinathane, 2000). High light intensity warms the leaves and may increase respiration. If warming becomes too high, it may cause thermal inactivation of enzymes. The chloroplast enzyme NADP Malate Dehydrogenase was totally inactivated when peas, maize & spinach were illuminated with high light intensity (Miginiac Maslow *et al*., 1990).

Evapotranspiration is inversely proportional to the stomatal resistance of leaves, which in turn is strongly dependent on the light intensity at leaf level. The temperature of the leaves, and the transfer of heat from leaves to the surrounding air by natural convection, is also directly related to the absorption of radiation by leaves. Therefore, light penetration into a crop stand is not only important component of plant growth, but it is also essential factor that determines the microclimate in plant stands (Yang *et al*., 1990).

The reduction of temperature in the interior of the greenhouses located in the warm regions is fundamental to obtain good control of the climate. Since natural ventilation is the cheapest method of lowering the temperature during warm periods, study was concentrated on naturally ventilated greenhouses. Higher the greenhouse constructions with ventilators at the ridge, better will be the chimney effect and the ventilation efficiency and hence, we can attain lower temperature inside the greenhouse (FAO, 1999). Unfortunately, along with light, the greatest amount of solar heat also get trapped inside the greenhouse, which increases greenhouse-cooling load. Since solar radiation and temperature inside the greenhouse are related and also the height of greenhouse and temperature are related,

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it is proposed to study the variation of light intensity with height of greenhouse and also to determine the relationship between the inside and outside light intensity. With this in mind, three naturally ventilated greenhouses having same floor area and different height was designed and constructed.

Materials and Methods

The study was conducted at Agricultural Engineering College & Research Institute, Tamil Nadu Agricultural University, Coimbatore during 2000-2002. Three similar, low cost greenhouses having ridge heights of 3 m, 3.75 m and 4.5 m with the same floor area of 8m x 5m was designed and constructed. Three greenhouses were provided with side ventilation on both sides at the floor level (30% effective opening area - ventilation was measured as the percent of floor area since the heat load derived from the solar radiation is directly proportional to the floor area) and roof ventilator on one side at the ridge level (6% effective opening area). As the major wind direction during summer months is SE-NW/NE-SW, the roof ventilator was provided at the western side to ensure smooth outflow of hot air and hence to attain lower temperature inside the greenhouse. In order to prevent the entry of the insects and pests, insect net was provided at the roof and side ventilators. The details of dimension of the greenhouses are given in Table.1. and the schematic representation of 3 m height green house is shown in Fig.1.

Table 1. Details of dimensions of different greenhouses

S. No.	Length (m)	Breadth (m)	Eave height (m)	Ridge height (m)	Roof angle Western side	Roof angle eastern side
I	8	5	1.65	3	17.54^0	28.37^0
I	8	5	2	3.75	25.45^0	34.99^0
III	8	5	2.32	4.5	32.94^0	41.09^0

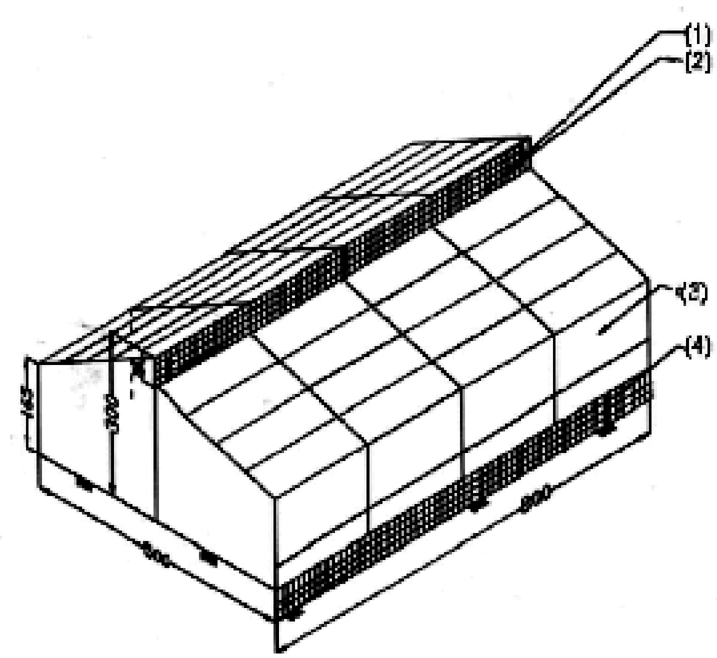

Figure 1. Schematic representation of 3 m ridge greenhouse

East-West orientation will help to capture more sunlight. But unfortunately, they simultaneously capture the greatest amount of solar heat, which increases greenhouse-cooling load. Hence greenhouses located at latitudes less than 35^0 should be oriented with roof ridges parallel to the north – south line (Albright, 1995). Since the study area is having latitude of 11^0, all the three greenhouses were constructed with their longer axis parallel to the N-S direction.

Both inside the greenhouses and open field, Cauliflower crop of Namdhari variety (NS 60-N) was raised. Light intensity inside the greenhouse was measured at the centre and at four corners and average of these readings was taken as the light intensity at a particular time. Outside the greenhouse, 3 readings were taken and were averaged out to get the outside light intensity.

Results and Discussion

Variation of light intensity with time and height of greenhouse is shown in Fig.2.

The light intensity inside the greenhouses was found to be much lower than that of outside. The

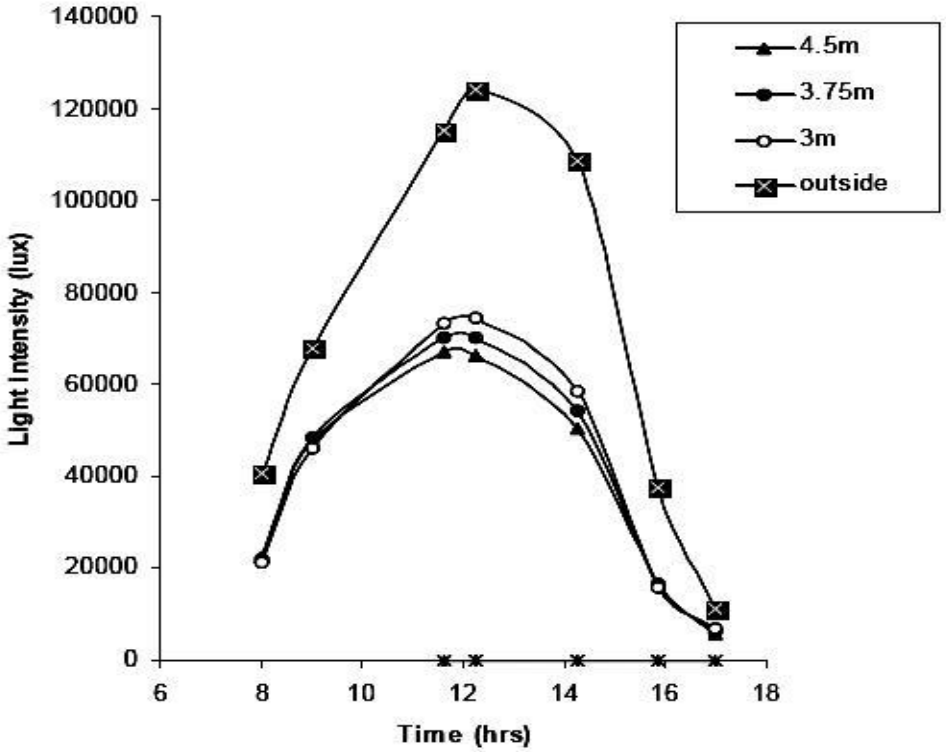

Figure 2. Variation of light intensity with fine and height of green house

rate of reduction of light intensity inside the greenhouses was found to increase with increase in light intensity. From the graphs, it was observed that, at higher light intensity (during peak hours), lower amount of light intensity was received by the 4.5 m height greenhouse and it was found to increase with decrease in height of the greenhouse. This was mainly due to the effect of slope of the roof.

Table 2. Effect of height of green house on light intensity

Treatment	Liin
4.5 m	35876.12
3.75 m	37293.83
3 .0 m	38636.54
Mean	37268.83
SE	661.02
CD (P=0.01)	2754.53
CD (P = 0.05)	1991.83
CD (P = 0.10)	1638.73

As per Lambert's cosine law, the radiant intensity emitted in any direction from a unit radiating source varies as the cosine of the angle between the normal to the surface and direction of radiation.

$I = I_o \cos r$

Where I = flux density on the surface unit S; I_o= intensity of the beam on a perpendicular surface unit S_N and r = angle of incidence, the angle between parallel beam of radiation and line normal to the surface.

Mears (1997) also specified that greater the angle of incidence, greater will be the surface reflectivity and thus less is the transmittance.

The greenhouse with 4.5 m height had higher roof slope compared to 3m and 3.75 m height greenhouses (Table 1). Hence, during peak hours, the angle between the incoming solar radiation and the plane normal to the roof (angle of incidence) is more in 4.5 m height greenhouse. Then, as per Lambert's cosine rule, the flux density on the roof surface will be less for the greenhouse having higher height. But, during the morning and evening hours, the angle of incidence will be more in the case of greenhouse having smaller height. But, during that time, intensity of light falling on the roof is very less. Hence marked variation could not be seen during this time.

Relationship between Inside and Outside Light Intensity

The curves showing the relationships between outside light intensity and light intensity inside the three greenhouses were drawn (Fig.3). It was observed that there is a linear relationship between the outside and inside light intensities. At lower value of light intensity, there was no marked variation in light intensity among the greenhouses and three lines were found to merge with each other and formed a single line (up to 2oooo lux). Beyond that limit, there was a distinct difference in light intensity between the greenhouses and it was found to increase with increase in light intensity. The relationship between

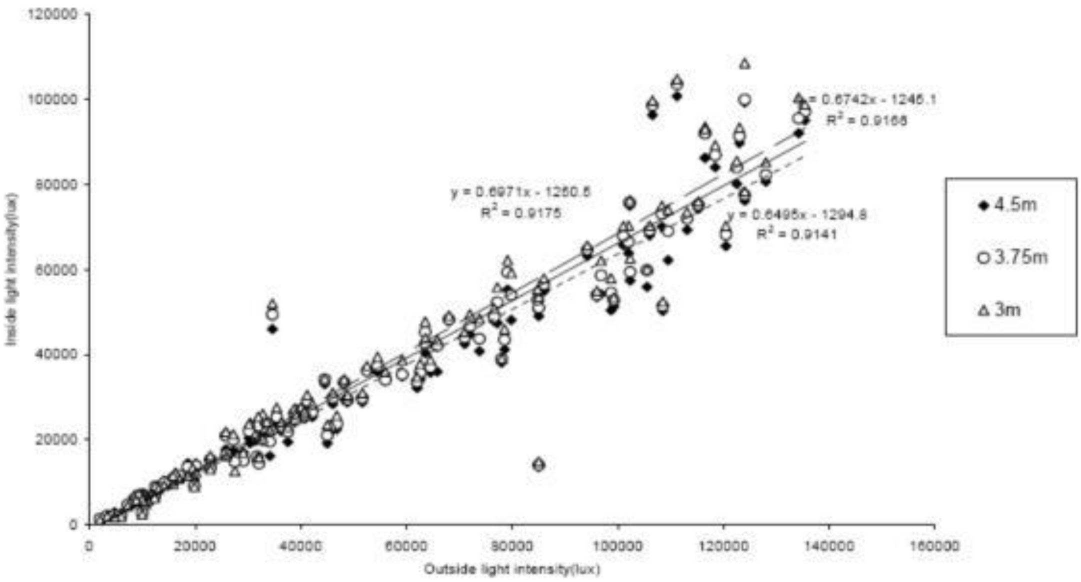

Figure 3.Outside light intensity inside light intensity

the outside light intensity and light intensity inside each greenhouse and their corresponding R square values are shown in Fig. 3.

Statistical Analysis

The height of the greenhouse was found to influence the microclimate of the greenhouse. Since the light conditions inside the greenhouse are much influenced by the outside solar radiations, on which we cannot make any control, the statistical analysis for light intensity was done by taking the corresponding value in the outside as the covariate and results are shown in Table 2.

The 3m and 3.75m and also 3.75m and 4.5m greenhouses were on par in respect of light intensity even at 10% level. But, there was a significant reduction ($P < 0.01$) of light intensity in 4.5m greenhouse compared to the 3m greenhouse.

Conclusion

There was a marked variation in light intensity received among the treatments of 3m and 4.5 m greenhouses. But there wasn't any significant difference in the light intensity received between 3 m and 3.75 m and also between 3.75 m and 4.5 m greenhouses. Since the light intensity and temperature inside the greenhouses increases with increase in floor area of the greenhouse, the height of the greenhouse and slope of the roof has to be increased with increase in floor area which will help to attain desirable light intensity and temperature inside the greenhouse in tropical climate

References

Albright, L.D. 1995. Controlling greenhouse ventilation inlets by pressure difference. *Hort. Technology*, July/ September, **5**: 260-264.

FAO: Cristian Von Zobeltiz and Baudoin, W.O. (Eds). 1999. Greenhouses and Shelter Structures for Tropical regions. FAO, Plant Production and Protection Paper No.154.

Mears, D.R. 1997. Multi span low to medium cost greenhouse facilities, design –fundamentals. In: Proceedings of the International Seminar on Protected Cultivation in India, Bangalore, India. pp: 5-16.

Miginiac Maslow, M., Decottignier, P., Jacquot, J.P. and Gadal, P. 1990. Regulation of Corn leaf NADP Malate Dehydrogenase light activation by these photosynthetic electron flow. Effect of photoinhebitation studied in a reconstituted system, **1017**: 273-279.

Radha Manohar, K. and Igathinathane, C. 2000. Greenhouse technology and measurements. BS publications, Sultan Bazar, Hyderabad,India.

Yang, X., Short., T.H., Fox, R.D. and Bauerle, W.L. 1990. A theoretical model of solar radiation transfer in row-crop canopy. *Transactions of the ASAE,* **33**: 917-924

Zanon, I.M.1990. Synergy between plastics research and protected agriculture. Proceedings of XI International Congress on The Use of Plastics in Agriculture, New Delhi, India. pp F31-F39.

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