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Short Communication

Impact of Shading and Forced-Air Ventilation on Greenhouse Climate Control in Mid-Country Intermediate Zone of Sri Lanka

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ABSTRACT. *Greenhouse crop production is becoming popular in Sri Lanka because of it applicability to most problems in horticulture sub-sector. However the local greenhouse growers face challenges due to unfavorable effects of high temperatures in greenhouses during daytime as in most other tropical countries. An experiment was conducted to evaluate the effectiveness of the selected temperature reduction strategies, namely shading and forced-air exhaust in Matale (WM3B). A commercial greenhouse of dimensions 10m x 20m with UV resistant polythene roofing and insect-proof side net covers was tested under mild winds. Both shade nets and forced-air exhaust reduced the mean internal temperature of the greenhouse by 3.1 °C. Relative humidity (RH) under shade nets was 7.7% higher than the out side (64.3%) whereas the use of exhaust fans resulted in the lowest humidity level of 63.7%.*

INTRODUCTION

Protected agriculture, with its uniqueness in productivity and adaptability, will play an important role in meeting the world's food demand in the future since it often provides new alternatives and economic opportunities in crop production (Jenson and Malter., 1994).Greenhouse crop production in tropical countries is affected by internal temperature increase up to a peak level of 35-40 °C, which is very unfavorable for the growth and development of the vegetation inside (Weerakkody *et. al.*, 2004).

A comparison between shading and forced-air exhaust was done to identify the most effective means of reducing greenhouse temperature under average agro-climatic conditions in the mid country intermediate zone of Sri Lanka.

MATERIALS AND METHODS

The experiment was conducted during the *Yala* season (July-August 2004) at a top-vent type commercial greenhouse, having UV resistant polythene roofing and insect-proof side net covers (Rovero system) with a 10m x 20m floor area and 3m gutter height. The experimental site was located in mid-country intermediate zone (7^0 28'N, 8^0 38'E) at an altitude of 357m above mean sea level and having a annual average minimum and maximum temperatures of 29.6 ^{0}C and 21.3 ^{0}C, respectively (Subasinghe, 2003).

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The experiment was conducted as a CRD with four treatments, namely forced-air ventilation (T1), 60% shade netting (T2), combination of exhaust fans and shade nettings (T3) and without forced-air exhaust or shading (the control) (T4). The exhaust fans used in T1 and T3 was 60 cm in diameter, having a $60m^3$/min air flow capacity. Data was collected for two consecutive sunny days for each treatment and were repeated three times.

The temperature and humidity (RH) data were recorded at 30-minute intervals inside (at canopy height) and out side the greenhouse. The wind speed and wind direction were also recorded throughout the experimental period. The statistical analysis of data was done using proc ANOVA procedure of software, SAS and MS Excel.

RESULTS AND DISCUSSION

Daily variation of temperature

There was no internal and external difference in mean minimum temperature (21.5 ^{0}C) recorded at 6.00 a.m. and 6.00 p.m. The peak temperature difference was about 4 ^{0}C during mid-day when the air inside the greenhouse reached 33 ^{0}C level in (Figure 1). The results agree with a similar study conducted on greenhouse ventilation (Weerakkody *et. al.*, 2004).

Effect on greenhouse temperature

Shade nets as well as exhaust fans were effective to keep the inside temperature always 1-2 ^{0}C below that of the outside (at a mean day temperature of 27.9 ^{0}C). The combined effect (T3) was highly significant when compared with the individual effects, resulting the lowest mean day temperature of 26 ^{0}C., which was a 3.1±1.1 ^{o}C reduction in mean internal greenhouse temperature (Figure 1).

De Costa (2002), stated that limited transmission of light during mid day peak does not adversely affect photosynthesis. Shaded roofing materials decrease the solar load on both plants as well as inside air and thus help to control temperature (Robinson and Spilman, 1980). The results of this study agree with the earlier reports on the effectiveness of forced-air exhaust under similar situations (Fernandez and Bailey, 1994). It might be due to the high air-flow rate of four exhaust fans (2666 cfm), compared to required ventilation rate (2000 cfm) for a greenhouse flow area of 200 m^2 (Nelson, 1998). Meanwhile the mean natural wind speed of 2.5 ms^{-1} across the greenhouse (South-west to North-east) might have positively affected greenhouse cooling through fast exchange of greenhouse air (Bailey *et. al.*, 2004).

Effect on relative humidity

The relative humidity (RH) inside greenhouse was marginally higher than the out side during daytime, disagreeing with the earlier results where, RH decreases with the increase of environmental temperature (Weerakkody, *et. al.*, 2004). Mean RH of the control was 65.0% inside the greenhouse from 10.00 a.m. to 4.00 p.m. while it was 64.3% at outside.

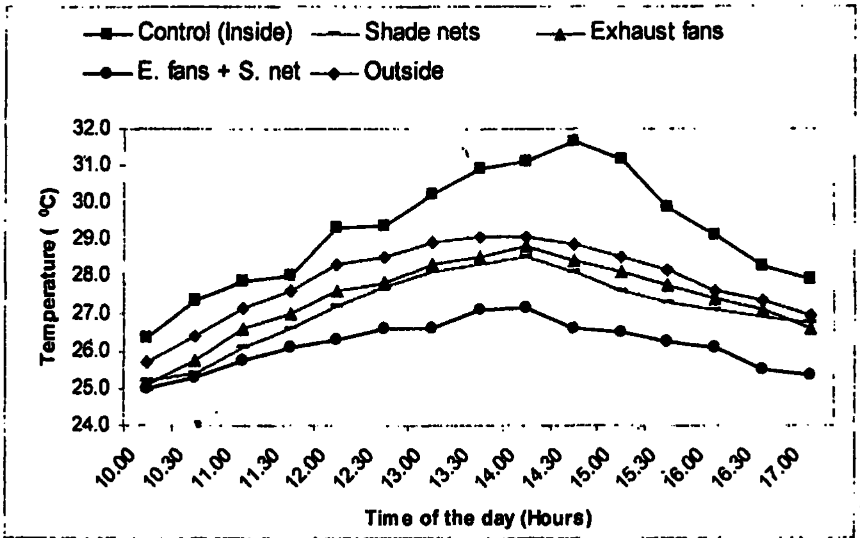

Fig. 1. Daily variation of greenhouse temperature under different temperature control strategies

The results revealed that the internal humidity was maintained at a higher level (7.7%) than the outside whenever the shade nets were used, and on an average, it was 72% between 10.00 a.m. and 4.00 p.m. This emphasizes that entrapment of wet air is higher whenever the shade nets are used. Meanwhile, exhaust fans with a minimum capacity of $60 m^3/min$ gave best results in terms of reduction in relative humidity (63.7%) in comparison with other treatments. This could have also been contributed by the top vent as well as high natural wind flow ($2.5\ ms^{-1}$) across the tunnel.

CONCLUSIONS

Shading was the most effective as well as economical solution for temperature control in greenhouses in the mid country intermediate zone. However, it increased the internal humidity (RH) to a greater extent. Meanwhile, forced-air ventilation with the use of exhaust fans was also equally effective as a greenhouse cooling strategy without significant increase in humidity. Therefore in situations where both high temperature and relative humidity are problematic issues, the best option is the use of exhaust fans. Combination of shade nets and exhaust fans was the most effective cooling strategy despite its negative effect on humidity. However, repetition of the research under minor variations in humidity and wind speed can be suggested before making general recommendations.

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