Danish Research Service for Plant and Soil Science
Research Centre for Horticulture
Institute of Glasshouse Crops
DK-5792 Årslev

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Thermal screens in greenhouses: Methods for estimation of heat saving effect

Metoder til måling af effekten af energiskærme i væksthuse

MARIUS G. AMSEN and OTTO F. NIELSEN

Summary

The heat saving effect of a thermal screen may be determined by measuring the heat consumption in a single greenhouse equipped with thermal screens, where the screens are subsequently in position or not in position during the night in alternating sequences. This method has the advantage that site, house, heat control, heating system, culture etc. are identical. The estimated heat saving effect will therefore be the genuine function of the material used for the thermal screen provided it is possible to eliminate differences in the outside climatic conditions.

Key words: Greenhouse, thermal screens, methodology.

Resumé

I en teknisk undersøgelse kan det være nærliggende at undersøge effekten af isoleringsgardiner i et enkelt væksthus, hvor man skiftevis måler energiforbruget med og uden isoleringsgardin. Fordelene ved denne metode er, at der kun behøves ét væksthus, og at der kan undersøges flere gardiner i samme forsøg. Vi har sammenlignet den traditionelle metode, hvor man anvender to væksthuse, ét med og ét uden isoleringsgardin i samme periode med den anden metode, hvor man skiftevis har isoleringsgardin for og ikke for.

Resultatet viser, at man udligner forskellen mellem hus og sted ved at anvende kun ét væksthus.

Det viser også, at antallet af iagttagelser med og uden isoleringsgardin skal være forskellige, når man kun anvender ét væksthus.

Som grundlag for rådgivning bør forsøgsperioden dog helst omfatte et helt år, eller mindst den periode, hvor energiskærme anvendes, dvs. vinterhalvåret.

For at måle forskelle mellem forskellige typer af energiskærme skal minimum 20 iagttagelser anvendes.

Nøgleord: Væksthuse, energiskærme, metodik.

Introduction

At the Department for Horticultural Engineering, Årslev, Denmark, a series of experiments has been carried out to find the »biological effect of heat saving on plant production in greenhouses«.

A part of this project consists of comparing the effect of thermal screens on heat consumption. In a previous paper (1) it was shown that the heat saving effect can only be based on diurnal observations.

The traditional way of detecting the heat saving effect of thermal screens is to compare two greenhouses, one with thermal screens and a reference house without thermal screens.

Another way is to use a single greenhouse and compare sequences of 24 hours with and without thermal screens in position (1, 2).

Using a single greenhouse has obvious advantages. Variations due to site, house, culture, heating system, climatic control systems, technical and maintenance standard of the greenhouse, will not influence upon the results.

On the other hand, significant variations in the outside climatic conditions will interfere with the results.

Materials and methods

The heat saving effect may be computed from values selected in five different ways:

a. Traditional
identical periods from two greenhouses, an experimental greenhouse and a reference greenhouse.

Alternating sequences
This method uses one single greenhouse where thermal screens are in position one day; the experimental sequence and one day where the thermal screens are not in position; the reference sequence.

Here we can choose to start either with thermal screens in position the first day or with the thermal screens in position the second day. As we may see this will influence the results.

b. Alternating (+)
first day with thermal screens in position.

c. Alternating (–)
first day without thermal screens in position.

To overcome the differences in the two previous methods one may begin and end the experiment with the same treatment. In this case we have one more observation for either treatment.

d. Alternating (+–+)
both first and last day with thermal screens in position, thus giving n – 1 observations without thermal screens.

e. Alternating (–+–)
both first and last day without thermal screens in position during night, thus giving n + 1 observations without thermal screens in position.

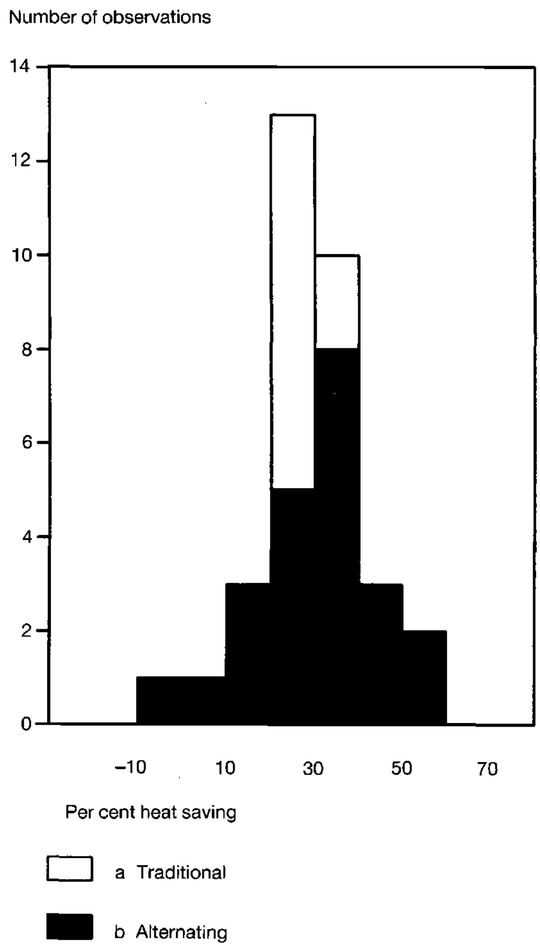

Fig. 1. The number of observations distributed on per cent heat saving shows that the method with alternating sequences in the same greenhouse has a much wider range of variation than the traditional method. The mean values 30.4 and 31.4 per cent respectively are although not identical, fairly in accordance with each other.

Two greenhouses 8 × 21,5 m, both clad with single glass but only one equipped with thermal screens of peritherm were used. At the time of the experiment, the thermal screen was three years old. The thermal screens covered roof, walls and gables and were in position every second night.

Heating is provided by a two step separate bottom heating and a top – and wall heating system, with first priority on the bottom heating.

The room temperature setpoint was 20°C minimum.

Data on heat consumption were collected continuously and hourly values saved for analyses. One observation takes 24 hours from 12.00 h until 12.00 h next noon. All results are based on 23 observations with thermal screens drawn in position.

The experiment was carried out from 11 January – 7 March 1983, when normal plant growth took place in the greenhouse. The experiment was repeated in a single greenhouse from 1 August – 20 September 1985.

Results

Range

The range of the variations of single observations turned out to be dependent on the applied method. When we compute the heat saving in the traditional way with identical sequences in two greenhouses (a) and compare this with the results from an alternating method in one greenhouse, we find a much wider range of variations in energy savings using the latter method, see Fig. 1.

This led us to the conclusion that climatic conditions vary significantly from day to day, and consequently, heat demand will differ as well. Therefore, the choice of method as well as the number of sequences are important.

Comparing different methods

In Table 1, first column, the energy saving is listed in per cent. A difference from the traditional method (a) of 1.6 per cent is seen. As the periods in which the thermal screens are in position are identical this difference can only be explained by the variation in the energy consumption in the reference sequences. This is illustrated in the third and fourth column in Table 1 which shows energy consumption in the reference greenhouse subsequently the reference sequences in the experimental greenhouse.

The fifth column shows the difference in energy consumption between the reference house and identical reference sequences in the experimental house. From this we see that a systematically lower energy consumption has occurred in the reference house, thus resulting in a lower energy saving with the traditional method (a).

The difference between the two greenhouses ranges between 1.0 and 1.4 per cent points. This is the effect of site, environmental control system, technical- and maintenance standard.

Not suprisingly the results of methods »d« and »e« are in between »b« and »c«.

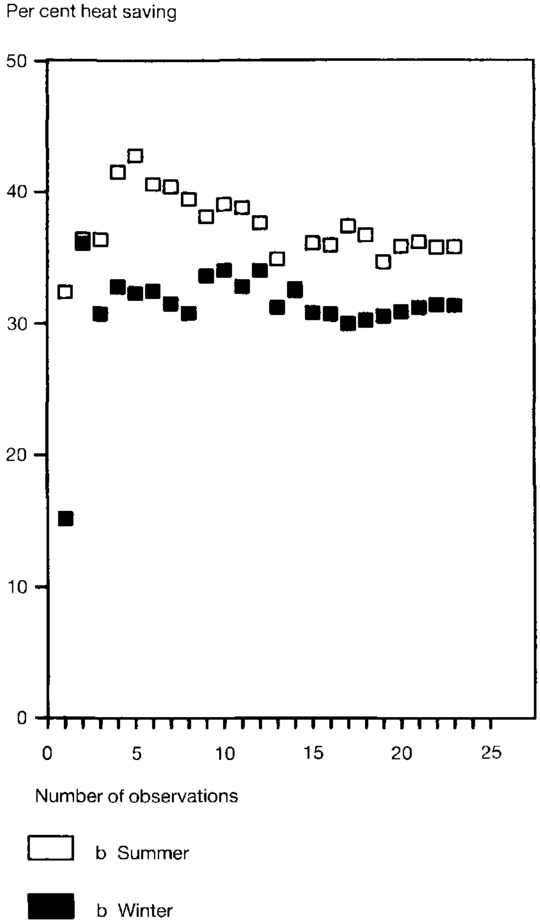

Fig. 2. The variation of per cent heat saving as a function of the number of observations. The average values in the summer experiment are consistently higher.

Table 1. Heat saving of thermal screens, computed in five different ways.
The third and fourth column show the energy consumption in reference sequences when thermal screens are withdrawn during the night.
A systematically higher energy consumption is found in the experimental greenhouse in the reference sequences during the winter experiment (fifth column).

Method	Heat saving, per cent		Energy consumption, w/m^2		Discrepancy
	winter 1	summer 2	winter 3	summer 4	winter 5
a. traditional	30.4	–	187.8		–
b. alternating (+)	31.4	37.4	192.0	47.3	2.7
c. alternating (–)	32.0	34.8	193.7	45.4	1.9
d. alternating (+–+)	31.8	35.9	193.0	46.2	2.6
e. alternating (–+–)	31.7	36.4	192.7	46.6	2.0

Seasonal variations

The experiment was repeated during August. 1985 using only one greenhouse. We find a greater difference between the four methods, method b, c, d and e, than in the winter experiment, Table 1, column 2.

The results obtained in the summer experiment show a higher energy saving effect than the experiment during the winter.

Number of observations

In Fig. 2 we have drawn the discrepancy from the final result of an increasing number of observations.

After 15 observations the discrepancy from the final result is less than one per cent and after twenty observations less than 0.5 per cent. Bearing in mind the pronounced differences which occur due to choice of method or time of the year a series of approximately 20 observations seems to be sufficient.

Discussion and conclusion

This experiment shows that the heat saving effect of thermal screens can be determined in a satisfying way by applying only one single greenhouse. But several precautions should be taken. Single observations are unacceptable and will give a very wide range of variation (Fig. 1) mostly due to climatic variations from day to day. The number of observations are of course important and from this experiment at least 20 observations are sufficient to obtain an applicable result. In order to distinguish between different screen materials short term experiments of 20 observations may suffice.

The time of the year will have a significant effect on the final result. Depending on the method a difference in the energy saving effect of 1.4 in winter or 2.6 per cent in summer has been found. The difference between summer and winter experiments is as much as 6 per cent.

For practical advice results from year round or at least winter period experiments are required.

References

1. *Amsen, Marius G.* 1984. Thermal screens in greenhouses: Diurnal variations in heat consumption. J. agric. Engng 33, 79-82.
2. *Meyer, J.* 1984. The influence of thermal screens on energy consumption of greenhouses. Gartenbauwissenschaft 49, 74-76.

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