Covering

NIR-screen as an en

As well as PAR-light, UV and NIR light also penetrate greenhouses. In months with cold weather, NIR helps to warm the greenhouse. However, during the summer the incidence of NIR light means that greenhouses require extra ventilation or cooling. Various methods can filter NIR from the greenhouse.

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Solar radiation consists of light of varying wavelengths, namely ultra-violet radiation UV (300 – 400 nm), photosynthetically active radiation PAR (400 – 760 nm) and near infra-red radiation NIR (760 – 2500). As the wavelength increases, the radiation loses energy and virtually all the UV radiation is absorbed by the earth's atmosphere, so that approximately half of the energy content of the solar radiation falls in the PAR range and the other half in the NIR range. The various wavelengths have different effects on what subsequently happens in the greenhouse.
Much attention has been paid recently to near infra-red radiation (NIR). NIR is not necessarily required for plant growth, but the energy created by this form of radiation does contribute to heating the greenhouse and therefore the plants.
During the summer, the extra temperature increase caused by NIR light is unwelcome. Without sufficient ventilation or cooling capacity, the high temperatures quickly cause symptoms of heat stress in the crops. In addition, the extra ventilation extracts a lot of CO_2. This causes the rate of photosynthesis to fall with all the negative results for plant growth. For this reason, growers try to keep the air vents closed as much as possible. By limiting NIR transmission in the summer, the CO_2 level will rise. In the winter, the sun is the cheapest energy source. By filtering (reflecting) infra-red radiation completely all year round, the energy consumption will rise by more than 10%.

Limiting NIR

Many light loving plants, such as tomatoes and roses need to be protected from too much heat (infra-red radiation). Too much PAR light is not a problem for most plants, with the exception of shade loving plants.

An experimental Near Infra-red reflecting screen is constructed on the outside of the greenhouse.

For the majority of plants cultivated in greenhouses, a high PAR and a low NIR transmission (in the summer) is therefore the optimal situation.
The amount of NIR that passes through a material depends on the properties of the material in question. In addition, depending on how the screen is constructed, there is a choice of whether the material is used or not. Various options can be used to reflect NIR light:

- screening (retractable or whitewash) inside or outside the greenhouse
- a greenhouse roof made of a material with a lowered NIR transmission, for example specially coated material.

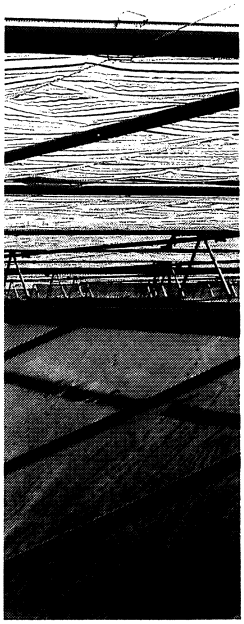
Indoor screens

Closing indoor screens is a good, flexible way of preventing unwanted irradiance of NIR and of protecting plants against excessively high temperatures. However, screens not only limit the amount of radiated energy, but also the amount of PAR light that reaches the plants in the greenhouse. Screens can have a negative impact on plant growth. Depending on the screen construction, they can also influence the ventilation capacity.

Outdoor screens

For a better air exchange, outdoor screens are more effi-

rgy saving solution



cient than indoor screens. But this type of screen has three disadvantages. Firstly, they are technically more complicated. Secondly, they reduce the total transmission of the greenhouse due to the heavy, permanent construction. And finally, these screens are more susceptible to damage caused by the weather conditions.
Painting the panes of the greenhouse with whitewash is also a method of (outdoor) screening, but then in an immobile form. Traditional whitewash cuts out a lot of light. Whitewash is also difficult to adapt correctly to the outside climate (too early or too late). A layer of whitewash also cuts out light on cloudy days in the summer and during other times of the day when the natural sunlight is actually needed. A selective whitewash that mainly reflects the NIR part of the light spectrum is already a considerable improvement.

New materials

Materials that let through as much PAR light as possible for optimal plant growth, but limits NIR to prevent the greenhouse from heating up too much, would be a step in the right direction.
Once such a material has been found, an effective way of using it has to be chosen. There are various types of NIR reflecting materials on the market that offer such possibilities. The optical properties of these materials require investigation first.
Many NIR-reflecting materials also greatly reduce the transmission in the PAR range.

Research

In the framework of the energy studies, Wageningen UR Greenhouse Horticulture, with funding from the Ministry of Agriculture, Nature and Food Quality and the Product Board Horticulture, will be running a trial using NIR film in the coming spring/summer. By measuring the effects of the filter on the plant response and processes in the greenhouse, this experiment should provide more answers as to the potential application of the film in the Dutch horticultural sector.
In two trial sections in the experimental greenhouses in Bleiswijk, a retractable NIR-screen as wide as the roof will be installed. As the greenhouse has an east-west orientation the upper screen on the south side can stay closed for longer, while ventilation takes place on the north side. This approach obtains the maximum effect from the film. Various measurements will be made of both the plants (roses) and the climate in the greenhouse.
The light properties of the film used are comparable to the film shown in *Figure 1*. This film can reflect about 40% of the NIR light. The film will be made into a screen so the researchers can choose whether to reduce the NIR in the greenhouse or not.
The main objectives of the study are to identify and register:

- The effect of the filter on the ventilation need and CO_2 management in the greenhouse;
- The consequences of a probably lower evaporation on the humidity (and energy) balance in the crop;
- The effect of the filter on crop temperature and DIF (difference between day and night) (the reduction in crop temperature is only present in the daytime), and consequently crop development.
- Reduction of CO_2 emission through less ventilation.
- Improved crop management and production in a NIR-poor greenhouse environment. ■

FIGURE 1: THE TRANSMISSION OF THE FOUR MATERIALS IN THE WAVELENGTH RANGE OF 300-2500NM

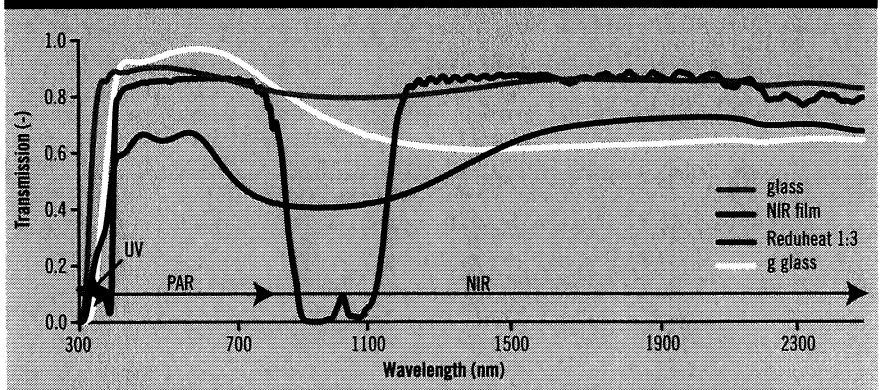


Figure 1 illustrates the spectral transmission of various materials and applications. A type of glass (g glass) with a coating with higher levels in the PAR range and lower transmission in the NIR range, a film that reflects NIR (suitable for use in screens) and a NIR reflecting whitewash (Redu Heat –1:3–). For the purposes of comparison, standard glass panes were also included in the figure.
The figure also shows the various bandwidths for the UV, PAR and NIR wavelength range. The transmission of the various materials differs greatly in the UV range. The level of PAR light transmitted is more or less equal (with the exception of whitewash). The main difference between the materials was their capacity to reflect unwanted NIR radiation. The energy content of the radiation is the greatest with shorter wavelengths, the relatively small range between 800 and 1100 nm, where the NIR film is highly effective, already contains approx. 35% of the "useless" solar energy in the entire NIR spectrum. The result is that materials that reflect selective radiation of 800 – 1100 nm, are better able to contain a temperature increase in the greenhouse than materials that reflect selective radiation between 1100 and 1400 nm.