Less transpiration and good q

Materials or additives for greenhouse cover that reflect or absorb a part of the NIR radiation can decrease the cooling requirement for the greenhouse and increase water use efficiency of the crop. By reducing the ventilation requirement, it might even decrease emissions of carbon dioxide from greenhouses with CO_2 fertilisation.

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Sunlight is more than only the light which meets the eye. Only about half of the energy that enters a greenhouse as sun radiation has wavelengths ('colours') that we can see, and that the plants can use in the photosynthesis process (Photosynthetic Active Radiation, PAR). Nearly all remaining sun energy is in the Near InfraRed wavelength range (NIR) which warms both the greenhouse and the crop and which contributes to transpiration. Materials that filter NIR more than PAR have recently become commercially available. In a first trial (carried out from May to October 2008) such material was installed as a movable screen on a rose crop 'Passion'.

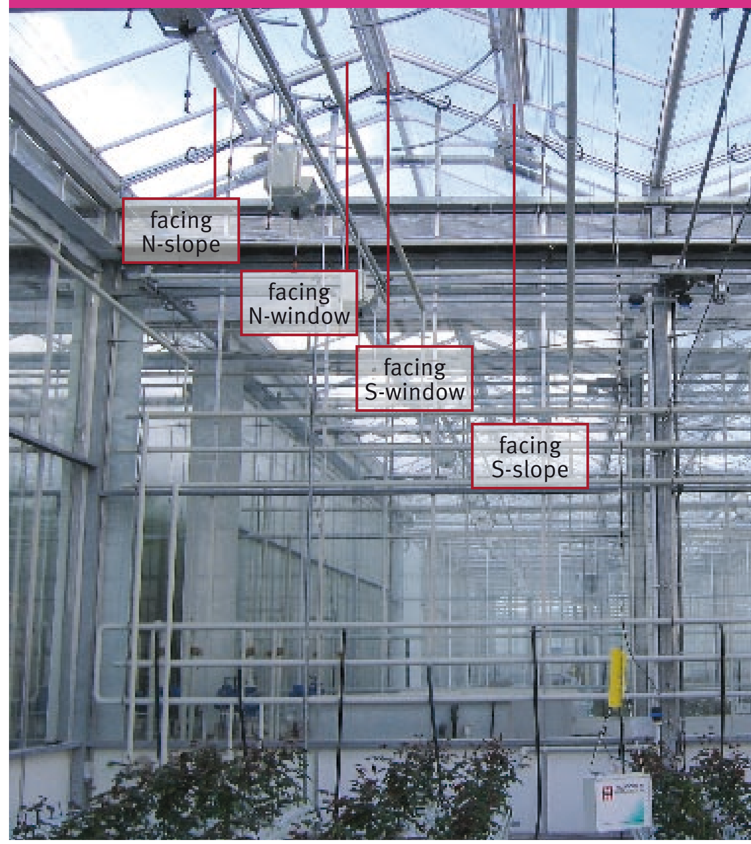
Movable screen

The NIR-reflecting cover should not be permanent. In the first place a grower often needs all sun radiation to heat the greenhouse. Therefore the NIR cover was installed as a movable screen, taking care, however, that the ventilation capacity of the house was not reduced.

The most selective material available at the time (end 2007) was a sheet that reflects about 50% of the NIR radiation (that is, about 25% of the energy content of sun radiation, *see Table 1*) and about 10% of the PAR. The sheet is manufactured and was kindly provided by the 3M Company, St Luis, USA. The screen was implemented as a rolling screen in two compartments (two spans each), sliding parallel to each slope, and segmented so that the section in front of an open window (zenithal, on both sides of the roof) could be open (*Figure 1*).

The purpose of the experiment was determining the effect of NIR-selective, movable screens on crop production, so that indirect effects (through greenhouse temperature, PAR interception and CO_2 concentration) had to be excluded. Hence the reference was a crop grown in exactly the same conditions, except the selective filtering of the NIR radiation. Therefore, in the two similar reference compartments screen material was installed that is non selective and filters about

Figure 1: The screen installations, for each span there were fo the roof slope, two in front of the continuous zenithal windov slopes.



10% of NIR as well as PAR (ILS ultra, Ludwig Svensson). At night no screening was applied and all screen segments were closed as soon as the greenhouse temperature approached the daylight ventilation set point. When this was not enough, the windows (and facing screen segment) were gradually open, starting from the North facing slope. The settings for greenhouse temperature and CO_2 concentration were the same in all compartments, which resulted in equal climate factors.

Climate

The number of hours in which ventilation was required was nearly the same in the two treatments. However, the average opening angle was 5% less in the NIR-screened compartments. Through a model accounting also for wind speed, it was determined that the NIR-filter decreased the mean air exchange rate by about 7%. As the capacity of the CO_2 injection system was not always enough to warrant the desired 1000 ppm under high ventilation rates, the mean daytime CO_2 concentration was 30 ppm higher (911 vs 881) under the NIR filter. This difference is however comparable with the accuracy of the CO_2 meters.

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Crop transpiration

The NIR screen appeared to have quite an effect on crop transpiration (*Figure 2*). Obviously, the effect increases as the transpiration gets higher. These are the conditions when sunshine is the main driving force for transpiration, and in such conditions the screens were closed. At night the screens were open and the transpiration was the same in all compartments. In the range in-between (little sun radiation, for instance 2 and 3 July in *Figure 2*), the effect of the NIR-selective screen on transpiration is smaller, since transpiration is partly driven by the humidity deficit of the air.

Crop production

No differences were detected in crop morphology and development. Production (dry matter and number of stems) was nearly the same in all compartments. In the NIR-screened compartments stems were 0.5 cm longer and a few grams heavier (fresh weight). The time from bud break to harvest was longer (29.0 days versus 27.9 days in the reference), which may have been caused by the fact that under the NIR screen the crop was slightly cooler.

Perspectives

The perfect NIR-selective filter does not exist yet. Nevertheless, the results of this experiment offer useful insights. The most interesting result is the significant decrease in crop transpiration in the compartments with NIR-screens.

There was no effect on crop production and quality. There is, therefore, a good potential for increasing water use efficiency, wherever good quality irrigation water is scarce or expensive.

In the well regulated greenhouses of the experiment, a NIR-selective filter may be worthwhile whenever the weather conditions would exceed the temperature-controlling capacity of ventilation and/or misting, or when the required ventilation would exceed the capacity of the CO_2 supply system. Unfortunately, such conditions hardly happened in the period of our experiment.

In more passive greenhouses - which is common in the Mediterranean region, where the limited ventilation capacity shortens the growing period, and whitewash is mandatory in late spring and early autumn - a good NIR-filter may significantly improve productivity, both in terms of length of cropping and increased crop assimilation with respect to whitewash.

Besides obvious financial cost/benefits considerations, the choice whether installing it as movable or seasonal screen must account for the fact that a permanent screen also lowers night time temperature, since less sun energy is harvested (and stored in the soil) during daytime. ■

Table 1: The wavelength ranges of sun radiation. The fraction of sun energy is approximate, since weather conditions may affect it. The last column gives the major effects relevant for greenhouse crops.

Wavelength (nm)	Colour	Name	Fraction of sun energy	Effect on...
300–400	ultra–violet	UV	4%	• Plant morphology • Insect orientation
400–700		PAR	48%	• Photosynthesis • Warming • Transpiration • Plant morphology
700–2500	near infrared	NIR	48%	• Warming • Transpiration

Figure 2: Transpiration in the four compartments, from June 29th to July 3rd. Data are hourly means of each compartment.