Calculation of NIR effect on greenhouse climate in various conditions

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Problem

The limit to a longer cropping period in greenhouses in temperate regions is high temperature. Cutting-off the Near Infra Red (NIR) component (~50%) of sun radiation might help. NIR can be excluded by reflection or absorption. Absorption warms up the cover, so that part of the absorbed energy reappears at longer wave-lengths in the greenhouse. Efficiency of reflection is limited by re-reflection by the cover surface of the high (~45%) fraction of NIR reflected by the crop. Usually reflection is achieved through interference caused by multilayer technique. A new development is absorption by surface-plasmon resonant (SPR) nano particles (BASF). Prior to implementation at the experimental station of the Fundación Cajamar in Almeria (ES), in the framework of the EU-project EUPHOROS, the effect of various combinations of these absorbers on greenhouse climate was established with a simulation model (KASPRO).

Photo 1: Experimental station of the Fundación Cajamar.

Films and calculations

Fig. 1 shows the spectral properties of the films that were investigated and for their effect on energy load of the greenhouse see tab. 1. The climate model was calibrated with data of a tomato greenhouse experiment with a commercial film that was slightly different from the BASF-reference.

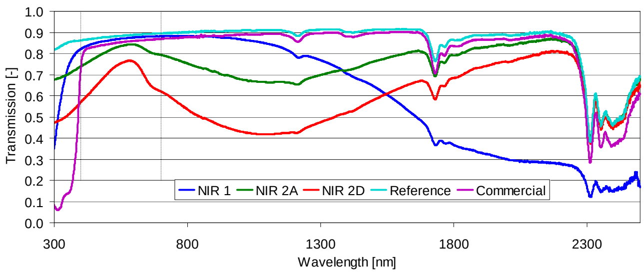

Figure1: Transmission spectra of the investigated films.

Table1: Effect of these films on energy load of the greenhouse and emission coefficient (%).

	NIR 1	NIR 2A	NIR 2D	Reference	Commercial
ε 2500-25000nm	37	29	35	61	70
τ PAR 400-700nm	86	81	69	88	85
τ NIR 700-2500nm	81	73	52	90	88
α PAR 400-700nm	4	12	26	2	10
α NIR 700-2500nm	12	19	39	1	3

Results

Calculations show that a NIR filter may cause summer greenhouse temperature even to increase (Fig. 2), in spite of the energy absorption. This is due to less conversion into latent heat, reradiation and convection.

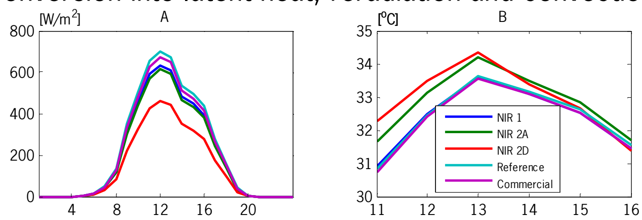

Figure 2: Global radiation inside the greenhouse [A] and detail of greenhouse air temperature from 11:00 till 16:00 [B] may 20th.

In winter a larger fraction of the absorbed energy is released outside, so that greenhouse temperature is lowered by the NIR-filter in the cover (fig 3).

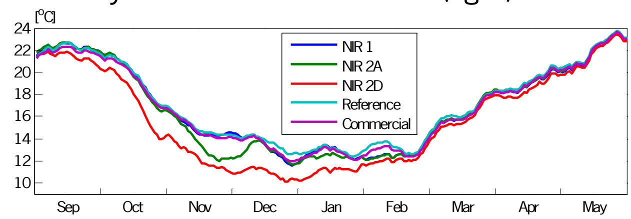

Figure 3: mean greenhouse air temperature during the cropping cycle. (moving average over 7 days)

Conclusions

- A year-round NIR filter will either lower temperature or increase heating requirement in winter.
- The combined effect of all spectral properties (transmittance, reflectance and emissivity) needs to be considered, particularly for summer conditions.
- As some of the negative effects of a NIR filter may be mitigated by adapting ventilation set-points, it is worthwhile to verify results in an experiment.

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