REQUIREMENTS OF PLASTIC FILMS FOR GREENHOUSE APPLICATION - LATEST DEVELOPMENT IN RESEARCH

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Abstract:

The requirements for plastic films for greenhouse applications can be summarised as follows:

- High light transmission (PAR 400-700nm)
- Optimum light spectrum (depending on crop needs)
- Optimum heat energy input (solar radiation 300-2500nm, depending on climatic region))
- Low heat losses (FIR >2500nm, insulation, depending on climatic region)
- Optimum condensation (no water drops)
- High mechanical resistance
- Low sensitivity to ageing (UV, temperatures, chemicals)
- Fabrication sizes
- Cost - benefit

The presentation will focus mainly on the optical properties of plastic materials: what is the right method to determine the light transmission of materials for greenhouse application, what is the effect of changing the light spectrum and which are the related plastic film developments. Next to that two major requirements from the crop point of view are pointed out: Diffuse light and NIR-filtering.

Diffuse light

In regions with high irradiation such as the tropics, subtropics and (semi-)arid regions, but also in Western Europe, the use of diffuse greenhouse coverings results in lower crop temperature, decreases transpiration, and increases photosynthesis and growth. Experimental results show that crops are able to utilise diffuse light better than direct light. Diffuse covering materials cause a better vertical light distribution within the crop, which leads to a higher photosynthesis of the middle leaf layers of high-grown crops (e.g. cucumber), which leads to a significantly higher production. Cast shadows normally caused by greenhouse construction elements, are also avoided, resulting in a better horizontal light distribution and a more uniform plant production.

Various greenhouse coverings and screens can be used to transform direct light into diffuse light. However, the light diffusing properties of the materials are often not known. Haze and hemispherical light transmission are the most important parameters to characterise diffuse materials. Studies showed that diffusing properties of a material, especially in plastic films, sometimes result in a decrease in hemispherical light transmission. During the development of new greenhouse covering materials with high diffusing characteristics it is important to keep the hemispherical light transmission as high as possible. It can be expected that the potentials of diffuse covering materials are high for most climatic regions and crops.

Experiments with cucumber in The Netherlands show that a production in crease of up to 10 % is possible with diffuse coverings.

NIR-filtering

Global radiation enters the greenhouse and can be divided into ultraviolet radiation UV (300-400nm),

photosynthetic active radiation PAR (400–700nm) and near infrared radiation NIR (800–2500nm). PAR absorbed by the crop is important for growth and photosynthesis, NIR is less absorbed by the crop (45% reflection) but it is absorbed by installations and construction elements of the greenhouse and increases air temperature. In Western Europe in greenhouses the heating effect caused by global radiation is desirable during winter, but during summer the temperature in the greenhouse can increase to undesirable levels. In fact, to prevent high temperatures or to reduce the cooling load in greenhouses during high temperature periods has been one of the most important problems to be solved in protected cultivation in most countries worldwide. Since many years scientists and companies are working on greenhouse covering materials to reduce greenhouse inside temperature significantly. NIR-reflecting materials (coverings, screens, coatings) are one possibility to control the energy coming inside the greenhouse and therefore the greenhouse climate. The first NIR-reflecting materials are now on the market. Analysing the optical properties show that materials reflecting NIR from 800-1100nm are most efficient and can result in an reduction of NIR energy of 40%.

It depends on the climatic region whether this effect is wanted year-round or only during summer periods. In Northern Europe adaptable NIR-filtering screens with a high light transmission are needed, which do not limit the greenhouse ventilation. In conditioned greenhouses NIR-filtering potentially reduces cooling capacity up to 30%. In Mediterranean Countries (adaptable) NIR-filtering screens should be used during in hot periods in order to extend the growing period. In unheated greenhouses NIR-filtering coverings lead to low crop temperatures and a reduction in crop development. In tropical regions NIR-filtering coverings reduce air and crop temperatures permanently and could be a good alternative in the future.

Experiments with a NIR-reflecting screen in The Netherlands on roses showed that the opening of the ventilation could be limited and crop temperature during warm periods could be reduced, which resulted in a reduction of crop transpiration and in an increase in water-use-efficiency. Crop production was slightly slowed down due to lower crop temperatures but crop quality was slightly increased.

The challenge for future materials is to reflect NIR more efficiently and having a high hemispherical light transmission at the same time.