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The role of condensation in greenhouses on light transmittance

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Introduction

Greenhouse crops transpire water, air humidity increases. In Northern latitudes in single glass greenhouses part of this water condenses at the inner surface of the greenhouse covering. With model calculations the amount of water can be quantified to be ca. 100 l per m² of greenhouse roof per year. Furthermore, model calculations show that during winter month from October to March under Dutch greenhouse conditions the inside of the greenhouse covering is wet during most hours due to condensation (Figure 1). Condensation in the form of droplets reduces light transmittance. However, the effect of condensation on new diffuse glass types is unknown. Since light is a limiting growth factor the light reduction by condensation on different types of glasses in situ in the greenhouse roof has to be quantified.

Conclusions

- Diffuse glasses investigated (pyramidal, etched) showed an increased light transmittance compared to uncoated, unstructured float glass if wet (Figure 3).
- Due to differences in laboratory and greenhouse in situ measurement methods, differences occur in measurement results.
- Laboratory measurements are carried out creating artificial drops under defined light conditions, in the greenhouse natural drops are created under fluctuating external light conditions.
- Since in situ measurements are time and space consuming and show high variability, currently an improved laboratory measurement method for reproducible data is developed for fast material screening.

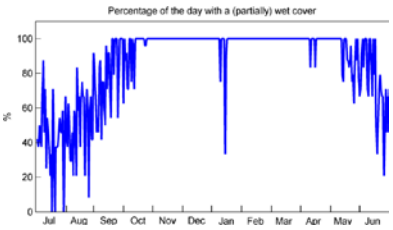
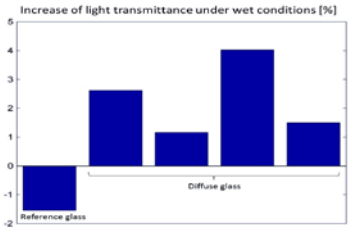


Figure 1. Model calculations (Kapspro, de Zwart, 1996) of the percentage of time that a greenhouse covering is wet by condensation on the inner side during the year in a single glass greenhouse with a tomato crop in The Netherlands

Figure 3. Increase of light transmittance of wet glasses compared to dry glasses measured in situ in a greenhouse



Objective

Quantification of light reduction by condensation behaviour of diffuse greenhouse glasses with different diffuse structures and anti-reflection coatings.

Materials and Methods

Diffuse greenhouse glasses have micro-structured surfaces (etched, matt/matt or pyramidal) for light diffusion and nano-sized surface treatments (anti-reflection coating) for higher light transmittance. Four diffuse materials and one non-diffused, non-coated reference material have been investigated (Table 1). Measurements of angular light transmittance of dry and wet materials have been carried out on an integrating sphere in the laboratory. Afterwards they have been mounted in a greenhouse roof at our experimental station. PAR Lite sensors have been placed at the inner side of the glass, just under the glass. Condensation occurred in a natural way on the glass. Duplicate glass panels were kept dry by blowing heated air (Figure 2). Measurements were done permanently during the winter period 2014/2015. Data show a comparison of dry and wet materials.

Code	Description
Float	Reference glass, no surface structure, no coating
Pyramid 1 inside	Diffuse glass type 1, pyramid surface structure inside, AR coating on both sides
Pyramid 1 outside	Diffuse glass type 1, pyramid surface structure outside, AR coating on both sides
Pyramid 2 inside	Diffuse glass type 2, pyramid surface structure inside, AR coating on both sides
Etched	Diffuse glass type 3, etched surface treatment both sides

Table 1. Description of glass materials used.

Figure 2. Glasses mounted in a greenhouse roof with dry upper part and wet lower part, PAR Lite sensors mounted below

Results

Light transmittance in the laboratory

- Figure 4 (left) shows the results of angular light transmittance of all glasses for dry and wet condition in the laboratory.
- Float glass and Pyramid 1 outside show a light loss if wet.
- Pyramid 1 & 2 inside show a higher transmittance at angles of 40-80°.
- Etched glass shows a transmittance increase at angles of 40-60° but a decrease above 60°.

Light transmittance in the greenhouse

- Figure 4 (right) shows the measured light transmittance of glasses mounted in the greenhouse roof in wet state compared to dry state.
- Float glass shows a clear light loss in wet state.
- All diffuse glasses show an increased light transmittance in wet state compared to dry state.
- Light increase in highest in pyramidal glasses. Pyramid 1 inside shows a higher light increase than Pyramid 2 inside, like in laboratory.
- Pyramid 2 outside shows a light increase in the greenhouse, but not in laboratory.

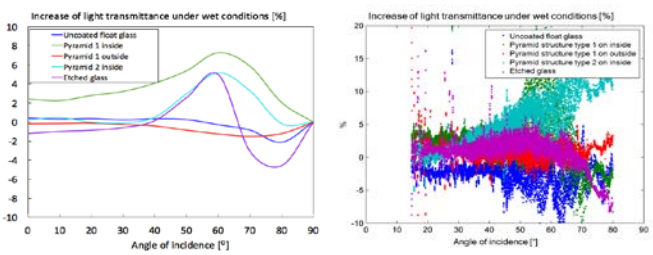


Figure 4. Difference between angular light transmittance of different glasses in dry and wet state measured in the laboratory (left) and in situ in the greenhouse (right).

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