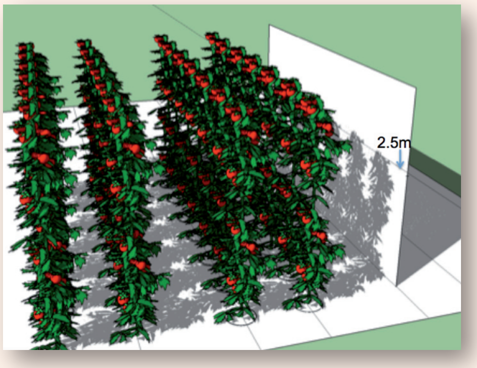
Enabling Diffuse Light

Introduction

The principle and benefits of diffuse light in greenhouse crops are widely accepted and these were covered in a previous technical update (July 2014). In this document, we remind ourselves why diffuse light is important, explain how it is measured and the different solutions available to enable this benefit in your greenhouse.

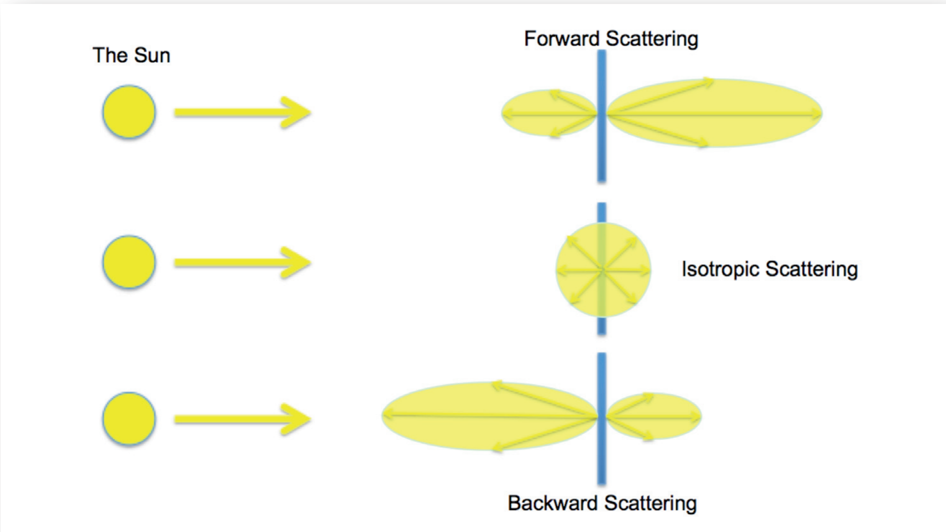


Why is diffuse light important?

The biggest issue with direct light is that it causes areas of very high light intensity (where the light penetrates) and areas of shade where light fails to reach. Although the calculated average light level may be high, there will be unevenness in crop growth and yield as a result. By scattering the light, areas of shade may be reduced to give better penetration into the crop canopy, as well as enabling the plants to improve their use of light. Waginingen UR reported yield benefits up to 10% for edible crops and a reduction in the time to market of ornamental crops of around 25% in some cases. Working conditions for staff in greenhouses are better too.

How is diffuse light measured?

As more growers begin to use diffuse, materials and realise their benefits, it is necessary to be able to explain the various diffuse light qualities of materials and the differences between them. Light scatter, F-Scatter and haze are three such measures.



Light scatter:

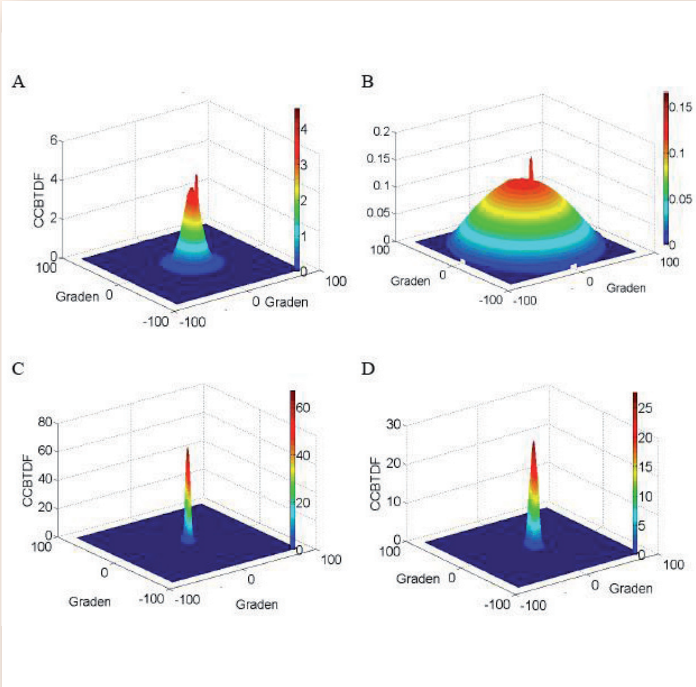
As light passes through different materials it can scatter in different ways, this characteristic is known as its scatter cone. Highly transparent materials have a forward scatter cone whilst less transparent or reflective materials will produce a backwards scatter cone. It is currently believed that crops respond best when light is scattered evenly in all directions, termed an Isotropic scattering pattern, as shown (left).

F-Scatter:

To assist with quantifying the scatter cones of different materials, Waginingen UR has developed a measurement known as F-Scatter. This is a relational measurement of the light scattering of a particular material, in comparison to the ideal isotropic pattern, quantified by a value between 0 and 1. Well scattered light approaching isotropic conditions would be given a value approaching 1, whereas direct light (highly forwards scattering) would be related by an F-scatter value close to zero. Different materials can thus be quantified, and material choice made by querying the F-Scatter value.

The measured scattering cones of four different glass materials are shown in the diagram on the right. The highest F-Scatter is exhibited by B, which as an almost ideal isotropic distribution with F-Scatter of 1.

Material	Light Distribution	Haze	F Scatter
A	Slightly Isotropic	92%	0.67
B	Ideal Isotropic	94.7%	1.0
C (etched glass)	Highly Forward Scattering	41%	0.153
D (Prismatic)	Forward Scattering	73%	0.351



The scattering pattern of 4 glass materials measured at Wageningen UR by Hemming et al.

Haze:

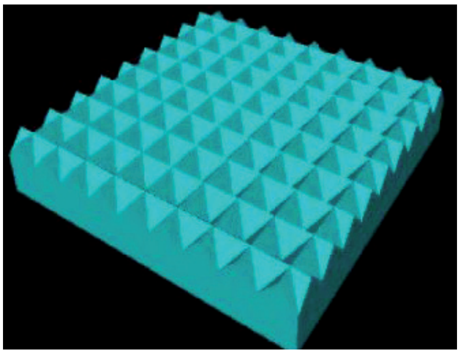
The proportion of light scattered by a particular material is termed its haze. High levels of scattering would have a high haze value, and vice versa. However, even if a material has a high haze value it does not necessarily mean the scatter pattern is idealised or isotropic. A haze value, usually given in percentage terms, refers to the proportion of light scattered. For example, a material with 25% haze has scattered a quarter of the light that passes through it. Typically, transparent surfaces exhibit 0% haze, while highly matt surfaces can have haze values up to 80%. Table 1 (right) demonstrates the haze levels achieved by a range of commercially available glass materials.

Material code	Basic glass	Surface structure	Haze
FLOAT	Normal	Float	0%
FLOAT ARAR	Low-iron	Float	0%
HT 20	Low-iron	Matt/matt	25%
HT 20 AR	Low-iron	Matt/matt	20%
HT 50	Low-iron	Matt/matt	52%
HT 50 AR	Low-iron	Matt/matt	51%
HT 75	Low-iron	Large matt/matt	76%
HT 75 AR	Low-iron	Large matt/matt	77%
HT 85	Low-iron	Prismatic	84%
HT 85 AR	Low-iron	Prismatic	85%

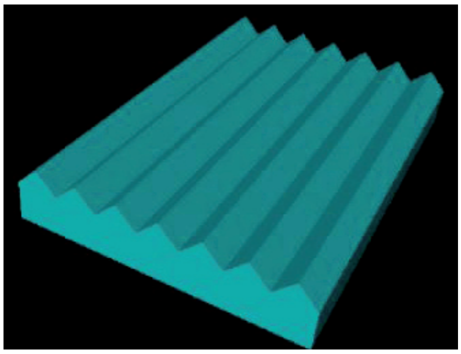
Table1: The optical transmission of a range of different glass materials tested at Wageningen UR by Hemming et al., 2012. Haze is given as a percentage relating to the proportion of light diffused. AR refers to anti reflective coatings.

Achieving diffuse light

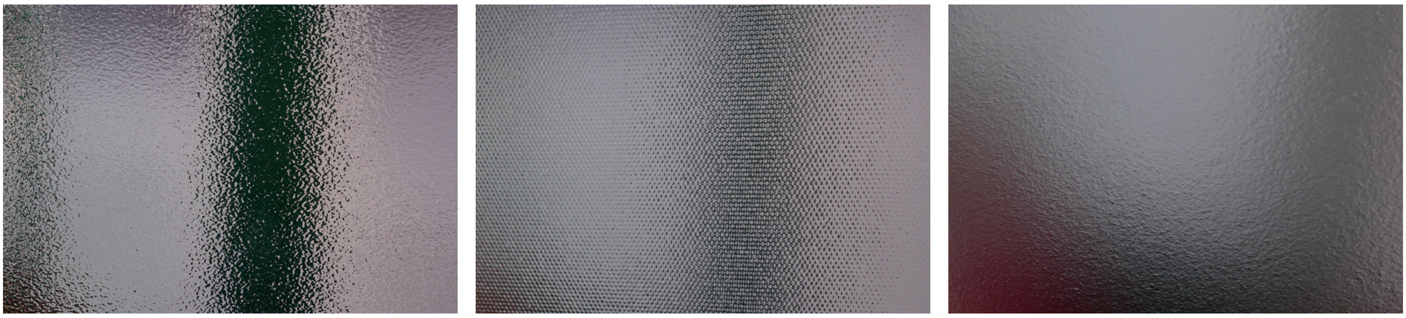
The best way to ensure a highly diffuse light environment is to clad the greenhouse in a material (usually glass) that has very high haze and F-Scatter properties. This is usually achieved by using glass with a 'prismatic' surface. In practice, this means the glass has grooves etched on one side or even an inverted pyramid type surface, (see examples right and below).



Inverted pyramid



Grooved surface



Examples glass etchings to achieve diffusion of light

However, as table 1 demonstrates high haze can be achieved with Matt surfaces. This then opens the possibility of coating existing glass with a suitable media i.e surface coatings such as Redolux and D-fuse. There is limited experimental evidence of the impact of glass coatings on yield; however, Dueck et al (2012, Wageningen report GTB-1158) showed that a proprietary coating applied in May yielded 5% more tomatoes than the control. While this is a significant impact for a short duration of application, more independent information is required on the performance of these materials, and AHDB trials are ongoing through the summer 2016.

It is also possible to retrofit screen materials within the greenhouse to achieve similar effects. For example, ETFE films which have a high scattering and haze effect. Similarly, thermal screens are available that also have haze enabling materials built in.

It is possible to deploy more than one diffuse light technique collectively. For example, even if a diffuse cladding is installed, further benefit would be had by also using a diffuse light enabling screen as light will be diffused further still. In addition, if diffuse claddings are used there will still be direct light transmitted when the vents are open.

Greenhouse structure fitted with ETFE film beneath glass as seen at Greentech 2016