GROWERTALKS

Technology

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Glazed and Diffused

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For decades, we've known that diffused sunlight is more beneficial to crop growth than direct sunlight. Diffused sunlight is scattered sunlight, which provides more uniform illumination of all plant surfaces, penetrating deeper into the crop canopy, providing lower leaves with more PAR light (photosynthetically active radiation—400-700 nm). This means more photosynthesis and hence more yield—researchers at Wageningen University (WUR) in the Netherlands report anywhere from 5 to 11% yield gains on high-wire crops like tomatoes (8.5 grams heavier) and cucumbers (10 to 15 grams heavier), while leafy greens can see up to a 7% biomass gain. But this isn't new data; WUR published this way back in 2011.

This new Dutch range by greenhouse builder Havecon Horticultural Products is typical of modern CEA greenhouses. The 70,000 sq. meter (700,000 sq. ft.) Venlo-style range, which will be producing cucumbers, features low-haze glass with double anti-reflective (AR) treatment to maximize the light transmission.

Knowing this, why don't all CEA greenhouses make use of diffused light as part of their growing regime? Higher up-front cost is one reason, along with a knowledge gap of the benefits, or even skepticism that the marginal gains justify the investment. Plus, more growers are making use of supplemental lighting via LEDs and are getting more light to their crop that way. That said, one Dutch academic estimates that 90% of new Dutch CEA greenhouses are equipped with diffused glass. However, one Dutch greenhouse builder told us, "The battle between clear and diffuse glass is ongoing. Some choose diffuse and some clear. Every grower has his own reasons for this."

Technical benefits of diffused light

Diffused light, which can be achieved through specialty coated or etched glass, plastic films or even retractable shade curtains, significantly benefits food crops like tomatoes, cucumbers, peppers and leafy greens.

In addition to the yield benefits seen by WUR, above, diffused light lowers leaf temperatures by 5-9 degrees F (3-5 degrees C) compared to direct sunlight, by reducing hot spots and intense radiation on upper leaves. This minimizes photo-inhibition and heat stress, reducing wilting and water use, especially in sunny climates like the U.S. and Israel.

Diffused light eliminates shadows cast by the greenhouse structure and improves light uniformity across the growing area, boosting fruit set and quality, and even shortening production times. For instance, trials on strawberries in Japan grown under diffused F-Clean ETFE film reported 4.3% higher yields and 7.8% more fruits due to better light distribution, while various university trials have shown that high-wire crops can reach harvest 5-10% faster than those grown in direct sunlight. Another potential benefit, according to various lighting research, is promotion of "secondary metabolites" like flavonoids and anthocyanins, improving color, flavor and nutritional value.

The degree or amount of diffusion a glazing offers is indicated in "haze." Low-haze glass/glazing offers less than 30% haze, providing minimal diffusion and higher light, which is more desirable in low-light regions and seasons. High-haze glass/glazing is rated at 70% or more diffusion. It scatters light much more and provides more benefits. High-haze glass is particularly effective for tall crops or those with dense canopies like tomatoes, peppers and cucumbers.

How to get diffusion

Standard greenhouse glass is designed to allow as much sunlight through as possible—maximum light for maximum growth, it has always been thought. To create diffusion, the glass surface is altered to influence how the light is scattered as it passes through. This can be done during manufacture or through post-processing techniques.

Standard "clear" glass and clear poly films provide some haze—generally 10 to 20%—with no special modifications. To create higher haze levels involves etching the surface mechanically or with chemicals. But the key is to create the etching without making the surface rough, which would cause it to gather dust. Some manufacturers create prismatic or textured patterns they say aid the diffusion. And they offer various haze levels depending on your needs. For instance, Chinese greenhouse glass manufacturer Yuhua offers haze levels of 5, 10, 20, 30, 50, 70 and 75%.

This is what diffusion looks like: no shadows, and even light throughout the crop. Note the supplemental lights for when sunlight isn't enough.

A light-scattering coating or film can also be applied to the surface of the glass to diffuse light. An anti-reflective coating can help increase the light coming into the glass by 2 or 3% to help compensate for any light loss due to scattering.

A downside of high-haze glass, besides the initial investment, is that you always get the haze feature regardless of light level. That's fine in the summer, but what about winter? And what if you grow various crops in the same greenhouse?

That is where an adjustable or temporary haze solution might be beneficial. ReduSystems makes a diffusion coating ("paint" for lack of a better term) called ReduFuse that can be applied to your glass just like a shade paint. It can be reapplied as needed, or removed seasonally using ReduClean.

An internal curtain system is another option. Ludvig Svensson offers their "Harmony" collection of light-diffusing curtain fabrics in various levels of shade to meet your crop needs. Being a curtain, it can be retracted when you want maximum light intensity.

Other diffusion options

Corrugated polycarbonate panels, such as the brand Dynaglas, offer durability and longevity, with good clarity (90–92%) light transmission and excellent diffusion properties, as well as large size options. Lifespan before yellowing is generally guaranteed around 10 years. Double-wall polycarbonate panels, such as ThermoGlas, offer much greater insulation than its single-panel counterpart, but with it comes less light transmission (around 80% or so). High-haze panels are available, offering nearly 100% haze—great in a high-light situation, but possibly a challenge in the winter in northern climes. A major benefit to polycarbonate panels, whether single or twin-wall, is durability—rarely will it be damaged by a hail storm, unlike glass, which could put you out of business for months.

Poly film, being less transparent than glass, automatically offers more diffusion, plus gives the benefit of greater energy efficiency (when installed in two layers, aka double poly). You can install a clear layer on top and a diffusion later underneath to control the light diffusion level. Poly is cost-effective, durable and energy efficient; the downside is its shorter (four-year) expected lifespan.

ETFE (ethylene tetrafluoroethylene) film is a high-performance plastic film known for its transparency, durability and resistance to UV radiation. Super tough and long lasting, it is in many ways superior to standard poly, but like glass, it's much more expensive. F-Clean is one trade name that has been around the greenhouse world for decades. Like poly, it is available clear (about 90% light transmission) and with a haze level of 60 to 70%.

The next big thing: electrochromic/photochromic glass?

Photochromic eyeglasses that go from clear to dark as you walk outside have been around since the 1960s, when Corning invented them. Why not greenhouse glass changing from clear to diffused? Or, for more control, electrochromic glass that changes its state with the application of an electrical charge, for instantaneous and variable adjustment? It can probably be done, but this so-called "smart glass" is not yet cost-effective for the greenhouse sector. And the research has not yet proven its benefit over "standard" diffuse glass.

WUR has recently tested two kinds of electrochromic (EC) glass—darkening and diffused—on two shade-loving crops, anthurium and schefflera. While the darkening EC glass did give the crops more constant and consistent light as the conditions changed from sunny to shady, the researchers found a downside: As the glass darkened, it generated thermal radiation that led to higher leaf temperatures, negating any gains from the more consistent lighting.

The diffusing EC glass did not seem to offer any benefits compared to standard diffused glass; in fact, the plants were shorter and had less leaf area, leading the researchers to believe they benefited more from constant diffuse light than a combination of direct and diffuse.