Update on greenhouse coverings©

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INTRODUCTION

The covering on a greenhouse allows us to provide an environment that enhances plant growth. The main purposes are to allow light energy through (Table 1) and to restrict heat from escaping (Table 2). It also provides some wind protection.

Table 1. Light transmission.

Glazing – clear	%
Glass – tempered	90
Acrylic – double	86
Polycarbonate – single	90
Polycarbonate – double	83
Polycarbonate – triple	78
Polyethylene – single	87
Polyethylene –double	78
Polyethylene – double w/IR	78

Table 2. Heat transmission ("U" = a heat transfer coefficient, Btu/hour-square foot-degrees F).

Glazing – clear	"U"
Single glass – tempered	1.1
Single glass w/ energy screen	0.5
Acrylic – double	0.6
Polycarbonate – single	1.1
Polycarbonate – double	0.6
Polycarbonate – triple	0.5
Polyethylene – single	1.1
Polyethylene –double	0.7
Polyethylene –double w/ screen	0.5
Polyethylene – double w/ IR	0.5

The amount of light energy that is transmitted through a covering depends on the type of material, orientation and location of the greenhouse and the structural design. A comparison of covering materials is usually measured in photosynthetically active radiation (PAR) (Figure 1). This includes the light spectrum that our eyes see.

GREENHOUSE COVERS

Diffusion properties

Most glazing materials are now available with additives that diffuse light. Research has shown that although light transmission is reduced a few percent, the light will penetrate better into the mid leaf layers of tall crops on cloudy days. There is no reported difference in light transmission on sunny days. Diffuse light can also reduce scorching, lower container temperature, reduce fungal spores and decrease insect propagation.

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Figure 1. Clear and stippled greenhouse glass.

Material used

What materials are being used to cover greenhouses? A recent survey by the National Greenhouse Manufacturers Association showed that for new construction: 10% of are covered with glass, 10% with acrylic, 30% with polycarbonate and 46% with polyethylene film.

1. Glass.

Wide pane, tempered glass is standard today. Sheets, as large as 6×12 ft, can be manufactured and placed on a greenhouse. Aluminum bars with EPDM rubber gaskets are used to seal the edges. The long life and high transmittance are an advantage for high light crops, such as tomatoes, cucumbers and peppers. Except for institutional greenhouses, most glass is used in gutter-connected structures. I don’t know of any double pane glass that is being installed. Stippled glass is used to diffuse light transmission and increases light transmissivity at low sun angles. Most glass installations have energy/shade screens underneath to reduce heat loss. This makes it comparable to double glazing (Figure 1).

2. Acrylic.

Available in single thickness corrugated and double wall flat sheets, most of this material is now modified with a percentage of polycarbonate or other plastic to give it better strength and a better fire rating. The warranty life has now been extended to 30 years. It is available in 8 and 16 mm thickness and in 4 and 6 ft wide sheets. Modified acrylic has been approved for institutional and garden center use.

3. Polycarbonate.

This is the most common semi-rigid material applied to growing structures. It is available in corrugated single wall material and 8 and 10 mm double wall material. Warranty is 10 years or longer. Fire and hail ratings are excellent.

4. Polyethylene sheets.

This is a semi-rigid double-wall material similar in design to polycarbonate (Solexx). It is available in 3.5 and 5 mm and requires more support to keep it from sagging. The material is white with a light transmission of 70-75% and used mostly in garden centers or for low light plants. Useful life is about 10 years.

5. Polyethylene film.

This is still the most common covering due to its low cost, ease of application and long life. Advantages include good weathering, several available thicknesses, additives such as condensate control and infrared heat inhibitor. The condensate control keeps the moisture in a film rather than droplets that drip onto the plants. Infrared inhibitor is installed as the inner layer and reduces heat loss at night by 10-20%. At an added cost of 2-3 cents ft^{-2}, the payback is only a few months from the energy saved. The IR additive may also increase early color, more compact plants and slightly accelerated plant development. For windy locations a woven poly (Solarig) or a film with a nylon scrim (Griffolyn) may be a better choice. These have more tear resistance.

Recent advances in polyethylene include photoselective properties and ultra violet blocking (Figure 2). To date film plastics have been made as three ply construction with different properties in each layer. New technology is now available to do 5 or 7-ply construction. This allows additional properties to be added. TIF (totally impermeable film) is being applied for soil fumigation. As there are no emission losses, the rate of application can be ½ of that of regular film. This same technology is being researched to use layers with different colors that will repel insects. It may also be developed to allow the outer layers to be removed when they become dirty or weathered. For example weathered poly has as much as 10% less light transmission than new poly. Another application may be to have a poly with a tougher outer skin.

Figure 2. Polyethylene film with infrared layer to reduce heat loss.

Photoselective films.

These absorb or reflect specific wavelengths of light. They can enhance plant growth, suppress insects and diseases and affect flower development. Red films such as Dupont IR and Smartlite Red film reduce PAR light and create a shading effect (Figure 3). They have also been shown to improve rose yield and quality.

Figure 3. Photoselective film.

Ultra-violet (UV).

Bees need UV to navigate. If you are using bees to pollinate plants in the greenhouse, purchasing a film that allows some of the UV part of the light energy spectrum to pass through may be important. Otherwise, UV blocking film will reduce whiteflies, thrips, aphids, and other insects. It can also control some fungal diseases.

Single or double layer poly.

Air inflated double poly is standard on all except spring season and overwintering hoophouses. The double layer reduces heat loss at night by about 35%. It also reduces moisture condensation, stress at the attachments and the rippling of the plastic on a windy day. Air inflation at ¼" water static pressure is best. A small blower with 100-200 $ft^3\ min^{-1}$ output is needed. Connect the blower inlet to outside air to reduce moisture build-up between the layers. A new product from a couple of manufacturers is a coextruded 12 mil material consist one sheet of 6 mil greenhouse grade and one sheet of 6 mil IR-AC grade. This is placed on the greenhouse at one time, sealed around the edges and then inflated. The weight of a 40×100 ft sheet is about 240 lbs. so a plastic support device on a forklift or tractor may be needed.

An anti-fogging additive may be included to prevent early morning and late afternoon fog formation in the greenhouse.

Reduced daytime heat gain.

In areas with strong sunlight, blocking part of the infrared spectrum can lower inside temperature up to 10°F. Selective pigments can be added to the outside layer in copolymer film to reflect or absorb the near infrared radiation which is useless for plant growth. Research has shown that the higher the outside temperature, the larger the temperature difference achieved by use of these films. The advantages include lower cooling costs, greater worker comfort, lower irrigation needs, reduced plant stress and improved fruit taste.

Plastic failure.

Early failure of poly can be attributed to stress as noted above, abrasion on rough surfaces and sharp edges or heat build-up in the area of rafters, purlins and extrusions. Contact with chemicals from pesticides or pressure treated lumber can also affect the life of the plastic. Poly that is left on the greenhouse during the winter is subject to cuts from blowing ice especially if there are multiple bays or hoophouses adjacent to each other. A scrim reinforce poly may be desirable in this situation.

Recycling.

Most plastic can be recycled if it is clean and bundled to exclude trapped air (Figure 4). It is sent to a recycler to shred it, remove dirt and chemicals, and process it into pellets. Much of it is reused for composite lumber.

Figure 4. Recycling plastic covering from a plastic house.