Special Features of Plastic Film Greenhouse Covers to Improve Growing Conditions©

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Important features of advanced plastic films that optimise greenhouse growing conditions are presented:

a) Thermic effect: thermic films have attracted attention for their ability to reduce heat loss at night. Film manufacturing technology and new additives can now provide superior clear (9% infra-red transmission) and diffusing (5% infra-red transmission) thermic films offering improved heat retention capacity.

b) Optical properties: light transmission can be tailored to suit the specific crop, growing season, area, and grower's expectations. A synopsis of the most important light manipulation effects is given.

c) Anti-mist effect: some manufacturers' and independent trials indicated that anti-drip, anti-mist films not only controlled the development of undesirable mist formation under certain conditions, but halved the number of fungicide applications required for adequate disease control, compared with standard film or standard anti-drip film.

d) Cooling effect: recently developed three-layer silver and bubble films counter excessive heat development in greenhouses.

INTRODUCTION

The plastics industry has developed polythene films with a range of features to help growers control crop environments. It is possible to combine several characteristics in a single film so selecting the right material for specific crops is increasingly important for growers.

Most commercial films are highly transparent to photosynthetically active radiation (PAR), unless designed for particular purposes. Optimum crop growth is achieved by allowing the right wavelengths to reach the plants and for that light to be uniformly distributed in the greenhouse. Water condensation can be controlled by using anti-drip films, but more recently anti-mist films offer further advantages.

Year-round production means a good film should retain heat in the greenhouse as much as possible in cold weather, while reducing excessive heat build up in warmer weather.

THERMIC EFFECTS

Additives and polymers are used in the formulation of films that reduce long-wave infra-red radiation (IR) transmission from beneath the film, to prevent heat loss from a greenhouse.

A standard film with no additives will absorb up to 55% of the IR radiation. Thermic films are formulated to block radiation transmission at infra-red wavelengths so that thermic clear and thermic diffusing films are available that transmit as little as 18% and 15% IR, respectively, at a typical thickness of 180–200 microns.

Increasing the amount of standard additives to further improve the thermic effect leads to unacceptable side-effects — unacceptable creep behaviour of the film or reduced light transmission.

Plastika Kritis uses a new IR absorber that does not affect film clarity, enabling it to produce Super Thermic (ST) clear films with IR retention up to 91%, and diffusing films with just 5% IR transmission.

A greenhouse clad using a film with 5% IR transmission requires approximately 8% less energy to heat it than a greenhouse clad with a film with 18% IR losses (Espí et al., 2006). Depending on the local conditions and the type of structure, energy saving can reach significantly higher levels (preliminary/unpublished data). The ST films prove to offer earlier maturity, higher yield, and improved crop quality.

OPTICAL PROPERTIES

Films that alter the ratio of red to far-red wavelengths are used to control plant morphology, in particular height (Rajapakse et al., 1999). Responses can be highly variable depending on species.

Another category of light manipulating films are those that control the amount of ultraviolet (UV) radiation passing through. Some absorb part or all of the incoming UV and are used for pest and disease management (Doukas and Payne, 2007a; Raviv and Antignus, 2004). On the other hand, UV-open films (completely transparent to UV radiation) are used to increase anthocyanin, flavonoid, and pnenolic compounds in plant tissues (Garcia-Marcia et al., 2007). Such films are commonly used to provide intense colour and increase the commercial value of certain flowers and for the production of plants with increased health benefits for humans.

The light passing through a greenhouse film and entering a greenhouse can be direct or scattered in various directions (diffused). Many studies have shown that diffused light benefits plant growth, as it increases photosynthesis because it reduces shade effects (Pollet et al., 2000; Brodersen et al., 2008). It can also protect plants from scorching (Pollet et al., 2000). Diffusion films ensure more uniform distribution of the available light, reaching even the lower parts of the plants. A film with 82% transmission of PAR and 50% diffusion, illuminates the lower parts of the plant better than a film with 95% PAR and 10% diffusion (Ashkenazi, 1996). While diffusion can be important for optimum light integration, it does not always mean that high diffusion films will offer further agronomic advantages over medium diffusion films (National Agricultural Research Foundation, 2007).

ANTI-MIST EFFECT

The introduction of anti-drip (AD) films was an important development for the greenhouse industry, as water condensation can reduce light transmission by up to 40%, decrease temperature (Ashkenazi, 1996), increase the risk of scorching by focusing sunlight onto leaves, and assist the development of certain diseases (Katsoulas et al., 2007).

However, AD films can make the structures they clad more prone to misting, usually at sun-set or dawn, when the air temperature drops below the dew point and the air lafer near the fim is 100% saturated — the additives in AD films affect saturation point. Mist diminishes the available light, reducing photosynthesis, and creates a favourable environment for development of certain pathogens. Many film-clad greenhouse structures are not heated or cannot be well ventilated for dehumidification to prevent mist formation — and even where they are, the use of heat to dehumidify is costly.

A new anti-mist additive has made it possible to develop AD films that also prevent or reduce mist formation. Recent research at the University of Thessaly, Greece, showed that air relative humidity (RH) was 95%–100% in a structure clad with AD film, while the AD+AM film resulted in lower RH values of about 80% (Katsoulas et al., 2007). Thus, early in the morning, the leaves of cucumber plants under the standard film were covered by water droplets, were totally wet under the AD film, but were dry under AD+AM film (Katsoulas et al., 2007). The subsequent *Botrytis cinerea* development required twice the number of fungicide applications for control under the standard and AD films, than under the AD+AM film.

COOLING EFFECTS

In many areas of the world there is an increasing requirement for films that control excessive heat during the day and maintain a cooler environment in the structure. Heat build-up is caused by transmission of "near-infra-red" (NIR) radiation into the greenhouse. Experience at Plastika Kritis' experimental station (Crete, Greece), and under commercial conditions in various parts of the world, show that the company's three-layer Silver and Bubble films have a strong cooling affect (unpublished data).

The silver film has a metallic silver appearance and reflects heat, while a small reduction in PAR transmission further contributes to its initial cooling effect. The particles used in the silver film also aid heat retention at night.

The Bubble film sandwiches a layer containing gas micro bubbles between two regular layers. The bubbles create insulation between the inside and the outside environment creating a strong cooling effect — a bit like the insulating properties of double glazing but to keep heat out, not in. Bubble film has about half the thermal conductivity of a standard three-layer film, both at typical thickness (200 microns). The bubbles also provide light diffusion, while heat retention additives are also used.

CONCLUSIONS

Advanced films modify the greenhouse environment and influence the plants and other organisms (e.g., pests and diseases) developing underneath them (Doukas and Payne, 2007b; Paul and Moore, 2006; Raviv and Antignus, 2004).

Plastic film selection should be an informed decision to avoid undesirable plant responses (stem elongation, unwanted changes to plant and/or fruit colour etc.) and secure optimum yields and/or quality (Paul and Moore, 2006). The factors to be evaluated are the percentage of diffusion, the wavelengths transmitted, and the need to control water condensation and mist. The local climate may bring additional requirements for cooling or heat retention.

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