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GREENHOUSE FILM SELECTION GUIDE

Greenhouse cultivation is not a new subject. Every year more area is coming under greenhouse cultivation. Taking the correct decision about plastic selection can be crucial for the success of the project.

The basic idea of greenhouse agriculture is to provide optimum growing conditions for the plant. ***Heavy investment is made in making strong greenhouse structures with an objective of fixing plastic cover on them*** which in turn should protect the plant from unfavorable conditions like rain, insects and diseases. **While the farmers spend 90 % and above to make the structure it is not advisable to compromise on the quality of plastic used for a small amount of money that one has to pay for a superior product**.

The only reason we make a greenhouse structure is to cover it.

Growers must analyze critically the following points before they decide to buy a plastic film for their project.

UV Stabilization

Flexible greenhouse films are usually made from low density polyethylene (LDPE), linear low density polyethylene (LLDPE), ethylene-vinyl acetate copolymers (EVA) and similar polymers. In their natural state these polymers deteriorate rapidly when exposed to sunlight. The sun's ultra violet (UV) light transfers its energy to the polyethylene molecules causing them to become so energized that they are readily subject to oxidation.

The degradation process is a series of reactions one leading to another of which the end products are carbon dioxide and water. The idea behind the stabilization packet which is put into the plastic mix at the time of production is to include components which will block, prevent as far as possible the onset

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of this process. As an example we are always including ultraviolet light blockers in order to try and prevent as far as possible the beginning of this reaction.

Several successful stabilizer additives have been used by film manufacturers to arrest this natural degradation. Big plastics manufacturers have begun to produce tough, clear, high PAR light transmission greenhouse films using ***hindered amine light stabilizers*** (HALS). HALS stabilizers protect greenhouse films by interfering with the propagation of free radicals. Free radicals are high energy, unstable, configurations which have a terminal, unpaired electron, formed when U V energy "breaks" a molecule (of the polymer, for example). A chain reaction can ensue with each radical potentially striking and breaking other molecules, releasing more and more radicals, until the film has degraded to the point of failure.

The HALS additive effectively restricts the multiplication of these free radicals. So a plastic film without proper UV stabilization (protection) will most certainly break down rapidly and leave the crop exposed. Hence all the greenhouse film manufacturers do stabilize their film against degradation due to solar radiation. ***A cover of 200 microns thickness can be guaranteed for three years of service in the field against degradation due to UV.***

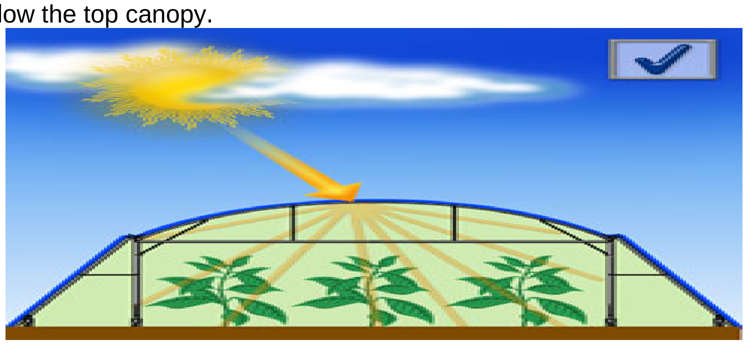
But a film which contains only a stabilization package, when used to cover a structure earmarked for growing crops, will not turn the structure into a greenhouse. At best the structure will be a "shelter". There are many other parameters to be considered to call a UV stabilized polyethylene cover, a greenhouse cover. A crucial difference between a simple shelter and a greenhouse is that a greenhouse must be a heat trap. In a true greenhouse the **escape of heat during the night is retarded** in order to maintain optimal temperature for as long as possible.

Diffused film vs Clear film

The incident light can reach the plant as "direct" radiation (waves moving parallel to one another) or as "diffused" radiation (in which the light waves are moving along trajectories which are at various angles with respect to one another and to a horizontal plane)

A diffused film has an advantage over a clear film. ***Diffused light does not allow the shadow formation*** of the top layers of leaves to prevent essential light from reaching the lower leaves. The end result is a facilitation of an effective dispersion of total light to the darker areas inside the plant volume enhancing photosynthesis and hence the production of biomass.

Under a clear film the top layer of the plant canopy is receiving the lion's share of the essential photosynthetic radiation. The inner leaves are almost not functioning as far as photosynthesis is concerned. In addition to losing potential biomass due to inactivity of the inner leaves of the plant, it also sheds these inactive leaves.If you want to observe this phenomenon walk into a forest and see the emptiness below the top canopy.

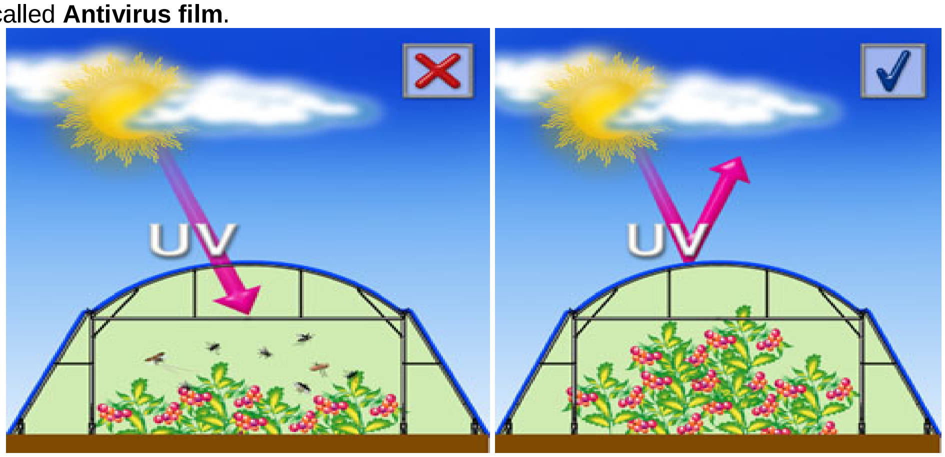


UV Blocker (Antivirus film):

An UV blocker film does not allow the UV radiation (**up to 381 nanometers** where 400 nanometers marks the end of U V radiation and the beginning of visible light) to enter the greenhouse. This part of the total spectrum of electromagnetic radiation is not necessary for photosynthesis.

Insects have compound eyes and they can see in the UV range as well as in the visible domain up to (but not including) the red section (600-700 nanometers wave length).Blocking out the UV blocks out a significant part of the visible range of insects. Since the insects can not see many of the signals which they normally would see outdoors, when they are under **UV blocker film, a considerable decrease in white fly, thrips and other insect activity has been observed inside the greenhouse covered with UV Blocker films. One of the subsequent positive results has been a marked reduction in the use of insecticide spray.**

Insects are the carriers and transmitters of many viruses and since this film affects the insect activity it also is called **Antivirus film**.



Blackening (or petal discoloration) of red roses is a major problem for the rose growers. This phenomenon is caused by the UV radiation acting together with low temperatures. **A crop under UV Blocker film does not experience blackening of rose petals.** The effect of the blocking of the U V radiation also helps in reducing **the extent of the damage caused by the Botrytis fungus**.

Anti Sulfur film:

Many rose growers use sulfur either by burning or sublimating or by dusting. **Sulfur is the enemy of stabilized polyethylene** and can reduce its life 50 %.

The sulfur reacts with the HALS (UV Stabilizers) and prevents it from performing its job of slowing down the degradation process. It reacts with HALS molecule exactly at the active site where it is defusing free radicals and as a result the HALS is crippled and ceases to function. To a certain extent halogens like chlorine, bromine also does the same thing. The worst case scenario is when we subject the film to sulphur and halogens at the same time.

Acid rain can be a significant source of noxious sulfur and its derivatives.The acid rain originates in clouds containing fumes from certain heavy industries and power plants which emit smoke containing sulfur, sulfur oxides and other sulfur compounds and radicals which are capable of chemically combining with the active site on the HALS molecules.

Nickel Quencher was the main stabilizer in plastic film before the advent of HALS in the 1990's. The big advantage of Nickel stabilizers was that they were relatively insensitive to the attack by the sulphur and the halogens. Their disadvantages were that they:

a. contain heavy metal nickel which is environmentally unfriendly,

b. are generally more expensive than the HALS ,
c. were less efficient than the HALS and
d. Cut out a few % of vital PAR light in the blue part of the spectrum (this is what gives the yellowish green appearance to an anti sulphur film).

A great amount of Nickel Quencher is still being used.In spite of the tremendous efforts in the last 15 years by the giant chemical companies producing plastic additives in cooperation with the companies producing master batches (concentrates) and the film manufacturers. Although newer improved HALS molecules have been developed and have enhanced resistance to sulfur and halogens and are in every day use today, no HALS stabilizer has been synthesized as yet, which is entirely immune to the negative effects of sulfur and/or halogens.

A film stabilized using this unique package can last for its entire promised life span of 3 years at 200 microns even when sulfur is sprayed or sublimated in the greenhouse. (**Ginegar Guarantees 3 years of life for a film stabilized to resist sulphur up to a maximum 150 ppm of Chlorine (Cl) and up to 1500 of Sulfur (S))**

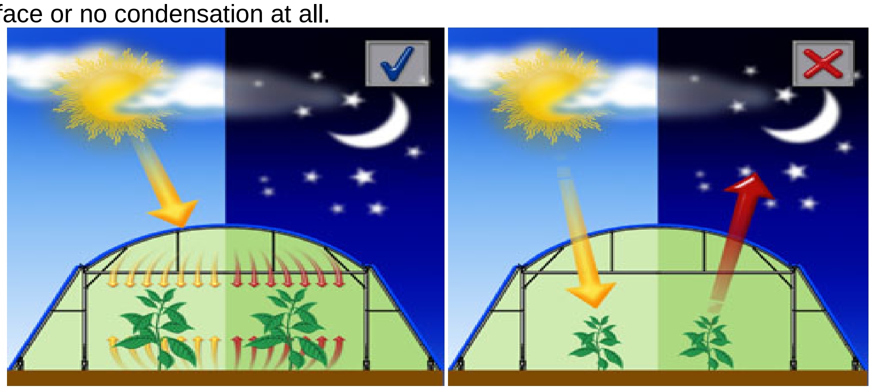
Thermic Film (IR Film):

A thermic film is also called an IR film. **A thermic film is necessary for the places where the night temperature drops below the optimum temperature necessary for the plants.** There are a few ways to make the non-thermic polyethylene greenhouse cover into a thermic cover:

- Include Ethylene Vynil Acetate in the mixture in high quantities (E V A)
- Use of mineral additives
- Use of Synthetic IR additives with a low light diffusion.

The IR additives absorb most of the long wave IR radiation from the greenhouse. In the day time this greenhouse needs more aeration. During the night, infrared additive creates a barrier to far infrared radiation (FIR: 5,000-20,000 nanometer) which is being emitted by all objects in the greenhouse. The net result is a decrease in the rate of temperature reduction during the night hours in the greenhouse.If the film cover is not thermic; the radiated energy will escape to outer space while the enclosed space within the greenhouse will eventually reach an equilibrium with the temperature of the air outside the structure.

This helps in maintaining a temperature close to the optimum needed by the plants. The most significant effect on the thermic greenhouse cover is the prevention of excess loss of heat by the leaves of the plant. When the plant leaves are warmer there will be reduced condensation of moisture on their surface or no condensation at all.



Lower temperature variation has a direct effect on earlier harvest, high crop yield, higher quality and uniformity of crops. ***With temperature conservation inside greenhouses, growers enjoy substantial energy savings when heating their greenhouses***.

Anti Drip Film:

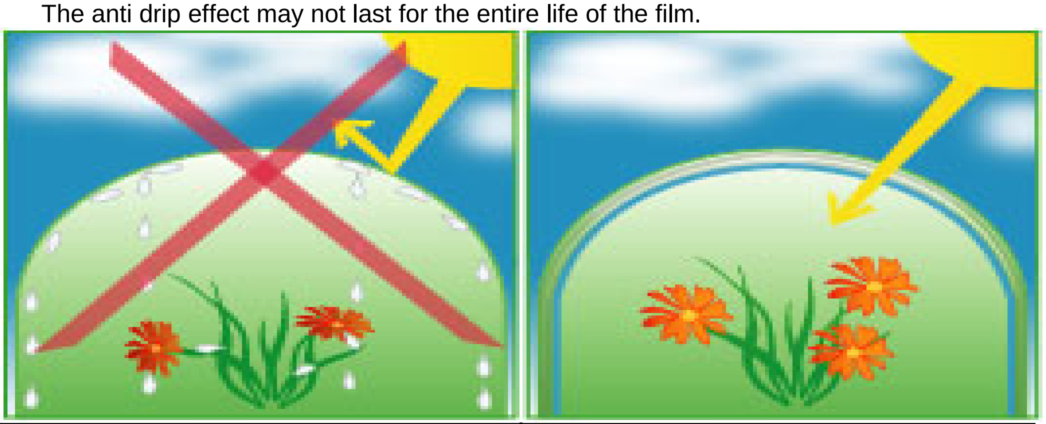
Moisture inside the greenhouse condenses in the form of large drops of water on the inner side of the plastic cover, if the plastic is untreated. This is undesirable because:

- The drops reflect back to the outer space a large portion of the incoming light.
- The drops fall on the plants and serve as focal points for the spread of plant diseases.
- water drops on the film focusing sunlight and scorching plant leaves

Anti-Drip additives reduce surface tension of condensing water vapor and raise the surface tension of the inner side of plastic. These additives are surfactants. Being surfactants these molecules have two distinct parts

a. Hydrophobic end (has affinity to waxes and fats) of the molecules anchor the anti drip additives to the plastic
b. Hydrophilic end (has affinity to water and other polar substances) which eliminates the large drops of water and transforms them into an ultra thin film of moisture.
c. The problem with the anti drip is that the water on which it is acting is simultaneously extracting anti drip surfactant molecules from the film all the time.

At any given thickness of the film there are two sets of factors which determine the length of time anti drip is going to be effective in the greenhouse. One set of factors depends on the technology used by the producer and the other set is related to the conditions in and around the greenhouse. The anti drip effect may not last for the entire life of the film.



Film without antidrip	**Film with antidrip**

<u>Factors Which Determine the Efficiency and Life Span of the Anti-Drip Effect of A Greenhouse Cover</u>

a. Factors related to the planning and production of the film (in the hands of the manufacturer)

- quality of the anti drip additive
- concentration in film (quantity) of the anti drip additive
- “holding power” of the polymer film (which helps determine the rate of leaching out of the additive from the film)

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- absence of excessive folds and waviness in the film , factors which can impede the desired flow of the sheet of moisture down the film to the drains

b. Factors related to the grower (film user) , the greenhouse environment and the greenhouse itself

- slope of the greenhouse cover on the roof of the structure (a minimum of 22 degrees to the horizontal is desirable)
- proper cladding of the film on the structure (to avoid folds, waviness and the like)
- the regime of periodical aeration of the greenhouse
- presence or absence of heating facilities and their use
- height of the greenhouse
- Cultivar growing in the greenhouse. Certain cultivars produce enormous quantities of moisture in the enclosed greenhouse space. Others are more moderate in their production of moisture.
- Use of mulch on the ground along the rows and in between rows. The mulch is beneficial from many points of view but it also significantly reduces the quantity of moisture in the air of the greenhouse
- incorrect (excessive) irrigation in the greenhouse (which can lead to the formation of puddles)
- proper drainage in the greenhouse
- external; climatic conditions (precipitation, winds, radiation, and all the factors which influence outside (and internal as well) relative humidity)

An anti drip layer is always on the inner side of the plastic. It is very important to note that when a customer buys an anti drip film the anti drip side must be fixed on the inside facing the plants.

Anti mist film:

When the humidity in the air in a greenhouse reaches 100% (especially a closed greenhouse in the cold season) and the temperature decreases, condensation starts and forms drops on everything, the plants the plastic, whatever. When the plastic is covered with droplets and it is flowing down the film, more humidity can continue to condense from the air to the surface of the film (or the leaves, which is just what you do not want) and mist will not form.

But when you have good performing anti drip, not only do the droplets turn into a thin uniform film of water, but they almost do not flow. The anti drip additive binds them to the film and they virtually are not moving. So the excess humidity remains in the air in the form of mist, especially when there are dust particles which act as nuclei for the mist drops. This is very detrimental for the plants because the mist settles on all parts of the plants (upper and lower surfaces of the leaves and stems) as opposed to the large drops which settle only on the upper surface. There are many farmers who understand this mechanism and prefer not to use anti drip and to suffer from the dripping rather than to have mist.

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The anti mist additives are very sophisticated and they actually work against the anti drip, thus facilitating the constant flow of the layer of moisture down the film to the drains. This allows the mist to continue to condense on the area of the film surface which becomes free, so that the moisture is on the film and not in the air. It is possible to get a better anti mist film in a 5 layer technology.

In temperate and subtropical climates it is sometimes sufficient for a grower to choose a film cover which contains the anti-drip function alone because there is no risk of the formation of mist. If the grower has had previous experience with the formation of mist or has good reason to expect the formation of mist during the cold nights of the winter season, he will surely do best to order a film which has both functions (anti mist and anti drip) incorporated in the film.

Anti Dust film:

Anti-Dust Property: A Means of Reducing Dust Accumulation on the Plastic Cover

Within one week after installing a greenhouse cover there can be a reduction of 40% in transmitted visible radiation solely because of the accumulation of dust on the upper surface. It is true that there are areas where dust is more abundant than in other areas, but all in all, dust is ubiquitous. The dust itself can render a greenhouse cover opaque rather than transparent by reducing transmittance of light by as much as 50%.

Dust is attached to the plastic cover through electrostatic forces. The dust particles are charged, as is the film cover. We delude ourselves into thinking that rain clears away the dust or that by directing a stream of water from a hose on to the cover we clean it from dust. Allow the film to dry after the rain or the hosing down and you will learn that the dust was not removed, by and large.

It is a pity to purchase a greenhouse cover with a (laboratory measured) value of 85% transmitted visible radiation and then allow it to spend months on the greenhouse with a de-facto value of 45% light transmission.

The presence of dust on the upper surface of the greenhouse cover is a pre-condition for the growth of algae and fungi on the film. The dust serves as the soil for the algae, providing the mineral elements necessary for healthy growth. Algae and fungi growth on a greenhouse cover will, if allowed to continue unchecked, eventually block out all incoming light and render the film cover useless.

Part of the maintenance routine of greenhouses must be periodic roof-cleaning. This includes climbing up and applying soap, water and physical force, using a soft cloth or a brush wrapped in a wet cloth.

Where does Ginegar come in to this scenario? We produce films with an Anti-Dust additive in the top, outside, layer. The additive does not prevent dust from settling on the greenhouse cover, but it makes it more difficult for the dust to remain on the plastic and makes it easier for the wind, the rain or your cleaning efforts to remove the dust from the plastic.

An anti dust layer is always on the upper side of the plastic. It is very important to note that anti dust side must be facing outside.

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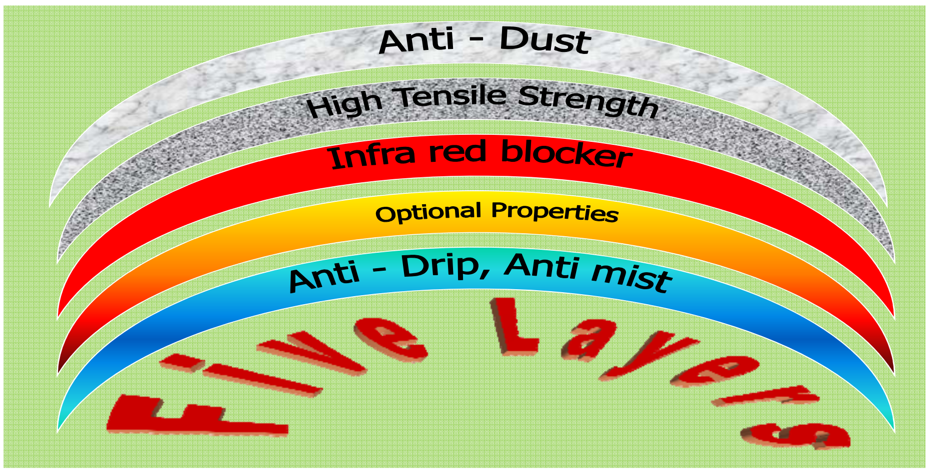
5 layer co-extruded films:

Polyethylene film is converted from raw material to film by the process called "extrusion". This consists of melting polyethylene resin by applying heat and pressure so that it is extruded through a ring-shaped orifice of determined dimensions.

Co-extrusion is the most advanced process used in polyethylene transformation and consists of the simultaneous extrusion of several layers of polyethylene which will produce multi-layer films. For agricultural applications the number of layers so far achieved is five. In this process, each of the layers can be composed of different polymers, which allows the different properties of the materials used to be combined in a single film.



Despite the apparent simplicity of the process, years of experience are required to achieve products of high quality. The advantages of 5 layer co-extrusion over mono-extrusion (single layer extrusion) and 3 layer extrusion are:

- Make it possible to use incompatible substances (resins). Very often we want to use two or more materials which are mutually incompatible. This is only possible in a multilayered film (2 or more layers).
- Some times we must use two different compatible materials but if they will be in the same layer they produce undesirable side effects on the film such as haze.
- Very often we want to use a material to give a film a very important property and it is sufficient to use this material in a very thin layer in a thick film(e.g. materials that give very high tear resistance like metallocene or barrier resins like nylon or ethylene vinyl alcohol)
- All the advantages of each individual material are maintained and any disadvantages are limited.
- It is often possible using five layer technology to confine an additive to the layer where it should be performing its job and prevent its migration throughout the entire film.e.g, Anti-dust on the top layer and an anti-drip /anti mist on the inner layer.
- Better mechanical properties as compared to mono/three layer film.

Greenhouse film manufacturing has come to a cutting edge. All the properties mentioned above are like **lego** and can be produced in any combination in a greenhouse film. At the time of writing this paper there is only one large five layer extruder in the entire world which is at Ginegar Plastic Products Ltd, Israel. ***Please remember all the plastics that look the same may not be the same. A critical analysis of the local conditions and best suited film for that area can make a difference between success and failure.***

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