

# Covering materials for protected cultivation systems



## Introduction

Covering materials such as plastic film, anti-insect nets and shade nets keep pests out, reduce the risk of fungal, bacterial and viral diseases (i.e. as transmitted by insects), and help to regulate temperature and humidity in response to changes in climate.

Covering materials are available in a wide variety of options, to be selected for their suitability to the given context, needs and constraints – including local climatic conditions, the most common pests and diseases, crop type, and budgeting for both purchase and maintenance.

## Plastic film

Plastic film increases crop yields by improving the quality and quantity of sunlight, increasing temperatures, and protecting seedlings and crops from rain, thus reducing the incidence of diseases such as from fungi and bacteria. Important characteristics to consider include:

- **Ultraviolet (UV) additive:** All plastic film intended for use in greenhouses must be treated for UV rays. This prolongs its lifespan, while also ensuring it can provide the highest quality of light, thus increasing efficiency for photosynthesis and growth.
- **Diffusion characteristic:** Plants under plastic film receive higher levels of light. This is due to the way sunlight diffuses in all directions when passing through the film, such that the leaves of the plants receive light from all angles, thus decreasing the effects of light saturation and shading from upper to lower leaves, as occurs in an open field.
- **Thickness:** The thicker the plastic film, the longer it lasts and the more resistant it is to extreme weather events such as heavy wind and snow. However, thicker plastic is also more expensive; thinner film may therefore be preferable in cases of limited use (for example, for less than one year or for short periods each year), and when taking into consideration the availability of proper recycling systems. Depending on the location, thickness may be expressed in different units. Approximate values are provided in Table 1 as a reference.



Figure 1. Installation of covering materials for a low-cost greenhouse

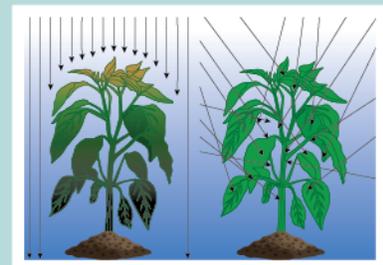


Figure 2. Open-field plant in direct sunlight (left), compared with plant under plastic film (right); the latter shows the increased quantity of light resulting from the diffusion effect



Millimetres	Microns	Inches	Mils	Gauges
0.12	120	0.0047	4.7	470
0.15	150	0.006	6	600
0.18	180	0.007	7	700
0.2	200	0.0079	7.9	790

Table 1. Measuring different thicknesses of plastic film across different units

- **Anti-drip additive:** These are available to be added to plastic film, to prevent the dripping typically caused by high humidity and condensation inside the greenhouse, thus reducing the risk of diseases such as from fungi and bacteria.
- **Anti-dust additive:** These may be added to plastic film to prevent the accumulation of dust, and to help increase and maintain the quality of light and luminosity.
- **Shade:** Plastic film comes with different percentages of shade and therefore of light transmission. Different levels of shade can be used in combination with shade nets to create tailored conditions for growth and productivity, as needed for each crop.
- **Multilayers:** Some plastics combine technologies by including additives or layers (for anti-drip, anti-dust, greater light diffusion, etc.) in a single material. Care must be taken to ensure this type of plastic film is installed correctly; for example (as seen in Figure 3), the side with anti-drip on the inside of the greenhouse, and the side with anti-dust on the outside.
- **Anti-thermic film:** Adapted for places that have year-round high temperatures such as tropical lowlands, “cold plastic film” uses the selective filtration of solar radiation to facilitate maximum photosynthetically active radiation (PAR) and minimum near infrared (NIR) radiation.



Figure 3. Multilayer plastic film indicating placement for proper installation, to ensure the anti-drip and anti-dust sides face inward and outward respectively

# Maintenance of plastic film

Sunlight is not only a free source of energy for plants, it is critical to energy production through photosynthesis. But plastic film that is dirty can reduce light transmission from 85 percent (as when clean) to 30–40 percent. Regular cleaning of the film as and when necessary – using cloth and water – is therefore fundamental to ensuring that plants receive the highest quantity and quality of sunlight, as well as for extending the lifespan of the film itself.

Plastic film must be changed according to the technical specifications of its lifespan, as the optical properties described will degrade as the material gets older.

## Anti-insect nets

Anti-insect nets are made of high-density polyethylene mesh that has been treated for UV rays. They serve as a physical barrier to keep out unwanted insects, while also reducing ventilation and thus increasing heat. In cases where beneficial insects are released inside a greenhouse or net house, these nets also work to keep such natural enemies in, thus increasing their effectiveness.

Nets can be installed on the sides, zenithal (roof) vents, or throughout the structure in the case of net houses. The type of net is defined by the number and diameter of its holes and the number of threads per square inch (mesh). The thicknesses of the threads on grid and the size of the holes also vary (see Table 2 for some examples and approximate values).

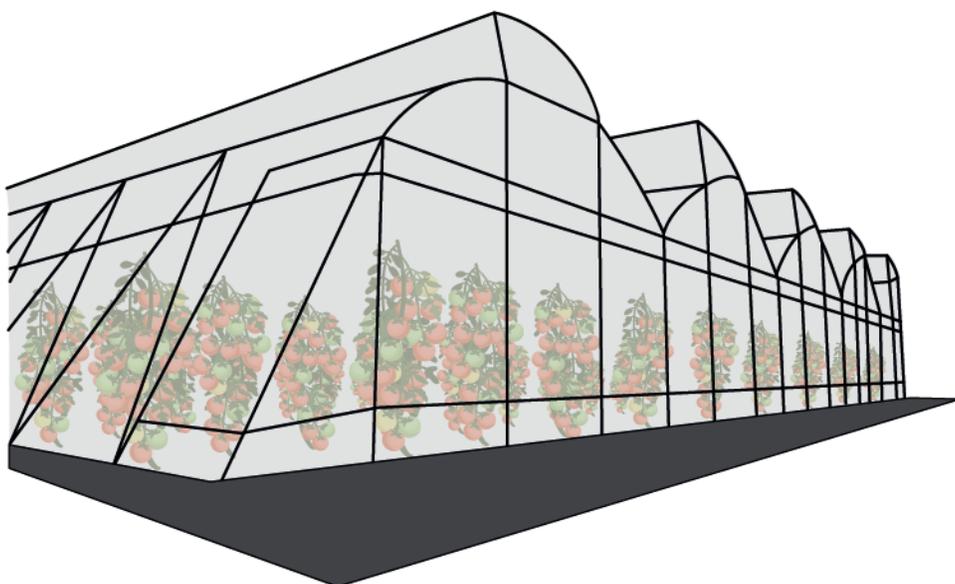


Figure 4. To ensure high productivity, plastic film should be cleaned whenever the light it transmits is reduced due to dust or algae accumulation



Figure 5. An anti-insect net prevents caterpillar larvae from entering a greenhouse

Mesh	Hole size (mm)	Thread diameter (mm)	Insects prevented/targeted (examples)	Shade factor (%)
17	1.2 × 1.2	0.27–0.28	Wasps, fruit flies and moths (also used in orchards to prevent damage from hail)	15
25	0.72 × 0.97	0.27–0.28	Wasps, fruit flies and moths	20
40	0.4 × 0.83	0.23	Wasps, fruit flies, moths, leaf miners and caterpillar larvae	23
50	0.26 × 0.83	0.23	Wasps, fruit flies, moths, leaf miners, caterpillar larvae, white flies and aphids	25

Table 2. Types of mesh, corresponding measurements and use

In selecting the mesh to be used, it is important to consider on one hand the degree of ventilation desired, and on the other hand the type and pressure of pests or insects to be prevented, achieving a balance between the two. In particular, the following should be taken into account:

- Ventilation or air exchange with the outside; the smaller the mesh, the greater the diameter of holes and the higher the air flow.
- The greater the mesh, the higher the shade factor. This is important to consider as it can reduce yield for crops that require high solar radiation.
- The types of insects and pressure of viruses in the area. A high risk of insect-borne viruses (such as from white flies and aphids) will require more threads per square inch with smaller holes (i.e. in diameter), resulting in less ventilation.

## Maintenance of anti-insect nets

A clean mesh provides better sunlight transmission and ventilation, while a dirty mesh does not allow air and light to pass through properly. For example, a dirty net can reduce ventilation from 50 percent (when clean) to 5 percent, and increase the shade factor from 25 percent to 80 percent.

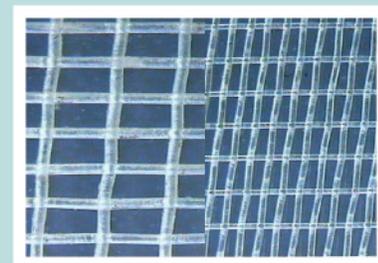
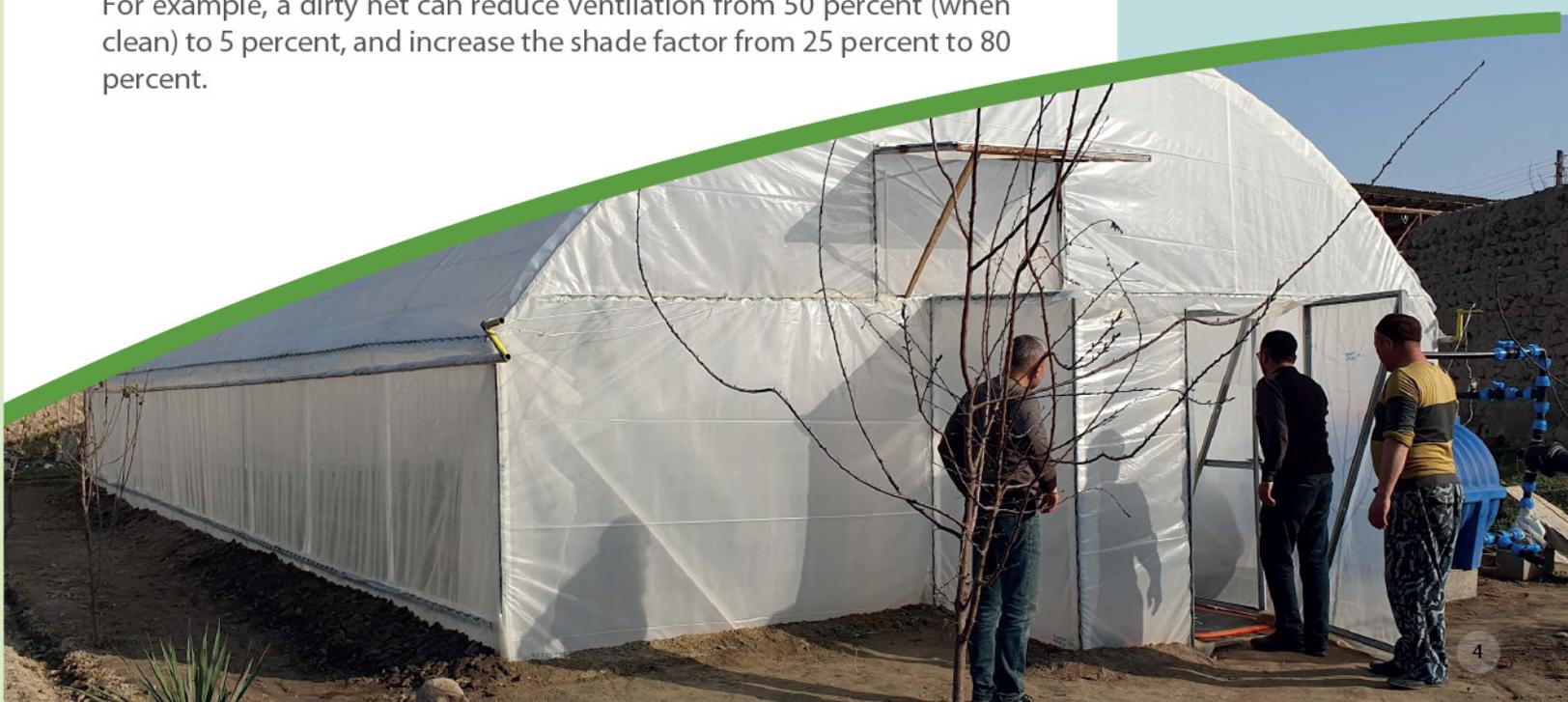


Figure 6. Magnified views of the difference in hole size between 25-mesh (left) and 50-mesh (right)



Figure 7. Comparing the difference in air exchange rates and light transmission between a dirty net (left) and a clean net (right)



There are two inexpensive and easy ways care for and maintain insect nets:

**1. Cleaning and washing**

Nets should be washed regularly with a brush and water or with a high-pressure washer to ensure good ventilation and to minimize humidity.



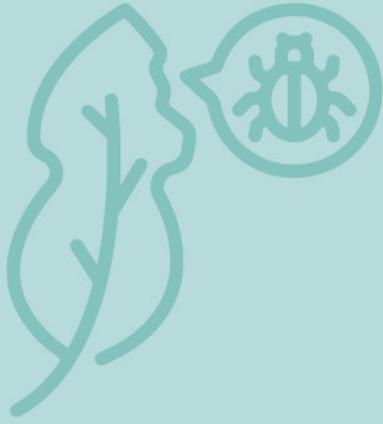
Figure 8. Cleaning and washing an anti-insect net to maintain good air exchange and sunlight transmission

**2. Repairing of holes**

As with all materials, damage from wear and tear will occur. All holes should be sewn or patched shut in order to keep pests out, especially virus-transmitting insects.



Figure 9. Repairs to an anti-insect net to ensure a proper physical barrier against the most important pests



# Shade nets

Nets made of 100 percent high-density polyethylene monofilament mesh of different colours and shade factors are used in combination with plastic film and anti-insect nets to reduce solar radiation (heat) and temperature, thus extending the planting season. The shade nets typically used in protected cultivation systems are knitted, lightweight and flexible, and are made of high-density polyethylene that has been treated for UV rays. Important factors to consider when selecting shade nets include the following:

- **Shade factor:** The shade factor of these nets ranges from 5 to 95 percent. Nets with a shade factor of 30–40 percent are often used for vegetable crops that produce fruits, such as tomatoes, peppers, eggplants and cucurbits, while nets with a shade factor of 50–60 percent are more likely to be used for leafy crops such as spinach and lettuces, particularly in summer or in tropical lowland areas.
- **Colour:** Light colours such as white reflect the sun's heat, while dark colours such as black or green absorb it. Black and green can also serve to reduce heat and sunlight. Reflective metalized nets are also used to reduce heat and reflect light. In addition to different shade factors, they come with aluminium foil strips; this reflective property increases the sunlight on lower leaves.

It is important to note that shade nets may only be needed during the hottest hours of the day, and may not be needed at all on cloudy days. To ensure the efficient use of available sunlight, shade nets therefore need to be managed on a daily basis, according to climate and weather. As such, they should be installed or fitted to allow for their expansion and retraction, whether manually or as part of a motorized system, according to climate and crop requirements, and using meters or sensors to track temperature and light.



Figure 10. Shade nets are used to help reduce the temperature for hydroponically grown lettuce



Figure 11. An expanding/retracting net system for efficient management of shade

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