# Environmental Control©

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## INTRODUCTION

For a plant to achieve optimum growth and the meeting of all the plant's requirements, a number of environmental requirements must be in balance. This balance changes for different types of plants, therefore environmental control is essential for profitable production. Plants require management of light, temperature, humidity, carbon dioxide, water, and nutrients.

## LIGHT

Modern greenhouse coverings can be adjusted by design and manufactured to give optimal light conditions. Light consists of three main ranges (Fig. 1):

**Ultra Violet (UV) range 300–400 nm.** This is normally completely blocked in polycarbonate and plastic coverings giving less heat during the day and greater heat retention at night. It is important that when bumblebees and integrated pest management (IPM) predators are being used that sufficient light in the spectrum 360–380mn is available. UV-B blocking films can be used to reduce fungi activity, particularly botrytis.

**Photosynthetic Active Range (PAR) range 400–700 nm.** This is the range used by plants for photosynthesis. When considering light transmissions in this range it is important to understand the three different types of light transmission. Global light transmission is the total available light. Diffusion is the scattering of light to decrease shadows and provide a softer light to plant leaves. Diffusion may be varied from none for a clear material such as glass to 40% or 50% from a double skin plastic, fiberglass, or polycarbonate. Modern requirements indicate 40% diffusion where shadows do not exist as having a very beneficial effect on plants. Photosynthetic active range (PAR) is the light transmission in the photosynthetic active range 400–700 nm. Examples of PAR include (Fig. 2):

| | |
|---|---|
| Single Skin UVA | 92% transmission. |
| Polycarbonate .08 mm | 91% transmission. |
| Glass 4 mm (Float Aussie) | 83% transmission. |
| Fibreglass with Tedlar | 86% (new) transmission. |
| Twinskin PE/IR | 82%–85% transmission. |

**Far Red Range 700–2500 nm**. This light is outside the visible range and is where surface cooling operates at night. It is beneficial to block this range for heat retention.

Total light transmission is the available light through a covering minus the shading created by the structure. This will vary considerably and the structure will decrease the available light by up to 50% in an older-style glasshouse particularly when the sun is low during winter periods. The modern trend in glasshouses is for larger panes to be used along with toughened safety glass, but this all comes at a price.

**Controlling Light.** It is relatively simple to control the amount of light entering a greenhouse. A simple method is to apply whitewash to the outside cover and is of most benefit only during bright sunny conditions (Fig. 3). This is of course going to

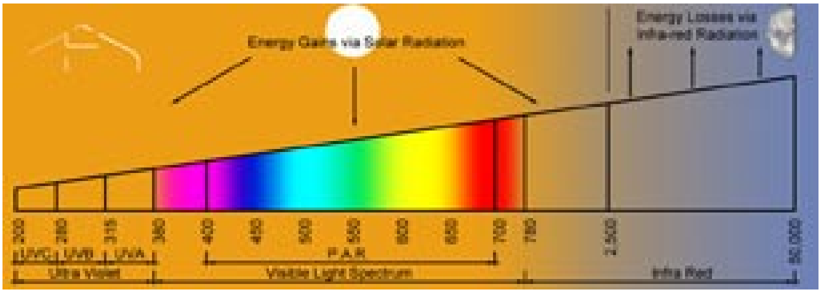


**Figure 1.** Light ranges.

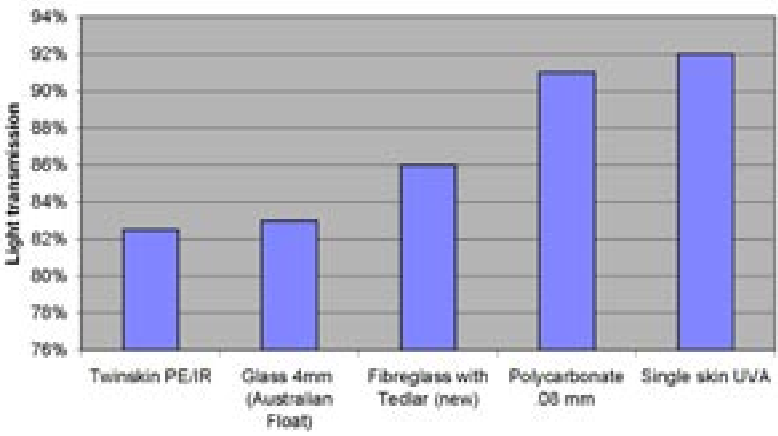


**Figure 2.** Light transmission of various coverings.

reduce all light and on a dull day the decision to whitewash can be regretted. The requirement to whitewash to prevent plant burning has been negated with the introduction of high diffusion covers.

**Thermal/Shade Screens.** The use of a shade screen is the sophisticated way to control light (Fig. 4). It is important that the correct screen is selected. Screens that contain aluminium foil that reflect a percentage of the incoming radiation are the best. It is also important that a reasonable service life is achieved and 10 years should be expected. Total blackout screens are also available. Humidity control options are available with thermal screens and the screen manufacturer can leave a percentage of the screen open to allow air to pass through the screen. This feature also allows cooler air from ridge vents that can be humidified to fall through the screen and further enhance the environment.

Outside screens such as those used on retractable roof structures are available to control the elements for outdoor propagating or hardening areas. The nursery

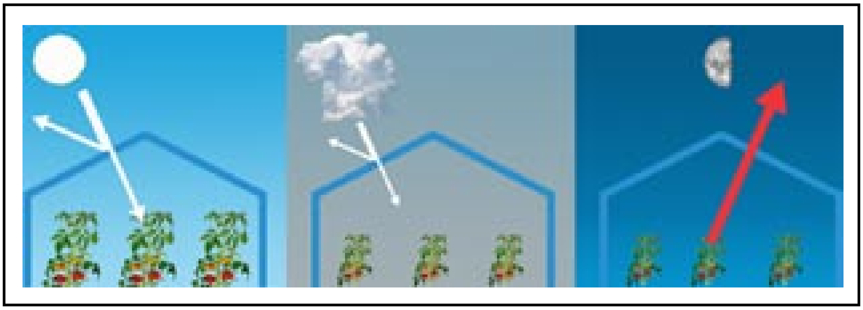

**Figure 3.** Effects of using white wash.

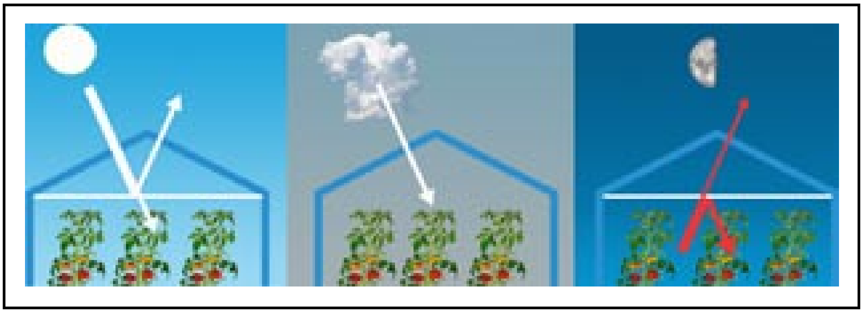

**Figure 4.** Effects of using a thermal/shade screen.

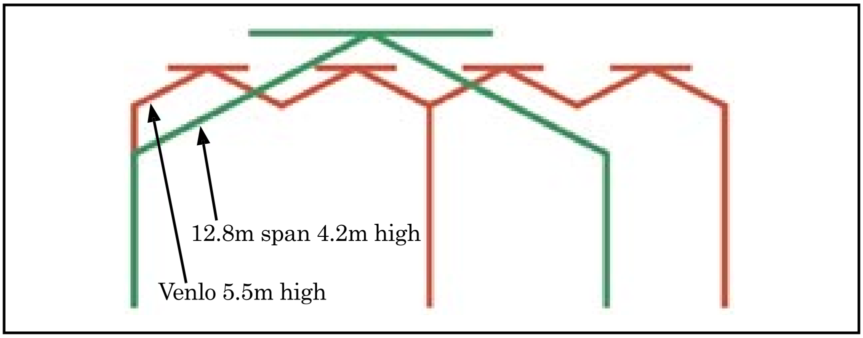


**Figure 5.** Natural ventilation: Venlo vs. widespan.

person has the option of full light or a selected amount of shade during the day with the added benefit of a heat reflective cover at night. Thermal screens give optimal conditions at all times.

## TEMPERATURE

Temperature is usually the first ingredient for any controlled environment. An increase in temperature results when incoming radiation is greater than the outgoing. On a bright sunny day this heat gain can be significant, therefore ventilation must be introduced to maintain temperature control.

**Natural Ventilation.** Ventilation can be introduced from the side or the roof of a structure. Natural ventilation offers a quiet solution and the current trend is to build higher greenhouses to increase the "chimney effect". Increasing the span of a greenhouse bay also has a beneficial effect on ventilation such that a 4-m-high, 12.8-m-span greenhouse is the equilavent of a 5.5-m-high Venlo-style glasshouse (Fig. 5).

What must be remembered is that the aim of a greenhouse is to control the environment inside, the use of side vents will introduce large volumes of air that is usually of a low humidity and this combined with the mechanical action of the direct wind puts extra stress on the plants. Side vents are only satisfactory for a maximum width of 20 m thereafter little benefit is gained and without further ventilation "hot spots" will occur. Some of these disadvantages can be reduced by having either a higher greenhouse or positioning the greenhouses on a slope.

**Forced Fan Ventilation.** Using large fans to ventilate a greenhouse is particularly effective especially when combined with an evaporative pad cooling system or humidifiers. You will need one to two changes of air per minute for full control. The noise created and running costs are a disadvantage. Forced fan systems are very effective for small propagation houses when the fan can be connected to a variable speed controller.

## HUMIDITY

Humidity is the one element that mostly affects the vapour pressure deficit (VPD). This is the pressure on a plant to transpire. When humidity is too low the rate of transpiration is such that the leaf can close down and transpiration will cease with a resulting increase in greenhouse temperature. This can result in leaves curling and blossom end rot. Proper control of humidity will lower the greenhouse temperature and reduce plant stress. Methods of control include basic misting and fogging.

**Basic Misting.** Misting is the application of fine water droplets overhead. Droplet size is large compared to fogging and will result in the plants becoming wet if the misters are run for a period exceeding a few seconds. A good controller should have a misting/fogging option with the pulse time adjustable.

**Fogging.** Fogging is the use of high pressure water normally 800-1000 psi to vapourising the water into droplets of approximately 10 μ such that the water is absorbed into the air rapidly resulting in increased humidity and cooling. For fogging and misting to be effective the ambient humidity should be 65% or less. On high humidity days humidity can be lowered by two methods:

- Increasing airflow over the plants to increase transpiration.
- Heating and ventilating the area to "dry the air".

High humidity can result from poorly ventilated structures, excessive moisture from run-off on the floor area, or high ambient humidity.

## CARBON DIOXIDE

During the process of transpiration plants absorb $CO_2$ and give off water vapour. Plant leaves appear to have a cool touch during this process. In a modern greenhouse it is important to monitor the amount of $CO_2$ and increase the concentration if necessary to maintain optimum plant growth. An example is in a tomato greenhouse with a full crop load where the ambient outside $CO_2$ level is 350 ppm. When transpiration takes place this level has been recorded to decrease as low as 80 ppm in the greenhouse with a resulting drop in production. By increasing the $CO_2$ level to

700 ppm, a 20% increase in production can be expected. Dutch growers, and of recent years, large New Zealand and Australian growers operate gas-fired boilers during the day time, recovering the heat into storage tanks and reticulating this at night to heat as required against the $CO_2$ demand. Properly operated the grower should end up with either free heat or free $CO_2$. Capital cost for this exercise is quite high, almost 40% of the greenhouse cost. For the smaller less sophisticated grower they should be aware of $CO_2$ depletion and ventilate to maintain a supply of fresh air.

## WATER AND NUTRIENTS

This is a complete subject in itself. This information is a general overview only.

**Water Supply.** It is important that the best quality water available is used. This will vary in different areas from the pure artesian waters of Christchurch to the recycled sewage or grey water of Adelaide. Treatments vary from reverse osmosis, biofiltration, and ozonation. It is important that the water is treated in an appropriate manner to remove pathogens, organic materials, and unwanted elements. These can all be done at a price and sometimes could be more cost effective to re-site the proposed nursery to source water of a higher quality. I have personally found that ozonation represents a reasonably priced solution for iron reduction and treatment for pond type reservoirs. Even "pure water" may contain pathogens containing *Pythium* species and *Fusarium* species. The safe rule is to always ozonate.

**Nutrients.** The modern grower must ensure a balanced feed to suit his particular crop. Regular leaf analysis is common for professional growers. Manipulation of the feed can be used to encourage growth for a vegetative plant or alternatively harden the plant for a generative growth. The correct combination of environmental and nutritional requirements will result in a plant ready on time and in the right condition for production for resale.

## ENVIRONMENT-CONTROLLING EQUIPMENT

There are many manufacturers of specific controllers. I have grouped them in the following categories.

- Basic environment: The control of temperature, humidity, and heating with no computer connection. Costs expectations from \$1,000.00–\$2,000.00.
- Advanced environment: Computerised temperature, humidity (vent purging, fogging, and screens), and vent adjustment to prevailing winds, light, heating, and $CO_2$. Cost expectations from \$5,000.00–\$50,000.00.
- Basic nutrient: Feeding on a time basis with some mixing capability. Cost expectations from \$1,000.00–\$2,000.00.
- Advanced nutrient: Computerised nutrient feeding on a light level or moisture content basis with the ability to have several time zones, in line or batch mixing of nutrients with electro conductivity adjustment for high light and night and day.

## ADDITIONAL READING

**Garzoli, K.**. 2003. Greener greenhouses. Casper Publ., Sydney, Australia.