MODULE 1. - Essential knowledge

2. Greenhouse Design and Climate Management

Understanding greenhouse design and management is very important, (even in low tech houses), to avoid stressing plants unnecessarily and keep them as productive as possible with good growing conditions. This fact sheet contains basic information on the relationship between greenhouse design and climate control.

The main purpose of the enclosed growing environment in a covered greenhouse is to accelerate and prolong plant growth and yields through keeping plants in a steady favourable climate. This means keeping them warm in winter and minimising over-heating and drying out under dry summer conditions. So the key components of climate control are about keeping temperature and humidity within a desirable range for the crop.

However this balance is very tricky to achieve under changing weather and seasonal conditions, even with active heating cooling and ventilation features! Temperature and humidity control tend to be in competition with each other so a constant balancing act is required. Rapid release of humidity needs to be achieved in winter with minimum heat loss, and excess heat needs to be released in summer with minimum reduction in humidity.

Conventional low-tech greenhouse design and farming practices have focused on simple ways of containing heat and humidity in tolerable ranges and releasing them rapidly when they are becoming too harmful for the plants. They have been designed with a single skin covering that can be closed up to accumulate warmth in winter, and open easily to release excess heat in summer.

Phuong's glasshouses are quite basic so that he has had to manage a lot of climatic challenges and develop his expertise under tough conditions. His structures are quite low, about 1.8m to the gutter. Because of this they are easier to heat in the day time but are limited in other ways such as:

- *In sustained cold and cloudy weather, it is hard to keep plants warm leading to issues with reduced vigour.*
- *These structures can also heat up too easily in really hot weather!*
- *Their low ceiling makes them harder to ventilate to reduce excess heat and humidity, but the sides and ends open to compensate for this.*
- *The ventilation surface area is probably too limited to consider using fine insect mesh to exclude flying insects.*

Issues created by poor climate control

Both low and high humidity can cause serious issues for plants and fruit. The greenhouse system must be capable of releasing excessive humidity in winter because it raises the risk of several foliar diseases and can cause cracking in semi-mature fruit. If humidity is over 85% for more than three hours botrytis infections are possible. Potentially damaging condensation, causing splitting, can occur on fruit when the when the fruit temperature is 4 degrees lower than air because it has cooled overnight, but the air warms up more quickly in a bright morning light.

The greenhouse must also be able to minimise sustained low humidity in summer to avoid too much dehydration stress that can lead to problems like blossom end rot.

Another often underrated issue is ***droplet condensation on the inner surface of the greenhouse covering (glass or plastic) which reduces the available light falling on the plants***. When light levels are too low this causes plants to become more vegetative which means they stretch, become thinner, and flowering and fruit set is reduced, often causing major reductions in the total harvest and fruit quality.

Example of avoidable condensation issues

A Virginia capsicum grower was having issues with poor fruit set in one particular block of glasshouses. During a morning visit it was noted that his plants were more vegetative in this glasshouse and that there was a higher level of condensation inside on the glass panels in this block. Close inspection revealed that the glass was not as clean above this crop. Because condensation begins on particles of dirt, dust, chalk etc. it was starting earlier and building up more during cool nights, so it lasted longer before evaporating. The persistent water droplets above these plants were blocking out more critical morning light.

Strategies for managing the risk of condensation and vegetative growth

Water droplets reflect up to 30 to 50% of the usable light entering a greenhouse. Given that the advice to hydroponic tomato growers is that 1% extra light = 1% increase in production this is a significant problem. Strategies to reduce the presence of water droplets on the glasshouse ceiling reduce this problem include:

- **Ventilation outlets:** This generally means sides and ends that can open fully for rapid ventilation and then be closed again. Usually these openings are screened with a shade mesh mostly to reduce damage to edge plants from buffeting by the wind. Sometimes there are upper ventilation windows in the ends, above the gutter line, and occasionally roof openings are included, especially for releasing excess heat. The latter is not included in generic low-tech greenhouse designs. Sawtooth plan greenhouses have vents on the vertical side of the curved roof ridges. Standard practice in winter involves opening vents when humidity is too high, usually late afternoon, to dispel excess humidity before night cooling sets in triggering condensation. In milder weather vents may be partially or fully opened depending on humidity readings outside. ***In summer during heat waves vents can be closed to conserve humidity. Although temperatures will remain high and plants will 'shut down' this will reduce dehydration damage and problems like fruit burning.***

- **Maintaining clean surfaces:**
  If dust or chalk are left to accumulate on the inside this will enable condensation to occur more easily – ie at a lower humidity and higher temperature – than if the surfaces are clean. The risk of plants stretching because low light is further increased by dust or dust or chalk on the outside. When chalk is not being used to reduce heat in summer the inner and outer surfaces should be kept as clean as possible to maximise light penetration and minimise condensation on the ceiling. Cleaning plastic coverings is said to increase incoming light significantly – ie by up to 15%.

- **Treated surfaces:** Condensation can be reduced by purchasing polysheet with inbuilt anti-condensation properties, or by using a cheap spray-on anti-condensate. These technologies work by assisting droplets to merge and run down off the ceiling, reducing any loss of light penetration when condensation is occurring.

- **Electric ceiling fans:** Circulating air can hold more moisture than still air. That is partly why there is more dew on the grass on still mornings. Switching on fans in the morning will evaporate any condensation more quickly. What about overnight sue of fans ?

NOTE: Where fine mesh is desirable to help exclude pests it will reduce ventilation and may cause issues. This makes good ventilation management and other condensation reduction measures even more important.

Costs and Benefits Related to Climate management

Significant crop losses can result from vegetative plants (stretching rather than flowering and setting), diseases and cold damage. Benefits depend on making changes that are compatible with your actual climate control issues, greenhouse design and budget. Benefits depend on the amount of structural and management or activity changes that can be made to reduce key threats. Structural costs are essentially once off but give a long term return.

Options to re-engineer Phuong's very low glass house are almost non-existent, but if you think your greenhouses may be suited to some modification create your own Cost-Benefit estimate by clicking here for *Module 4. Cost Benefit fact sheet* and *'Capsicum Calculator'*.

Additional Fact Sheets

More information on greenhouse climate management can be found in the '**Resource Index'** under *2. Greenhouse design and climate management*, including an extensive Vegetable R&D report covering the cost and benefit of various strategies and designs

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