Technology for Greenhouse Heating and Cooling©

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INTRODUCTION

In a greenhouse we can influence the growth and development of plants by controlling the environment. This also makes it possible to grow out-of-season crops. Greenhouses with environmental control are designed to optimise the factors that contribute towards favourable conditions in the greenhouse. Heating and labour are major cost items in greenhouse crop production and any increase in the efficiency of heating systems can have a significant effect on reducing production cost. In order to maximise the effectiveness of heating, it is also essential to have an effective control system, as poor control of the air temperature wastes energy.

PLANT REQUIREMENTS

Different plants have different optimum temperature ranges for maximum vegetation growth and flowering. The effects of temperature on plant growth are as follows:

- Temperature/plant age: optimum temperature changes with age. Younger plants require higher night temperatures in general.
- Temperature/humidity: plant stress will be reduced if humidity is increased when the temperature is high.
- Temperature/light: plants respond positively to increased temperature combined with increased light.

GREENHOUSE HEATING LOADS

The following factors influence the heating load required to obtain optimum temperatures:

- Location/orientation: minimum and maximum outside temperatures.
- Greenhouse structure: type of greenhouse (single-span or multi-span), type of covering material (glass, film plastics [single or double layer], polycarbonate)
- Thermal screen: saves energy consumption at an average of 40%.
- Plant requirements: depending on type of plant.

Greenhouse crops as a whole can be produced at lower temperatures than are generally recommended, but the cropping time is increased. In some cases the heating energy savings resulting from lower temperatures are lost in the form of overhead cost and fuel consumption during the period of extended growth. This might mean that optimum growing conditions, e.g., optimum temperature, might not yield the maximum return on costs for the farmer.

VENTILATION

Among the requirements for greenhouse ventilation systems are:

- Temperature reductions: high temperatures can cause loss of stem length, the reduction in flower size, delay in flowering, narrow

leaves, and hard, spiky growth.
- Humidity control: high relative humidity are conducive to fungus diseases.
- Carbon dioxide replacement: high levels become a growth-limiting factor.

Temperature reductions are achieved by replacing the warm air with sufficient cold air from outside. The inside temperature can even be reduced to below that of the ambient air by using evaporative cooling (e.g., wetwall and fan). The two secondary functions of a ventilation system will usually be achieved if a ventilation system is designed to fulfill the primary requirement, being temperature reduction.

Natural ventilation inside the greenhouses is achieved by supplying openings, both in the walls and roof of the greenhouse. The required total ventilation opening area should be divided equally between the side and the roof, and should be equal to no more than 25% of the greenhouse floor area. If only the roof-opening ventilation is to be provided, then it is advisable to increase the total ventilation opening to at least 33% of the greenhouse floor area. Advantages of a natural greenhouse ventilation system are that no capital cost for fans and evaporative cooling is required. A disadvantage is that the efficiency of the ventilation system is dependent on wind and the rise of the warm air.

In a force ventilation, wetwall and fan system, extraction fans are placed on the greenhouse wall opposite a porous pad, which can be kept wet. When the extraction fans operate, ambient air is drawn through the pad. When cooling of that air is required, the pad will be wet, and by evaporation of water on the pad, the air will be cooled and the relative humidity of the incoming air will be increased. Alternatively, the fan can extract warm, humid air, which will be replaced by ambient cooler air, without the incoming air being cooled and humidified.

Because the air heats up as it travels through the greenhouse, the maximum pad-to-fan distance should be about 35 m. The air speed through the greenhouse determines the power consumption of the ventilation fans. An effective design should ensure that the airspeed is no less than 1.5 $m \cdot s^{-1}$ anywhere inside the greenhouse.