An Update on Greenhouse Environmental Control

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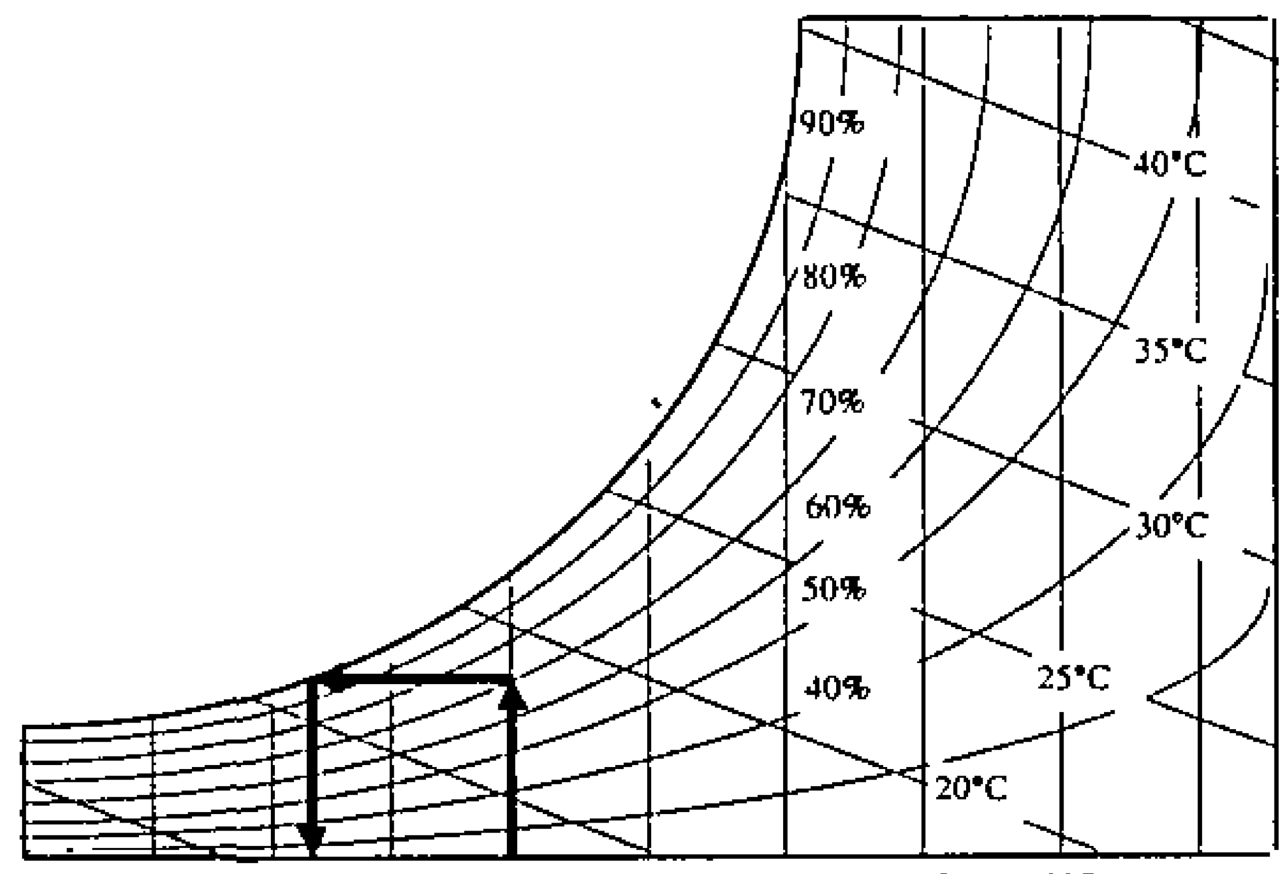
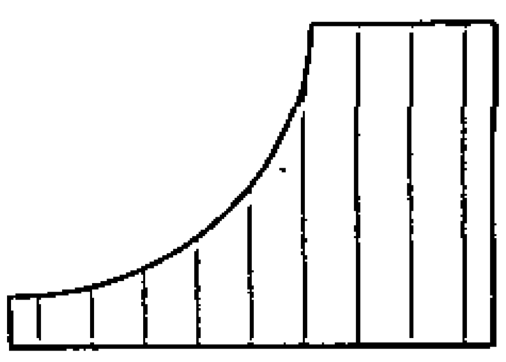
AN INTRODUCTION TO PSYCHROMETRICS

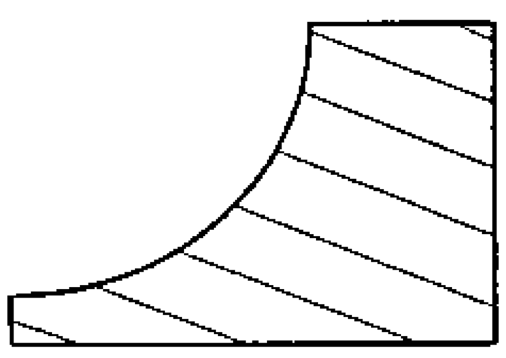
A greenhouse manager cannot maximise control of the greenhouse without some understanding of the relationship between temperature, light, and humidity. This paper will mainly discuss the relationship between temperature and humidity. A good understanding of these processes starts with the psychrometric chart.



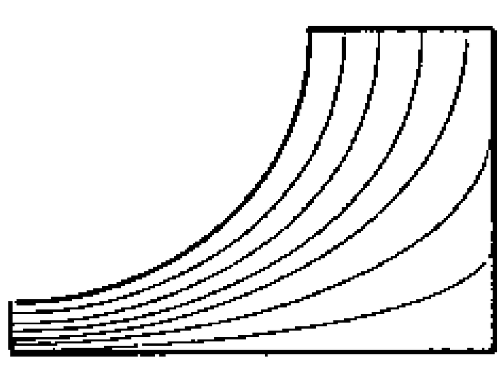
HOW IT WORKS



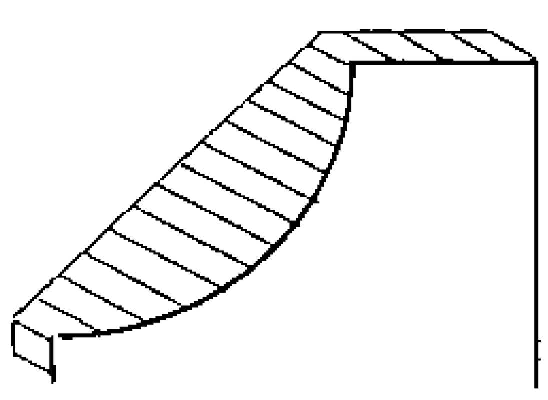
The vertical lines represent the dry bulb temperature (air temperature measured with a dry thermometer).



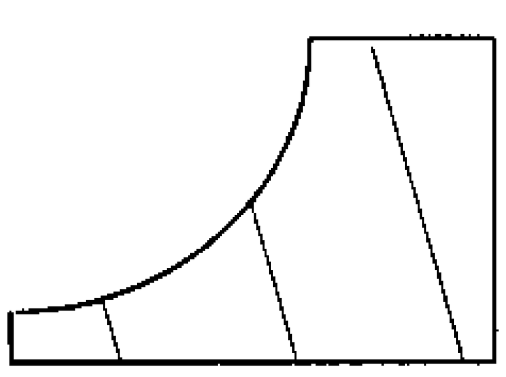
These lines represent the wet bulb temperature (air temperature measured with a thermometer with a wet wick — usually also involves a fan blowing air on the wick to make water evaporate).



The curved lines represent the relative humidity of the air (amount of water vapour in air expressed as a percentage of amount of water vapour in 100% saturated air)



These diagonal lines represent enthalpy (total energy of the air in kilojoules kg^{-1} — used to calculate heat loads in greenhouses, especially when sizing heaters and refrigerative coolers)

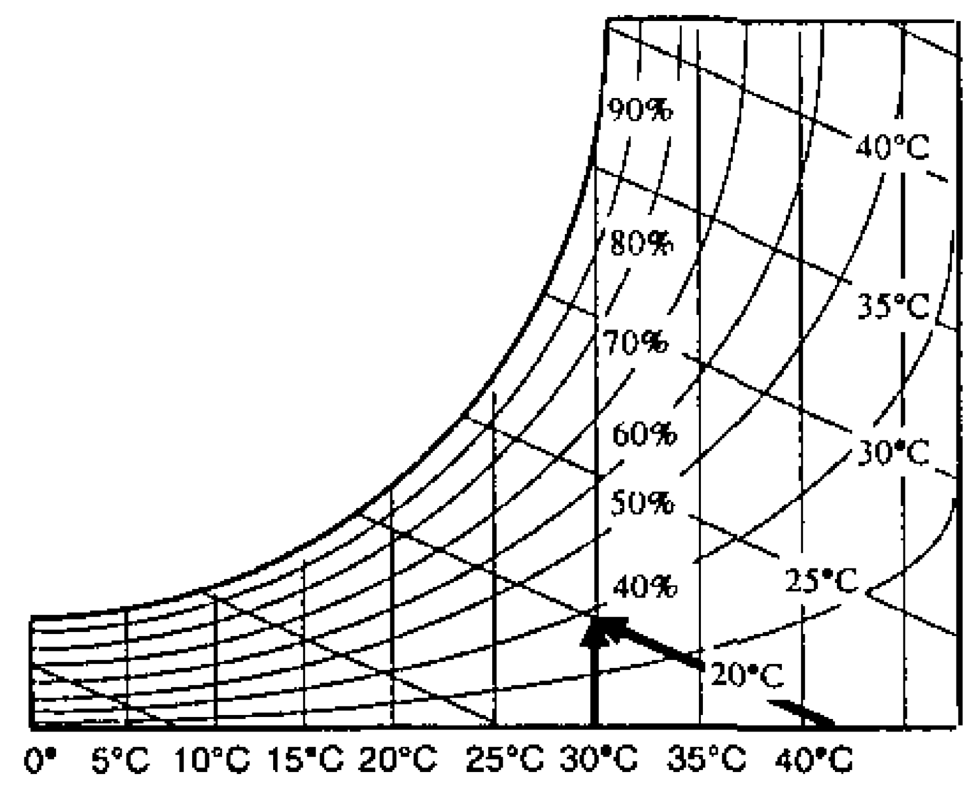


These lines represent the specific volume (volume of air in m^3 kg^{-1} of air — used to calculate mass of air in greenhouse)

The psychrometric chart can be used in the greenhouse for many purposes.

CALCULATING RELATIVE HUMIDITY (RH)

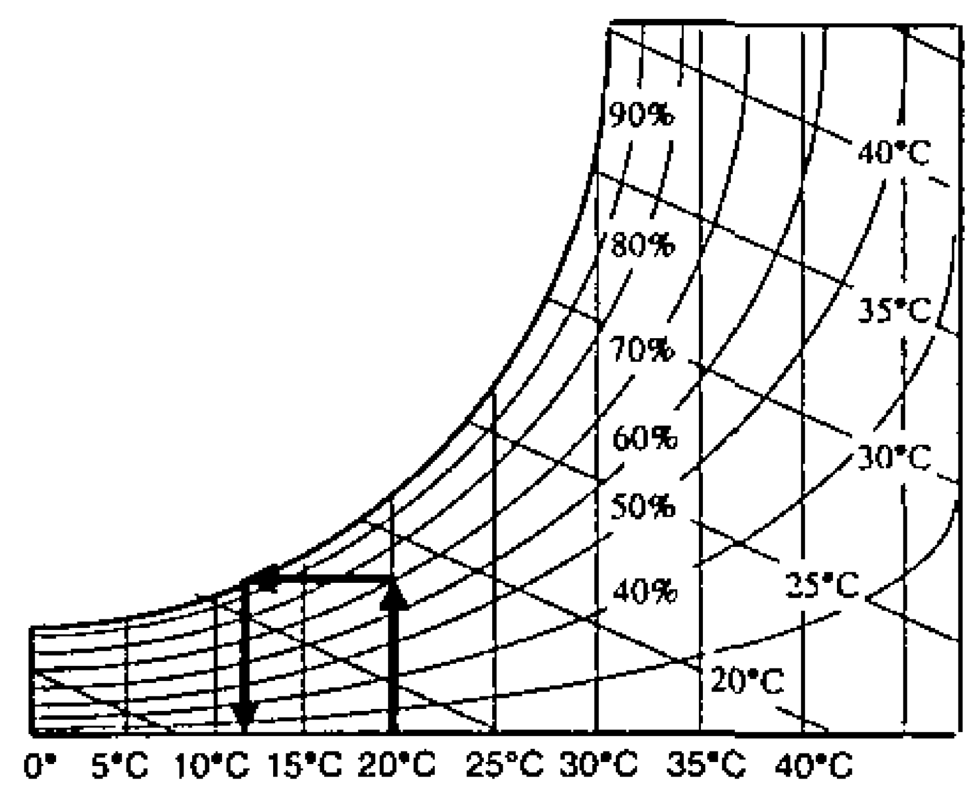
The grower can purchase several types of hand-held RH meters, but if one is not available, a fairly accurate measurement can be taken by taking the temperature in the greenhouse (dry bulb) and then taking the wet bulb temperature. To do this, set up a thermometer with a wet shoelace over the mercury reservoir, with the other end of the shoelace dipped into a small container of water. A small fan should be set up, blowing air onto the shoelace. The wet bulb thermometer should always read lower than the dry bulb thermometer.



If the dry bulb temperature is 30C and the wet bulb temperature is 20C, find the point where the vertical dry bulb temp line intersects with the wet bulb temp line. The nearest curved relative humidity line will indicate the relative humidity in the greenhouse. In this case, the indicated relative humidity is just under 40%.

CALCULATING DEWPOINT TEMPERATURE

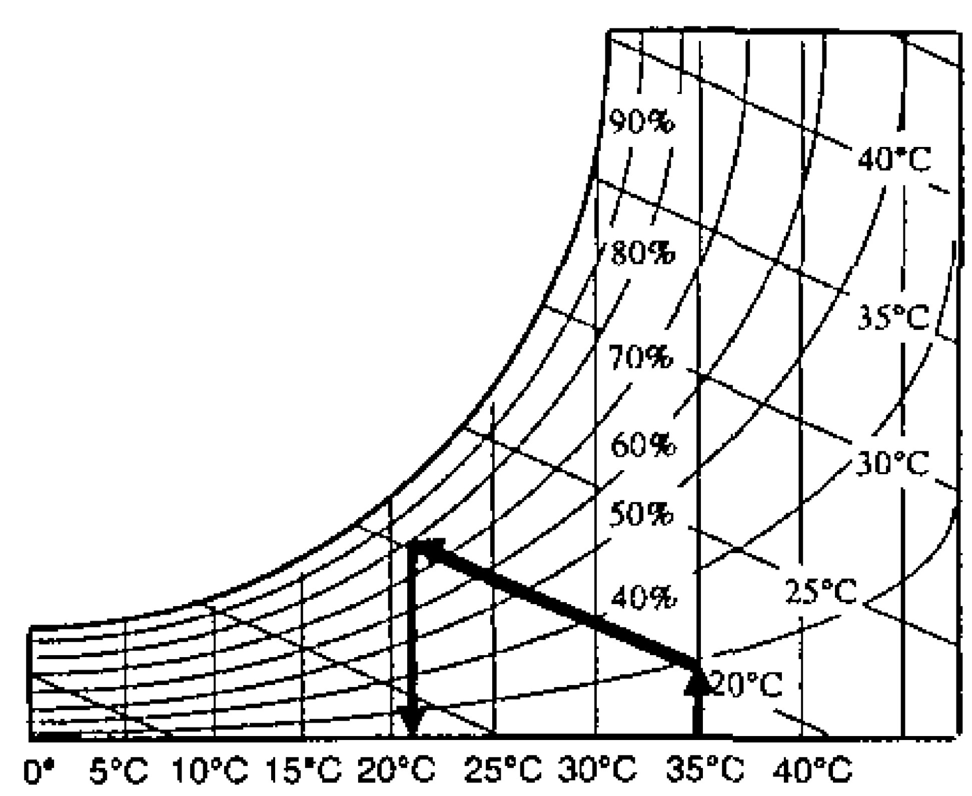
Given a starting temperature and humidity, it is possible to find out at what temperature the air will become saturated (100% relative humidity). This is called the dewpoint temperature and it is a greenhouse condition to be avoided.



If the air temperature is 20C and at 70% RH, go to that point on the chart and draw a horizontal line to the 100% saturation line. From there, draw another line directly down and this is the dewpoint temperature.

CALCULATING COOLING SYSTEMS

It is also possible to calculate the effect of cooling the greenhouse by adding water vapour to the air.

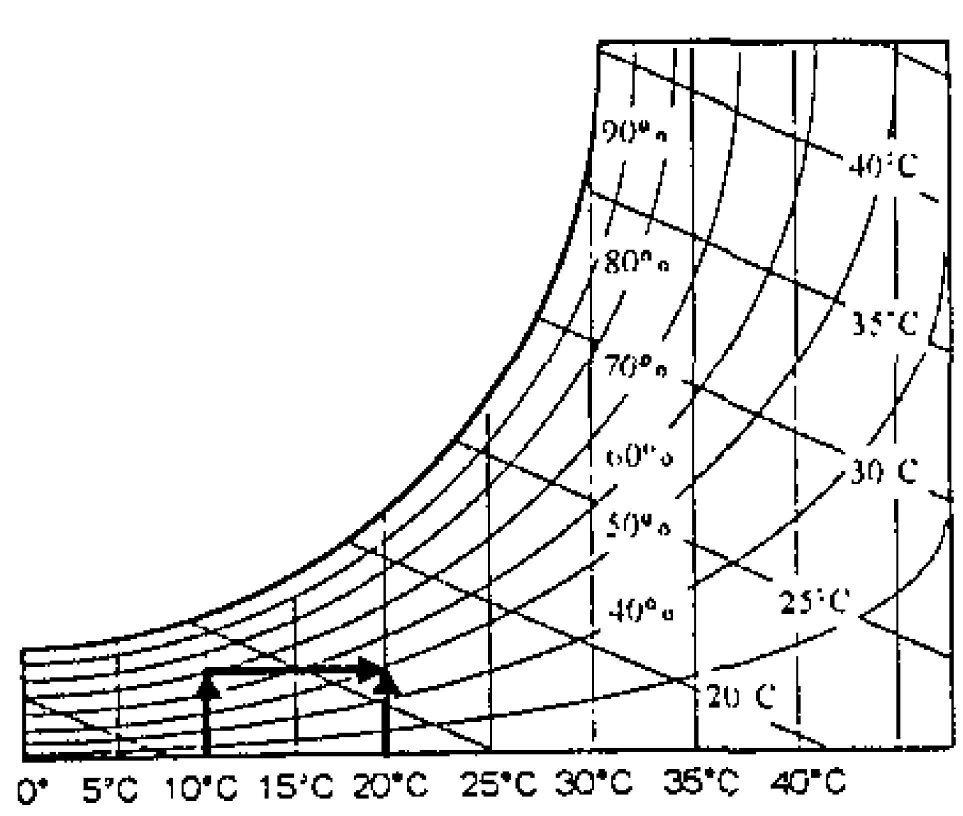


If the starting conditions are 35C at 20% RH and the aim is to cool the greenhouse as much as possible without exceeding 80% RH, draw a line from that starting position, parallel to the wet bulb lines until it intersects the 80% RH curve. Draw another line down from there to indicate the temperature that the greenhouse would then be. In this case it is about 21C — a 14C drop in temperature.

From the same chart, it is also possible to determine how much water would be required to cause that drop in temperature so that a fogging system could be designed to perform the task.

CALCULATING HEATING SYSTEMS

Using the psychrometric chart it is also possible to calculate the effect on humidity of heating the greenhouse air. Heater size can also be calculated.



If the greenhouse starts at 10C and 70% relative humidity and the greenhouse is to be heated to 20C, to find the final relative humidity, draw a line from 10C at 70% RH, horizontally until it hits the 20C vertical line. The nearest curved relative humidity line indicates that the humidity drops to 50%.

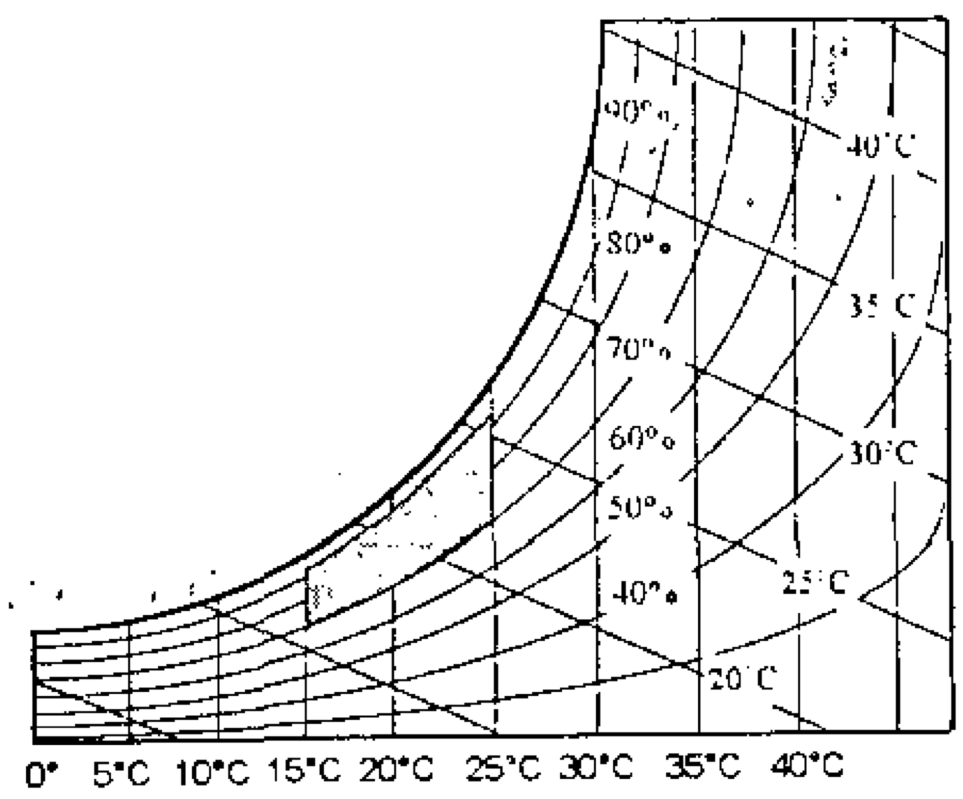
The heater size can be calculated by the change in enthalpy, but the calculations are too complex for the purpose of this paper.

The calculation of refrigerative cooling (air conditioning) can also be done, but with the horizontal line moving from right to left instead of left to right.

NOTE: These representations of psychrometric charts are not to scale.

SUMMARY

One of the most important aspects of successful propagation is maintaining a low-stress environment for the cuttings or young seedlings. For many crops there is a very small 'window' of temperature and humidity ranges, as depicted in the chart — between 15 to 25C and between 70% to 95% relative humidity.



Keeping the greenhouse environment within that window can be very difficult and requires good equipment and good management.

I hope that this paper helps with the implementation of both.

LITERATURE CITED

Connellan, G. 1992. Lecture notes from Horticultural Engineering II. University of Melbourne, Burnley College.

Merkel, J.A. 1983. Basic engineering principles. AVI Publishing Col., Westport . U.S.A.