ELSEVIER international
2002, VOL. 5 NO. 3
US$12

PRODUCTION AND MARKETING OF ORNAMENTALS WORLDWIDE

Flower TECH

Tropicals with high potential

Novel way to reduce energy and humidity

Perseverance with Helleborus pays off

Novel means of humidity control and heating

A system which reduces relative humidity in the greenhouse and therefore brings about less disease has also been designed to save energy.

By Gad Assaf, Agam Energy Systems, Israel, and Naftaly Zieslin, Hebrew University of Jerusalem, Faculty of Agricultural, Environmental and Food Scienses.

Control of two environmental factors, relative humidity and temperature in the greenhouse atmosphere is of great economical importance in cultivation. The most known effect of sub-optimal humidity and condensation of moisture on plant organs is proliferation of moisture dependant diseases, in particular, *Botrytis cinerea* (grey mold) in rose flowers. The second, a lesser known effect, is a significant decrease in longevity of harvested flowers when rose plants are exposed to a relative humidity of over 90% in the greenhouse.

A new method of reducing the relative humidity in the greenhouse is by installation of dehumidifiers known as Latent Heat Convertors (LHC) or AGAM units. Not only do they bring about a significant decrease in the extent of plant and flower diseases which require high humidity conditions, there is also a decrease in energy required for heating the greenhouse. The decrease in energy consumption is due to the latent heat conversion of the greenhouse water vapor to sensible heat* of the condensed water.

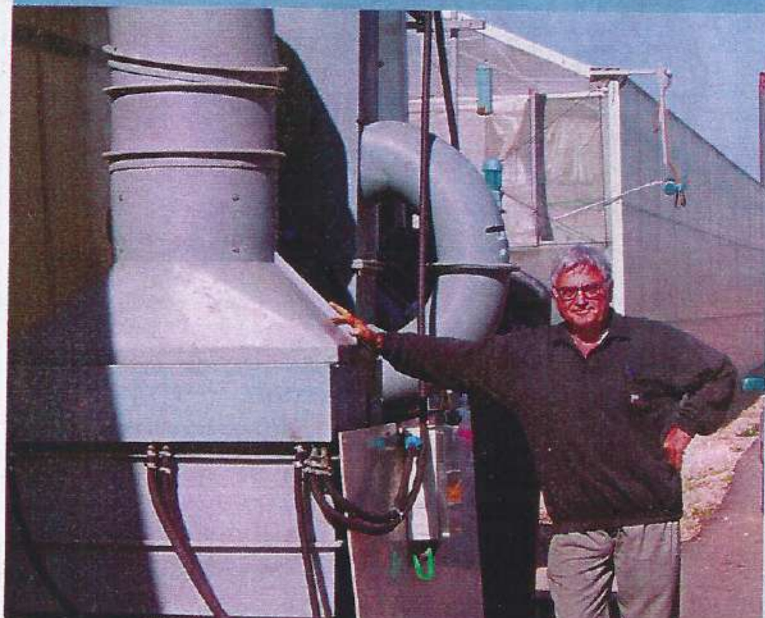
Principles of LHC units

The principles of Latent Heat Convertors (LHC) are based upon direct contact of air with downward flowing hygroscopic solution (brine). Each one of the units composed of two separate heat exchang ers, A and B. When the humid greenhouse air makes contact with the brine exchanger A, the vapour is condensed c the brine. The sensible heat of the condensation heats the brine and the warr brine heats the air which is introduced with a lower relative humidity (RH) ba into the greenhouse.

The warm brine, which accumulates i the reservoir of exchanger A, is pumpec to the top of exchanger B and is distrib uted downward on the exchanger. The warm brine of exchanger B exchanges heat with the cooler outdoor air, the ter perature of the outdoor air increases an is also introduced into the greenhouse.

The brine, which is now cooler due to the exchange with the air, accumulates i the reservoir of exchanger B and is pumped on top of exchanger A.

The diluted brine is concentrated in a brine evaporator heated with hot water from the greenhouse general boiler. Hea from the brine evaporator is also introduced into the greenhouse.



Gad Assaf with the Latent Heat Convector pictured outside the greenhouse.

**Sensible Heat (or enthalpy) is defined as the heat energy absorbed or transmitted by a substance during a change of temperature which is not accompanied by a change of state*

Two Latent Heat Convector units installed in the greenhouse which measures 30m x 120m. Each unit has two openings which can be seen from the inside. The air is distributed via six circulation blowers.

Units on trial

To test the system two neighbouring greenhouses, each 3600 m² (120mx30m), with evaporative pads and clad with double polycarbonate sheets were used in the experments. Pipes for greenhouse heating were placed beneath the plant canopy and two lines of two circulation fans each line, were installed in each greenhouse to improve the air movement between the plants.

The number of plants, the cultivars as well as the methods of plant handling were similar in both greenhouses.

Two models of LHC (AGAM) units were installed outside on the eastern wall of one of the greenhouses (greenhouse A). The second greenhouse (B) was used as a control.

The greenhouses were placed under the following conditions:

Greenhouse A: 1) LHC heating without addition of conventional hot-water heating.

2) LHC heating with conventional hot-water heating.

Greenhouse B: 1) The greenhouse only ventilated without heating.

2) Conventional heating and ventilation.

LHC in operation

The efficiency of the AGAM units was examined twice during the spring of 2001 when the minimal ambient temperatures were 11.0°C-11.5°C and air humidity was 90%-95%. In one of the experiments greenhouse A was heated and dehumidified with the AGAM units without additional heating, while greenhouse B was ventilated continuously without heating as a control treatment.

The results (*Table 1*) show that at ambient temperature of 11.5°C the two AGAM units were able to raise the temperature in greenhouse A to 16.5°C compared with11.5°C in greenhouse B. Furthermore, the air humidity in the control greenhouse remained at 95% similar to the outdoor humidity, while in the greenhouse heated with the AGAM units the humidity has been reduced to 88%. The rise of 5°C over the outdoor temperature is a substantial donation to energy saving in the greenhouse, whereas the reduction of the humidity to 87% and 89% at 30m and 90m from the AGAM units respectively was sufficient to prevent grey-mold and other diseases requiring high humidity from forming.

In the second experiment a minimum of 18°C was maintained in greenhouse B. For maintenance of this temperature during 12 hours at night, 1545 kWh of energy were required (*Table 2*). This amount of energy was not efficient for dehumidification, nor a reduction of the relative humidity below 90% and hence not for a decrease in the level of grey-mold disease. On the other hand, main-

Table 1: Mean temperature (°C), mean relative humidity (%) and energy input (kWh) in greenhouse A with LHC heating and greenhouse B with continuous ventilation without heating during 12h of night period.

Greenhouse conditions	Mean night temperature (°C)	Night relative humidity (%)	Energy input (kWh)
Continuous ventilation without heating	11.5	95	Fan operation only
LHC heating only	16.5	88	280*

*For brine concentration

Table 2. Mean temperature (°c), mean relative humidity (%) and energy input (kWh) in greenhouse A with LHC + conventional heating and greenhouse B with conventional heating and ventilation.

Greenhouse conditions	Mean night temperature (°C)	Night relative humidity (%)	Energy input* (kWh)
Conventional heating and ventilation	18	90	1545
LHC and conventional heating	18	87	963

12 hours of operation

Table 3. Efficiency of LHC operation with and without addition of conventional hot- water heating in comparison to conventionally heated and ventilated greenhouse .

Greenhouse handling	Vapor condensation ($l\ night^{-1}$)	Dehumidification ($l\ night^{-1}$)	Coefficient of heat transfer ($Wm^{-2}\ °C^{-1}$)	Energy saving ($kWhl^{-1}$)
LHC heating only	280	560	1.30	
LHC and conventionals heating	160	320	3.27	3.64
Conventional heating and ventilation	-	-	5.25	

taining a temperature of 18°C with two AGAM units in greenhouse A with the addition of conventional heating required only 963 kWh. This lead to a mean decrease in RH to 87% and energy savings of 3.64 kWh l^{-1} of water. During the 12 hour operation, the greenhouse water vapour condensed to 160 litre of water, with an additional 160 litre obtained due to dehumidification of the outdoor air (*Table 3*).

The coefficient of heat transfer from the greenhouse A dehumidified by the AGAM units was 1.3 Wm^{-2} °C $^{-1}$. In greenhouse A with AGAM units and conventional heating the coefficient was 3.27 Wm^{-2} °C $^{-1}$, whereas in the conventionally heated and ventilated greenhouse the heat transfer coefficient was 5.25 Wm^{-2} °C $^{-1}$ (*Table 3*).

When the average temperature in the hot-water boiler is only 65°C, as it was during the experimental period, the condensation of water vapor was 8-12 l h^{-1} per one AGAM unit. When the boiler water temperature will be increased to 70°C the condensation of vapor is about 13 lh^{-1}. At 75°C the vapour condensation will increase to 17 lh^{-1} and to 20 lh^{-1} per AGAM unit when the boiler water temperature will be elevated to 85°C.

With these conditions the RH in the greenhouse will be reduced to 85%, energy savings will be 6 kWh^{-1} and they will provide a high level of protection against high humidity requiring diseases.

For further information contact: Gad Assaf, email: agamga@netvision.net.il and Naftaly Zieslin, email: zieslin@hotmail.com