Controlling the Temperature and Humidity in a Greenhouse

Adrian Zărnescu, Răzvan Ungurelu and Gaudenţiu Vărzaru
Syswin Solutions, Bucharest, România

Abstract

Traditionally, the control of the temperature and humidity in a greenhouse is based on the exchange of air masses between its interior and exterior, either by ventilation (curtains), either by circulation (fans). While might be cost and energy efficient solutions, a curtain system requires a certain amount of maintenance to keep it operating, and the efficiency of the control depends on other air parameters, like speed and direction of the wind. Modern solutions are based on water vaporization under high pressure. In terms of control, a known solution is based on the difference between the temperature and humidity levels outside the greenhouse, and the temperature and humidity inside the greenhouse. However, vaporisation methods are known to be prone to condesation under the roof or on the leaves of the plants, which is favorable to the production of spores, increased fungal growth, presence of foliar diseases. The novelty of the solution is the control of the generator of the vapours based on air temperature inside the greenhouse and the information from a leaf wetness sensor. The solution was implemented and tested in a greenhouse last summer.

Introduction

In order to avoid condensation on leaves, the air temperature should be controlled to be above the Dew Point temperature (T_{DP}), assuming that the pressure and the amount of vapour are constant during cooling. There is a correlation between T_{DP} on and temperature and humidity which allows its computation, but there are different equations and different constant sets in use. A simplified equation found states that:

$$T_{DP} = T - ((100 - RH)/5)$$

where T_{DP} and T, the actual temperature, are in [°C], and RH, the relative humidity, is in [%]. Apparently this relationship is fairly accurate for relative humidity values above 50%. For a higher acuracy, a specialized sensor was prefered which can offer the leaf wetness, the electronic leaf. This solution allows for temperature control within the greenhouse and the wetness of the leaves, which is a direct information about the condensation on the leaves.

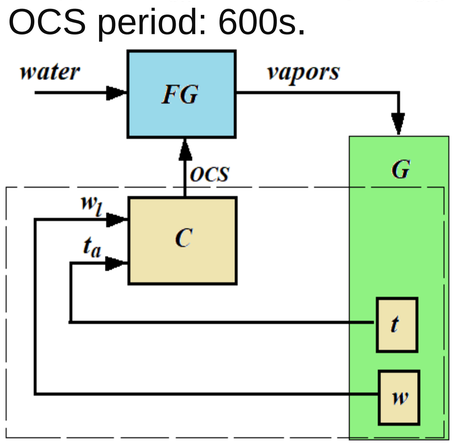
Experiment

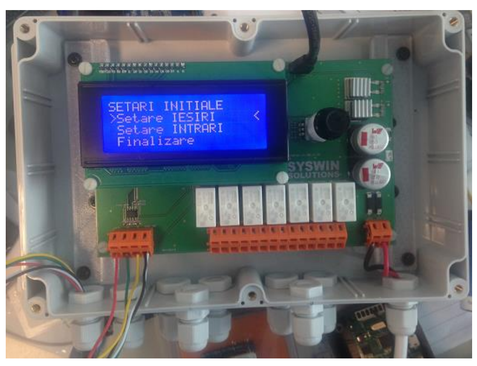
Implementation of the solution consists in an automated system built around a controller (C), that drives the generator of vapours (FG); the feedback from the air temperature (t) and leaf wetness (w) are compared with preset threshold by the controller.

The output command signal (OCS) is a periodical rectangle voltage having two states:

- ON (t_{on}): the output signal has 24VDC; vapours are generated; t_{on} may vary from 5 to 25 s.
- OFF (t_{off}): the output signal has 0VDC; the FG is stopped; t_{off} is 540 + (60-t_{on}) s.

OCS period: 600s.





The electronic leaf parameters: the temperature (in the range -40°C … 80°C, ±0.5°C accuracy); wetness (in the range 0 … 100%, ±5% accuracy). Data are available digital format (RS-485). RISC microcontroller type Cortex M0+ (ATSAMD 21, Microchip). The air temperature: dedicated sensor placed on an electronic module and shelterd in a water-proof and UV housing. The measurement range of the temperature: -40°C … 60°C, ±0.5°C accuracy.

Results

The system was installed in a greenhouse placed somewhere in the North of Romanian Plain. The electronic leaf sensor, together with the water-proof shelter of the temperature sensor were placed at the plant leaves level. All 6 outputs were connected to the solenoid valves of the FG. The power feeding was obtained from the mains.

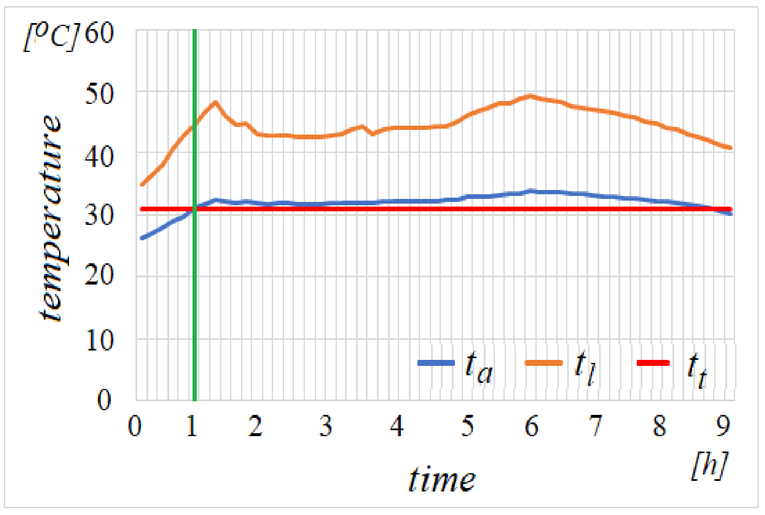
Target parameters and priority:

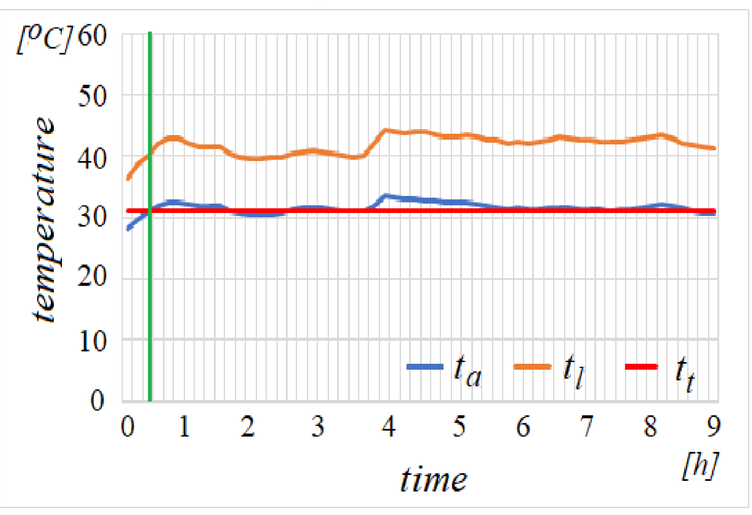
1) air temperature: 31 ° C, 2) leaf wetness: 15%.

Temperature control by evaporation						
Time [h:m:s]	t_a [°C]	t_l [°C]	W_l [%]	Out	t_{on} [s]	t_{off} [s]
10:00:19	26.15	34.96	0	0	0	0
10:10:20	27.11	36.45	0	0	0	0
10:20:21	27.98	38.09	0	0	0	0
10:30:22	28.93	40.71	0	0	0	0
10:40:23	29.65	42.92	0	0	0	0
10:50:24	31.18	44.68	0	0	0	0
11:10:25	31.65	46.59	0	0	0	0
11:20:26	32.54	48.26	0	1	20	540
11:30:27	32.18	46.15	5	1	5	540
11:40:28	32.05	44.59	2	1	5	540

Temperature control by evaporation						
Time [h:m:s]	t_a [°C]	t_l [°C]	W_l [%]	Out	t_{on} [s]	t_{off} [s]
10:00:19	28.06	36.54	0	0	0	0
10:10:20	29.65	38.65	0	0	0	0
10:20:21	30.93	40.18	0	0	0	0
10:30:22	31.76	42.09	0	0	0	0
10:40:23	32.52	42.92	0	1	20	540
10:50:24	32.48	42.78	19	1	5	540
11:00:24	32.07	41.93	11	1	5	540
11:10:25	31.98	41.52	6	1	5	540
11:20:26	31.75	41.62	4	1	5	540
11:30:27	31.82	41.52	1	1	15	540

t_a is air temperature in the greenhouse, t_f is the temperature of the leaf, W_l is the wetness of the leaf, *Out* is the logic state of the OCS for the fog generator (0: OFF, 1: ON), t_{on} is the ON state duration, t_{off} is the OFF state duration.





Conclusions

► An equipment for control of the temperature and humidity in a greenhouse by evaporation technique was designed and tested.

► The air temperature in the greenhouse was maintained during eight hours with a maximum overpass of 2.85°C (on July 1st), and 2.68°C (on July 2nd).

► The direct method of determining the condensation state on the leaf was preferred; instead of air relative humidity, the leaf wetness parameter was monitored. this provides more accurate information on the probability of occurrence of some plant diseases.

► The wetness on the leaf was maintained in the range 0 … 6%, both days of experiment, below the target condition, 15%, even taking into account possible errors due to the accuracy of the sensor (±5%).

► The system permanently maintained the air parameters in an acceptable range to avoid the conditions of emergence of diseases of the greenhouse plants.

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