Colorado Flower Growers Association, Inc.

IN COOPERATION WITH COLORADO STATE UNIVERSITY

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Air Movement and Temperature Control II.

by Joe J. Hanan

The greater the air flow past a plant, the closer the plant temperature will be to that of the air. The more even the flow, the narrower will be the fluctuations in plant temperatures, provided the air temperature itself does not vary.

Numerous publications have dealt with the relationship of plant temperatures to the temperature of the immediate surroundings (1, 2, 3, 7, 8, 9). In some instances the statements made appear to be contradictory because it is impractical to attempt any but sweeping generalizations except under the most accurate environmental control.

The purpose of the study presented here has been to obtain a clearer picture of the temperature control available in the CSU Temperature House, and to gain an insight into what might be expected in commercial greenhouses. For an introduction and comparison of control as measured at the thermostats, refer to "Air Movement and Temperature Control" in CFGA Bulletin 98.

Experimental Methods

For those who may be interested in the use of thermocouples for temperature measurements, the principle of operation may be found in most physics textbooks, and the articles by Eggert (4) and Esau (5) might also be useful.

In this study, No. 24 B & S gauge copper and constantan wire was used with one junction at a constant 32°F and the temperature read directly from a GE potentiometer. The positions of the stationary thermocouples, used for air temperatures, may be located in figure 1. Vertical thermocouple 6 was located at the cooling thermostat and No. 7 on the mercury thermometer. Since plant temperatures were measured in different areas of each compartment, the locations for these junctions are not indicated.

Only stem and bud temperatures were measured on the carnation plants, since the thermocouples in this investigation were too large. It was also thought that errors due to conduction in the wires would prevent sufficient accuracy of leaf temperature measurements. However, since the temperature of any part of a plant depends upon its mass, the intensity and angle of the incident light, and the velocity of the air flow, in addition to the air temperature; the direction and degree of variation in leaf temperatures might be surmised from the data obtained.

An attempt was made to run a series of determinations under constant conditions and within a period of one hour. This was not entirely possible as the air flow in the 60° compartment was directed on the plants (figure 2), whereas in the

75° compartment the air flow was into the ridge. Likewise, the overhead circulating fan in the 75° compartment (figure 1) was twice as large as the 60° overhead fan. In all instances the small circulating fans on the control shelters were operating continually.

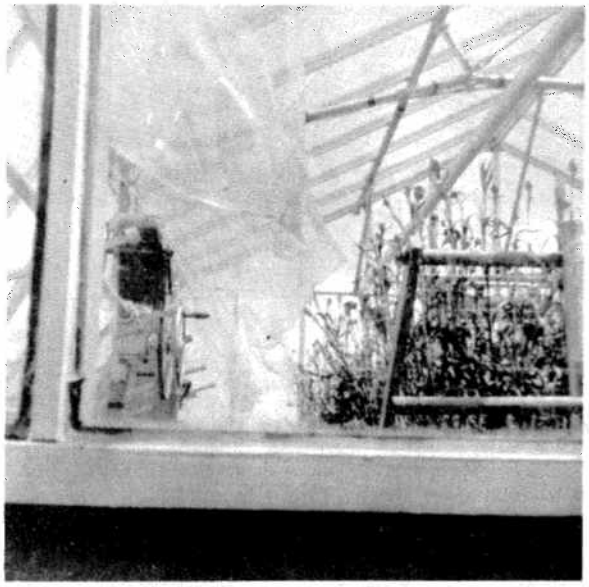

Figure 2: Placement of air baffle in the 60° compartment

Results

With the exception of table 1, all data given are the means of at least 4 individual readings and in some cases as many as 112. The effect of increasing the number of readings included in a single figure can be seen in tables 2 and 4. The process sometimes results in reducing the variations in temperatures and, in total averages, bringing air and plant temperatures closer together. It is left to the individual's discretion as to which figures he might consider most important.

Conclusions

It may be assumed that under high light intensity and slow air movement, the temperature of the plant will be above the air temperature. As air velocity past the plant is increased the plant temperature will approach that of the air, provided violent fluctuations do not occur.

This study and previous observations point out that temperature control can usually be improved and fluctuations re-

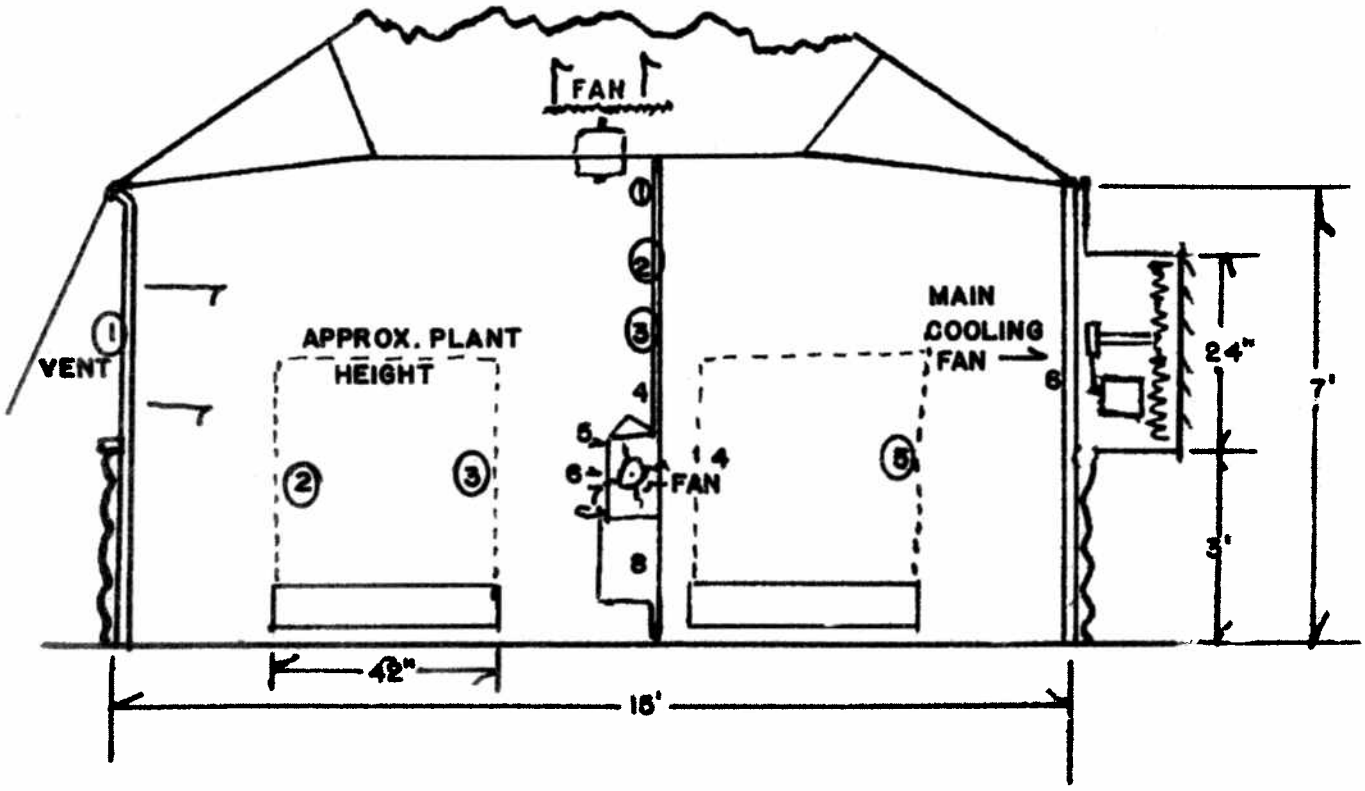

FIGURE 1; MID CROSS SECTION OF ONE COMPARTMENT SHOWING APPROXIMATE LOCATIONS OF STATIONARY THERMOCOUPLES

duced by: 1) increasing the rate of air flow past the plant, and 2) making sure that the flow is even throughout the house and around all portions of the plant. The latter is probably the most difficult problem and the one deserving the greatest attention. Until it is satisfactorily solved, increasing thermostat and heating system sensitivity merely results in greater temperature fluctuations and thereby poorer control. Similarly, increasing the rate of air movement without increasing thermostat and heating system responsiveness will result in the same effect. A balance must exist at all times between air, thermostat, and system, if accurate and efficient temperature control is to be achieved.

Table 1. A sample of individual temperature readings taken in the 60° compartment on a clear day.

	Time									
	1215					1230				
Location	Vertical		Plant			Vertical		Plant		
1	57	63	61	61	63	68*	65	61	61	60
2	61	63	64	67	65	70*	65	64	64	63
3	64	64	65	64	62	76*	65	64	63	62
4	73*	73*				65	62			
5	63	63				63	62			
6	59	60				64	62			
7	61	60				65	65			
8	60	60				61	63			

*Thermocouple in the sun.

Table 2. Mean temperature measurements in the 60 and 75°F compartments.

Thermocouple location (refer to figure 1)	Sunny		After dark		
	60°*	75°**	60°***	75°***	
				Air circ.	No air circ.#
I. Vertical:					
Air: 1 (top)	64	78	65	77	84
2	65	78	66	77	83
3	70	79	64	77	81
4	66	79	60	75	80
5	61	76	59	75	77
6	62	76	58	73	75
7	62	77	58	75	76
8 (bottom)	60	76	57	71	74
Plant:					
1 (top)			63	75	80
2			60	73	78
3			59	73	76
4 (bottom)			59	73	76
II. Horizontal:					
Air: 1 (entrance)	60	71	60	75	83
2	57	75	56	77	76
3	61	73	58	70	76
4	61	74	56	72	75
5	61	76	57	74	77
6 (exhaust)	61	70	59	73	78

* Cooling fan in continuous operation, baffle in place (figure 2).
** Cooling fan intermittent, no baffle.
***Greenhouse closed tight, heat in the coils, overhead fans operating (figure 1).
Overhead fan turned off.

Table 3. Mean plant temperature comparisons under varying conditions during a clear day.

	60°*	75°**
1. Thermocouple in direct sun-	66	83
2. Shaded plant----------	61#	73
3. Plant in direct sun--------		80
Maximum air flow--------	64	
Minimum air flow--------	68	
4. Average plant temperature in direct sun----------	65	
5. Average plant temperature--	63	79
6. Average air temperature----	63	75
7. Maximum plant temperature variation----------	7	7

* Cooling fan in continuous operation, baffle in place.
** Cooling fan operation intermittent, no baffle
\# In direct air flow

Table 4. Mean temperature comparisons

Variation	Sunny		After dark		
	60°	75°	60°	75°	
				Air circ.	No air circ.
Between plant and air	1	4	1	1	1
Maximum air temperature					
vertical	10	4	9	6	10
horizontal	4	6	4	8	8
Maximum plant temperature					
vertical			3	2	4
from one location to the other	7	7			

Your editor,
W. D. Holley

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