Programmed Split Night Temperatures: Pot Mums

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The response of pot chrysanthemums[1] to a programmed split night temperature (PSNT) regime was tested in the University of Connecticut Floriculture Greenhouses. Energy savings were determined for the programs.

Microcomputer capability permitted the use of a PSNT that gradually reduced the greenhouse temperature at a rate of approximately 2°F per hour, beginning at 1600 hours, until an intended low night temperature of 50°F was reached at about midnight. This temperature was maintained for 4, 5 or 6 hours, at which time the temperature was increased at a uniform rate per hour to achieve a day set-point of 65°F by 0800 hours. The day temperature was maintained from 0800 to 1600 hours except when solar radiation increased it. Ventilation was begun at 75°F. The control plants were grown under a constant night temperature (CNT) of 60°F and the same day temperatures.

The PSNT program can reduce heating costs by lowering heating requirements during the night which is usually the most demanding heating period. Energy savings were based on the difference of Btu's required to maintain the average temperature per hour of the night period for both the PSNT and CNT programs. The formula used for the calculations was $HL = AU\Delta T$ where;

HL = heat used by the greenhouse section/hr. (Btu's/hr.)

A = surface area of the greenhouse (sq. ft.)

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[1] rooted cuttings were supplied courtesy of Yoder Bros., Barberton, Ohio and Stafford Conservatories, Stafford Springs, Ct.

U = heat loss factor - relating to the covering material, in this case, glass (1.25 btu's/sq. ft./hr. °F)

ΔT = average inside temperature minus average outside temperature (°F)

The center sections were used in greenhouses of 3 sections. No heat loss was figured for the 2 gable end walls. It was assumed that heat was not lost through them.

In these experiments PSNT was begun with the onset of long nights. The greenhouse atmosphere was not enriched with CO_2. Actual temperatures obtained fluctuated from those projected due to a combination of the following factors: 1) unusually warm weather; 2) greenhouse section placement; 3) not having the advantage of modulating heat valves.

For height control, B-Nine was applied as a spray of 0.25% at the rate of approximately 1 gallon/200 sq. ft. One to three applications were made depending on the cultivar and time of year.

Experiment One: A 4 hour low PSNT. Flowering dates, the number of flowers per plant, and flower diameter were not significantly different under PSNT. PSNT plants were consistently taller. Complete results of this experiment were reported by Shabot and Koths (1987).

The reduction of heating requirements associated with this PSNT, 4 hour low of 53°F was calculated at approximately 8% when compared to the control.

Theoretically, 50 heating degree hours could have been saved using the 4 hour low (Table 1). Actual heating requirements were reduced by 44 degree hours per night (Table 2).

Experiment Two: An early fall crop with a 6 hour low PSNT. In this experiment a lower day temperature of 68°F following disbudding was tested since Heins (1985) reported that temperatures above 68°F late in the growth of mums delay rather than accelerate flower development.

Plant growth was affected only slightly by the night temperature programs (Table 3). Some were taller with larger flowers under PSNT but weighed the same. Similar findings were reported by Schneider (1980) and Watson (1982). Days to flower (1 to 2.5 days) were consistently increased under PSNT but they still generally flowered with the scheduled time according to the Yoder Mum Catalog. Even this unimportant delay can be compensated by adjusting the onset of long nights.

Actual heating requirements were reduced by 94 heating degree hours per night when compared with CNT which was incorrectly maintained at 62°F (Table 2). Theoretically, 78 degree hours would have been saved if the night temperature had reached the intended 50°F for the 6 hour period (Table 1) and the control had been run at 60°F.

Experiment Three: A 5 hour low PSNT. A higher day temperature of 79°F following disbudding was studied since results from experiment two indicated slower bud development with day temperatures of 68°F.

In general, PSNT plants were taller while flower diameter was comparable to CNT plants (Table 4). PSNT plants weighed less, were more succulent and flowered 0.8 to 3.3 days later than CNT plants. Even with the flowering delays reported, all plants under both PSNT and CNT flowered 100% at least one day prior to the scheduled flowering dates according to the Yoder Mum Catalog.

Raising the ventilation setpoint to 79°F following disbudding had a positive effect on flower bud development. This reinforces the recommendations of this university (Koths and Schneider, 1984) for not venting most crops (with CO_2 enrichment) until solar radiation has increased the temperature to 80°F.

Theoretically, 65 heating degree hours could have been saved if the intended 50°F night time low had been reached for the 5 hour period under PSNT (Table 1). Actually, the heating requirement was reduced 40 degree hours per night (Table 2) since the house did not cool to 50°F on many occasions.

Discussion

The small differences between PSNT and SNT plants indicate that, horticulturally, plant appearance and/or salability were unaffected by the programmed split night temperature program.

The delays of flowering in these experiments are of little importance in a production situation since flowering coincided with the projected schedule. However, the flowering delays associated with split-night temperatures

(SNT) may be eliminated by adjusting the beginning of the long night period, in a process known as long night advance (LNA) [(Watson (1982) and Koths, Schneider and Watson (1984)].

The main advantage of PSNT is to reduce heating costs. It was calculated that if the percentage saved on heating costs is correlated with the number of degree hours saved (Table 4), an energy savings of approximately 2% is realized for every 10 degree hours per day saved using a PSNT program.

Conclusion

As a result of this study, it would be recommended for a PSNT model for pot chrysanthemum production that: 1) begin the PSNT in conjunction with the start of long nights*; 2) the temperature fluctuation suggested is a programmed decline of 15°F from the day heating setpoint of 65°F at a rate of approximately 2°F per hour. This reduction should begin at 1600 hours. A low temperature of 50°F should be reached about midnight and maintained for 5 to 6 hours. The temperature should then be increased at a uniform hourly rate so a heating setpoint of 65°F is reached at 0800 hours; 3) a ventilation setpoint of 80°F should be maintained for the duration of the crop.

The above PSNT program represents a theoretical savings of between 65 and 78 heating degree hours each night compared to a CNT of 60°F; a 13 to 16% saving in heat with no sacrifice in quality or production.

* A long night advance (LNA) of 1 - 4 days may be considered in conjunction with the PSNT. The shorter LNA may be desirable in early fall and spring crops while the longer advance may be necessary for mid-winter crops.

References

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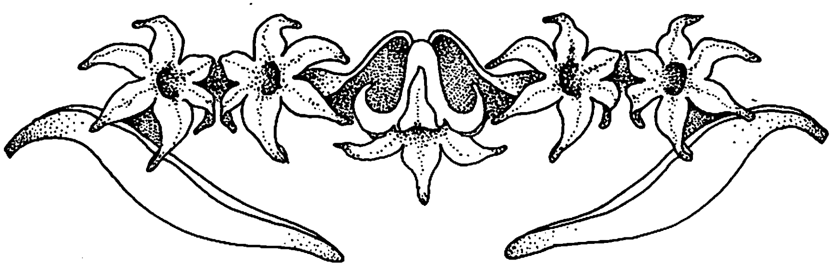

Table 1. The effect of various night time temperature programs on theoretical hourly temperature levels and the resulting heating degree hours saved when compared to the CNT program.

Night Programs	Hourly Night Time Avg. Temp. / °F																	Deg. Hrs > 60°F	Deg. Hrs < 60°F	Deg. Hrs saved over CNT
	16	17	18	19	20	21	22	23	0	1	2	3	4	5	6	7	8			
CNT (control)	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	65	--	--	--
PSNT,4 hr. low	65	65	64	62	60	58	56	54	52	50	50	50	50	54	58	62	65	68	18	50
PSNT,5 hr. low	65	64	62	60	58	56	54	52	50	50	50	50	50	54	58	62	65	78	13	65
PSNT,6 hr. low	64	62	60	58	56	54	52	50	50	50	50	50	50	54	58	62	65	86	8	78
6 hr. SNT	60	60	60	60	60	60	60	50	50	50	50	50	50	60	60	60	65	60	--	60

Table 2. The effect of various night time temperature programs on actual hourly temperature levels and the resulting heating degree hours saved when compared to the CNT program.

Night Programs	Hourly Night Time Avg. Temp. / °F																	Deg. Hrs below CNT	Deg. Hrs above CNT	Deg. Hrs saved over CNT
	16	17	18	19	20	21	22	23	0	1	2	3	4	5	6	7	8			
CNT (control)	63	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	65	--	--	--
PSNT,4 hr. low	66	64	62	61	59	58	56	55	53	53	53	53	55	59	62	64	66	56	12	44
CNT (control)	63	61	60	60	60	61	61	60	60	60	60	60	61	60	60	60	63	--	--	--
PSNT,5 hr. low	66	65	63	62	60	58	57	55	53	52	51	51	53	56	59	62	66	58	18	40
CNT (control)	66	63	62	62	62	62	62	62	62	62	62	62	62	62	62	63	66	--	--	--
PSNT,6 hr. low	66	65	63	60	58	56	54	53	53	52	52	52	52	53	57	60	64	97	3	94
CNT (control)	63	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	65	--	--	--
6 hr. SNT	63	60	60	60	60	60	60	57	53	53	53	52	52	57	60	60	65*	43	--	43

* estimated actual temperatures under this regime

Table 3. The effect of split night temperatures (PSNT) and constant night temperature (CNT) on various aspects of plant growth using four cultivars of Chrysanthemum morifolium.

	Golden Yel. Prin. Anne			Charm			Windsong			Yellow Puritan		
	PSNT	CNT	t-value	PSNT	CNT	t-value	PSNT	CNT	t-value	PSNT	CNT	t-value
Plant Ht. (cm)	28.6	26.8	4.72	23.1	22.4	NS	23.1	23.1	NS	23.7	24.1	NS
Flower Dia. (cm)	12.2	12.0	NS	10.9	10.3	NS	11.6	11.5	NS	9.1	8.7	5.57
No. of Flowers	4.8	4.7	NS	7.7	7.9	NS	7.0	7.1	NS	6.8	6.9	NS
Days to Flower	67.3	65.4	7.50	56.0	55.6	NS	60.0	59.0	4.59	64.6	62.1	11.34
Fresh wt. (gm)	109.5	106.8	NS	87.1	90.9	NS	103.1	101.6	NS	72.6	82.4	-3.44
Dry wt. (gm)	11.7	11.4	NS	9.7	9.9	NS	10.5	10.3	NS	8.4	9.5	-2.78
% of Dry Matter	10.7	10.6	NS	11.2	10.9	NS	10.3	10.1	NS	11.6	11.5	NS

Treatment differences determined using the t-test at a 95% level of confidence

Table 4. The effect of split night temperatures (PSNT) and constant night temperature (CNT) on various aspects of plant growth using four cultivars of Chrysanthemum morifolium.

	Golden Yel. Prin. Anne			Charm			Windsong			Yellow Favor		
	PSNT	CNT	t-value	PSNT	CNT	t-value	PSNT	CNT	t-value	PSNT	CNT	t-value
Plant Ht. (cm)	28.7	27.4	3.29	20.3	20.5	NS	20.5	21.8	-3.37	22.8	21.9	2.95
Flower Dia. (cm)	13.3	13.0	3.80	11.1	11.2	NS	10.9	10.9	NS	10.1	10.1	NS
No. of Flowers	4.1	4.3	NS	7.5	7.6	NS	6.2	6.4	NS	6.5	6.7	NS
Days to Flower	65.9	62.6	10.75	55.1	53.0	48.68	59.7	58.9	3.33	58.6	57.4	4.23
Fresh wt. (gm)	92.9	102.7	-4.57	63.7	75.7	-7.77	96.9	105.0	-3.72	80.2	85.0	-2.66
Dry wt. (gm)	11.1	12.6	-4.11	7.5	9.3	-8.43	10.8	13.6	-7.26	9.9	11.3	-4.41
% of Dry Matter	11.9	12.3	NS	11.7	12.2	-5.03	11.1	12.9	-9.49	12.3	13.3	-5.86

Treatment differences determined using the t-test at a 95% level of confidence