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Influence of Reduced Night Temperatures on Growth and Flowering of 'May Shoesmith' Chrysanthemums[1]

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Abstract. **Plants of 'May Shoesmith' chrysanthemum (*Chrysanthemum morifolium* Ramat.) were grown in controlled environment chambers at optimal (16°C) and sup-optimal night temperatures. Reduced night temperatures were imposed for all or part of the night cycle. Number of days to flowering was delayed as night temperature decreased from 16° or as duration of reduced temperature during each diurnal cycle was increased. Compared to plants grown at a continuous 16° night temperature, plants grown at 10° for 9 or 10½ hours each night (with the remaining hours at 16°) had greater stem diameter, were taller and had flowers with greater diameter and fresh weight. Number of nodes was not affected.**

Recommended temperature for glasshouse production of floricultural crops usually refers to the minimum night temperature at which plants should be grown. Production schedules for chrysanthemums are based on a night temperature of 16°C (6). Night temperatures in excess of 21° have been reported to increase pedicel length and delay flowering (3). Conversely, lower night temperatures have been found to either prevent flower bud formation or delay flowering (8, 9), decrease leaf number and promote basal rosetting (10), reduce internode length (12), and increase flower diameter (13).

Concern over the economics of fossil fuels used for greenhouse heating has stimulated research on the use of lower night temperatures. In the production of petunias it was reported (1) that growing plants at 10°C resulted in about a 2-week delay in flowering when compared to 14°. However, plants grown at the cooler temperature had more axillary branches and more intense flower color. Field-planted tomatoes had higher yield and decreased cropping interval when seedlings had been grown at cool as compared to warm night temperatures (5).

Utilization of reduced temperatures during a portion, as compared to all, of the night cycle could conceivably alleviate the problem of delayed flowering. Thorne and Jaynes (11) grew chrysanthemums in a conventional glasshouse at reduced night temperatures (24°C from 0600-1700 hr, 16° from 1700-2300 hr, 7° from 2300-0600 hr) and found no difference in stage of floral development compared to plants grown at a continuous 16° night temperature. In their study, however, they utilized established plants which were obtained from commercial growers and floral initiation and partial development already may have taken place prior to exposing plants to reduced night temperatures.

The following studies were conducted to determine the effect of reduced night temperatures, imposed from time of planting, on growth and flowering of 'May Showsmith' chrysanthemums.

Materials and Methods

To maintain precise control of the environment, studies were conducted in the Phytotron (4) at N. C. State University.

Rooted chrysanthemum cuttings were grown one to an 11.5 cm standard plastic pot in a medium consisting by volume of 2 parts number 16 mesh gravel:1 part RediEarth (Tradename for peatlite mix manufactured by W. R. Grace Co., Atlanta, Georgia). Plants were watered with deionized water and placed in a controlled environment glasshouse at day/night temperatures of 26/22°C. Photoperiod consisted of natural daylengths with a 3 hr (2300-0200 hr) night interruption from incandescent filament lamps. While in the glasshouse, plants were misted 4 times daily with deionized water and, for the duration of each study, were irrigated twice daily with Phytotron nutrient solution (4). Four days after potting, plants were transferred to growth chambers.

In the growth chambers, photoperiods consisted of 9 hr (0800-1700 hr) of high intensity light from cool white fluorescent and incandescent lamps which provided a photon flux density of 450-492 $\mu E\ m^{-2}\ s^{-1}$ between 400-700 nm at plant level, equivalent to 300-320 hlx. For the first 2 weeks, plants were kept under physiologically long days by interrupting the dark period (2300-0200 hr) with 9.6 Wm^{-2} of photomorphogenic radiation (700-850 nm) from incandescent filament lamps. Two weeks after being placed in chambers, the night light interruption was discontinued and plants were subsequently subjected only to 9 hr of high intensity light. Plants were grown single stem with lateral shoots and buds removed manually.

Experiment I, initiated July 1977, was conducted as a preliminary test to determine the feasibility of utilizing precisely controlled reduced night temperatures, imposed in a split fashion. Plants were grown at 5 different day/night temperatures (Table 1). Treatment 1 approximated a temperature regime utilized in glasshouse production while treatment 2 was identical to that used by Thorne and Jaynes (11). Thirty-four plants were assigned to each temperature treatment.

Experiment II was initiated October 1977. Temperatures in the chambers were maintained at 24°/16°C (0800-1700/1700-0800 hr), 24°/16°/10°, 24°/16°/5° or 18°/14°/10° (0800-1700/1700-1230/1230-0800 hr). Twenty-four plants were placed in each chamber. At the commencement of short days, 6 plants from each chamber were transferred to each of the other chambers and 6 plants remained in the chamber in which they had been growing (Table 2).

Experiment III was initiated February 1978. Plants in all chambers were grown at 24°C for 9 hr, 16° for 4½, 6, 9 or 15 hr during the night with the remaining portion of each 24 hr period at 10° (Table 3).

Results and Discussion

Experiment I. Sixty-nine days from initiation of short days plants grown at 24°/16°C were in flower and plants in all chambers were harvested. Plants in all other treatments had

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Table 1. Temperatures at which 'May Shoesmith' chrysanthemums were grown in preliminary test (Experiment I).

Treatment	Temperature (°C)	Time (hr)
1	24	0800-1700
	16	1700-0800
2	24	0600-1700
	16	1700-2300
	7	2300-0600
3	24	0900-1600
	16	1600-2000
	7	2000-0700
	16	0700-0900
4	24	0800-1700
	7	1700-0800
5	18	0900-1700
	13	1700-0100
	7	0100-0900

developed flower buds but were at various stages of floral development. It was estimated that compared to plants in treatment 1 flower development on plants in treatments 2, 3, 4, and 5 were delayed by 2, 4, 5, and 5 weeks, respectively. This would indicate that in the study conducted by Thorne and Jaynes (11) either the plants had initiated flower buds prior to being subjected to the 7° night temperature regime or glasshouse temperature was not controlled accurately at 7°. A third alternative could be that there is a great deal of variation between cultivars in response to thermoperiod. Temperature at which plants were grown had no adverse effect on the number of nodes produced (33 nodes/plant).

Experiment II. At each temperature all plants were harvested when at least 75% of the population was at a commercially marketable stage. Plants in treatments 1-4, 5-8, 9-12 and 13-16 were flowering 62, 67, 84 and 78 days, respectively, after initiation of short days. Parups (7) reported that cooler than normal temperatures result in premature budding of some chrysanthemum cultivars which could account for plants in

Table 2. Influence of temperature during long (A) and short (B) days on growth and flowering of 'May Shoesmith' chrysanthemums grown in Experiment II.

Treatment	Temp (°C) (A)	Temp (°C) (B)	Bud diameter[z] (mm)	Plant height[y] (cm)	Flower diameter[y] (cm)	Fresh weight[y] (g)
1	24/16	24/16	18.0 a[x]	62.8 bc	14.5 abcd	184.4 a
2	24/16/10		18.3 a	63.3 bc	14.7 abcd	187.8 a
3	24/16/5		17.1 ab	60.3 cde	15.0 abc	174.6 abc
4	18/14/10		16.1 bc	57.4 ef	14.4 bcd	162.6 cd
5	24/16	24/16/10	14.6 de	63.0 bc	15.2 a	178.2 abc
6	24/16/10		14.6 de	57.4 ef	15.0 abc	175.0 abc
7	24/16/5		14.8 cd	57.2 ef	14.7 abcd	161.8 cd
8	18/14/10		14.6 de	55.3 f	14.4 bcd	154.0 de
9	24/16	24/16/5	12.6 fgh	68.2 a	15.2 a	189.2 a
10	24/16/10		13.3 efg	61.5 bcd	15.0 abc	189.9 a
11	24/16/5		13.6 def	63.3 bc	15.1 ab	180.7 ab
12	18/14/10		12.1 gh	58.5 def	14.3 cd	164.0 bcd
13	24/16	18/14/10	12.3 fgh	64.5 b	14.7 abcd	162.0 cd
14	24/16/10		13.0 fgh	60.6 cde	14.6 abcd	148.4 de
15	24/16/5		13.0 fgh	58.6 def	14.7 abcd	151.9 de
16	18/14/10		11.6 h	57.4 ef	14.1 d	144.8 e

[z]Flower bud diameter determined 5 weeks after start of short days.

[y]Determined at harvest.

[x]Mean separation within columns by Waller-Duncan K ratio.

Table 3. Vegetative and floral characteristics of 'May Shoesmith' chrysanthemums grown in Experiment III.

Treatment	Temperature (°C)	Time (hr)	Plant height (cm)	Plant fresh wt (g)	Leaf area (cm^2)	Stem diameter[z] (mm)	Flower diameter[z] (cm)	Flower height (cm)	Flower fresh weight (g)
1	24	0800-1700	60.2 c[y]	117.4 c	1104.8 b	7.6 c	13.6 b	8.3 a	51.5 c
	16	1700-0800							
2	24	0800-1700	65.9 b	120.4 c	1213.3 a	7.9 b	13.8 b	7.8 b	47.5 d
	16	1700-2000							
	10	0200-0800							
3	24	0800-1700	65.5 b	139.5 b	1204.8 a	8.1 ab	14.3 a	8.3 a	60.9 b
	16	1700-2300							
	10	2300-0800							
4	24	0800-1700	69.2 a	144.1 a	1179.4 a	8.3 a	14.4 a	8.4 a	64.5 a
	16	1700-2130							
	10	2130-0800							

[z]Measured 5 cm below calyx.

[y]Mean separation within columns by Waller-Duncan K ratio t-test, 5% level.

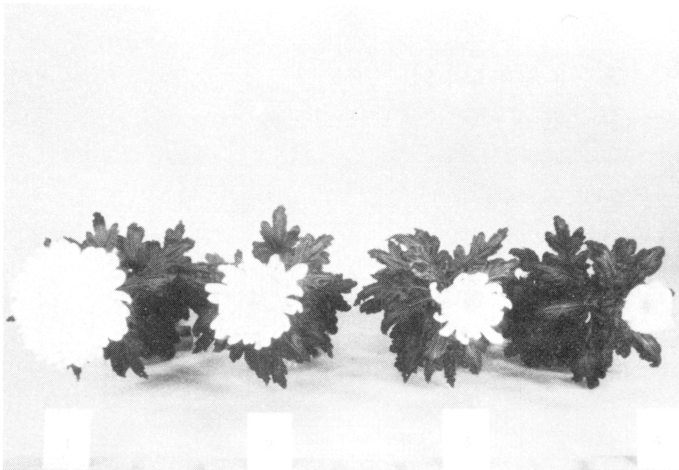

Fig. 1. Relative stages of floral development of plants in Experiment III 64 days after initiation of inductive photoperiods. Treatments are listed in Table 3.

treatments 13-16 flowering sooner than plants in treatments 9-12.

Diameters of floral buds on plants in all treatments were measured 35 days after initiation of inductive photoperiods (Table 2). Flower buds with the greatest diameter were on plants subjected to short days at 24°/16°C, irrespective of the temperature at which they were grown during the non-inductive phase (Table 2). Plants in treatments 5-8 had flower buds of a similar diameter, but they were smaller than those produced in treatments 1-4. At any given temperature during the inductive phase, plants which had been subjected to 18°/14°/10° during the non-inductive phase produced flower buds with the smallest diameter.

Final flower diameter was similar for treatments 1-3, 5-7, 9-11 and 13-16. Since flower diameter was not adversely affected on plants originally given long days at 24°/16°/10°C or 24°/16°/5°, temperature during inductive rather than during non-inductive photoperiods is more crucial.

At harvest, plants in treatments 4, 8, 12 and 16 had less fresh weight than plants from others exposed to any given temperature during short days (Table 2).

Experiment III. Plants were harvested, based on the same criteria utilized for Experiment II. Sixty-four days after initiation of inductive photoperiods a representative plant from each of the treatments was photographed (Fig. 1). Plants in treatments 1, 2, 3 and 4 were harvested 64, 68, 75 and 75 days, respectively, after initiation of inductive photoperiods.

At harvest, plants exposed to 10°C for 10.5 hr each night (treatment 4, 2130-0800) were taller and had greater fresh weight, leaf area and stem diameter than plants maintained at 24/16° (Table 3). Number of nodes (37/plant) was unaffected by temperature.

Flower diameter was greatest when plants were exposed to 10°C for 9 or 10.5 hr each night and was smallest when plants were grown at 10° for 0 or 6 hr (Table 3). Fresh weight of flowers was also greater in treatments 3 and 4 than in treatments 1 or 2. Byrne et al. (2) reported that at a day temperature of 21°, 'Cara Mia' roses had more petals when grown at 4°C, compared to a conventional 16° night temperature. Increase in diameter and fresh weight of the flowers of 'May Shoesmith' chrysanthemums, grown in treatments 3 and 4, may have been the results of a similar phenomenon.

Conclusions

'May Shoesmith' chrysanthemums can be grown and flowered at night temperatures lower than 16°C. Whether a single reduced night temperature was utilized or the night cycle was partitioned into several temperatures, flowering was delayed compared to plants grown at 24°/16°. Length of time that flowering was delayed was influenced by the night temperature and by its duration. However, flowers produced at reduced night temperatures were larger and heavier.

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