Temperature Regime at Various Stages of Production Influences Growth and Flowering of *Dendranthema × grandiflorum*

H.F. Wilkins¹, W.E. Healy², and K.L. Grueber³

Department of Horticultural Science and Landscape Architecture, University of Minnesota, St. Paul, MN 55108

Abstract. For chrysanthemum (*Dendranthema × grandiflorum* (Ramat.) Kitamura), the hypothesis that a 12-hr 5C or 13C dark treatment could be used in conjunction with a 12-hr 27, 21, 17, or 13C light treatment for rapid flowering when applied during certain developmental stages was valid. Flowering of ‘Bright Golden Anne’, planted on 23 Sept., was not delayed by 12-hr light/12-hr dark growth chamber treatments of 21/5C or 27/13C (day/night) if treated from planting (P) of the rooted cutting to the start of short days (SD), 3 weeks after start of SD to visible bud (VB) (SD + 3 to VB), or from VB to flower (F) when compared to the glasshouse control plants grown at 21/18C. Plants responded similarly if grown at 13/13C or 21/21C, but flowering was delayed compared to the 17/17C glass house control. Delays were absent, however, when 13/13C was used from P to SD, SD + 3 to VB, or when 17/13 or 21/13C was used from VB to F.

Chrysanthemum floral initiation and development is influenced by temperature (Cockshull, 1979; Tawagen and Hassan, 1974). Cultivars that initiate and develop flowers in 6 to 7 weeks after short days (SD) appear to be more temperature-sensitive, whereas cultivars that require 13 to 15 weeks to flower after SD are less sensitive to temperature but more sensitive to photoperiod (Cockshull, 1979; Langhans, 1964).

Inappropriate temperatures during SD can delay flower initiation and/or development (Doorenbos and Kofranek, 1953; Furuta and Nelson, 1953). Post (1939) found that when plants were under high irradiance and high temperature (27C), floral initiation and development were hastened and flower bud numbers increased, as compared to 10C at night. Several researchers have reported an increase in flower bud numbers at low night temperature (Kohl and Mor, 1981; Parups, 1978; Vince, 1960). DeJong (1978) reported that the optimum developmental temperatures were between 17 and 21C. Bonamino and Larson (1978, 1980) found that the optimal temperature for rapid initiation and development was a 24C light/16C dark (9 hr/15 hr) sequence, and any change in the light or dark temperature increased the time for flower development. Cathey (1954a) and Vince (1960) both recommended 16C at night for initiation and development to the visible bud (VB) stage, then 10 to 13C to anthesis (Vince and Mason, 1959).

Recently there has been interest in reducing night temperatures to reduce fuel costs in commercial glasshouses (Cathey, 1954b; Parups, 1978; Parups and Butler, 1982). Samman and Langhans (1960) found that 4.5C during the dark period delayed floral initiation. Vince (1960) found that most chrysanthemum cultivars failed to flower when held at 4.5C from floral initiation to VB and that 4.5 or 10C treatments delayed flowering up to 100 days. Furthermore, flower initiation and development to VB were delayed by 10C at night when applied during low irradiance. After VB, neither 10 nor 15C dark temperature had a significant effect on the rate of floral development.

Cathey (1954b) stated that dark temperatures were 3.3 times more effective in hastening flowering than temperatures during the light period, and the averaging of night and day temperatures was not correlated with days to anthesis. Cockshull et al. (1981) recalculated Cathey’s (1954b) results as “number of temperature treatment hours” and concluded that average (light/dark) temperatures were important for flower development and, therefore, flowering was not specifically influenced by night temperature. Cockshull (1979) further reported that flower development was hastened by 16 days when the plants were held at 20C rather than 10C (Langhans, 1964).

Kohl and Thigpen (1979) grew plants from the beginning of SD to flower (F) in an 8-hr 15.6C light period with a 16-hr dark period at 15.6 or 5.6C. The 15.6C light/5.6C dark regime delayed flowering by 25 days, compared to continuous 15.6C. However, if the first 3 weeks of SD were lowered to 5.6C and the plants were then returned to 15.6C, flowering was delayed by 6 days. When dark temperatures were held at 15.6C for the first 3 weeks of SD, then lowered to 5.6C, flowering was delayed by 16 days.

Samman and Langhans (1960) reported that a 21C light period and 16C or lower dark period, when SD first commenced or during early floral initiation, increased the number of leaves initiated. At the beginning of SD, Vince (1960) also reported leaf initiation to increase with 10C vs. 16C dark temperatures. Bonamino and Larson (1980) reported that node numbers on plants in a 24C/9-hr light treatment followed by 16C/4.5-hr light and 10C/10.5-hr dark treatments were similar to the controls held at 16C.

Abbreviations: P to F, planting to flower; P to SD, planting to beginning of short days; P to SD + 3, planting to end of 3 weeks of short days; P to VB, planting to visible bud; SD to F, beginning of short days to flower; SD to SD + 3, first 3 weeks of short days; SD to VB, beginning of short days to visible bud; SD + 3 to VB, 3 weeks after start of short days to visible bud; VB to F, visible bud to flower.

Received for publication 12 Feb. 1987. Contribution no. 16,330 Agriculture Experiment Station, Univ. of Minnesota, St. Paul, MN 55108. Research made possible in part from a Fred C. Gloeckner Foundation grant and plant material from Yoder Brothers, Inc., Barberton, Ohio. We thank Brenda Wickenhauser for her aid on conducting this research. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisements solely to indicate this fact.

¹Professor.
²Former Research Assistant. Presently: Assistant Professor, Univ. of Maryland, College Park, MD 20742.
³Presently: Assistant Professor, Virginia Polytechnic Inst. & State Univ., Blacksburg, VA 24061.
Our research was designed to test the hypothesis that specific low night temperature plus high day temperature could compensate for the previously reported delay in flowering due to low night temperatures. Further, the optimum daily temperature combination would vary depending on the specific stage of plant development.

**Materials and Methods**

'Bright Golden Anne' rooted chrysanthemum cuttings from Florida were harvested from stock plants, rooted, and shipped to the Univ. of Minnesota, St. Paul. Experiment 1 commenced on 25 Sept., after the autumnal equinox, during a period of rapidly decreasing fluence. Experiment 2 commenced on 21 June, the longest day of the year with high fluence. Experiment 3 started 7 Jan., shortly after the shortest day of the year with increasing fluence. Cuttings were grown as one cutting per 1-liter plastic pot. A 2 soil : 1 peat : 1 perlite (by volume) medium was used.

After potting, plants were grown under long days using a 4-hr (2200 to 0200 hr) incandescent night interruption (9 to 12 µmol·s⁻¹·m⁻²) until the start of the SD treatment. The SD treatment in the glasshouse occurred from 0800 to 1600 hr, when a black cloth was used to reduce the photoperiod. In the growth chambers, the light period was 12 hr and coincided with the changing thermoperiods. The longer light period in the growth chamber was used to compensate for the lower fluence in the growth chamber than in the glasshouse.

From mid-April through mid-September, the fluence within the glasshouse was reduced by 50% with white shading compound applied to the glass. The photosynthetic photon flux in the growth chamber was 440 µmol·s⁻¹·m⁻² at plant height. Plants were fertilized as needed based on weekly soil tests. No growth retardants were used.

In Expts. 1 and 2, the glasshouse was maintained at minima of 18C night and 21C day and served as the control. The switch from day to night set points occurred at 0600 and 1800 hr, respectively. In Expt. 3, the temperature was maintained at a constant 17C. The glasshouse was equipped with fan and evaporative pad cooling that was staged at 5C increments and that maintained the glasshouse below 35C. To achieve the combination of temperature treatments used in the growth chambers (Table 1), plants were rotated between chambers at 0800 and 2000 hr. Temperatures within the chambers were maintained within 1C of the set points.

In Expts. 1 and 2, regimes of 21/5C or 27/5C were selected that resulted in an average of 13 or 16C (Table 1). Experiment 3 imposed temperature regime combinations of 21, 17, or 13C that led to averages of 21, 19, 17, 15, or 13C.

The temperature treatments were applied during specific stages of plant development (Table 1). Plants were grown in the glasshouse when not under treatment. In the glasshouse, plants were maintained in two blocks with five plants in each block. All plants were randomly assigned to a location in the growth chamber. The type of data collected for the three experiments are presented in Table 2.

The data from each experiment were analyzed independently using Statistical Package for the Social Science multivariate analysis of variance. The temperature and stage of development main effects were analyzed as separate factors and then com-

---

Table 1. Growth chamber temperature regimes (12-hr photoperiod and thermoperiod) used in Expts. 1, 2, or 3 (started 25 Sept., 21 June, or 7 Jan., respectively) during various developmental stages of chrysanthemum growth. Plants were grown in a glasshouse when not under treatment.

| Temp (°C) | Day/night | Average | Expts. 1 and 2 | Expt. 3 |
|----------|-----------|---------|----------------|---------|
| 21/5     | 13        | x       |                 |         |
| 27/5     | 16        | x       |                 |         |
| 21/21    | 21        | x       |                 |         |
| 21/17    | 19        | x       |                 |         |
| 21/13    | 17        | x       |                 |         |
| 17/13    | 15        | x       |                 |         |
| 13/13    | 13        | x       |                 |         |

Table 2. Data collected from chrysanthemum plants in all the experiments noted in Table 1.

| Term used               | Definition                                      |
|-------------------------|-------------------------------------------------|
| Vegetative node no.     | The number of nodes without reproductive laterals. |
| Reproductive node no.   | The number of nodes with reproductive laterals.  |
| Total nodes             | The number of vegetative and reproductive nodes. |
| Total flower no.        | The sum of reproductive nodes + secondary flowers on the primary pedicels. |
| Days to flower          | The number of days from planting of the cuttings to the time the outer ring of petals reflexed to the horizontal. |
| Days to visible bud     | The number of days from planting the cutting to buds visible. |
| Days from visible bud to flower | The number of days from buds visible to the time the outer ring of petals reflexed to the horizontal. |

Table 3. Days to visible bud and flower of ‘Bright Golden Anne’ chrysanthemum plants when grown in 12-hr light/dark thermoperiods during specific treatment periods. Experiment 1 commenced 25 Sept., while Expt. 2 commenced 21 June.

| Treatment period | Days to flowering | Days to visible bud |
|------------------|-------------------|---------------------|
|                  | 21/5C             | 27/5C              | 21/5C             | 27/5C              |
| P to SD          | 75.8              | 77.4               | 42.0              | 43.8               |
| P to VB          | 103.8             | ...                | 70.0              | ...                |
| P to F           | 97.0              | ...                | 70.2              | ...                |
| SD to VB         | 96.4              | 97.0               | 47.2              | 72.2               |
| SD to F          | 94.4              | 102.4              | 48.2              | 79.6               |
| VB to F          | 76.4              | 67.8               | 42.0              | 41.2               |
| P to SD + 3      | 110.0             | 97.0               | 64.2              | 63.0               |
| SD to SD + 3     | 85.0              | 89.4               | 45.0              | 53.4               |
| SD + 3 to VB     | 76.4              | 73.6               | 42.0              | 43.0               |
| Glasshouse control| 66.8              | 41.2               |                   |                   |
| HSD (P = 0.05)   | 17.2              | 26.6               |                   |                   |

* Dashes indicate plants failed to flower.
pared to the glasshouse control. The specific temperatures and stages of development effects were separated using Tukey’s HSD at \( P = 0.05 \).

**Results**

**Experiment 1**

**Days to visible bud and flower.** All plants grown at 21/5C flowered, while plants grown at 27/5C from P to VB and P to F did not flower (Table 3). The days to VB were delayed by the 21/5C combination from P to VB and from P to F, while 27/5C delayed the days to VB, compared to the glasshouse control, when applied from SD to VB or SD to F.

Days to flower were delayed by both the 21/5C and 27/5C light/dark treatments (Table 3). There were no differences in days to flower between 21/5C or 27/5C treatments from P to SD, VB to F, or SD + 3 to VB. Based on these data, the critical developmental treatment period for increased sensitivity to high light and low dark temperatures would be from the beginning of SD to SD + 3. Before or after this time period, a 12-hr 5C dark temperature could be used without a significant delay in days to flower.

**Flowers.** The total number of flowers produced was not affected by the 21/5C combination during any treatment period (Table 4). Compared to the control, fewer flowers were formed when plants were treated at 27/5C during P to SD, SD to VB, or SD to F. Plants treated at 27/5C from VB to F or SD + 3 to VB had more flowers than plants treated from P to SD, SD to VB, or SD to F.

**Number of vegetative nodes.** When plants failed to flower or flowering was delayed, the number of nodes increased as the mean of the temperature combinations increased (Table 4).

**Experiment 2**

**Days to flower.** The number of days to VB was increased, relative to the control, when the temperature combinations were given from P to SD + 3 (Table 3), but no delay in flowering was observed once plants had reached the VB stage. The days to flower were delayed by the 21/5C and 27/5C combinations (Table 3). Plants flowered at 27/5C when treatments were imposed from P to VB, P to F, SD to VB, or SD to F. The only treatment period that did not delay flowering was SD + 3 to VB. These results concur with those observed in Expt. 1.

**Flowers.** When 21/5C was used from P to SD + 3 or from SD to SD + 3, more flowers were produced than in the control. In Expt. 1, no such trends were observed (Table 4).

**Number of vegetative nodes.** When the number of nodes was increased by a specific temperature or during a treatment period, the days to flower also increased (Tables 3 and 4). We also observed that treatments that delayed flowering also increased the total number of flowers and increased the number of vegetative nodes (leaves).

**Experiment 3**

**Days to visible bud and flower.** When days to VB from date of planting were considered, only the 13/13C treatment from SD to SD + 3, P to F, or SD to VB delayed development to VB (Table 5). When the days from VB to F were calculated and compared to the 17/17C glasshouse control, plants were delayed by 21/21C from P to F.
Plants grown from P to F at 21/21C flowered faster than those held at 13/13C (Table 5). A constant 13/13C or 21/21C from P to F delayed flowering when compared to the glasshouse control or plants grown at the 21/17C, 21/13C, or 17/13C combinations. This response was also observed for plants in the SD to VB or plants grown at the 21/17C, 21/13C, or 17/13C combinations. Therefore, the combinations of thermoperiods during specific treatment periods. Experiment 3 commenced 7 Jan.

When plants were in the glasshouse and then shifted to 13/13C (Table 5). A constant 13/13C or 21/21C from P to F delayed flowering, while 21/21C did not (Table 5). Plants held at 21/17C, 21/13C, or 17/13C, combinations that were imposed during the various stages of growth, responded similarly to the 17/17C glasshouse control plants in the developmental characteristics measured. Therefore, the combinations of temperatures that resulted in a diurnal average between 15 and 19°C were not detrimental to plant development.

Number of nodes. The number of vegetative nodes was not affected by any of the treatments (Table 5). The ratio of vegetative to reproductive nodes shifted from ≈ 2:1 to 1:2 when the dark temperature was 13°C during treatment late in the development of the plants.

Seasonal response. Plants started in June were less tolerant of being held in growth chambers at 27/5°C and 21/5°C (Tables 3 and 4) than plants grown during the decreasing fluence period of the year. With a 25 Sept. starting date (Expt. 1), plants failed to flower. With a 21 June plant date (Expt. 2), treatment from P to VB, P to F, SD to VB, and SD to F failed to induce flowering under 21/5°C or 27/5°C. With the 25 Sept. planting date, only those plants treated in 27/5°C during the treatment periods from P to VB and P to F failed to flower.

Discussion

The hypothesis tested in the June and September plantings (Expts. 1 and 2) that a low temperature (5°C) during the 12-hr dark period could be compensated for by a 12-hr 21°C or 27°C light period was not valid from P to F or P to VB (Tables 3

---

**Table 5. Rate of development and developmental responses when ‘Bright Golden Anne’ chrysanthemum plants were grown at 13, 17, or 21°C combinations of 12-hr light/dark thermoperiods during specific treatment periods. Experiment 3 commenced 7 Jan.**

| Temp (°C) | Days to F | Days to VB | Days from V13 to F | Flowers (no.) | Nodes (no.) |
|----------|-----------|------------|-------------------|---------------|-------------|
|          |           |            |                   |               | Vegetative | Reproductive |
| P to SD  |           |            |                   |               |            |              |
| 21/21    | 78.2      | 41.6       | 36.6              | 9.4           | 13.0        | 8.4          |
| 21/17    | 76.0      | 41.6       | 34.4              | 7.6           | 14.4        | 7.0          |
| 21/13    | 76.8      | 41.2       | 35.6              | 10.6          | 12.4        | 8.8          |
| 17/13    | 78.4      | 42.2       | 36.2              | 10.8          | 15.0        | 7.8          |
| 13/13    | 76.8      | 41.8       | 35.0              | 10.5          | 11.0        | 9.8          |
| SD to SD + 3 | 78.6 | 41.8       | 36.8              | 12.6          | 14.6        | 7.0          |
| 21/21    | 76.4      | 41.6       | 34.8              | 10.6          | 11.6        | 9.2          |
| 21/17    | 76.5      | 41.7       | 34.8              | 11.5          | 9.2         | 11.5         |
| 17/13    | 75.8      | 42.4       | 33.4              | 10.0          | 11.7        | 9.8          |
| 13/13    | 83.8      | 48.0       | 35.8              | 13.0          | 12.2        | 8.5          |
| SD + 3 to VB | 77.6 | 41.2       | 36.4              | 10.0          | 13.0        | 8.6          |
| 21/21    | 76.8      | 41.2       | 35.6              | 14.2          | 11.0        | 11.4         |
| 21/17    | 74.8      | 41.6       | 33.2              | 12.6          | 9.0         | 12.0         |
| 21/13    | 75.6      | 42.0       | 33.6              | 12.2          | 10.6        | 9.8          |
| 17/13    | 75.4      | 43.6       | 31.8              | 17.4          | 6.8         | 14.4         |
| 13/13    | 83.8      | 54.6       | 29.2              | 13.4          | 11.2        | 10.4         |
| SD to VB | 80.8      | 41.8       | 39.0              | 14.8          | 14.0        | 8.6          |
| 21/21    | 77.4      | 41.6       | 35.8              | 10.8          | 12.0        | 9.4          |
| 21/17    | 73.0      | 41.8       | 31.2              | 13.2          | 7.2         | 13.2         |
| 21/13    | 74.0      | 42.4       | 31.6              | 12.8          | 8.2         | 12.8         |
| 17/13    | 74.8      | 43.6       | 31.8              | 17.4          | 6.8         | 14.4         |
| 13/13    | 81.4      | 54.8       | 29.2              | 13.4          | 11.2        | 10.4         |
| VB to F  | 81.8      | 41.4       | 40.4              | 5.4           | 11.4        | 9.4          |
| 21/21    | 75.8      | 40.8       | 35.0              | 13.2          | 7.8         | 12.0         |
| 21/17    | 74.2      | 42.0       | 32.2              | 14.0          | 5.8         | 14.0         |
| 21/13    | 74.6      | 43.0       | 31.6              | 13.0          | 7.2         | 13.0         |
| 17/13    | 90.8      | 53.8       | 37.0              | 18.0          | 7.4         | 11.6         |
| Glasshouse control | 76.8 | 41.4       | 35.4              | 13.2          | 10.4        | 11.0         |
| HSD (P = 0.05) | 3.4  | 3.7        | 4.0               | 5.8           | 5.0         | 5.2          |

J. Amer. Soc. Hort. Sci. 115(5):732-736. 1990.
and 4). Even though some plants held at 21/5°C flowered following the September planting date (Table 3), flowering was delayed significantly. Plants in 27/5°C during P to F or F to VB failed to flower (Table 3). Our results support Cathey’s (1954a, 1954b) work that temperatures below 10°C or above 27°C delays flowering, and our work further defines a specific stage of development when plants are most sensitive to low temperature. The data suggest that the sensitive period for exact temperature is from SD to SD + 3, since 17/17°C, 13/13°C, and 21/21°C during SD + 3 to VB did not affect flowering.

The hypothesis was valid when 21 or 27°C was used to compensate for the 5°C dark treatment, if the warmer temperatures were imposed before SD (P to SD) or after SD had commenced (SD + 3 weeks to VB or VB to F) (Table 3). De Jong (1978) reported that between 17 and 21°C was optimal for flower development. Furuta and Nelson (1953) found similar response to such average temperatures. Evidently, the first 3 weeks of the SD period, when floral induction, initiation, and development occur, is critical, and appropriate temperatures must then be used. Kohl and Thigpen (1979) reported similar trends. Certainly, 21/5°C or 27/5°C could be used commercially before SD and from VB to F.

The number of flowers produced during autumn was not impacted by temperature treatments (Table 4). Although flowering was delayed in summer-grown plants treated from SD to SD + 3 (Table 5), they consistently had more flowers than the glasshouse controls, particularly with the 27/5°C treatment.

From the data in Expts. 1 and 2, we concluded that an average of 21°C was the maximum at which Bright Golden Anne would consistently flower. Experiment 3 was based on this result. The hypothesis proved to be valid in that 21°C could be used continuously or in an equal thermoperiod combination with 13 or 17°C during the various stages of growth (Table 5).

Cockshull et al. (1981) concluded that the average temperature during the light/dark period was important during floral initiation and early development. Plants from stages P to F in 21/21°C flowered in 82 days, those at 13/13°C flowered in 91, both of which were delayed relative to the glasshouse control, which flowered in 77 days. *When plants were grown at 13°C in combination with 17 or 21°C during any of the growth phases tested, there was no delay. Blooming of plants in 13/13°C was not delayed when this combination was used from P to SD or SD + 3 to VB or when 17/13°C or 21/13°C was used from VB to F (Table 5). Considerable energy presumably could be saved if 13°C were used at appropriate growth stages.

In a comparison between Bright Golden Anne plants that were started 7 Jan., i.e., during increasing fluence (Expt. 3), and plants started 25 Sept., i.e., decreasing fluence (Expt. 1), or with summer-grown plants (Expt. 2), the latter were more sensitive to temperature treatments, as evidenced by an inhibition in flowering. However, plants that did initiate flowers reached anthesis more rapidly in Expt. 2 than in Expt. 1 or 3. Transition from a vegetative to reproductive meristem has been reported to be slower under lower radiance levels (Cockshull, 1979; Tawagen and Hassan, 1974). Therefore, during the summer (Expt. 2) and fall (Expt. 1), 21/5°C or 27/5°C should not be applied during SD + 3, whereas during late winter (Expt. 3), average temperatures between 15 and 19°C can be used with no delay in flowering.

**Literature Cited**

Bonaminio, V.P. and R.A. Larson. 1978. Influence of potting media, temperature, and concentration of ancymidol on growth of Chrysanthemum morifolium Ramat. J. Amer. Soc. Hort. Sci. 103:752-756.

Bonaminio, V.P. and R.A. Larson. 1980. Influence of reduced night temperatures on growth and flowering of ‘May Shoesmith’ chrysanthemums. J. Amer. Soc. Hort. Sci. 105:9-11.

Cathey, H.M. 1954a. Chrysanthemum temperature study. B. Thermal modifications of photoperiods previous to and after flower bud initiation. Proc. Amer. Soc. Hort. Sci. 64:483-498.

Cathey, H.M. 1954b. Chrysanthemum temperature study. C. The effect of night, day, and mean temperature upon the flowering of Chrysanthemum morifolium. Proc. Amer. Soc. Hort. Sci. 64:499-502.

Cockshull, K.E. 1979. Effects of irradiance and temperature on flowering of Chrysanthemum morifolium Ramat at continuous light. Ann. Bot. 44:451-460.

Cockshull, K.E., D.W. Hand, and F.A. Langton. 1981. The effect of day and night temperature on flower initiation and development in chrysanthemum. Acts Hort. 125:101-110.

Doorenbos, J., and A.M. Kofranek. 1953. Inflorescence initiation and development in an early and late chrysanthemum variety. Proc. Amer. Soc. Hort. Sci. 61:555-558.

Furuta, T. and K.S. Nelson. 1953. The effect of high night temperature on the development of chrysanthemum flowers. Proc. Amer. Soc. Hort. Sci. 61:548-550.

de Jong, J. 1978. Selection for wide temperature adaptation in Chrysanthemum morifolium (Ramat). Hems. Neth. J. Agr. Sci. 26:110-118.

Kohl, H. C., Jr., and Y. Mor. 1981. Producing pot chrysanthemums at low night temperature. J. Amer. Soc. Hort. Sci. 106:89-91.

Kohl, H. C., Jr., and S.P. Thigpen. 1979. Rate of dry weight gain of chrysanthemum as a function of leaf area index and night temperature. J. Amer. Soc. Hort. Sci. 104:300-303.

Langhans, R.W. 1964. Light and photoperiod, p. 73-85. In: R.W. Langhans (ed.). Chrysanthemums. A manual of the culture, diseases, insects and economics of chrysanthemums. New York State Ext. Serv. and New York State Flower Growers Assn., Ithaca.

Parups, E.V. 1978. Chrysanthemum growth at cool night temperature. J. Amer. Soc. Hort. Sci. 103:839-842.

Parups, E.V. and G. Butler. 1982. Comparative growth of chrysanthemums at different night temperatures. J. Amer. Soc. Hort. Sci. 107:600-604.

Post, K. 1939. The relationship of temperature to flower bud formation in chrysanthemums. Proc. Amer. Soc. Hort. Sci. 37:1003-1006.

Samman, Y. and R.W. Langhans. 1960. Interactions of temperature and photoperiodism in Chrysanthemum morifolium. Proc. 15th Intl. Hort. Congr. (1958) 2:400-411.

Tawagen, A.M. and H.A. Hassan. 1974. Effect of temperature, day-length and cytokin on chrysanthemum. Egyptian J. Hort. 1:57-65.

Vince, D. 1960. Low temperature effects on the flowering of Chrysanthemum morifolium Ramat. J. Hort. Sci. 35:161-175.

Vince, D. and D.T. Mason. 1959. Low temperature effects on internode extension in Chrysanthemum morifolium. J. Hort. Sci. 34:199-209.