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PHOTOPERIODIC LIGHTING OF MINIATURE CARNATIONS

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Abstract

Two cultivars of Dianthus caryophyllus L., 'Elegance' and 'Georgia Ann', were grown under 9 and 15 hour photoperiods, natural days, and combinations of these treatments. Plants given long and short day treatments were covered with black sateen shade cloth from 5:00 pm to 8:00 am. Long days were achieved by lighting with incandescent lamps from 5:00 pm to 11:00 pm. In comparison to plants grown under natural days, long days reduced the time to flowering by over three weeks for 'Georgia Ann'; and more than two weeks for 'Elegance'. Stem length was reduced by 5 cm in the long day treatment of 'Georgia Ann', but was unchanged in 'Elegance'. The number of flowers per stem was not significantly effected by long photoperiods in either cultivar. In comparison to natural days, plants grown in short days bloomed 22 days later for 'Georgia Ann' and 10 days later for 'Elegance'. Stem length was unchanged in both cultivars. The number of flowers per stem was increased for 'Elegance' and unchanged for 'Georgia Ann'. The number of nodes in both cultivars was increased by short days.

Standard carnations have long been an important greenhouse crop in Colorado. The idea of multiple flowered carnations was introduced to Colorado by Holley (1959). Multiple flowered stems can be obtained by a different method of bud removal or "disbudding" than is used for standard carnations. For a single, large flowered standard carnation, the lateral buds, subtending the terminal bud, are removed. If a multiple flowering stem or "spray" is desired, the terminal bud is removed. Carnation growers first disbudded for a multiple flowering form in order to produce more flowers per stem for corsages (8). Over the years, varieties of carnations have been selected to favor smaller flowers arranged on the stem in an attractive spray formation. A much improved spray carnation is now a commercially important crop.

Many cultural practices are used to improve the quality and yield of carnations. An important aspect of commercial production is timing. Highly specific periods of peak demand are imposed by holiday dates. Matching peaks of production (i.e. flowering) to demand cycles requires precise control of plant development. Control of photoperiod is one of the major ways that the timing of flowering can be regulated.

The objective of this experiment was to determine whether flowering of spray carnation cultivars 'Georgia Ann' and 'Elegance' can be advanced with supplementary lighting. The influence of supplementary illumination on the length of stems, number of nodes per stem and number of flowers per stem was of interest since such factors comprise stem quality.

Methods

Rooted cuttings of spray carnation cultivars 'Elegance' and 'Georgia Ann' were planted in 6 in. standard plastic pots on July 26, 1980. The growing medium was a 1:1:1 mixture by volume, of Fort Collins clay loam, peat, and perlite. The pots were placed on a gravel bench located along the north side of the east-west oriented greenhouse. When no ventilation was occurring, CO_2 was injected to an average of 500 ppm as determined by an infrared CO_2 analyzer. The greenhouse temperature was 65-70°F during the day and 52-55°F at night.

Pots were spaced within each treatment to produce a plant density of 4 plants ft^{-2}. Each pot was watered by hand as needed; fertilizer was automatically injected according to rates determined by Hanan (5). Each plant was pinched to four nodes on August 18, 1980; each stem was "disbudded" by removing the terminal bud as soon as it could be clearly recognized (usually when approximately 0.5 cm long).

A total of eight combinations of long day, natural day and short day photoperiod treatments were given as follows (Figure 1):

1. Long days from July 26 to the end of the experiment (LD).

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2. Short days from July 26 to September 12 and long days from September 12 to end of the experiment (SD-LD).
3. Natural days from July 26 to September 12. Long days from September 12 to September 22 and natural days from September 22 to the end of the experiment (1OLD).
4. Natural days from July 26 to September 12. Long days from September 12 to October 2 and natural days from October 2 to the end of the experiment (2OLD).
5. Natural days from July 26 to September 12. Long days from September 12 to October 12 and natural days from October 12 to the end of the experiment (3OLD).
6. Natural days throughout the experiment (ND).
7. Long days from July 26 to September 12 and natural days from September 12 to the end of the experiment (LD-ND).
8. Short days from planting to the end of the experiment (SD).

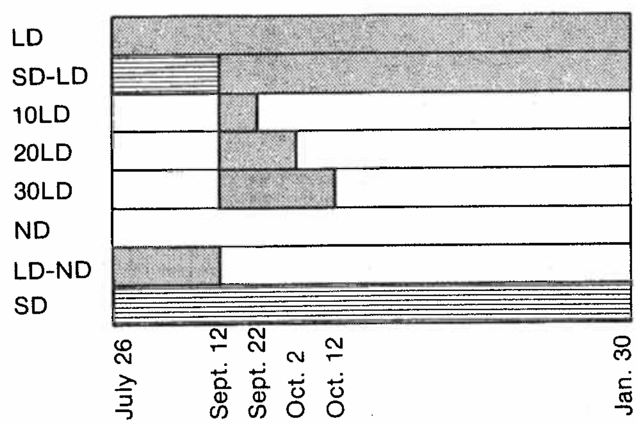

Figure 1. Photoperiod treatments.

The plants given long and short day treatments were covered with black sateen shade cloth from 5:00 pm to 8:00 am. Long days were achieved by lighting two 100 watt incandescent lamps beneath the black cloth, from 5:00 pm to 11:00 pm. These lamps were placed 4 ft. apart and 4 ft. above plant level. The light intensity was approximately 35 ft. cd. at plant level. Plants within the ND treatment were never covered with shade cloth. Daylight hours measured for the natural day plants are given in Figure 2.

Plants were moved between treatments on September 12 when the shoots had seven to nine fully expanded leaf pairs which previous workers have determined to be the photosensitive stage (9). Data were collected three times weekly; carnation stems were harvested when one flower was fully open. Recorded data included stem length from base to the tip of the tallest flower, number of nodes, and number of flowers and buds per stem, for the first four stems per plant to flower.

Results and Discussion

Days to Flowering

'Georgia Ann'

The mean number of days from planting to flowering was significantly different among plants grown under long, natural, and short days (Table 1). Plants in the LD, ND, and SD treatments flowered after 133, 156, and 178 days, respectively. Plants in the SD-LD treatment flowered later than plants in the LD treatment.

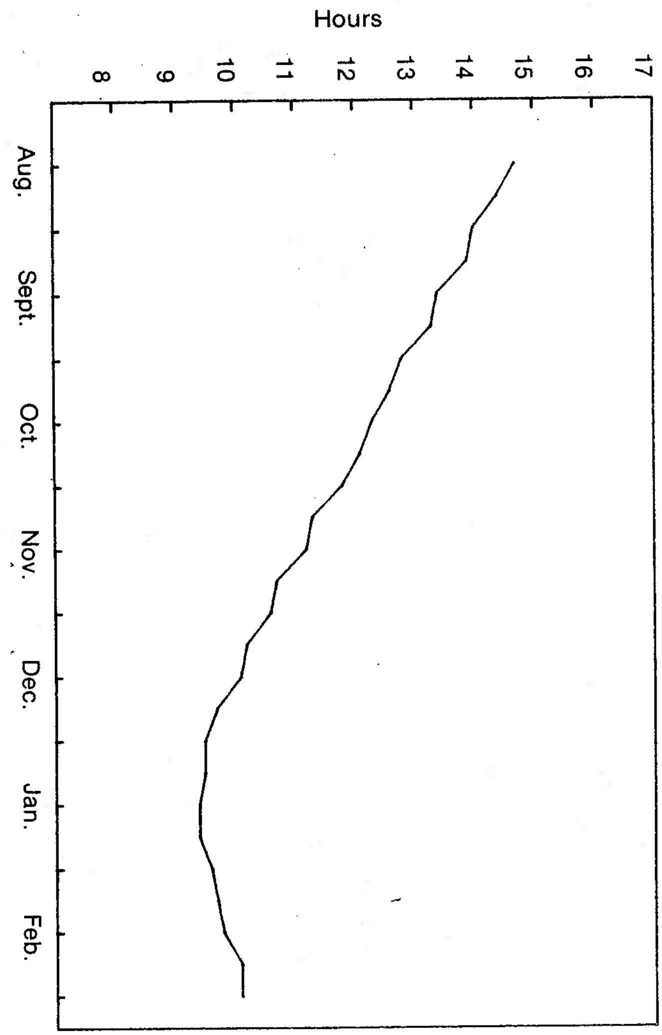

Figure 2. Daylength in Fort Collins, Colorado from July 26, 1980 through January 30, 1981.

The time to flowering of plants given 10 long days was not different from those given 20 or 30 long days, but plants receiving 20 long days bloomed significantly later than those in the 30LD treatment. However, plants in the 10LD, 20LD, and 30LD treatments showed no difference in time of flowering compared to plants grown under natural days. Therefore, in order to achieve an advance in the flowering of 'Georgia Ann' spray carnations, continuous long days were necessary.

'Elegance'

'Elegance' spray carnations exposed to long, natural, and short days flowered after 148, 167, and 177 days, respectively; treatment differences were statistically significant (Table 1). Plants in the SD-LD treatment flowered later than those in the LD treatment, but flower timing under the SD-LD treatment was not different from that under natural days. The 10LD and 20LD treatments were no earlier than the ND treatment, but plants in the 30LD treatment bloomed an average of 12 days earlier than those given only natural days. The effect of 30 long days was essentially the same as continuous long days. The plants which received 30 long days and those under continuous long days bloomed significantly earlier than plants in any of the other treatments. It is concluded from this that 30 days of supplemental illumination are sufficient to obtain the maximum advance bloom for 'Elegance' spray carnations.

Table 1. Days to flowering, stem length, nodes/stem and flowers/stem of two spray carnation cultivars given eight photopheriod treatments.

	Days to Flowering		Stem Length		Nodes/Stem		Flowers/Stem	
	Geo. Ann	Elegance	Geo. Ann	Elegance	Geo. Ann	Elegance	Geo. Ann	Elegance
LD	133 d	148 d	48 c	63 ab	7.2 c	8.0 b	5.1 ab	6.1 ab
SD-LD	159 b	159 bc	60 a	67 a	8.4 b	8.5 b	4.9 ab	6.1 ab
10LD	152 bc	163 bc	52 bc	61 b	8.0 bc	8.3 b	4.6 b	4.9 b
20LD	158 b	162 bc	56 ab	63 ab	8.1 b	7.9 b	5.0 ab	4.5 b
30LD	145 c	155 cd	53 b	63 ab	8.1 bc	8.0 b	5.9 a	5.6 ab
ND	156 bc	167 ab	53 b	64 ab	8.2 b	8.5 b	5.1 ab	4.4 b
LD-ND	154 bc	160 bc	51 bc	60 b	7.7 bc	8.0 b	5.0 ab	4.8 b
SD	178 a	177 a	57 ab	59 b	10.5 a	10.0 a	4.5 b	7.3 a
$HSD_{.05}$	10.98	10.65	5.19	5.77	.90	1.03	1.24	1.78

Stem Length

'Georgia Ann'

Stem length was also influenced by photoperiod. Plants given all long days had a mean stem length of 48 cm which was the shortest of all the treatments (Table 1). This was significantly shorter than the 53 cm length achieved by plants grown under natural days. Although the LD treatment produced shorter stems, the effect was not great enough to reduce market quality. Pokorny and Kamp (1960) also reported that long days reduced stem length, although the stems were still long enough to be considered superior grade flowers. There was no difference in mean stem length of the plants in the ND and SD treatments. The SD-LD treatment resulted in a mean stem length of 60 cm which was significantly longer than the stem lengths observed in both the LD and ND treatments. There was no difference between the 10LD, 20LD, and 30LD treatments. Exposure to continuous long days was the only treatment which substantially reduces stem length in 'Georgia Ann' spray carnations.

'Elegance'

Stems in the SD-LD treatment were longer than stems in the SD, LD-ND and 10LD treatments. These were the only significant differences in stem length observed for 'Elegance' (Table 1).

Nodes

The number of nodes per stem contributed to the differences in stem length. Several researchers have reported an increase in the number of nodes, or leaf pairs, with a decrease in daylength (1,2,4,7).

'Georgia Ann'

'Georgia Ann' plants grown under continuous long days produced the fewest number of nodes per stem (Table 1). Plants given all short days had significantly more nodes than stems in any of the other treatments, while those exposed to natural days had an intermediate number of nodes. No significant differences in number of nodes per stem were observed among the 10LD, 20LD, and 30LD treatments. Plants grown in the SD-LD treatment had more nodes than those given only long days. These plants may have initiated more leaves during the short day phase of the SD-LD treatment. No difference was observed in the number of nodes per stem between the ND and SD-LD treatments. Previous work with carnations has shown that the duration of the vegetative stage (the stage during which leaves are initiated) is inversely related to the length of the photoperiod (1).

'Elegance'

The plants in the SD treatment had more nodes than any of the plants from the other treatments (Table 1). There were no other significant differences observed.

Number of Flowers Per Stem

'Georgia Ann'

No difference in the number of flowers per stem was observed for plants given the LD, ND, or SD treatments (Table 1). The number of flowers on stems from the SD-LD treatment was also not different than the number on plants within the LD treatment. Although plants given 10 long days produced as many flowers as those given 20 long days, plants given 30 long days produced more flowers than did plants in the 10LD treatment. Plants given 30 long days had 5.9 flowers per stem which was significantly more than the 4.5 flowers per stem produced under natural days.

'Elegance'

Plants grown under long days produced no more flowers per stem than plants in either the ND or SD treatment (Table 1). However, plants in the SD treatment produced more flowers than those in the ND treatment. There was no significant difference in number of flowers among plants given either 10, 20, 30 or continuous long days. Plants in the SD-LD treatment produced the same number of flowers per stem as those grown in long days. It can be concluded from this that supplemental illumination does not reduce the number of flowers per stem of spray carnations. Gaone (1980) also reported no reduction in the number of flowers per stem on spray carnations receiving supplemental illumination.

Summary and Conclusion

'Georgia Ann' Spray carnations given supplemental illumination flowered more than three weeks earlier than those grown under natural days. Continuous long days were necessary for advancing flowering; 10, 20 or 30 long days were not enough. In comparison to plants grown under natural days, those receiving continuous supplemental lighting had fewer nodes per stem and therefore shorter stems, but the stems were long enough to be of salable quality. During the short day phase of the SD-LD treatment, plants may have initiated more leaves than plants given only long days. It has been observed that the length of internodes of carnations is longer when plants are grown under long days (6). This would account for the plants in the SD-LD treatment having the longest stems. More leaf pairs were initiated under short days and the internodes became elongated when the plants were placed under long days. The number of flowers per stem was not reduced by supplemental illumination.

Flowering of 'Elegance' spray carnations can also be regulated by photoperiod. Plants of this cultivar given supplemental illumination bloomed at least two weeks earlier than those plants grown under natural days. Thirty days of supplementary illumination was sufficient to produce the maximum advance of flowering with this cultivar. The number of nodes per stem, stem length and number of flowers per stem of the plants given 30 days of supplementary lighting were no different than those of plants grown under natural days.

Plants of 'Georgia Ann' and 'Elegance' given the LD-ND treatment showed no significant differences from plants given natural days for any of the parameters measured.

It has been reported (7) that a greater acceleration of flowering could be achieved for standard carnations planted in Janaury in comparison to those planted in June. A greater advance of spray carnation flowering in the spring could be beneficial to the greenhouse grower. Such an advance in flowering has potential commercial importance because demand and prices are usually higher in early spring.

Spray carnation cultivars 'Georgia Ann' and 'Elegance' responded somewhat differently to the photoperiod treatments used in this experiment. 'Georgia Ann' did not respond as consistently as did 'Elegance'. 'Georgia 'Ann' is a relatively new cultivar; the expression of selected, desirable characteristics is more likely in a cultivar which has been in production for a much longer period of time, such as 'Elegance'.

'Georgia Ann' is inherently a very fast blooming cultivar. When grown under natural days, it flowered in 156 days. Therefore, because no advance in flowering was observed unless 'Georgia Ann' carnations were lighted continuously, it may not be commercially feasible for the grower to light 'Georgia Ann'. That is, a favorable cost:benefit ratio is more likely with cultivars such as 'Elegance'. 'Elegance' grown under natural days bloomed at 167 days from planting; by lighting for 30 days, flowering in this cultivar could be advanced to 155 days. With short term supplemental lighting, 'Elegance' will flower at the same time as the normally early cultivar 'Georgia Ann'.

From this experiment it can be concluded that the response of supplemental illumination is not the same for all cultivars of spray carnations. More work needs to be done to determine the duration of extended days which will provide the greatest advance of bloom for each cultivar. Supplemental illumination of spray carnations could provide the grower with a means of regulating the flowering date of his crop for maximum profit.

Literature Cited

1. Cheng, L.H. and R.W. Langhans. 1971. Floral initiation, development, and associated phenomena of *Dianthus caryophyllus* L. Part I. Effect of photoperiod. *J. Am. Soc. Hort. Sci.* 96:504-509.
2. Freeman, R. and R. Langhans. 1965. Photoperiod affects carnations. *N.Y. State Flower Growers' Assn. Bull.* 231.
3. Gaone, N.F. 1980. Planting dates, pinching dates, and supplemental lighting of spray carnations. M.S. Thesis. Colorado State University, Fort Collins, Colorado. 109p.
4. Garibaldi, E. and R.W. Langhans. 1971. Light intensity and photoperiod both affect the growth and flowering of the greenhouse carnation *(Dianthus caryophyllus* L.). *Florist's Review.* April 22, 1971:19,62-63.
5. Hanan, J.J. 1979. Carnation fertilizer injection analysis for the Denver region. *Colo. Flower Growers' Assn. Bull.* 343.
6. Harris, G.P. 1968. Photoperiodism in the glasshouse carnation: the effectiveness of different light sources in promoting flower initiation. *Ann. Bot.* 32:187-197.
7. Harris, G.P. and J.E. Harris. 1962. Effects of environment on flower initiation in carnation. *J. Hort. Sci.* 37: 219-234.
8. Holley, W.D. 1959. Crop control on carnations. *Colo. Flower Growers' Assoc. Bull.* 110.
9. Holley, W.D. and C. Rudolph. 1969. Lighting of carnations. *Colo. Flower Growers' Assoc. Bull.* 224.
10. Pokorny, F.A. and J.R. Kamp. 1960. Photoperiodic control of growth and flowering of carnations. *Ill. State Florists' Assoc. Bull.* 202.

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