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Flower and Shoot Development in the Greenhouse Roses, 'Cara Mia' and 'Town Crier', under Several Temperature-Photoperiodic Regimes[1]

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Abstract. **Plants of the 'Cara Mia' rose (*Rosa hybrida* L.) grown at elevated day temperatures with long photoperiodic cycles or at reduced night temperature with short photoperiods differed in shoot growth rate, petal number, final stem length, and harvest date when compared to plants grown at suggested day and night temperatures. Node number remained nearly constant under all growing conditions. Plants of 'Town Crier' rose grown with a night temperature of 13°C (minimum) during the first 3 weeks following shoot removal produced flowering shoots of the same length in the same amount of time as did those grown at a minimum night temperature of 17°C throughout shoot development. Cooler night temperatures during the second 3-week period after shoot removal increased flower development time by four days but did not affect stem length. Results indicate that some rose cultivars can tolerate lower than normal night temperatures for a portion of the growing cycle without reduced growth and/or yield.**

Temperature during growth has a pronounced influence on flower and shoot development of several greenhouse rose cultivars (1, 4, 9, 10, 11, 12, 13, 14, 17). However, the maintenance of recommended growing temp can be costly during the summer months when considerable cooling may be required and during the winter when heating is required. Also, nearly all energy sources adaptable to greenhouse heating and cooling are becoming less available and more expensive.

Expt. I was undertaken to determine 1) the response of the 'Cara Mia' rose to temp and photoperiods similar to those occurring in an uncooled greenhouse in coastal Northern California in the spring and early summer and 2) the response of this cultivar to conditions similar to those occurring in an unheated greenhouse in the same locale in the winter.

Expt. II was conducted to determine if a 4°C reduction in the normal rose greenhouse minimum night temperature early in the crop cycle can be used to reduce energy input without greatly affecting the quality and development time of a midwinter crop of the 'Town Crier' rose.

Materials and Methods

Expt. I was conducted with 2-year old 'Cara Mia' rose plants (*Rosa manettii* understocks) growing in 19 liter cans that were removed from the greenhouse and pruned to the second lowermost 5-leaflet leaf on Oct. 14, 1975. Plants were then grown under the temp – photoperiodic cycles shown in Table 1 by moving them into appropriate growth chambers at specified times. Plant top ht was adjusted periodically to provide a luminous intensity of about 43 klx (mixed fluorescent and incandescent) at the uppermost leaves. Spectral energy distribution of the growth chambers was matched by use of a spectral radiometer.

The growth medium consisting of 1 medium clay loam: 1 redwood sawdust (by vol) was irrigated daily with half strength Hoagland's solution.

Stem length was measured at weekly intervals and petal number, node number, and harvest date were determined at harvest (sepals slightly reflexed).

Developing shoot meristems from similar plants growing in the greenhouse under natural photoperiods (maximum day temp 21°C; minimum night temp 14°) were collected every 2 days for 22 days after the removal of the previous flowering shoot. These were fixed in FAA, dehydrated through a tert-butyl-alcohol series, and embedded in paraffin (6). Longitudinal

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Table 1. Performance of 'Cara Mia' rose plants grown under 4 different temp – photoperiodic regimes. Means are for total flowers harvested from 4 plants except in the case of petal numbers where means are from "N" flowering stems.

Day temp (°C)	Night temp (°C)	Daylength	Days pruning to harvest	Total no. of flowers harvested	Stem length (cm)	No. of nodes	No. of petals	N
32	16	16	51.0 c[z]	93	25.7 c	11.3 b	26.7 c	12
21	16	16	58.6 b	52	42.3 a	12.5 a	37.9 b	16
21	16	8	60.1 b	48	39.5 a	11.4 b	37.9 b	13
21	4	8	71.1 a	42	30.5 b	12.3 a	49.0 a	13

[z]Mean separation in columns by Duncan's multiple range test, 5% level.

sections (10 μm) stained with periodic acid – Schiff reagent (6), were examined to ascertain leaf number and floral state.

Four-year-old 'Town Crier' roses (*Rosa manettii* understock) grown in 19 liter cans under natural photoperiods were used in experiment II These were pruned Oct. 31, 1975 and harvested on Dec. 26, 1975 when about 80% of the return crop was judged commercially mature. These plants were then grown under the following temp: day maximums of 21° to 23°C during sunny weather but as low as 17° when cloudy; night minimum 17° (8) except for two 3-week periods when some of the plants were moved to an adjacent greenhouse with similar day temp but a night minimum of 13°. Soil mix and fertilizer were similar to those used for Expt. I.

'Town Crier' shoot length was measured at weekly intervals.

Results

Flowers from 'Cara Mia' rose plants grown in growth chambers with elevated temp, (32°C day and 16° night), had shorter stems and fewer petals than flowers grown at the suggested 21° (day) and 16° (night) (8) (Table 1, Fig. 1). Moreover, plants grown with the 32° day temp produced more flowers and matured sooner than plants grown under any of the other temp-photoperiodic regimes (Table 1). The flowers from these plants were noticeably faded. Also, shoots from these plants developed no side shoots in the uppermost leaf axils; side shoots developed in all of the other treatments.

Plants grown at reduced night temp (4°C) also had shorter stems than plants grown with a 16° night temp (Table 1). Flowers from these plants had significantly more petals and appeared much darker in color than those from plants grown at warmer night temp. Flower yield was decreased at lower night temp, and the time from pruning to flower maturity was considerably longer than with the other treatments (Table 1).

There was little variation in the number of nodes on a flowering stem with the treatments given (Table 1). Six true leaf primordia were present in an arrested bud, and 5 to 6 additional leaves were formed before flower initiation. Sepal primordia were observed as early as 12 days after an Oct. 14 pruning in excised buds of 'Cara Mia' grown under natural photoperiods and suggested rose greenhouse temp (8). Petal development was complete in all the buds sampled 22 days after pruning. The first stage of receptacle invagination just prior to carpel initiation was observed after 18 days in the most advanced bud collected.

A summary of the data for 'Town Crier' flowers following a Dec. 26, 1975 harvest is given in Table 2. These plants were exposed to differing minimum night temp during the first or second 3-week period after harvest.

Flowering shoots from plants grown under the suggested greenhouse temp (21° to 23°C day maximum; 17° night minimum) (8) were about 56 cm long at harvest and required 55 days to bloom (sepals reflexed, petals beginning to unfurl). Flowers of plants given cooler night temp (13° minimum) for the first 3 weeks after pruning were not adversely affected in terms of stem length or blooming time. Shoots of plants given cooler night temp (13° minimum) during the second 3-week period after pruning took longer to bloom (about 59 days) but were not significantly shorter. One flower atrophied late in the developmental period in this treatment (Table 2).

The growth of 'Town Crier' shoots based on average weekly stem length is shown in Fig. 2. No significant differences existed between treatments until 5 weeks after pruning when the stem length for the treatment that received cooler nights for the second 3-week interval of the growing cycle was less

Table 2. Stem length and development time of 'Town Crier' roses subjected to 13°C minimum night temp during a portion of the crop cycle, San Jose, Calif., 1975-76. Values are means and SE for 10 stems.

Variable	Normal temp throughout[z]	13°C Night minimum first 3 wk	13° Night minimum second 3 wk
Length (cm)[y]	55.8 ± 1.33	56.3 ± 1.26	53.2 ± 1.74
Days to bloom[x]	55.0 ± 0.82	55.4 ± 0.63	58.9 ± 0.76

[z]17°C minimum night temp and 21 – 23°C maximum day temp throughout bud development period.

[y]differences between treatment means are not significant.

[x]LSD, 1% level between treatment means is 3.1 days.

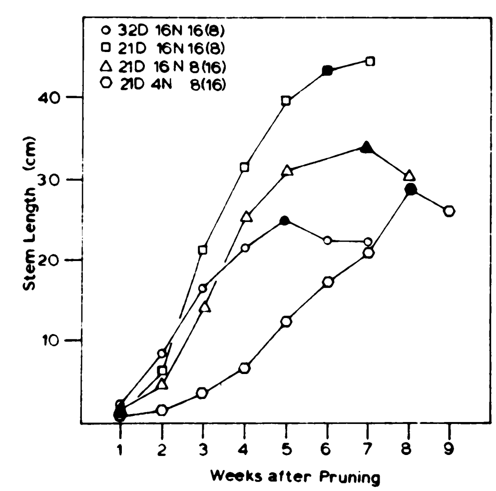

Fig. 1. Stem growth of 'Cara Mia' rose plants grown under 4 temp – photoperiodic regimes. Solid symbols indicate appearance of first harvestable flowers; SE ranged from 0.14 to 3.25 cm. Data points represent means for 12 to 16 stems. Decrease in stem length reflects earlier harvest of longer stems with three of the four treatments. The notation 32 D 16 N 16(8) refers to a temp – photoperiodic regime with 32°C (day), 16°C (night) and a 16 hr photoperiod. Other notations can be interpreted similarly.

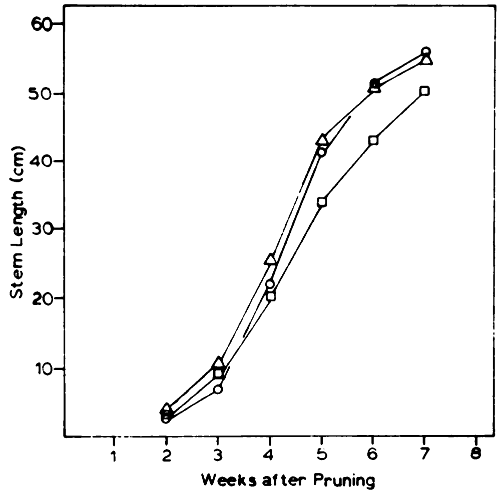

Fig. 2. Growth of developing buds of 'Town Crier' rose plants after pruning shoots and imposition of 3 growing temp regimes: Δ = normal greenhouse temp throughout the crop (17°C night minimum and 21° to 23°C day maximums); ○ = 13°C night minimum during the first 3 week interval and □ = 13°C night minimum during the second 3 week interval after pruning. Data points represent means for 9 – 10 stems. Differences between □ and the other treatments for weeks 5 – 7 are statistically significant, 5% level.

than that for the other 2 treatments. Stem length differences based on harvest length were not significant.

Discussion

Elevated temp causes higher yields, shorter stems, reduced petal numbers and earlier flowering in rose cultivars other than 'Cara Mia' (10, 11, 12, 13). These responses are therefore not restricted to this particular cultivar of *R. hybrida.* However, with still other cultivars yield is reduced at elevated growing temp (14).

Biran and Halevy (1), Moe and Kristoffersen (12), and Tesi (14), report that high growing temp lead to less intense flower color with several cultivars. This is also true of 'Cara Mia.' Conversely, as others report (1, 12, 14), low temp results in darker flower color and greater leaf pigmentation. This probably relates to low temp stimulation of anthocyanin synthesis seen with many plants (2).

Reduced stem length does not become apparent in plants grown at an elevated day temp until 3 to 4 weeks after pruning (Fig. 1). Moreover, the number of leaf-bearing nodes on a flowering stem is relatively unaffected by differences in either day or night temp (Table 1). Finally, the total number of flowering stems per plant is increased by higher than normal day temp. These findings suggest the possibility of growing marketable greenhouse rose flowers with higher than recommented day temp during the early part of the growing cycle. Thus it may be feasible to reduce greenhouse cooling and still obtain a marketable rose crop.

A 4°C night temp leads to reduced stem growth of 'Cara Mia' roses from the time of bud break (Fig. 1). If the growth rate during a large part of the growing cycle is proportional to the amount of stem and leaf tissue present (3), it is unlikely that stems whose growth is retarded through exposure to 4° nights can be made to elongate more rapidly than those grown continuously under warmer conditions. However, marketable flowers can be obtained from plants grown under cool nights if reduced yield and a longer growing cycle can be tolerated.

Night temp did not affect flower abortion (blindness) with 'Cara Mia,' since the same number of stems used for growth measurements eventually flowered in the 21°C day/16° night, 8 hr daylength treatment as flowered in the 21° day/4° night, 8 hr daylength treatment. This finding apparently conflicts with reports that lower growing temp cause flower bud abortion in 'Baccara' and other cultivars (9, 12, 16). Shoot diam from which these aborted buds developed is not reported, and unpublished data indicate that shoot diam is a factor in the amount of blindness that occurs due to lower temp.

Zieslin et al. (17) analyzed greenhouse production of rose flowers to be the product of buds sprouted and the percentage of sprouted buds that flower. Since blindness is not increased, decreased flower yield in 'Cara Mia' plants subjected to lower temp is the result of the influence of temp on bud break.

Flower development in 'Cara Mia' is similar to that observed in other greenhouse rose cultivars (5, 7, 15). Flower initiation begins relatively soon after the lateral bud is released from correlative inhibition after the formation of several additional leaf primordia.

Reducing the night minimum greenhouse temp 4°C during the first 3 weeks of a midwinter crop of 'Town Crier' results in flowers that are neither delayed nor reduced in stem length at harvest. If other cultivars respond in a similar manner, greenhouse temp may be modulated over the growing cycle to conserve heating energy sources.

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