Table 3. The average number of hours the heaters were active per day with a constant minimum temperature and with a dual minimum temperature regime.

	Hours per day					
	1978–79		1979–80		1980–81	
Month	Constant	Dual	Constant	Dual	Constant	Dual
December	6.2	3.1	5.6	2.4	4.3	2.1
January	8.8	6.2	4.6	1.6	5.7	3.2
February	7.0	4.5	6.7	3.3	4.3	2.2
March	3.1	1.4	3.8	1.9	2.4	1.0
April	.7	.1	1.4	.7	.2	.0
Avg	5.2	3.1	4.4	2.0	3.4	1.7

days earlier with a constant thermostat setting and 22–24 days earlier with a dual thermostat setting than 'Ace', 'Croft', and 'Nellie White'.

Dual thermostat settings resulted in a 1.2 increase in flower number and a substantial increase in plant height (Table 2). 'Harson' produced the most flowers followed by 'Ace' and 'Nellie White'. 'Croft' produced the least number of flowers. Plants of 'Ace' and 'Harson' were the tallest, 'Croft' were intermediate, and 'Nellie White' were the shortest (Table 2). Results with 'Harson' lilies forced in 1980 in both temperature regimes were similar to data obtained in 1979 and 1981.

Southern-grown bulbs produced flowering pot plants for Easter that forced in an acceptable period of time with a high flower number per plant. However, plant height, especially with 'Harson' and 'Ace' with dual night temperatures, was excessive and detrimental to plant quality.

Thermostat settings to maintain greenhouse minimum temperatures of 16.7°C in 1979 and 15.6° in 1980 and 1981 for the months of December of the previous year through April resulted in average minimum temperatures of 17.0° in 1979 and 15.4 and 15.8° in 1980 and 1981, respectively. Thermostat settings of 7.8° for 1979 and 4.4° for 1980 and 1981 for the greenhouse compartment with dual thermostat settings were not always attained and resulted in average minimum temperatures of 10.7, 9.9 and 10.5°, respectively, in 1979, 1980, and 1981.

Dual minimum temperatures reduced heater usage per day from 5.2 to 3.1 hr, a 40% reduction in 1979, from 4.4 to 2.1 hr, a 55% reduction in 1980, and from 3.4 to 1.7 hr, a 50% reduction in 1981 (Table 3).

The expense incurred to force lilies an additional 9 to 13 days with dual minimum temperatures was substantially offset by the reduction in heater usage of about 50% per day and could also allow production when fuel availability is limited. In 1980, for example, heater usage with a constant minimum temperature for the entire period of December 1979 through April 1980 amounted to 664 hr and with a dual minimum temperature amounted to 302 hours. The additional 2 weeks of forcing time required resulted in an additional 28 hr of heater usage, for a total of 330 hr when using a dual minimum temperature.

The 'Harson' lily forced in 85 days with a dual night temperature, as compared to 98, 96, and 98 days, respectively, with 'Ace', 'Croft', and 'Nellie White' with a constant temperature (Table 1). The use of 'Harson' resulted in savings not only due to less fuel usage, but also because less forcing days were required for flowering. As a result, problems of programing the lilies for an early Easter because of overlap with greenhouse crops such as poinsettia would be avoided by using 'Harson', even when using a dual night temperature regime.

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Photoperiod and Temperature Effects on NonStop Tuberous Begonias[1]

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Additional index words. flowering, tuberization, *Begonia* X *tuberhybrida*

Abstract. **Extended long days or interrupted night photoperiods increased leaf number and top fresh weight, and decreased tuber formation compared with short days with 2 cultivars of the "NonStop" series of tuberous begonia (*Begonia* X *tuberhybrida* Voss). Short days increased tuber size and fresh weight and reduced top fresh weight of both cultivars. 'Double Red' showed greater leaf number, top fresh weight, tuber fresh weight, and tuber size at 22°C than at 26°, while 'Double Orange' showed only greater top fresh weight at 22°. Flowering was enhanced in both cultivars under long days.**

Tuberous begonias are attractive garden plants in regions where high temperatures do not persist for extended periods. Commercial flower growers have grown tuberous begonias as flowering pot plants for spring sales with varying degrees of success, largely dependent on season and locality. Large, colorful, attractive flowers in an assortment of colors have appealed to customers when high-quality plants were produced.

Recently, the "NonStop" tuberous begonias have attracted attention and interest, as they seem more adaptable to warm temperatures than traditional tuberous begonias. In 1980, NonStop tuberous begonias were forced successfully in commercial and university greenhouses in North Carolina with little apparent difficulty. In 1981, several of the same greenhouses reported poor growth and sporadic flowering. The reasons for these failures were unknown.

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Table 1. Growth response of NonStop tuberous begonia 'Double Red' and 'Double Orange' to long-day, short-day, and interrupted-night photoperiods.[z]

Cultivar	Photoperiod (hr)	No. of leaves	Top fresh weight (g)	Tuber fresh wt (g)	Tuber size (cc)
Double Red	9	10.5 b	65.4 b	19.0 a	32.3 a
	9+3	21.0 a	220.8 a	0.8 b	1.1 b
	16	24.0 a	208.5 a	0.7 b	1.1 b
Double Orange	9	9.7 c	52.8 b	18.0 a	29.7 a
	9+3	15.1 b	162.5 a	1.2 b	1.9 b
	16	21.8 a	165.0 a	1.3 b	1.8 b

[z]Mean separation within columns for cultivars using Duncan's multiple range test, 5% level.

The scientific name of NonStop tuberous begonias is difficult to verify. According to Haegeman (3) who classified them as *Begonia* X *tuberhybrida* Voss, the firm of E. Benary in Hann-Münden, West Germany, introduced the hybrids to the European market in 1977. Ewart (2), refers to them as a new series. Klougart and Birke (5) do not specifically refer to these begonias in their recent references on classification of greenhouse crops.

Photoperiodic response and temperature interact to control vegetative and reproductive phases of most begonia species, but the situation is more complex with tuberous begonias. Tuberization must also be considered. Lewis (7) reported that vegetative growth must be at a proper stage of development or neither tubers nor flowers would be formed. He considered tuberization to be a function of a combination of excessive carbohydrates and short days. In earlier studies, Lewis (6) showed that tubers were formed under natural short days (10 to 12 hr daylengths), while plants subjected to longer than 12-hr photoperiods did not produce tubers. Vegetative growth ceased when plants were moved from long to short days but resumed when plants were returned to long days. The plants also flowered when moved to long days (18-hr daylength). He considered night temperatures of 13 to 16°C to be optimum for growth and the production of large flowers with a minimum daylength of 14 hours.

Horton (4) subjected flowering tuberous begonia plants to 9-hr daylengths for 1 to 8 weeks. Top growth was then removed and plants were placed at a daylength of 14.5 hr. Plants previously subjected to only 1 week of short days readily resumed growth; however, sprouting was delayed if plants had been exposed to 2 weeks of short days. Plants previously grown under short days for 3 to 8 weeks failed to resume growth after the tops were cut back. Horton did not report the temperatures used in his study. Peters (9) studied the influences of temperature on tuber formation and vegetative growth. He considered 15 to 20°C to be the optimum temperatures for tuber formation, but higher temperatures were optimum for vegetative growth. Forty to 60 continuous short days seemed to be necessary for tuber formation. Oloomi and Payne (8) found that a 9-hr photoperiod promoted tuber formation and reduced top growth and flowering in 'Non Stop Yellow' tuberous begonias. Pinching delayed flowering but did not alter tuber development.

Cultural information on NonStop tuberous begonias has been provided to commercial growers by Earl J. Small Growers, Inc., suppliers of these plants. Their instructions state that to promote early flowering, the plants must be grown under long days from November to March. They advised that the best results would be obtained if lighting was initiated 30 min before darkness and extended until about 2200 HR. No temperature regimes were suggested.

Objectives of this study were to compare growth and flowering of NonStop tuberous begonia plants under interrupted dark periods and extended daylength, at different temperature regimes. The effects of tuberization on growth and flowering were also determined.

Seedling plants of 'Double Red' and 'Double Orange' tuberous begonia, grown under a 16-hr photoperiod for about 10 weeks, were obtained from Earl J. Small Growers on May 5, 1981, and planted in 16.5-cm plastic containers with a medium of milled pine bark humus (screened to 6 mm), Canadian sphagnum peatmoss, and washed concrete grade sand (3:1:1 by volume) amended with 7 kg dolomite and 1 kg treble superphosphate per m^3 of medium. The study was conducted in the controlled-environment greenhouses of the Southeastern Plant Environment Laboratories (Phytotron) on the NCSU campus. Plants received 9 hr of 50% natural daylight. Long days were provided by incandescent light only, either as a 7-hr addition to the natural sunlight (16 hr total) or as a 3-hr night interruption (2300 to 0200 HR). Incandescent irradiation produced 27 $\mu E\ m^{-2}s^{-1}$ of PAR (400–700 nm) or 1.35 klux. Two temperature regimes were used, 26/18° or 22/18°C (day/night). Plants were watered and fertilized daily with a modified Hoagland's solution, as routine Phytotron care (1).

After 60 days, plants were cut at the soil line and top fresh weight, leaf number, and tuber fresh weight determined. Tuber size was estimated by measuring diameter and height using the formula, volume $= \pi r^2 h$ where r = radius and h = height. Tuber size (cc) was very highly correlated with tuber diameter, height, and fresh weight. For simplicity, only tuber fresh weight and tuber size are reported.

The experiment consisted of 2 temperatures, 3 photoperiods, and 2 cultivars (12 treatments), with 10 plants per treatment.

Photoperiod. Long days repressed tuber formation and increased leaf number and top fresh weight over short days with both cultivars (Table 1). Both the night-interruption and the extended-day photoperiods resulted in similar shoot and tuber values. The short-day treatments promoted tuber formation (Fig. 1). Flowering was indirectly affected by pho-

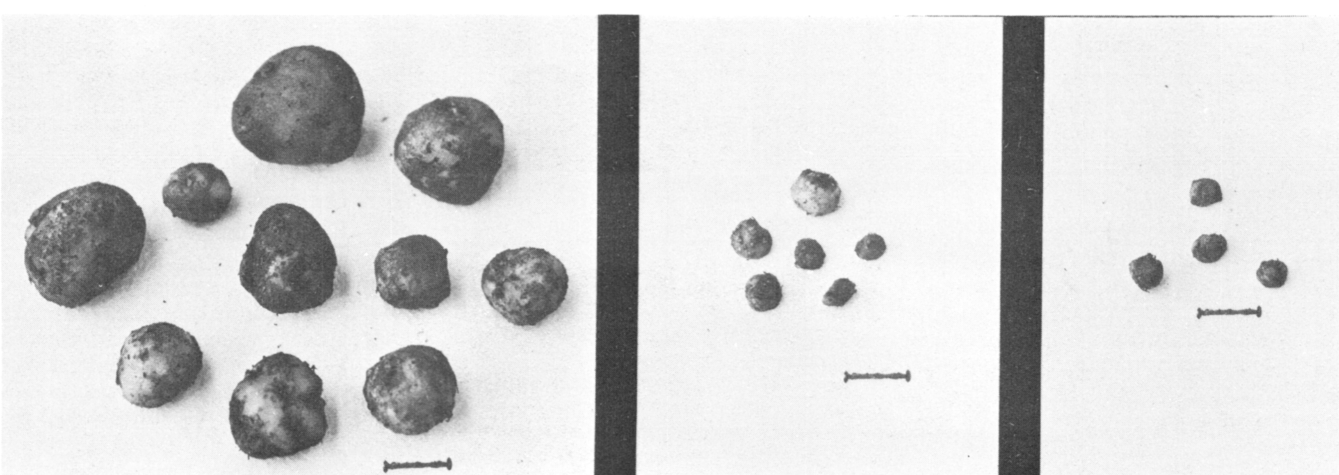

Fig. 1. Tubers of NonStop tuberous begonia, 'Double Red', grown at 26°C (day)/18° (night) temperature under 3 photoperiods. Left photo = 9 hr; middle photo = 9 hr + 3 hr interrupted night; right photo = 16 hr. Scale = 2 cm.

Table 2. Growth response of NonStop tuberous begonias 'Double Red' and 'Double Orange' to different temperatures.

Cultivar	Temp (Day/Night) (°C)	No. of leaves	Top fresh weight (g)	Tuber fresh wt (g)	Tuber size (cc)
Double Red	22/18	20.9	194.4	8.1	14.1
	26/18	16.2*	134.9*	5.5*	8.9*
Double Orange	22/18	16.0	147.6	7.2	11.6
	26/18	15.1	105.9*	6.4	10.6

*Paired means significantly different at 5% level, F test.

toperiod. Longer photoperiods promoted larger plants which, in turn, seemed to enhance flowering of both cultivars. However, plants under short days, while exhibiting less vegetative growth, did produce flowers. Number of flowers was related to size of plants, since plants produce axillary flowers while terminal growing points remain vegetative.

There were no differences between cultivars or the 2 long-day treatments with respect to tuber formation or top fresh weight. Leaf number was similar under the 2 long-day treatments with 'Double Red'. However, a higher leaf count was recorded for the extended-day treatment than for the night-interruption treatment in 'Double Orange'. Short-day treatments produced similar leaf numbers with both cvs.

Temperature. Lower day temperatures had greater effects on 'Double Red' in both vegetative growth and tuber formation than on 'Double Orange' (Table 2). Leaf number, top fresh weight, tuber fresh weight, and tuber size increased at 22°C in 'Double Red', while only plant fresh weight of 'Double Orange' increased compared with plants at 26°. Flowering was unaffected directly by temperatures; more flowers were present on the larger plants. The lower temperature seemed to produce more flowers as a result of producing larger plants. Tuber formation was enhanced at the lower day temperature.

Best flowering and best vegetative growth were at 22°C for both cultivars under either the extended-day or the night-interruption photoperiods. Short days (9 hr) and 22° day temperature produced the largest tubers.

These data on 'Double Red' and 'Double Orange' are in strong agreement with those of Oloomi and Payne (8) for 'Non-stop Yellow'. Tuber fresh weight (Table 1) for both cultivars ranged from 18.0 to 19.0 g under short days and 0.7 to 1.3 g under long days, whereas the tuber fresh weights in the Oloomi and Payne study under similar photoperiods were 19.2 g and 1.4 g, respectively. These data also indicate that short photoperiods and high day temperatures may have caused the forcing problems reported for the 1981 season.

Production of NonStop tuberous begonias as commercial pot plants would be enhanced by growing plants under long days and cool day (22 vs. 26°C) temperatures. For commercial production in the winter months, long-day treatments can be easily provided with night-interrupted incandescent lighting, such as is standard with short-day crops such as chrysanthemum and poinsettia.

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Postharvest Performance of Poinsettia as Affected by Micronutrient Source, Storage, and Cultivar[1]

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Additional index words. *Euphorbia pulcherrima*, culture, interior environment, minor elements, posthandling, shipping

Abstract. **After 4 weeks indoors, 'Annette Hegg Dark Red' ('AHDR') and 'Gutbier V-14 Glory' ('GV14') had higher leaf abscission than 'Mikkel Improved Rochford' ('MIR'). 'AHDR' abscised more bracts than 'MIR' or 'GV14'. Plant grade was highest for 'GV14'. Fritted Trace Elements-treated (FTE) and Micromax-treated (MICROMAX) plants lost fewer leaves and bracts and had a higher plant grade than Perk-treated (PERK) or Soluble Trace Element Mix-treated (STEM) plants. Plants held in dark storage for 3 or 6 days had greater leaf abscission than plants not subjected to storage. Bract drop was highest for 6 days storage. Dark storage of 0 or 3 days had higher plant grade than 6 days dark storage.**

Changes in poinsettia marketing in recent years have affected postharvest keeping quality. Extended holiday sales and longer distance shipping prolong dark storage. Marketing through chain stores staffed with inexperienced personnel has increased. Although new cultivars have been introduced with longer postharvest life, problems associated with postharvest handling have not been alleviated. Decreased postharvest quality in poinsettias was related to a decline in the endogenous level of auxin, associated with increased senescence and bract abscission (1, 2), high light and high temperatures (5), and high N, P, and K levels (3) during production.

'Annette Hegg Supreme' and 'AHDR' retained better quality when held in dark storage for a minimal time in paper sleeves at 10°C (6). Dark storage may cause leaf and bract abscission, with the rate of abscission being dependent on duration of storage and subsequent interior lighting (4). However, leaf and bract abscission of poinsettias have

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