EFFECTS OF PHOTOPERIOD AND PINCHING ON GROWTH AND FLOWERING OF *BEGONIA X TUBERHYBRIDA* POT PLANTS

By

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AND FLOWERING OF BEGONIA X TUBERHYBRIDA

POT PLANTS

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CHAPTER I

INTRODUCTION AND REVIEW OF LITERATURE

There are over 1000 species of begonias (1). Commercially they are usually grouped into Rhizomatous begonias such as 'Rex' and 'Iron Cross'; the Fibrous-rooted or everblooming begonias such as 'Charm' and 'Scarletta'; the Christmas begonias such as 'LadyMac' and 'Melior'; the Elatior begonias originating from crosses between Christmas and tuberous begonias, with the Rieger series of cultivars such as 'Aphrodite' and 'Schwabenland Red' being popular; and the Hybrid Tuberous Begonias such as the NonStop series, Double-Ruffled Camellia series, Picotee series and others (3, 6, 8, 10, 11, 12).

Since this thesis deals only with tuberous begonias, further discussion will be limited mainly to this type, and especially to the NonStop begonias.

Hybrid Tuberous Begonias (*Begonia* x *tuberhybrida*) consist of a group of plants originally derived through hybridization and selection from several andean species (1). The development of the tuberous hybrids has resulted in sufficient commercial production of plants to be of economic importance in Europe, and more recently in America (7). Tuberous begonia flower colors include tones of white, yellow, orange, red, and pink (4,9) and are noted because of their variation in color, form, size and texture. There are staminate and pistillate flowers on each plant, the double flowers being more abundant and showy (8).

The F_1 NonStop series used in this study is a European strain producing about 70% double, semidouble and crested flowers, with the remainder being duplex flowers 5 to 7.5 cm (2-3 inches) in diameter (11).

Although asexual propagation by tubers or cuttings is practiced for tuberous begonias (8), seed is the principal propagation method used for the NonStop tuberous begonias. Seeds of six different colors can be obtained individually (Apricot, Orange, Pink, Salmon, Scarlet or Red, and Yellow), or a seed mixture containing these colors can be purchased (2, 11, 13). These begonias are advertised as being suitable for flowering pot plants, hanging baskets, shady area gardens or bedding plants (2, 8, 11, 12).

Begonia seeds will remain viable for 9 years, but most seeds that are sown are only a year old. They require an after-ripening period of one month (8). There are about 2 million seeds per ounce. A light, well-drained sowing medium is recommended, and it is suggested that seeds should not be covered with the germination medium and that soil temperature should be an even 18.3°C (65°F) (2). Brown (5) stated that germination occurs in 8 to 13 days under maximum temperature of 23.8°C (75°F) (5) whereas Ball indicated 15 to 30 days at 18.3°C (65°F) (2,3). Larson (8) and Ball (2) stated that a November seed-sowing can produce "spring flowering" and "prime pots and baskets for Mother's Day", respectively. According to Brown (5), tuberous begonias grown from seed will bloom in 6 or 7 months after sowing and that January sowing is recommended to insure a full blooming season the first year.

Started seedlings are available from specialist growers November to May, and Small indicates that 5.7 cm (2 1/4-inch) seedlings will flower in 6 to 7 weeks in 10 cm (4-inch) pots, or in 8 to 10 weeks if pinched and grown in 15 cm (6-inch) pots (13).

Apparently high summer temperatures limit the use of tuberous begonias in commercial floriculture. Larson in referring to work by Post, indicated that plants performed better when night temperatures do not exceed 16°C (about 60°F), but that some of the newer hybrids grow satisfactorily at higher temperatures (8).

Flowering of tuberous begonias is promoted by long days, plants become dormant under short days, and tuber formation is promoted by short days (8). Genetic background may contribute to reduced growth under low light conditions (3).

There appears to be agreement that long days are necessary for good growth and early flowering (2, 3, 8, 13), but in personal communication with a specialist seedling grower (14), it was found that it would be beneficial to know detailed information relative to more specific effects of photoperiod on growth and flowering, and whether there are significant differences between extension of the natural day and "night-break" or middle-of-night lighting. With these objectives in mind, an experiment was designed to compare 4 photoperiod treatments on plants grown either without pinching or a single pinch to induce branching. Accurate timing information for Oklahoma growers should enable them to better take advantage of this potentially profitable crop.

CHAPTER II

MATERIALS AND METHODS

This research was conducted in a fiberglass greenhouse at the Oklahoma State University Horticulture Department greenhouse in Stillwater (36^{o} 9' N latitude, 97^{o} 5' N longitude).

The 'Bright Yellow' NonStop begonia plants utilized in this study were 5.7 cm (2 1/4-inch) potted seedlings which were grown by Earl J. Small Growers, Inc., Pinellas, Florida. The seedlings arrived on March 4, 1981, and were transplanted, one per pot, to 11.4 cm (4 1/2-inch) pots on March 7. The growing medium was .465 cu m sphagnum peat, .155 cu m vermiculite, .155 cu m perlite plus 4.54 Kg dolomite, 1.134 Kg 0-20-0 superphosphate, 680g KNO_3, 85g fritted trace elements and 142g wetting surfactant (a cubic yard of potting medium or 22 bushels plus the fertilizer additives). A drench of Lesan and Benlate (2g per 3.785 1), 90cc per pot was applied after transplanting to aid in control of damping-off.

Throughout the experiment, 20-8.8-16.6 fertilizer was applied every 2 weeks to supply 500ppm N, 220ppm P and 415ppm K per application. Tap water was applied by hose as needed between fertilizer applications.

The night temperature was maintained as closely as possible to 15.5-17.2^{o}C (60-63^{o}F), with daytime temperatures 18-20^{o}C (65-68^{o}F) on cloudy days and 21-23.8^{o}C (70-75^{o}F) on sunny days. Occasionally, daytime temperatures exceeded this range.

On March 12, the photoperiod experiment was started, with 4 photoperiods:

1. 9-hour photoperiod--Natural daylight 8:00 a.m. - 5:00 p.m., with no supplementary light (abbreviation - "9 hr. days").
2. 14-hour daylength including 9 hours natural daylight (8:00 a.m. - 5:00 p.m.) plus incandescent lighting from 5:00 p.m. - 10:00 p.m. (abbreviation - "Light 5:00 - 10:00 p.m.").
3. 14-hour daylength including 9 hours natural daylight (8:00 a.m. - 5:00 p.m.) plus incandescent lighting from 10:00 p.m. - 3:00 a.m. (abbreviation - "Light 10:00 p.m. - 3:00 a.m.").
4. 24-hour daylength including 9 hours natural daylight (8:00 a.m. - 5:00 p.m.) plus incandescent lighting from 5:00 p.m. - 8:00 a.m. (abbreviation - "24 hr. day").

Two types of plants were grown in each of the photoperiods without pinching or with a single pinch (pinched March 20) making a total of 8 experimental treatments (4 photoperiods and 2 pinching methods).

The experimental design was a split plot, where the main plots (photoperiod) were in a 4 X 4 latin square design with 12 plants per bench, 6 No-Pinch and 6 Pinched (sub-plots). Guard rows surrounded the 12 experimental plants in each square. Pots were spaced 15 X 15 cm (6 X 6 inches).

In establishing the 4 X 4 latin square each chamber or bench was a wooden frame 81 X 122 cm (32 X 48 inches), covered with welded wire mesh 2 1/2 X 5 cm (1 X 2 inches) and supported on concrete blocks 46 cm (18 inches) from the floor. Number 9 galvanized wire arches were attached to the bench corners to allow support for the black cloth covering (Figure 1). A 75-watt incandescent bulb was suspended 91 cm

(36 inches) from the bench or 81 cm (32 inches) from the pot rim, supplying approximately 205 lux (19 foot candles) of light at plant level. All benches were covered with black cloth at 5 p.m. The appropriate supplementary lighting followed, and the black cloth was removed at 8 a.m.

The following measurements were made and data stored in the computer:

A. Data recorded at first flowering

1. Number of days from start of treatment to first open flower.
2. Flower diameter (cm).
3. Plant height above the pot rim (cm).
4. Number and average length (cm) of side vegetative breaks or branches.
5. Number of nodes on main stem for No-Pinch plants.

B. Data recorded at second and third flower opening

1. Number of days from start of treatment to second and third flowering, and flower diameter (cm).

C. Data at termination of experiment (11 weeks from March 12, or May 28)

1. Final plant height above pot rim (cm).
2. Above-ground vegetative dry weight (g)--each plant was dried in a 54.5^{o}C (130^{o}F) oven. Flowers were removed, so only vegetative growth was included.
3. Tuber fresh weight (g)--the potting medium was washed away, roots and tops removed uniformly, tubers allowed to air-dry for 24 hours, and then weighed.

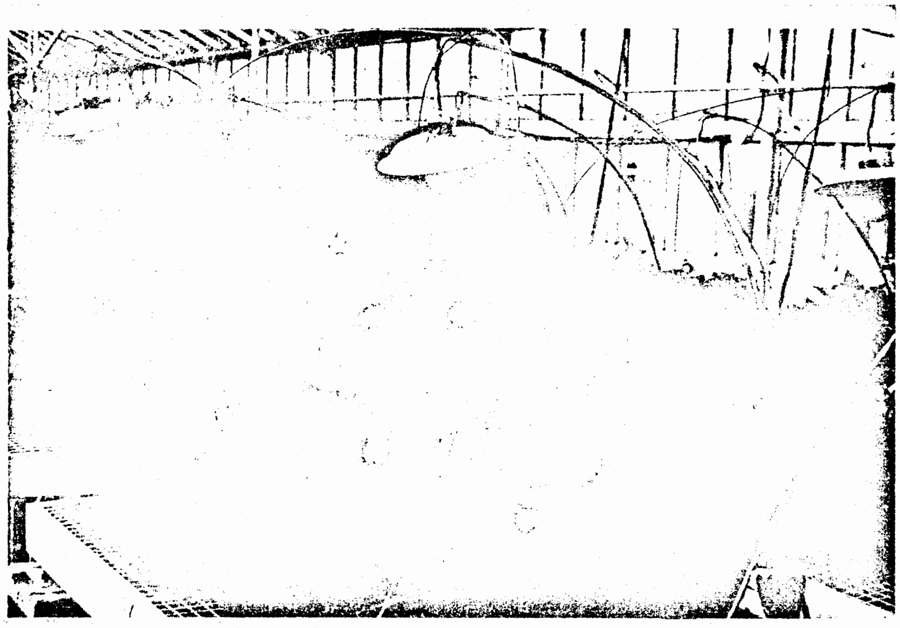

Figure 1. 4 X 4 Latin Square Design Showing Individual Photoperiod Treatment Benches.

CHAPTER III

RESULTS AND DISCUSSION

The means from the four replications of each treatment derived from plants which responded were used to obtain an analysis of variance for each character measured at first, second, and third flowering. Least square means were used except when Duncan's multiple range test was employed to derive effects of photoperiod. In these cases, raw means over both pinching methods were used.

Measurements at First, Second and Third Flowering

Number of Days to Flower and Flower Diameter

The analysis of variance indicated that photoperiod had significant effects on number of day to first and second flower, but not to third flower (Table I). Pinching also caused significant differences in days to first, second and third flower. There was no interaction between photoperiod and pinching.

The apparent significance of earlier flowering associated with the 9-hour day No-Pinch treatment is misleading, since only 3 plants out of 24, or 12.5%, flowered in this treatment (Table II). These flowered rapidly, but were not a true indication of the 9 hour day effect, since 21 plants or 87.5%, did not flower at all throughout the 11-week experiment. No plants in the 9 hour day Pinched treatment flowered during the 11-week period, March 12-May 28.

Pinching delayed flowering from 9-19 days for first flowering in the long day treatments (Table II). In no treatment was there 100% flowering during the 11-week period. The highest percent of plants reaching first flower was 87.5% for No-Pinch plants in each of the three long day treatments.

For those plants that flowered, 4 1/2 - 5 weeks were required for No-Pinch plants in the 3 long day treatments to have 3 flowers open, and 5 1/2 - 7 weeks for the Pinched plants. It is not clear why 100% of the plants, especially No-Pinch, didn't flower within 11 weeks. Genetic seedling variation may be responsible.

The main effect of photoperiod on flower diameter was small flowers on the few plants that flowered in the 9 hour treatment (Tables I & II). Although not analyzed statistically, it was also evident that the second and third flowers were smaller than the first flowers (Table II & III).

When photoperiod effect was considered, over both No-Pinch and Pinched plants, there were few significant differences in days to flower or flower diameter between any of the long-day treatments (Table III). In every case, the 24 hour day plants flowered in slightly before the 5:00 - 10:00 p.m. lighted plants or the 10:00 p.m. - 3:00 a.m. lighted plants, but the difference was statistically significant in only one instance. In looking at the earlier flowering of the 9 hour day plants (Table III), it should be pointed out that only 3 out of 48 plants receiving this short day treatment flowered.

TABLE I

SIGNIFICANCE OF MAIN EFFECTS AND INTERACTIONS
AT FIRST, SECOND AND THIRD FLOWERING

Source of Variation	Mean Number of Days to First Flower	Mean Diameter of First Flower	Mean Number of Days to Second Flower	Mean Diameter of Second Flower	Mean Number of Days to Third Flower	Mean Diameter of Third Flower
Photoperiod Treatment	0.01	0.01	0.05	NS	NS	NS
Pinching	0.01	NS	0.01	NS	0.05	NS
Photoperiod Treatment X Pinching	NS[y]	NS	NS	NS	NS	NS

[y]No interaction in the long day treatments (None of the 9 hr. day Pinched plants flowered).

TABLE II

EFFECT OF PHOTOPERIOD TREATMENTS AND PINCHING ON FIRST, SECOND AND THIRD FLOWER

Treatment	No-Pinch or Pinched	A First Flower				B Second Flower				C Third Flower			
		Mean Days to First Flower[w]	No. Plants that Flowered[x]	Percent Flowered[y]	Dia. of First Flower[z] (cm)	Mean Days to Second Flower	No. Plants that Flowered	Percent Flowered	Dia. of Second Flower (cm)	Mean Days to Third Flower	No. Plants that Flowered	Percent Flowered	Dia. of Third Flower (cm)
9 Hour Day	No-Pinch 1	18.0	3	12.5	5.2	19.0	3	12.5	4.3	22.8	2	8.3	2.9
	Pinched 2												
Light 5:00-10:00 p.m.	1	21.6	21	87.5	7.4	26.4	20	83.3	6.0	32.5	19	78.1	6.1
	2	37.2	11	45.8	7.5	44.0	9	37.5	6.3	48.6	3	12.5	6.4
Light 10:00 p.m. - 3:00 a.m.	1	21.1	21	87.5	7.6	25.4	21	87.5	5.6	30.3	20	83.3	5.6
	2	40.9	10	21.6	7.7	45.5	10	41.6	5.1	47.5	3	12.5	4.7
24 Hour Day	1	23.7	21	87.5	7.3	27.6	21	87.5	6.0	34.3	19	78.1	5.8
	2	33.0	8	30.3	6.0	39.9	8	30.3	5.0	35.3	4	16.6	5.0

[w]Means of plants that reached first, second or third flower.

[x]Number of plants out of 24 that reached first, second or third flower.

[y]Percent of the total plants (24) in each treatment that reached first, second or third flower.

[z]Diameter of first, second or third flower.

Plant Height at First Flower

Photoperiod and pinching significantly affected plant height measured at first flowering, but there was no interaction (Table IV). The No-Pinch plants in the 9 hour days were considerably shorter than plants lighted 5:00 - 10:00 p.m., 10:00 p.m. - 3:00 a.m., or for 24 hours (Table V, Figure 2). Pinched plants were taller at flowering than No-Pinch plants. Appearance of pinched plants 7 weeks after start of photoperiod treatments is shown in Figure 3.

Over both pinching methods (No-Pinch or Pinch) there were no significant height differences between means in any of the long day treatments (Table VI).

Number and Length of Side Vegetative Branches at First Flowering

Photoperiod and pinching caused significant differences in number of branches, and pinching significantly affected length of the branches at flowering (Table IV). Nine hour day plants had the fewest branches (Table V) for plants reaching first flower (No-Pinch only since none of the pinched plants flowered) during the experiment, no data were recorded. Pinched plants definitely had longer side branches at flowering than No-Pinched (Table V). This would be expected when the apical dominance of the terminal growing tip was removed on the pinched plants, but was still present on the No-Pinch plants. There was a significant difference in number of branches between 9 hour day and 10:00 p.m. - 3:00 a.m. lighting or 24 hour day (Table VI), although it should be emphasized that none of the pinched plants (9 Hr.) reached first flower during the experiment, so 9 hour day data are for No-Pinch plants only.

TABLE III

EFFECT OF PHOTOPERIOD TREATMENT (OVER BOTH PINCHING METHODS) ON NUMBER OF DAYS TO FLOWER AND FLOWER DIAMETER[y]

Photoperiod Treatment	Mean No. of Days to First Flower	Mean Diameter of First Flower (cm)	Mean No. of Days to Second Flower	Mean Diameter of Second Flower (cm)	Mean No. of Days to Third Flower	Mean Diameter of Third Flower (cm)
9 hour day	16.3c[z]	5.3c	17.6b	4.1b	18.0b	0.25b
Light 5:00 - 10:00 p.m.	29.4b	7.4a	35.2a	6.1a	37.3a	2.7a
Light 10:00 p.m. - 3:00 a.m.	31.0a	7.6a	35.4a	5.3a	37.8a	2.8a
24 hour day	28.4b	6.7b	33.7a	5.5a	35.5a	2.8a

[y]Mean separation in columns by Duncan's Multiple Range Test, 5% level.

[z]Only three out of 48 plants flowered in the 9 hr. day treatment.

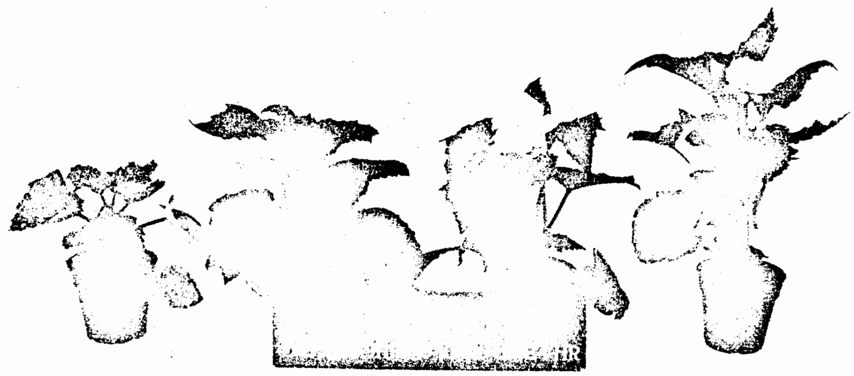

Figure 2. Effect of Photoperiod on No-Pinch Plants'Development by April 29, 7 Weeks After Start of Photoperiod Treatments. L to R: 9 Hour Day; Light 5:00 - 10:00 p.m., Light 10:00 p.m. - 3:00 a.m.; 24 Hour Day.

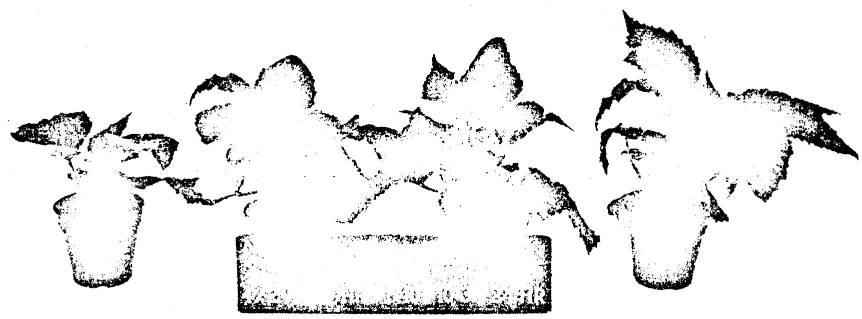

Figure 3. Effect of Photoperiod on Pinched Plants' Development by April 29, 7 Weeks After Start of Photoperiod Treatments. L to R: 9 Hour Day; Light 5:00 - 10:00 p.m.; Light 10:00 p.m. - 3:00 a.m.; 24 Hour Day.

TABLE IV

SIGNIFICANCE OF MAIN EFFECTS AND INTERACTION ON PLANT HEIGHT, NO. AND LENGTH OF SIDE VEGETATIVE BRANCHES, AND NO. OF NODES AT FIRST FLOWER

Source of Variation	Plant Height at First Flower (cm)	No. of Side Vegetative Branches at First Flower	Length of Side Vegetative Branches at First Flower (cm)	No. of Nodes on No-Pinched Plants at First Flower
Photoperiod Treatment	.01	.01	NS	NS
Pinching	.01	.01	.01	
Photoperiod Treatment X Pinching	NS	NS	NS	

TABLE V

EFFECT OF PHOTOPERIOD TREATMENT ON PLANT HEIGHT, LENGTH AND NUMBER OF SIDE VEGETATIVE BRANCHES AND NO. OF NODES (NO-PINCH ONLY) AT FIRST FLOWER

Treatment	No-Pinch or Pinched	Plant Ht. at First Flower (cm)	No. of Side Vegetative Branches at First Flower	Length of side Vegetative Branches at First Flower (cm)	No. of Nodes on No-Pinched Plants at First Flower
9 Hour Day	No-Pinch	13.9	2.7	5.0	5.3
	Pinched				
Light 5:00-10:00 p.m.	No-Pinch	23.1	2.8	4.7	6.6
	Pinched	26.1	3.5	7.7	
Light 10:00 p.m. - 3:00 a.m.	No-Pinch	22.8	3.6	4.2	6.2
	Pinched	24.6	3.7	7.6	
24 Hour Day	No-Pinch	24.5	3.4	5.3	6.7
	Pinched	26.9	3.5	9.6	

TABLE VI

EFFECT OF PHOTOPERIOD TREATMENTS ON PLANT HEIGHT, NO. AND LENGTH OF SIDE VEGETATIVE BRANCHES AND NO. OF NODES (NO-PINCH ONLY) AT FIRST FLOWERING

Photoperiod Treatment	Mean of Plant Height at First Flower (cm)	No. of Side Vegetative Branches at First Flower	Length of Side Vegetative Branches at First Flower	No. of Nodes on No-Pinched Plants at First Flower
9 Hour Day	13.3[b][y]	2.6[b]	3.9[a]	5.5[a]
Light 5:00-10:00 p.m.	24.6[a]	3.1[ab]	6.2[a]	6.2[a]
Light 10:00 p.m. - 3:00 a.m.	23.7[a]	3.6[a]	5.9[a]	6.6[a]
24 Hour Day	25.7[a]	3.4[a]	7.4[a]	6.8[a]

[y]Mean separation in columns by Duncan's Multiple Range Test, 5% level.

Table VI data show that over both pinching methods there were no significant differences in number or length of side branches for any of the long day treatments.

Number of Nodes at First Flower

There were no significant differences among treatments in the number of nodes at first flower (Tables IV, VI).

Measurements at Termination of the Experiment,
Eleven Weeks After Start of the Photoperiod
Treatments(Started March 12,Terminated May 28)

Final Plant Height

Photoperiod and pinching significantly affected final plant height (Tables, VII, VIII, and IX). It is interesting that in all cases, No-Pinch plants were slightly taller than pinched plants at the end of the experiment (Table VIII), whereas at first flowering (Table V), the reverse was true. Later internode elongation of the main stem on No-Pinch plants contributed to overall greater height. Also, all plants were measured for final height, whereas earlier, only those that flowered were measured.

When only photoperiod was considered (Table IX), a striking difference in final plant height was noted between 9 hour day plants and those in the three long day treatments, with the short day plants being much shorter than any of the long day plants. There were no significant differences between any of the long day treatments.

TABLE VII

SIGNIFICANCE OF MAIN EFFECTS AND INTERACTIONS FOR FINAL PLANT HEIGHT, VEGETATIVE DRY WEIGHT AND TUBER FRESH WEIGHT

Source of Variation	Plant Height (cm)	Vegetative Dry Weight (g)	Tuber Fresh Weight (g)
Photoperiod Treatment	0.01	0.01	0.01
Pinching	0.05	NS	NS
Photoperiod Treatment X Pinching	NS	NS	NS

TABLE VIII

EFFECT OF PHOTOPERIOD TREATMENTS AND PINCHING ON FINAL PLANT HEIGHT, VEGETATIVE DRY WEIGHT AND TUBER FRESH WEIGHT[y]

Treatment	No-Pinch or Pinched	Mean Final Plant Ht. (cm)	Mean Vegetative Dry Wt. (g)	Mean Tuber Fresh Wt. (g)
9 Hour Day	No-Pinch	12.2	2.0	19.2
	Pinched	11.9	1.6	19.4
Light 5:00-10:00 p.m.	No-Pinch	33.1	6.7	1.4
	Pinched	30.7	7.1	1.3
Light 10:00 p.m. - 3:00 a.m.	No-Pinch	31.7	7.1	1.3
	Pinched	28.4	6.6	1.5
24 Hour Day	No-Pinch	33.0	7.0	1.4
	Pinched	31.7	7.6	1.3

[y]Final data were recorded 11 weeks from the start of the experiment (started March 12).

TABLE IX

EFFECT OF PHOTOPERIOD TREATMENTS (OVER BOTH PINCHING METHODS) ON FINAL PLANT HEIGHT, VEGETATIVE DRY WEIGHT AND TUBER FRESH WEIGHT[y]

Photoperiod Treatment	Mean Final Plant Height (cm)	Mean Vegetative Dry Wt. (g)	Mean Tuber Fresh Weight (g)
9 Hour Day	12.1[b]	1.8[b]	19.3[a]
Light 5:00 - 10:00 p.m.	31.9[a]	6.9[a]	1.4[b]
Light 10:00 p.m. - 3:00 a.m.	30.0[a]	6.9[a]	1.4[b]
24 Hour Day	32.3[a]	7.3[a]	1.3[b]

[y]Final data were recorded 11 weeks from the start of the experiment (started March 12).

[z]Mean separation and columns by Duncan's Multiple Range Test, 5% level.

Final Above-Ground Vegetative Dry Weight

Photoperiod significantly affected dry weight but pinching did not (Table VII). The only really significantly difference was due to short versus long day treatment, and the 9 hour day plants weighed much less than plants in any of the long day treatments. No significant differences were found between long day treatments (Tables VIII and IX).

Tuber Fresh Weight

The only significant effect on tuber fresh weight was caused by photoperiod (Table VII), and the effect was great (Tables VIII and IX). Short day plants' (9 hour day) tubers averaged 19.2 grams for No-Pinch plants and 19.4 grams per tuber for Pinched plants; and long day plants' (Light 5:00 - 10:00 p.m.; Light 10:00 p.m. - 3:00 a.m.; and 24 hour day) tubers averaged only 1.3 and 1.5 grams per tuber, respectively. All of the long day treatments were effective in preventing tuber enlargement. Rapid tuber development, if desired, could be obtained by maintaining short day treatment.

Although not statistically significant, it appears that the 24 hour day photoperiod may have had a slightly stronger "long day" effect than lighting from 5:00 - 10:00 p.m. or lighting from 10:00 p.m. - 3:00 a.m. because plant height and dry weight were greatest and tuber weight the least in the 24 hour day treatment (Table IX).

CHAPTER IV

PRINCIPAL CONCLUSIONS

Extending the daylength by lighting from 5:00 to 10:00 p.m. was generally just as effective as breaking up the night period with lighting from 10:00 p.m. - 3:00 a.m., even though a 10-hour uninterrupted dark period (10:00 p.m. - 8:00 a.m.) existed in the former treatment as compared to only a five hour uninterrupted dark period (3:00 a.m. - 8:00 a.m.) for the latter treatment.

No practical advantage would be gained by lighting to achieve a 24-hr. daylength, although there were slight trends (not statistically significant) to indicate that this treatment had a slightly stronger long day effect.

Classic photoperiod effects on tuberous begonias were evident in this experiment, with greatly reduced growth and flowering occuring in short days, although 'dormancy' might not be correct because the plants continued to grow, and also produced large tubers during continuous short day treatment. Long days enhanced both vegetative growth and flowering, and would be a necessity if large flowering plants were desired during natural short day periods.

One of the most striking effects of photoperiod was seen in tuber development, and all three long day treatments employed were effective in preventing significant tuber development. The 'triggering' process for tuber development related to photoperiod must be very sensitive.

Pinching delayed flowering and probably would not be necessary to produce saleable plants in 10 cm (4-inch) pots, but branches on No-Pinch plants did not elongate sufficiently to produce nice, full plants without pinching if grown in 15 cm (6-inch) pots, one plant per pot. Genetic variation of seedlings probably resulted in the failure of 100% of plants in any treatment to flower during the 11 weeks of photoperiod treatments. Selection of early-flowering clones and vegetative propagation of these clones might provide more uniformity for commercial growers.

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