EFFECTS OF TIME OF PROPAGATION AND SUPPLEMENTAL LIGHT ON FLOWERING OF POINSETTIA, *EUPHORBIA PULCHERRIMA*

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INTRODUCTION

The poinsettia, *Euphorbia pulcherrima* Willd., was introduced to the United States in 1825 from Mexico by Joel Robert Poinsett who was the first U. S. ambassador to that country. This plant which belongs to the family *Euphorbiaceae* has become one of the most popular potted plants for Christmas.

The popularization of poinsettia is credited to the Ecke family who grew them on a large scale in Hollywood, California, since 1906. In 1923 Garner and Allard determined that the poinsettia is a short-day plant. Since then, various researchers have investigated factors affecting growth and flowering of the poinsettia.

Relatively little is known about the requirements of poinsettias in Hawaii, which is situated between latitudes of 19° and 22° N. The climate of Honolulu is subtropical with mean monthly temperatures for the entire year between 71° and 78°F (Philipp, 1953).

The purpose of this investigation was to obtain information on the effects of time of propagation and supplemental lights on the growth and flowering of two poinsettia cultivars, 'Paul Mikkelsen' and 'Henriette Ecke.'

REVIEW OF LITERATURE

The effects of photoperiod on poinsettia, _Euphorbia pulcherrima_, were first recorded by Garner and Allard in 1923. They showed that poinsettias are short-day plants. Several years later, Post (1937, 1941) reported that flower buds were initiated when the natural daylengths decreased close to 12 1/4 hours and were adversely affected at temperatures higher than 65°F.

Several workers investigated flower bud initiation under natural conditions at different locations. Post (1937) found that plants initiated flower buds between October 10 and 20 at 42°N latitude, and Lattimer (1953) noted that flower initiation occurred near September 25 at 40°N latitude. Kofranek and Sciaroni (1954) observed that flower bud initiation occurred between September 25 and October 12 at 38°N latitude depending on variety and light intensity. Post (1949) mentioned that as far south as 26°N latitude plants reached their peak bloom in late January.

According to Mitlehner and Davidson (1961), long-day effects can be obtained on poinsettias at light intensities above 0.3 to 1.8 foot candles. Miller and Kiplinger (1961) provided supplemental light in the middle of the night from September 22 to October 10 to cuttings taken on September 1. Flowering of the plants subjected to light for 15 minutes nightly was delayed for 12 days, whereas lighted for 1 or 4 hours flowering was delayed by 18 days. This investigation clearly indicates that the duration of supplemental light also affects flowering of the poinsettia.

The effects of time of propagation on flowering were investigated by Goddard (1961). He observed that date of propagation between July and September had very little effect on the time of flower initiation under natural daylengths. The first flower primordia were visible between October 3 and 8 in 1958 and between October 9 and 20 in 1959.

The relation of temperature and photoperiod has been considered important in preventing or promoting the initiation of flower buds. Langhans and Larson (1960) showed that flowering was prevented by night temperatures of 80°F regardless of day temperature, but when temperatures under 70°F were applied at night, earlier flowering was obtained. With short-day treatments flowering was promoted most rapidly at 70°F night temperature. When the day temperature was increased from 60° to 80°F with night temperature at 60°F, flowering was 15 days earlier.

Work by Langhans and Miller (1960) showed a very close relationship between temperature and photoperiod. They reported that the higher the temperature, the shorter the daylength necessary for flowering. When plants were under 60°F, 11 1/2 hour days were required, when 70°F was given, 10 1/2 hour days were needed, and at 80°F, 8 1/2 hour days were necessary in flowering of each group.

Larson and Langhans (1963) further tested the interaction of temperature and photoperiod on the cultivar, 'Barbara Ecke Supreme.' When the plants were grown under a 9-hour photoperiod, flower initiation occurred in 16 days at 70°F, 18 days at 60°F and 65°F, 24 days at 50°F, and 30 days at 80°F.

An experiment with combinations of photoperiod and night temperatures was employed by Kofranek and Hackett (1965) to determine the environmental conditions which inhibit flower initiation in 'Paul Mikkelsen.' They noticed that flower bud initiation in this cultivar occurred under widely varying temperatures and daylengths, and this cultivar tended to stay in a vegetative condition under 10 hour days and at high temperatures of 70° and 80°F, but it eventually showed bud initiation even under these conditions. They concluded that flower bud initiation was favored by short photoperiods and a night temperature of approximately 65°F. In contrast, Goddard (1961) reported for 'Barbara Ecke Supreme' that vegetative growth stopped at 62°F at the onset of short days, and flower initiation was more rapidly promoted at 68°F than at 62°F. The initiation was more uniform with an 8-hour daylength than with 11 or 12 hours daylengths.

Hackett and Miller (1967) exposed plants of 'Paul Mikkelsen' and 'Barbara Ecke Supreme' to two temperature regimes and several lengths of light interruption during the dark period. Two light intensities were also used for 'Paul Mikkelsen' plants with various durations of photoperiods. They concluded that the most outstanding difference in the control of floral initiation in the two cultivars depended upon their response to temperature. There was almost no difference in the length of photoperiod required for initiation but to prevent bud initiation in both cultivars high temperatures (72°F minimum, 85°F maximum) were required. When low temperatures (59°F minimum, 75°F maximum) were applied to the two cultivars, 'Barbara Ecke Supreme' remained in a vegetative condition with 2 hours of light at 10 foot candles, whereas 'Paul Mikkelsen' showed floral primordia even under 4 hours of light. On the other hand, under high temperatures (70°F minimum, 81°F maximum) 10 foot candles of incandescent light was as effective as 35 foot candles in preventing flower bud initiation in 'Paul Mikkelsen.'

For preventing premature budding in 'Paul Mikkelsen' Kofranek, Hackett, and Miller (1965) suggested lighting at least 4 hours in the middle of the night at a minimum light intensity of 10 foot candles in the darkest corners and growing the stock plants at a minimum night temperature of 70°F. They noted that lighting during the night for as long as 2 hours was not as effective in preventing bud initiation as lighting for 4 or 8 hours.

Excessive elongation of the inflorescence peduncle has been attributed to photoperiod and temperature. Kofranek, Hackett and Miller (1965) observed premature flower buds on 'Paul Mikkelsen,' which had initiated but not developed into normal flowers. When the primary cyathium failed to develop, it caused undesirable branching by breaking the apical dominance. If initiation occurs in late September or early October, the peduncles elongate and eventually produce a large flower head. It was believed that this abnormality occurs more often in 'Paul Mikkelsen' because this cultivar can initiate flower buds even under unfavorable environmental conditions but their further development is usually inhibited. Shanks (1965) reported that "flower splitting" was increased at high temperatures and when additional lighting was applied at night. It was most common when these treatments were combined. More recently Schupp (1968) working with cultivars 'Cardinalis' and 'Barbara Ecke' showed that such branching resulted from a period of 10 short days followed by 12 long days inserted between the usual change from long-day to short-day treatment.

MATERIALS AND METHODS

Two cultivars of Euphorbia pulcherrima, 'Paul Mikkelsen' and 'Henriette Ecke,' were selected for this investigation. The former is one of the most popular cultivars in mainland greenhouses, and the latter is widely cultivated in Hawaii.

The soil used was sterilized at 160°F for 30 minutes. The soil mix for cuttings was 1:1:1 mixture of soil, peat and perlite, and for potted plants was 3:1:1.

Plants were watered manually 1 to 3 times a day depending on the weather condition. During winter less watering was required but during summer and fall plants had to be watered as often as 3 times a day.

All potted plants were fertilized with Foliar-63 (21:21:21). Twenty ounces of the fertilizer were dissolved in 5 gallons of water and applied to the plants with Hozon water proportioner biweekly from May 6 to August 5 and once a week thereafter.

Data on color initiation of bracts, peak condition of flowering, diameter of flower head, and height of plant were recorded. The term flower used in this investigation refers to the combination of bracts and the true flowers of cyathia of the poinsettia. Plants were observed carefully every other day from November 1 in order to establish as accurately as possible the date of initiation of bract color. Usually red color showed first at the tip of the bract. Later, the color spread out over the entire bract. Peak of flower condition was determined in the case of 'Henriette Ecke' by the attainment of a maximum size of head and the development of bracts at the normal site of cyathia. With 'Paul

Mikkelsen' the number of open cyathia was the basis for the determination of peak flower condition. When the flower produced 5 cyathia with developed anthers it was considered to be in peak condition. The diameter of head and the height of plant were measured at the time of termination of the experiments.

The data obtained were summarized and analyzed according to the analysis of variance and Duncan's Multiple Range Test. The results of significant tests at the 5% level have been included in the tables by means of alphabets.

Experiment 1. The effect of time of propagation on flowering of poinsettia.

In order to establish the appropriate time for propagation of the two cultivars, cuttings were made at various dates from March through September. The treatments are shown in Table I. Each treatment consisted of 5 replicates and 2 plants in each pot.

Five-inch hardwood cuttings of 'Paul Mikkelsen' were taken from stock plants for treatments 1 to 3. Cuttings were taken on March 14 and rooted in flats. They were transplanted into 6-inch pots on May 9. With 'Henriette Ecke' rooted 9-inch hardwood cuttings were received from Paul Ecke, Inc., California, on March 22 because hardwood propagation material of this cultivar was not available. These were planted directly in 6-inch Lerio cans for treatments 1 to 3. The plants were kept in a shaded greenhouse until they were established, at which time they were moved into a saran house. Plants in the above treatments were pinched on June 15. The second pinch was performed on August 25 for treatment 1, September 1 for treatment 2 and September 9 for treatment 3.

Hardwood cuttings of both cultivars were used for treatments 4 to 6. Four-inch hardwood cuttings were made on June 15 and rooted cuttings were potted in 6-inch pots on July 29. Plants were pinched on August 25 for treatment 4, September 1 for treatment 5 and September 9 for treatment 6.

In treatments 7 to 10 plants were grown as single stems. Softwood cuttings were taken on August 26 for treatment 7, September 2 for treatment 8, September 9 for treatment 9 and September 16 for treatment 10. In order to minimize shock due to transplanting, the cuttings were

TABLE I. TREATMENTS TO DETERMINE THE EFFECT OF TIME OF PROPAGATION ON FLOWERING OF POINSETTIA.

Treatment No.	Date of propagation	Type of cutting	Date of first pinch	Date of second pinch
1	Mar. 15	Hard	June 15	Aug. 25
2	Mar. 15	Hard	June 15	Sept. 1
3	Mar. 15	Hard	June 15	Sept. 9
4	June 15	Hard	Aug. 25	
5	June 15	Hard	Sept. 1	
6	June 15	Hard	Sept. 9	
7	Aug. 26	Soft		
8	Sept. 2	Soft		
9	Sept. 9	Soft		
10	Sept. 16	Soft		

rooted in 2 1/4-inch Jiffy Pots under intermitten mist and potted as soon as the cuttings rooted.

All transplanted plants were grown in a saran house which provided approximately 30% shade.

Experiment 2. The effect of light intensity on flowering of poinsettia.

This experiment was designed to determine the effect of light intensity in delaying or preventing flowering in the two cultivars. The treatments are presented in Table II. Each treatment consisted of 4 replicates and 2 plants in each pot.

Five-inch hardwood cuttings of 'Paul Mikkelsen' were taken from stock plants. Cuttings taken on March 14 were rooted in flats, and they were transplanted into 6-inch pots on May 9. With 'Henriette Ecke' rooted 9-inch hardwood cuttings were received from Paul Ecke, Inc., California, on March 22 and planted directly in 6-inch Lerio cans. The plants were kept in a shaded greenhouse until they were established, at which time they were moved into a saran house. All plants were pruned on June 15.

The plants were moved outdoors for supplemental light treatments on August 26. The source of light was a 300 watt incandescent lamp mounted 6.7 feet above ground. This light provided 62 foot candles directly below the source but about 4.8 feet above ground. The light was applied for 4 hours from 10 p.m. to 2 p.m. from August 26, 1968 to February 1, 1969 when the experiment was terminated. Plants were spaced 2 feet apart beginning with treatment No. 1 as shown in Table II. The light intensities at plant height on February 2 are shown in the same table.

TABLE II. TREATMENTS TO DETERMINE EFFECT OF LIGHT INTENSITY ON FLOWERING OF POINSETTIA.

Treatment No.	Distance in feet from spot directly below light source	Foot candles at plant height on February 2
1	2	26.20
2	4	11.91
3	6	5.88
4	8	3.47
5	10	2.07
6	12	1.85
7	14	0.90
8	16	0.83
9	18	0.20
10	20	0.16

Experiment 3. The effect of supplemental light on flowering of poinsettia.

In order to study the effect of supplemental light on flowering of the cultivars and to indirectly determine the normal date of floral initiation of poinsettias in Hawaii, 10 different light treatments were made from August 15 through October 18. The treatments shown in Table III consisted of 5 replicates and 2 plants in each pot.

Rooted 9-inch hardwood cuttings of 'Henriette Ecke' were received from Paul Ecke, Inc., California, on March 22 and planted directly in 6-inch Lerio cans. These were pinched on June 15 and August 15. Rooted cuttings of 'Paul Mikkelsen' were received from Mikkelsen and Sons Greenhouses, Inc., Ohio, on June 18 and were planted directly in 6-inch cans. These plants were pruned on August 15.

The experiment was carried out in the saran house. All plants with the exception of the control (treatment 10) were placed under supplemental lights on August 15. Lights were provided by mounting 100-watt incandescent lamps with reflectors 4 feet above ground and spaced 3 1/4 feet apart. The light intensity at plant height was at least 10 foot candles. The lighting schedule was 4 hours at night from 10 p.m. to 2 a.m. Treatments 1 to 9 were removed from the supplemental light to natural daylengths at weekly intervals. Removal dates from the supplemental lights and the number of weeks under light are shown in Table III.

TABLE III. TREATMENTS TO DETERMINE THE EFFECT OF SUPPLEMENTAL LIGHT ON FLOWERING OF POINSETTIA.

Treatment No.	Date of removal from supplemental light	No. of weeks under light
10	Control	0
1	Aug. 23	1
2	Aug. 30	2
3	Sept. 6	3
4	Sept. 13	4
5	Sept. 20	5
6	Sept. 27	6
7	Oct. 4	7
8	Oct. 11	8
9	Oct. 18	9

RESULTS

Experiment 1. The effect of time of propagation on flowering of poinsettia.

'Paul Mikkelsen' in treatments 1 to 6 showed extreme variability in growth and flowering, and consequently no significant differences were obtained. The variability of propagation material and the unseasonably high temperatures during the fall months contributed to the poor performance of these treatments.

In contrast, treatments propagated from August 26 to September 16 showed differences in initiation of bract color, date of flowering, number of cyathia, diameter of head and plant height (Table IV, Fig. 1).

The date of initiation of bract color and date of peak flowering were delayed with delayed date of propagation. The differences were significant at the 5% level. It is obvious that the treatment propagated on September 16 was too late for Christmas since the plants reached peak flowering condition in January (Fig. 1D), and even the treatment propagated on September 9 was slightly late from the standpoint of producing marketable flowers for Christmas (Fig. 1C).

The number of days required from initial bract coloration to peak flowering condition for the treatments propagated from August 26 through September 16 were 22, 24, 23, and 27 days, respectively. This gradual increase of the number of days required for peak flower condition seems to be due to the seasonal decrease in daylengths.

The height of plants decreased with delayed date of propagation although the difference between the treatments propagated on August 26 and September 2 was not significant (Fig. 1A, 1B). The ultimate height

TABLE IV. NUMBER OF DAYS PRIOR TO JANUARY 1 FOR COLOR INITIATION AND PEAK FLOWERING CONDITION, HEIGHT OF PLANT, AND DIAMETER OF HEAD OF 'PAUL MIKKELSEN' IN EXPERIMENT 1.

Treatment No.	Date of propagation	No. of days prior to January 1 for color initiation (date)	No. of days prior to January 1 for peak flowering condition (date)	Diameter of head (inch)	Height of plant (inch)
7	Aug. 26	44.4 (Nov. 18)	22.0 (Dec. 10) (a)*	12.6 (a)	28.2 (a)
8	Sept. 2	41.8 (Nov. 20)	18.0 (Dec. 14) (b)	12.5 (ab)	27.0 (a)
9	Sept. 9	33.4 (Nov. 29)	10.6 (Dec. 21) (c)	11.5 (ab)	20.6 (b)
10	Sept. 16	18.0 (Dec. 14)	0.0 (January) (d)	7.2 (c)	10.4 (c)

* Data followed by a common letter are not significantly different from one another at the 5% level according to Duncan's Multiple Range test.

Figure 1. Date of propagation affecting flower development and plant height in 'Paul Mikkelsen' (Exp. 1). Photographed on Dec. 23, 1968.

A. Plants propagated on August 26.

B. Plants propagated on September 2.

C. Plants propagated on September 9.

D. Plants propagated on September 16.


A
B
C
D
1

of 28 and 27 inches for these treatments, respectively, are considered too tall for acceptability as pot plants. However, the height of the treatment propagated on September 9 was acceptable (Fig. 1C).

No significant differences in flower head diameter was obtained for the treatments propagated between August 26 and September 9 (Figs. 1A - 1C). The size for the treatment propagated on September 16 was significantly smaller (Fig. 1D). This reflects the small size of the plants of this treatment.

The results for 'Henriette Ecke' are shown in Table V. There were no significant differences among the treatments propagated on March 15 and June 15 for all characters (Figs. 2-7), despite the fact that the last date of pinch differed by as much as 2 weeks. However, in treatments propagated on June 15 which had the pinch dates of August 25, September 1 and September 9, respectively, peak flowering dates appeared to be delayed slightly with delayed pinching (Figs. 5-7).

Treatments propagated between August 26 and September 16 showed similar results as those with 'Paul Mikkelsen' (Figs. 8-11). Date of initiation of bract coloration and date of peak flowering condition were similar in the treatments propagated on August 26 and September 2 (Figs. 8, 9), but the treatments propagated on September 9 and September 16 showed a significant delay in flowering (Figs. 10, 11). Treatments propagated on August 26 and September 2 reached peak flowering condition about December 2 while treatment propagated on September 9 reached peak flowering on December 23 and treatment propagated on September 16 reached after Christmas. It may be noted that the treatments propagated on August 26 and September 2 reached peak flowering ahead of the treatments

TABLE V. NUMBER OF DAYS PRIOR TO JANUARY 1 FOR COLOR INITIATION AND PEAK FLOWERING CONDITION, DIAMETER OF HEAD, AND HEIGHT OF PLANT OF 'HENRIETTE ECKE' IN EXPERIMENT 1.

Treatment No.	Date of propagation	No. of days prior to January 1 for color initiation (date)	No. of days prior to January 1 for peak flowering condition (date)	No. of stems per pot	Diameter of head (inch)	Height of plant (inch)
1	Mar. 15	41.0 (Nov. 21)	14.0 (Dec. 18) (ab)*	5.4	11.8 (ac)	24.6 (ac)
2	Mar. 15	41.0 (Nov. 21)	17.0 (Dec. 15) (c)	6.2	12.3 (a)	27.2 (b)
3	Mar. 15	40.8 (Nov. 21)	17.0 (Dec. 15) (c)	5.8	11.0 (c)	24.0 (ac)
4	June 15	44.0 (Nov. 18)	21.2 (Dec. 11) (d)	3.1	13.8 (b)	26.2 (ab)
5	June 15	41.6 (Nov. 20)	14.2 (Dec. 18) (a)	5.4	12.7 (a)	22.2 (c)
6	June 15	42.0 (Nov. 20)	13.8 (Dec. 18) (ab)	3.4	12.4 (a)	22.2 (c)
7	Aug. 26	49.0 (Nov. 13)	30.0 (Dec. 2) (e)	2.0	14.4 (b)	24.6 (ac)
8	Sept. 2	46.0 (Nov. 16)	29.4 (Dec. 3) (e)	2.0	14.0 (b)	24.6 (ac)
9	Sept. 9	39.6 (Nov. 22)	9.0 (Dec. 23) (f)	2.0	12.7 (a)	19.8 (d)
10	Sept. 16	29.2 (Dec. 3)	0.0 (January) (g)	2.0	8.5 (d)	11.6 (e)

* Data followed by a common letter are not significantly different from one another at the 5% level according to Duncan's Multiple Range test.

Figure 2. 'Henriette Ecke' propagated on March 15 and pinched on June 15 and August 25, (Tr. 1, Exp. 1). Photographed on Dec. 23, 1968.

Figure 3. 'Henriette Ecke' propagated on March 15 and pinched on June 15 and September 1, (Tr. 2, Exp. 1). Photographed on Dec. 23, 1968.

Figure 4. 'Henriette Ecke' propagated on March 15 and pinched on June 15 and September 9, (Tr. 3, Exp. 1). Photographed on Dec. 23, 1968.

2

3

4

Figure 5. 'Henriette Ecke' propagated on June 15 and pinched on August 25, (Tr. 4, Exp. 1). Photographed on Dec. 23, 1968.

Figure 6. 'Henriette Ecke' propagated on June 15 and pinched on September 1, (Tr. 5, Exp. 1). Photographed on Dec. 23, 1968.

Figure 7. 'Henriette Ecke' propagated on June 15 and pinched on September 9, (Tr. 6, Exp. 1). Photographed on Dec. 23, 1968.


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6
7

Figure 8. 'Henriette Ecke' propagated on August 26 (Tr. 7, Exp. 1). Photographed on Dec. 23, 1968.

Figure 9. 'Henriette Ecke' propagated on September 2 (Tr. 8, Exp. 1). Photographed on Dec. 23, 1968.

Figure 10. 'Henriette Ecke' propagated on September 9 (Tr. 9, Exp. 1). Photographed on Dec. 23, 1968.

Figure 11. 'Henriette Ecke' propagated on September 16 (Tr. 10, Exp. 1). Photographed on Dec. 23, 1968.


8
9
10
11

propagated in March and June.

The diameter of flower head for the treatments propagated on August 26 and September 2 were larger than those of the treatments propagated in March and June. This can be explained by the fact that the former treatments were grown as single stem plants while the latter group as multiple stem plants.

As with 'Paul Mikkelsen' the treatment propagated on September 16 produced small plants with small flower heads developing into peak condition well after Christmas (Fig. 11).

Experiment 2. The effect of light intensity on flowering of poinsettia.

Plants under most of the treatments had remained in a vegetative condition up to Christmas except those under very low light intensities. Treatment 10 of 'Paul Mikkelsen' exposed to 0.16 foot candles just started showing bract coloration about Christmas (Table VI). Flower buds, however, were detectable in various stages in treatments receiving 0.90 to 0.16 foot candles. With 'Henriette Ecke' treatments receiving 0.83 to 0.16 foot candles had initiated or developed bract coloration by December 25. The recorded dates of bract coloration are presented in Table VII.

At the time of final evaluation on February 1, 1969, both cultivars receiving 26.20 to 2.07 foot candles were still prevented from flowering (Figs. 12A-E, Figs. 13A-E).

Dates of bract coloring for 'Paul Mikkelsen' are shown in Table VI. On February 1 the bracts developed to an immature stage in the treatment subjected to 1.85 foot candles (Fig. 12F), peak stage in treatments subjected to 0.90 and 0.83 foot candles (Figs. 12G, 12H) and advanced stage in treatments subjected to 0.20 and 0.16 foot candles (Figs. 12I, 12J).

Relatively long peduncles were observed for treatments between 1.85 and 0.16 foot candles in both cultivars (Fig. 14). The elongation of peduncles might be attributed to the photoperiods and high temperature effects.

The height of plants on August 26, 1968 at the date of initiation of treatments was relatively uniform. At the termination of the experiment, there was no difference in height among the treatments placed between 26.20 and 2.07 foot candles which remained in a vegetative

TABLE VI. NUMBER OF DAYS PRIOR TO FEBRUARY 1 FOR COLOR INITIATION, NUMBER OF CYATHIA, DIAMETER OF HEAD, LENGTH OF PEDUNCLE, AND HEIGHT OF PLANT OF 'PAUL MIKKELSEN' IN EXPERIMENT 2.

Treatment No.	Light intensity at plant height on February 1 (foot candle)	No. of days prior to February 1 for color initiation	No. of cyathia	Diameter of head (inch)	Length of peduncle (inch)	Height of plant on August 26 (inch)	Height of plant on February 1 (inch)
1	26.20	0	0	0	0	16.5	37.8 (abc)
2	11.91	0	0	0	0	15.1	39.5 (a)
3	5.88	0	0	0	0	15.3	36.8 (bcd)
4	3.47	0	0	0	0	14.9	38.0 (ab)
5	2.07	0	0	0	0	17.0	38.0 (ab)
6	1.85	27.0	0.6 (a)*	2.3 (a)	0.6 (a)	16.8	36.0 (bcde)
7	0.90	21.0	5.5 (a)	6.5 (ab)	2.3 (a)	15.3	35.5 (cde)
8	0.83	27.5	5.5 (a)	6.9 (ab)	3.2 (a)	16.0	35.0 (de)
9	0.20	24.6	13.9 (b)	15.8 (b)	3.4 (a)	16.4	33.8 (e)
10	0.16	37.7	17.5 (b)	10.8 (ab)	2.0 (a)	17.1	30.3 (f)

* Data followed by a common letter are not significantly different from one another at the 5% level according to Duncan's Multiple Range test.

TABLE VII. NUMBER OF DAYS PRIOR TO FEBRUARY 1 FOR COLOR INITIATION, DIAMETER OF HEAD, CONDITION OF BRACT DEVELOPMENT, LENGTH OF PEDUNCLE, AND HEIGHT OF PLANT OF 'HENRIETTE ECKE' IN EXPERIMENT 2.

Treatment No.	Light intensity at plant height on February 1 (foot candle)	No. of days prior to February 1 for color initiation (date)	Diameter of head (inch)	Condition of bract development	Length of peduncle (inch)	Height of plant on August 26 (inch)	Height of plant on February 1 (inch)
1	26.20	0	0	0	0	19.6 (a)	40.8 (ac)
2	11.91	0	0	0	0	21.6 (bc)	43.5 (ab)
3	5.88	0	0	0	0	21.0 (ab)	41.3 (ab)
4	3.47	0	0	0	0	22.9 (cde)	43.3 (ab)
5	2.07	0	0	0	0	22.1 (bcd)	44.0 (b)
6	1.85	19.0 (Jan. 13)	1.5 (a)*	Very immature	0	23.0 (cde)	41.8 (abc)
7	0.90	19.2 (Jan. 13)	5.3 (b)	Immature	0	24.3 (ef)	43.3 (ab)
8	0.83	37.5 (Dec. 25)	11.1 (c)	Intermediate	1.9 (a)	23.4 (de)	40.8 (abc)
9	0.20	43.4 (Dec. 20)	10.6 (c)	Intermediate	2.0 (a)	25.0 (fg)	38.8 (c)
10	0.16	44.6 (Dec. 18)	12.0 (c)	Mature	2.4 (a)	26.1 (g)	40.8 (abc)

* Data followed by a common letter are not significantly different from one another at the 5% level according to Duncan's Multiple Range test.

Figure 12. Stage of flower development of 'Paul Mikkelsen' under various light intensities (Exp. 2). Photographed on February 7, 1969.

Plants exposed to:

A. 26.20 foot candles (Tr. 1).

B. 11.91 foot candles (Tr. 2).

C. 5.88 foot candles (Tr. 3).

D. 3.47 foot candles (Tr. 4).

E. 2.07 foot candles (Tr. 5).

F. 1.85 foot candles (Tr. 6).

G. 0.90 foot candles (Tr. 7).

H. 0.83 foot candles (Tr. 8).

I. 0.20 foot candles (Tr. 9).

J. 0.16 foot candles (Tr. 10).

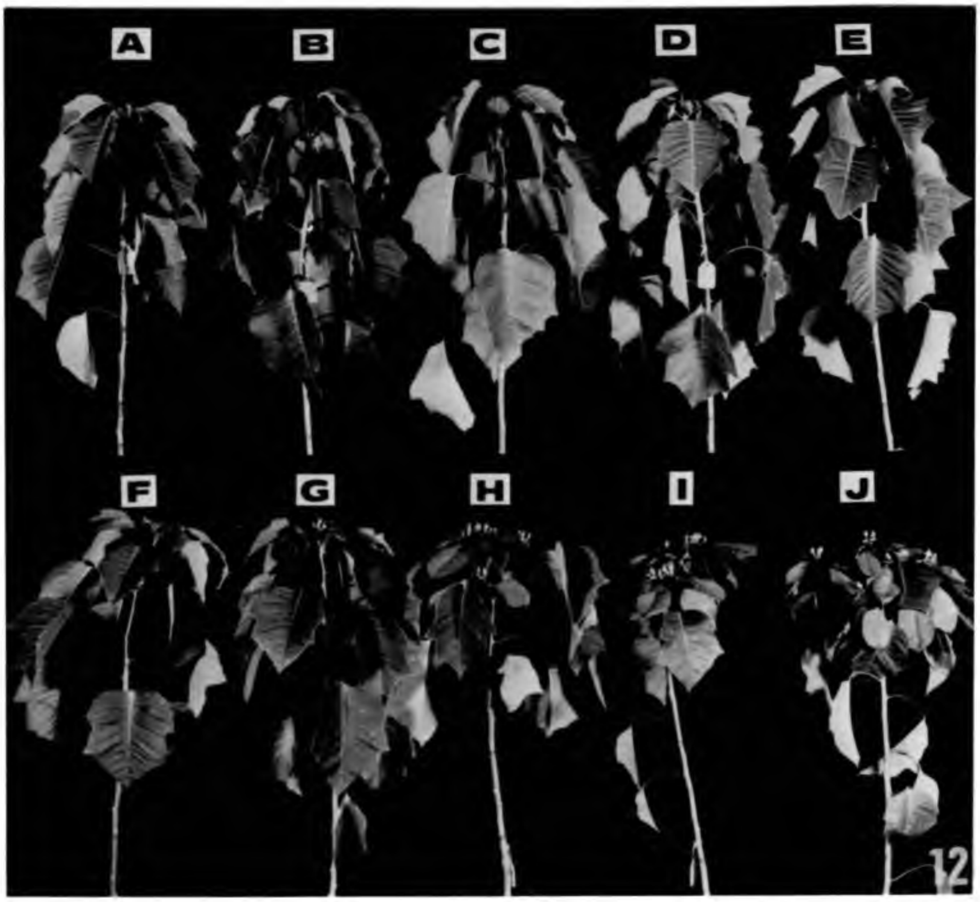
A
B
C
D
E
F
G
H
I
J
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Figure 13. Stage of flower development of 'Henriette Ecke' under various light intensities (Exp. 2). Photographed on February 7, 1969.

Plants exposed to:

A. 26.20 foot candles (Tr. 1).

B. 11.91 foot candles (Tr. 2).

C. 5.88 foot candles (Tr. 3).

D. 3.47 foot candles (Tr. 4).

E. 2.07 foot candles (Tr. 5).

F. 1.85 foot candles (Tr. 6).

G. 0.90 foot candles (Tr. 7).

H. 0.83 foot candles (Tr. 8).

I. 0.20 foot candles (Tr. 9).

J. 0.16 foot candles (Tr. 10).


A
B
C
D
E
F
G
H
I
J
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Figure 14. Elongated peduncle of 'Paul Mikkelsen.'

Figure 15. Abnormal bract development of 'Henriette Ecke' in Exp. 2.


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condition, but treatments between 1.85 and 0.16 foot candles showed a progressive decrease in height which could be directly correlated with floral initiation and development. As can be expected plants receiving 0.16 foot candles were in the most advanced stage of floral development and were the shortest.

With 'Henriette Ecke' the results obtained were similar to those of 'Paul Mikkelsen' (Table VII, Fig. 13). However, plant height with this cultivar was highly variable even at the beginning of the experiment on August 26, 1968 and no significant differences were observed at the termination of the test. Also, this cultivar, unlike the upright habit of 'Paul Mikkelsen,' tended to produce spreading and drooping stems. As a consequence some of the drooping branches flowered in advance of the more upright stems.

Even with those stems which flowered, development was often irregular. The side closer to the light source was retarded as seen in Fig. 15.

Experiment 3. The effect of supplemental light on flowering of poinsettia.

The number of mature cyathia recorded at successive dates for 'Paul Mikkelsen' are presented in Table VIII. On December 2, at the first recording of cyathia, treatments lighted until August 23 to September 13 and the control showed about three mature cyathia each (Figs. 17-20, 16). Treatments lighted until September 20 and September 27 averaged 0.6 cyathia (Figs. 21, 22) while no mature cyathium was seen for treatments lighted to October 4 to October 18 (Figs. 23-25). The same pattern continued throughout the successive recordings. By December 22, the last day of observation, treatments lighted until August 23 to September 13 and the control were past their peak flowering condition with over 12 mature cyathia, while the treatment lighted until October 18 showed an average of 2.4 cyathia.

The results indicated that supplemental lighting prior to September 13 has little or no effect in delaying flower bud initiation of 'Paul Mikkelsen' in Hawaii because the normal photoperiods up to that time were long enough to prevent bud initiation. Since treatments involving supplemental lights provided after September 13 showed significant delays in flowering, it can also be concluded that the date or period of normal bud initiation for this cultivar lies between September 13 to September 20. The daylength for Hawaii at this time, including civil twilight, is about 12 hours and 35 minutes.

If one considers the stage of 5 mature cyathia as peak flowering condition from a sales standpoint, and if one prefers the peak condition to fall about a week ahead of Christmas, then treatments lighted until

TABLE VIII. NUMBER OF MATURE CYATHIA AND HEIGHT OF PLANT OF 'PAUL MIKKELSEN' AT SUCCESSIVE DATES IN EXPERIMENT 3.

Treatment No.	Date of removal from supplemental lights	Number of cyathia Date					Height of plant (inch)
		12/2	12/7	12/12	12/17	12/22	
10	Control	4.4 (a)*	6.9 (a)	9.4 (a)	12.5 (a)	17.4 (a)	24.9 (ae)
1	Aug. 23	2.4 (b)	3.4 (bcd)	4.6 (cd)	9.0 (abc)	15.9 (ab)	24.8 (ae)
2	Aug. 30	2.8 (ab)	3.3 (bcd)	5.0 (bcd)	7.9 (bc)	12.2 (abc)	27.3 (cde)
3	Sept. 6	4.0 (ab)	5.8 (ab)	7.7 (ab)	11.0 (ab)	14.9 (abc)	24.1 (a)
4	Sept. 13	3.4 (ab)	4.9 (abc)	6.6 (abc)	9.0 (abc)	13.6 (abc)	26.9 (de)
5	Sept. 20	0.6 (c)	1.7 (cde)	2.9 (def)	5.1 (cd)	10.4 (bc)	28.0 (bc)
6	Sept. 27	0.6 (c)	2.1 (cde)	3.6 (cde)	6.0 (cd)	10.2 (c)	26.0 (e)
7	Oct. 4	0.0 (c)	0.6 (de)	1.3 (ef)	2.2 (de)	4.6 (d)	28.8 (f)
8	Oct. 11	0.0 (c)	0.0 (e)	0.0 (f)	0.2 (e)	2.5 (d)	31.6 (cd)
9	Oct. 18	0.0 (c)	0.0 (e)	0.0 (f)	0.5 (e)	2.4 (d)	26.9 (ab)

* Data followed by a common letter are not significantly different from one another at the 5% level according to Duncan's Multiple Range test.

Figure 16. 'Paul Mikkelsen' without supplemental light (Tr. 10, Exp. 3). Photographed on Dec. 20, 1968.

Figure 17. 'Paul Mikkelsen' lighted from August 15 to August 23 (Tr. 1, Exp. 3). Photographed on Dec. 20, 1968.

Figure 18. 'Paul Mikkelsen' lighted from August 15 to August 30 (Tr. 2, Exp. 3). Photographed on Dec. 20, 1968.

Figure 19. 'Paul Mikkelsen' lighted from August 15 to September 6 (Tr. 3, Exp. 3). Photographed on Dec. 20, 1968.


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Figure 20. 'Paul Mikkelsen' lighted from August 15 to September 13 (Tr. 4, Exp. 3). Photographed on Dec. 20, 1968.

Figure 21. 'Paul Mikkelsen' lighted from August 15 to September 20 (Tr. 5, Exp. 3). Photographed on Dec. 20, 1968.

Figure 22. 'Paul Mikkelsen' lighted from August 15 to September 27 (Tr. 6, Exp. 3). Photographed on Dec. 20, 1968.

Figure 23. 'Paul Mikkelsen' lighted from August 15 to October 4 (Tr. 7, Exp. 3). Photographed on Dec. 20, 1968.


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Figure 24. 'Paul Mikkelsen' lighted from August 15 to October 11 (Tr. 8, Exp. 3). Photographed on Dec. 20, 1968.

Figure 25. 'Paul Mikkelsen' lighted from August 15 to October 18 (Tr. 9, Exp. 3). Photographed on Dec. 20, 1968.


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August 23 to September 13 and the control can be considered as too early (Figs. 17-20, 16). Treatments lighted to September 20 and September 27 showed desirable rate of flower development (Figs. 21, 22). On the other hand, treatments lighted until October 4 to October 18 produced an undesirable delay in flowering (Figs. 23-25). These results suggest that controlled flowering might be obtained with 'Paul Mikkelsen' by providing supplemental lights up to September 27.

The plant height was expected to increase with a corresponding delay in flowering. There were no significant differences although treatments lighted until August 23 to September 13 and the control averaged less than the rest (Figs. 16-20).

Similar results were obtained with 'Henriette Ecke' (Table IX). The results on flowering, however, were not as clear cut because of the difficulty in establishing the exact dates of peak flowering with this "double" cultivar. There were no significant differences in flowering among treatments lighted until August 23 to September 27 and the control. However, there were significant differences in plant height between the treatment lighted until September 27 and the treatments lighted until August 23 to September 20, thereby suggesting a possible differential response. Also with this cultivar, treatments lighted until October 11 and October 18 showed significant increases in plant height as expected of those with extended periods of vegetative growth.

On the basis of the results supplemental lighting prior to September 20 has little or no effect on flowering of 'Henriette Ecke.' The normal date of flower initiation probably lies between September 20 and 27 and the critical photoperiod for flower initiation may be

TABLE IX. NUMBER OF DAYS PRIOR TO JANUARY 1 FOR COLOR INITIATION AND PEAK FLOWERING CONDITION, AND HEIGHT OF PLANT OF 'HENRIETTE ECKE' IN EXPERIMENT 3.

Treatment No.	Date of removal from supplemental lights	No. of days prior to January 1 for color initiation (date)	No. of days prior to January 1 for peak flowering condition	Height of plant (inch)
10	Control	41.0 (Nov. 21) (cd)*	13.8 (Dec. 18) (a)	26.8 (a)
1	Aug. 23	44.8 (Nov. 17) (ab)	13.6 (Dec. 18) (ab)	26.9 (a)
2	Aug. 30	43.0 (Nov. 19) (bc)	11.4 (Dec. 21) (ab)	25.8 (a)
3	Sept. 6	45.6 (Nov. 16) (a)	18.2 (Dec. 14) (d)	25.4 (a)
4	Sept. 13	42.8 (Nov. 19) (bc)	21.0 (Dec. 11) (d)	26.4 (a)
5	Sept. 20	43.8 (Nov. 18) (ab)	14.4 (Dec. 18) (a)	25.4 (a)
6	Sept. 27	43.4 (Nov. 19) (abc)	12.0 (Dec. 20) (ab)	29.8 (b)
7	Oct. 4	40.0 (Nov. 22) (d)	10.0 (Dec. 22) (b)	27.0 (a)
8	Oct. 11	40.0 (Nov. 22) (d)	5.6 (Dec. 26) (c)	32.0 (bc)
9	Oct. 18	40.0 (Nov. 22) (d)	4.0 (Dec. 28) (c)	34.2 (c)

* Data followed by a common letter are not significantly different from one another at the 5% level according to Duncan's Multiple Range test.

slightly shorter than that for 'Paul Mikkelsen.' The daylength including civil twilight at this time in Hawaii is about 12 hours and 27 minutes.

The dates for peak flowering for this cultivar for treatments lighted until August 23 to September 27 and the control were satisfactory for cultivation. This probably explains why this cultivar has been cultivated year after year in Hawaii with fair degree of success.

DISCUSSION

Poinsettias are associated with Christmas and therefore should be in prime flowering condition at that time. The length of the period under cultivation and the time of flowering are important considerations for the commercial grower. In Hawaii poinsettias do not perform as in mainland greenhouses since daylengths, temperatures, and other environmental factors differ. Moreover, growers in Hawaii have not utilized greenhouses and temperature and daylength control systems. Floriculture in Hawaii is changing and it is conceivable that with this change poinsettias will be cultivated in greenhouses under better controlled environments.

The experiment on time of propagation can be divided into three groups: early hardwood cuttings propagated in March which is the conventional method for outdoor culture, hardwood cuttings propagated in June which is also practiced for outdoor culture when March propagations are inadequate, and softwood and single-stem plants propagated in August and September designed for greenhouse culture.

There are several advantages of the use of hardwood cuttings in March. Cuttings can be obtained from gardeners who cut back their poinsettias each year in March. Cuttings are relatively easy to root. Through two pinches, large, many-stemmed attractive plants can be produced. The major disadvantage is the long period of cultivation. However, the culture during the earlier period until the last pinch in August is not very critical. The height of the plant and the stage of flowering at Christmas are usually influenced by the date of final pinch.

The single-stem plants propagated as softwood cuttings from August 26 to September 16 showed significant differences as one might expect. The earlier the propagation the earlier was the peak flowering stage and the taller the plants. The best results were obtained from those propagated on September 9. However, further tests under improved greenhouse conditions should be conducted to determine the most suitable date of propagation of single-stem potted plants for Christmas.

Since poinsettias are short-day plants, Experiment 2 was designed to determine the amount of light intensity required to prevent or delay flowering. Light intensities obtained in this experiment ranged from 26.20 to 0.16 foot candles. At Christmas, the plants which received 0.83 to 0.16 foot candles showed various stages of flowering in both cultivars. This indicates that the light intensities were not effective in preventing flower initiation. Although the plants were not completely prevented from flowering, they were delayed several weeks in flowering in comparison with the plants that were entirely free from light treatment. At the time of final evaluation on February 1, 1969, the plants located within a range of 26.20 and 2.07 foot candles did not show any flower bud formation. This indicates that light intensities above 2 foot candles are required to prevent flower initiation.

Abnormal flower formation was observed when the plants were illuminated at low light intensities from one direction (Fig. 15). The illuminated side was prevented from normal development of bracts while the opposite side developed normally.

Excessive elongation of peduncle was observed in both cultivars, although less severe in 'Henriette Ecke' (Fig. 14). It was reported by

Kofranek, Hackett, and Miller (1965) that such undesirable branching was caused by the initiation of premature flower buds which caused breaking of the apical dominance. Shanks (1965) reported that such "flower splitting" was observed when high temperatures and additional lighting were provided. Schupp (1968) recently emphasized the effect of photoperiod on elongation of peduncle. The results obtained from the present experiments showed that 'Paul Mikkelsen' produced elongated peduncles under various treatments including those without supplemental lights. Thus high temperatures as well as photoperiods are factors causing such undesirable peduncle elongation, rather than photoperiod alone.

The recommended date of providing supplemental lights to plants is from September 20 to October 1 to 10 in mainland greenhouses since flower bud initiation in most areas occurs around September 25. However, the present experiment indicates that the normal date of bud initiation in Hawaii is between September 13 to September 20 for 'Paul Mikkelsen' and between September 20 to September 27 for 'Henriette Ecke.' The results obtained in this experiment indicate that the supplemental light should be provided slightly earlier in Hawaii than on the mainland. The daylengths of Hawaii, including civil twilight, are 12 hours and 35 minutes between September 13 and September 20 and 12 hours and 27 minutes between September 20 and 27. Consequently, the critical daylengths for the two cultivars are about 12 1/2 hours under Hawaii conditions.

SUMMARY

The purpose of this investigation was to determine the effects of time of propagation, light intensity and duration of supplemental lights on two cultivars, 'Paul Mikkelsen' and 'Henriette Ecke.'

To determine the appropriate date of propagation, plants were propagated in March, August, and September. Hardwood cuttings were propagated in March and pinched on June 15 and pinched a second time on August 25, September 1, and September 9 for treatments 1, 2, and 3, respectively. Plants propagated in June were also hardwood cuttings and pinched only once on August 25, September 1, and September 9 for treatments 4, 5, and 6, respectively. Softwood cuttings were propagated on August 26, September 2, September 9, and September 16 for treatments 7, 8, 9, and 10, respectively.

Plants propagated in March and June (treatments 1-6) showed similar flowering behavior, although with the June planting a slight delay in flowering which corresponded with the pinching dates was observed in 'Henriette Ecke.' With plants grown as single stems from softwood cuttings (treatments 7-10) there were considerable differences in time of peak flowering and height of plant. Delayed flowering and reduced height resulted with the corresponding delay in date of propagation. Best result was obtained from plants propagated on September 9.

To determine the effect of light intensity on flowering, plants were placed at various distances from a 300-watt incandescent lamp which was illuminated from 10 p.m. to 2 a.m. each night. Actual light intensities at plant height ranged from 26.20 to 0.16 foot candles. At

Christmas plants receiving between 0.83 to 0.16 foot candles of light showed various stages of flower development, while those receiving more than 0.90 foot candles remained vegetative. At the termination of the experiment on February 1, plants subjected to light intensities above 2.07 foot candles remained vegetative, while those below 1.85 foot candles were in various stages of floral development. Thus intensities above 2 foot candles are necessary to obtain a complete prevention of flower bud initiation for the two cultivars and intensities below 1.85 foot candles will not prevent flowering but will delay development.

In order to control flowering for Christmas it is necessary to establish the normal period of floral initiation in Hawaii. Plants were removed from supplemental lights at weekly intervals from August 23 to October 18. Delay in flowering was obtained for supplemental light treatments after September 13 for 'Paul Mikkelsen' and after September 20 for 'Henriette Ecke.' Accordingly the date of normal bud initiation was between September 13 and 20 for 'Paul Mikkelsen' and between September 20 and 27 for 'Henriette Ecke.' Light treatments after those dates delayed flowering corresponding with the duration of the supplemental light treatments. The critical daylengths determined for the two cultivars were about 12 1/2 hours. The best results for Christmas flowering were obtained when plants were lighted until September 27.

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