# EFFECTS OF HIGH PRESSURE SODIUM LAMP ILLUMINATION AND COOLING ON THE FLOWERING OF *APHELANDRA SQUARROSA* NEES 'DANIA'


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EFFECTS OF HIGH PRESSURE SODIUM LAMP
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# CHAPTER I

# INTRODUCTION

After a slow down in the early 1960's, the tropical foliage plant industry has seen great increases in sales in the late 1960's and early 1970's (2, 3, 33). One tropical foliage plant *Aphelandra squarrosa* Nees (Zebra plant), unlike many, is not only produced for its dark, glossy-green and white-striped foliage, but also for its four-sided, bright yellow flower spike (6, 28). However, producing uniform flowering plants is often difficult, especially in seasons of low light intensity due to long production time and sporadic flowering which in turn complicates marketing of the plants (19). A method of producing a more consistent flowering crop with a shorter production time would prove beneficial for producers.

High intensity supplemental lighting of plants with high pressure sodium (HPS) lamps has resulted in reduced production time in several floricultural crops (1, 11, 13). Based on this information and other research findings relating *Aphelandra* flowering to light intensity (25, 35) and/or cooling treatment (7, 15, 22, 32), a decision was made to:

A. Investigate the effects of 24 hour high intensity supplemental lighting with high pressure sodium lamps on the flowering of *Aphelandra squarrosa* 'Dania'.

B. Determine the effect of cooling at 10° C. and 24 hour 50 ft-c incandescent lighting on *Aphelandra* flowering.

C. Compare the overall plant appearance and flowering date from the above treatments to a natural light control.

D. Analyze the possible commercial applications and production costs.

# CHAPTER II

## REVIEW OF LITERATURE

Research with *Aphelandra squarrosa* has shown that flowering is not affected by low intensity photoperiodic lighting (6, 7, 24, 37). Growth retardants such as Cycocel or B-Nine have also failed to stimulate flower buds (6, 30). *Aphelandra* have been shown to be photocumulative, that is they must be grown at a certain light intensity over a period of time to induce flowering (19, 25, 35). Herklotz (24) reported that there appeared to be a critical daily light duration and intensity dose below which flower formation did not occur. In articles by Laurie (29), Poole and Conover (34), it was stated that plants that received 1,000-1,500 ft-c, flowered in approximately 16 weeks. If the plants received less than 300-400 ft-c they remained vegetative.

Temperature has also been reported to cause a fluctuation in flowering time (35). Christensen (15) working with *Aphelandra squarrosa* 'Dania' found that the optimum temperature for flower induction was 10° C. for a minimum of 6 weeks. He noted that induction took longer at higher temperatures. Other research (37), using several photoperiodic and temperature treatments for a 7 week period also showed the optimum temperature to be 10° C. with higher temperatures delaying flower formation. Otto (32) found that Aphelandra squarrosa 'Dania', when subjected to a two-month cooling period (5° C.) between November and February, flowered on April 22 compared to June 5 for uncooled plants. Uncooled plants flowered irregularly, but cooled plants were uniform in foliage and flowers with good quality and market value.

Heide (22) growing Aphelandra squarrosa 'Dania' and 'Ivo' under natural low intensity light stated that flowering was promoted by 9° or 12° C. temperature treatments for 9 or 12 weeks, but shorter periods and higher temperatures (18°, 21°, and 24° C.) had no effect. Herklotz (24) found that higher temperatures (25°-27° C. compared to 20°-22° C.) promoted growth and flower development but did not change the light threshold for flower induction. Heide and Hildrum (23) found that Aphelandra squarrosa 'Fritz Prinsler' flowered earliest at a high night temperature (21° C.) when grown under high light intensity, but when grown under low light intensity, plants did not flower after 21 weeks at 21° C. If these plants were then transferred to high light intensity and 12° or 15° C., they flowered after 10 weeks but they still did not flower after 10 weeks if kept at 21° or 24° C. Brundert and Stratmann (7) reported that when the temperature was lowered during periods of low illumination flowers were formed.

Few studies have been done using supplementary light on *Aphelandra*. Brundert and Stratmunn (7) found that "plants could be forced at 20° C. with supplementary fluorescent light at night (lamps 50 cm above plants) in January and February but flowering and growth were poorer than with the cooling treatments". Habermann (18) reported that *Aphelandra squarrosa* could be produced year-round by growing 'Dania' in the summer and 'Typ Koniger' in the winter because the latter has a lower light requirement for flower induction. He also found that 'Dania' potted in January flowered earlier and more uniformly with supplementary fluorescent light (200 ft-c for 12 hours), although 'Typ Koniger' potted on the same date and receiving no light treatment, flowered earliest. Fearon (16) found that when *Aphelandra* were given long days by fluorescent lamps in the winter, faster growth resulted. Hall (20) reported that fluorescent lighting with a two-hour night break resulted in longer leaves.

High Intensity Discharge (HID) lamps have been tried in the past with limited success (10), but more recently good results have been obtained with a newer high pressure sodium (HPS) type of HID lamp. These HPS lamps have already been used with success on chrysanthemums, bedding plants, snapdragons, roses, poinsettias, impatiens, geraniums, cinerarias, begonias, gloxinias, and African violets (1, 4, 5, 8, 11, 12, 14, 27, 31, 36, 38, 39). As one example, rose growers in Connecticut received a 73 to 100%

increase in winter flower production. Based on costs and revenues during the experiment a return on investment in excess of 30% could be achieved (34).

One of the HPS lamps, produced by General Electric Co., is the Lucalox lamp equipped with Luminares which help insure uniform distribution of the light over the bench area (20). HPS lamps can provide higher levels of radiant energy in more uniform distribution than is possible with other commonly used sources (8), as well as being more efficent (30%) in converting electric energy into radiation energy (26, 40). They also have longer life than fluorescent lights and require half the voltage and electrical connections for the same level of illumination (9). For these reasons HPS lamps were selected to determine their effect on the flowering of *Aphelandra squarrosa*.

# CHAPTER III

## MATERIALS AND METHODS

Rooted leaf bud cuttings were planted November 8, 1974, in 13.75 cm (5½ in.) clay pots and given a 4 week establishment period under two layers of cheesecloth (average 600 ft-c on randomly selected days at 1:30 pm) on the west side of the glass house. The soil mix used was a mixture of one part sandy soil, two parts peat and two parts perlite. On December 6 the cheesecloth shading was removed and the following treatments were started (the plant heights averaged 56 mm at this time):

Treatment 1. Greenhouse natural light control (full incident light 1558 ft-c average at 1:30 pm for 6 weeks).[1]

Treatment 2. 6 weeks cooling at 10° C. and 24 hours of incandescent lighting at 50 ft-c in a growth chamber.

Treatment 3. 6 weeks of 24 hours supplemental lighting under 400 watt High Pressure Sodium

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[1]No shading was used for the 6 weeks treatment period. After this treatment period cheesecloth shading was again used to reduce the natural light intensity on all plants in all treatments.

(HPS) lamps[2] at 21° C. minimum in a glass greenhouse with full natural light.

Treatment 4. 3 weeks of supplemental light under 400 watt HPS lamps at 21° C. minimum with full natural light followed by 3 weeks of cooling at 10° C. with 24 hours incandescent lighting at 50 ft-c in a growth chamber.

After the above 6 weeks treatment period, the plants in treatments 2, 3, and 4 were moved back to their original pot positions with plants in treatment 1 located on the west side of the greenhouse (Figure 1). A randomized complete block design was used with 32 plants per treatment, 4 replications of 8 plants each. The block design was formed as follows: 32 plants were placed in each of the 4 block (replication) locations on the west side of the greenhouse (Figure 1). The plants were spaced 17.5 x 17.5 cm (7.5 x 7.5 in.) in a 4 x 8 plant arrangement with border rows surrounding all 4 sides.

An additional 16 plants per replication (to be used as filler plants)[3] were placed under the Lucalox lamps on

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[2]General Electric Lucalox LU 400-BU High Pressure Sodium Lamps with Wide Lite IL 409-DT-WRB-LX Luminares.

[3]Filler plants were used in addition to border rows so that all treated plants when moved to their treatment locations were always surrounded on all 4 sides by other plants to keep competition constant.

Figure 1. Randomized Complete Block Design With the 4 Replications on the West Side of the Greenhouse.

the east side of the house at the same spacing, again with surrounding border rows (Figure 2). These plants were placed off-center in 3 rows since another research project with crapemyrtlettes occupied part of the space under the lamps (Figure 2).

Another 16 filler plants per replication were also placed in a growth chamber, in randomized complete block design, with 4 blocks in a 4 x 4 plant arrangement (21) to be used for the 10° C. cooling treatment.

The plants for treatments 1 through 4 in each block (west side of house) were numbered 1 through 32 and randomly selected as to treatment. The plants in treatments 2, 3, and 4 were also randomly assigned to a position in either the 10° C. growth chamber (treatments 2 and 4) or under the HPS lamps (treatments 3 and 4). On December 6, the 6 weeks treatment period was begun by placing each plant in treatments 2, 3, and 4 in its assigned random treatment position. The filler plant already in each position was moved to the vacant space left by the treated plant on the west side of the greenhouse. The control plants (treatment 1) remained in their random location on the west side of the house.

On December 27, 3 weeks after start of the treatments, plants in treatment 4 were moved from HPS lighting to the previously selected random locations in the growth chamber to receive 3 weeks of cooling at 10° C. (these plants in treatment 4 were exchanged for filler plants already in

Figure 2. Randomized Lighting Treatments, 4 Replications With 4 HPS Lamps, East Side of the Greenhouse.

the growth chamber).

At the end of 6 weeks, plants in treatments 2, 3, and 4 were moved back to their original positions on the west side of the house where they remained, along with treatment 1 plants, until the experiment was terminated on July 21, 1975 (249 days after potting).

The HPS lamps were hung on the east side of the greenhouse 1.27 meters (approximately 51 in.) from plant tops at the start of treatments and 8 feet apart (69.4 watts/sq.m. or 6.25 watts/sq.ft.). An average intensity of 585 ft-c was achieved.[4] A black cloth partition was used to prevent light leakage between the lighted east side and non-lighted west side of the greenhouse.

Light measurements[5] were recorded periodically at plant tops during the treatment period at 1:30 pm on both the lighted and unlighted sides. At the end of the 6 weeks treatment period light intensity was again lowered with cheesecloth. On April 16 the plant spacing was increased to 25 cm x 30 cm (10 x 12 in.). Light measurements were also made at all positions in the growth chamber at plant tops. Leaf temperature readings were recorded at night with an IT-3 model infared thermometer on both the lighted

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[4]Night measurements. More information is found on Page 28.

[5]Weston Illumination Meter Model 657. Weston Electrical Instrument Corporation.

and unlighted sides of the greenhouse.

The temperature of the greenhouse was kept at a minimum night temperature of 21° C. Daytime temperatures were kept as close as possible to 24° C. on cloudy days to 27-30° C. on sunny days. Plants were watered manually and fertilized as follows:

1. ½ teaspoon of osmocote 14-14-14 per pot at potting time.
2. Liquid fertilizer applications were applied as shown below by filling each pot to capacity with solution at each application:
   A. 10-30-20 1 oz per 3 gallons of water plus $CA(NO_3)_2$ 1 oz per 3 gallons of water, 6 days after treatments were started.
   B. Mg $SO_4$ 1 oz per 3 gallons of water 2½ weeks after treatments were started.
   C. 20-20-20 1 oz per 3 gallons of water periodically throughout the experiment according to soil test results.
   D. Peter's soluble trace elements, 1 oz per 25 gallons of water, on January 15.

Electric meter readings for each separate Lucalox lamps were recorded periodically for 24 hour periods. In addition the following data were recorded:

A. Number of days from potting until the flower spike was 4 cm in length (Figure 3).
B. Percent of plants having visible flower buds 2


Figure 3. Four and Seven Cm. Flower Spike Lengths.

weeks after the first bud was visible in that treatment.

C. Number of lateral bud breaks longer than 2.5 cm, 90 days after potting.

D. Amount of leaf crinkling and distortion at maturity[6] on a scale 1-9 (Figure 4).

E. Number of lateral branches greater than 1 cm long and less than 3 cm long and the number of branches greater than 3 cm long at maturity.

F. Stem diameter half way between the second and third node at maturity.

G. Plant height, and number of nodes before treatments, after treatments, and at maturity.

H. Number of visible buds in each treatment at 90, 120, 150, 180, and 210 days.

I. Number of days from potting until the flower spike was 7 cm in length (Figure 3).

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[6]Maturity date of plant was defined as the date that the 7 cm flower spike length was reached.


Figure 4. Standard Plants Used to Rank the Amount of Leaf Crinkling and Distortion (Scale of 1-9).

# CHAPTER IV

## RESULTS

The mean number of days to 4 and 7 cm flower spike lengths (Table I) were significantly reduced by the 6 weeks of HPS illumination (treatment 3). Plants in this treatment required an average of 112 days for the flower to reach the 4 cm length and 127 days to reach the 7 cm length compared to 215 and 228 days respectively for plants in the natural light control (treatment 1 and Figure 5). Treatment 2 (6 weeks cooling) and treatment 4 (3 weeks of HPS lighting and 3 weeks of cooling) had no significant effect on the mean number of days to 4 and 7 cm flower lengths compared to the control. However, plants given 3 weeks of HPS lighting plus 3 weeks of cooling reached the 4 and 7 cm flower lengths significantly sooner compared to plants given 6 weeks of cooling.

The 6 weeks of HPS lighting resulted in plants with the least sporadic flowering (Table II). Twenty-nine of the 32 plants in that treatment had a visible bud within two weeks after the first bud was visible in that treatment. The control plants had only 6 flower buds visible within 2 weeks of the first, while plants that received 6 weeks of cooling had 3 visible buds and plants given 3

TABLE I

MEAN NUMBER OF DAYS FROM POTTING TO FOUR AND SEVEN CM FLOWER SPIKE LENGTHS[1]

| Treatment | Days to 4 cm | Days to 7 cm |
|---|---|---|
| 1. Natural Light Control | 215.4b[2] | 228.5b |
| 2. 6 Weeks Cooling | 217.5b | 230.0b |
| 3. 6 Weeks HPS Lighting | 112.3a[3] | 127.2a[3] |
| 4. 3 Weeks HPS Lighting and 3 Weeks Cooling | 210.4b[4] | 223.1b[4] |
| Error Mean Square | 139.88 | 122.76 |
| Degrees of Freedom | 9 | 9 |

[1]Average of 32 plants unless otherwise noted.

[2]Means within a column followed by the same letters do not differ significantly at the 5% level (LSD test).

[3]Average of 29 plants. 3 plants had aborted terminal tips. Although probably due to treatment, averages from the other plants in their respective replication and treatment were used in place of the missing values resulting in a downward biased F value.

[4]Average of 26 plants. 4 plants had aborted terminal tips. Although probably due to treatment, averages from the other plants in their respective replication and treatment were used in place of the missing values resulting in a downward biased F value. Averages from others in their replication and treatment were also used for missing values due to 1 plant broken by mechanical damage, and 1 plant with a flower that never reached the 7 cm stage.


Figure 5. Representative Plants From the Four Treatments on April 1, 134 Days After Potting, Left to Right - Control, 6 Weeks Cooling, 6 Weeks HPS Lighting, and 3 Weeks HPS Lighting, Plus 3 Weeks Cooling.

TABLE II

PERCENT OF PLANTS WITH VISIBLE FLOWER BUD WITHIN TWO WEEKS AFTER APPEARANCE OF FIRST FLOWER BUD IN THE SAME TREATMENT[1]

| Treatment | Percent With Visible Bud Within 2 Weeks |
|---|---|
| 1. Natural Light Control | 18.8% |
| 2. 6 Weeks Cooling | 9.4 |
| 3. 6 Weeks HPS Lighting | 90.6 |
| 4. 3 Weeks HPS Lighting 3 Weeks Cooling | 6.2 |

[1]Chi-square value of 70.37. Significant at the 1% level. Validity of the 2 x 4 table is reduced however due to the presence of cell values less than 5. There were 32 plants per treatments.

weeks HPS lighting and 3 weeks cooling had only 2 plants with visible buds within 2 weeks of the first bud.

Three plants receiving the 6 weeks HPS lighting never produced flowers on the original terminal stem. The terminal tips are believed to have aborted, causing lateral branches to form, and subsequent flowering of these branches. Four plants receiving 3 weeks HPS lighting and 3 weeks cooling also had similar blind terminal shoots.

Plants receiving 6 weeks HPS lighting had significantly more leaf crinkling and distortion compared to the other 3 treatments (Table III). The 6 weeks of HPS lighting also resulted in plants that had significantly smaller stem diameter at maturity than the control plants, the plants given 6 weeks of cooling, and the plants given 3 weeks of HPS lighting plus 3 weeks of cooling (Table III).

The number of lateral bud breaks at 90 days after potting (before any plants had reached maturity) was significantly larger for plants illuminated with HPS lamps for 6 weeks compared to the other 3 treatments (Table IV). Also, plants treated with 3 weeks of HPS lighting plus 3 weeks of cooling had significantly more bud breaks at 90 days compared to the control plants and those given 6 weeks of cooling.

Plants treated with 3 weeks of HPS lighting plus 3 weeks of cooling had significantly more lateral branches greater than 1 cm and less than 3 cm at maturity (Table V). Otherwise there were no significant differences at maturity

TABLE III

AMOUNT OF LEAF CRINKLING AND DISTORTION AND THE STEM DIAMETER AT MATURITY[1]

| Treatment | Crinkling and Distortion[2] | Stem Diameter (mm) |
|---|---|---|
| 1. Natural Light Control | 5.41b[3] | 16.21b |
| 2. 6 Weeks Cooling | 5.19b | 15.43b |
| 3. 6 Weeks HPS Lighting | 6.69a[4] | 13.47a[4] |
| 4. 3 Weeks HPS Lighting and 3 Weeks Cooling | 5.25b[5] | 15.71b[5] |
| Error Mean Square | 1.50 | 11.59 |
| Degrees of Freedom | 9 | 9 |

[1]Average of 32 plants unless otherwise noted.

[2]Ranked from 1 to 9, with 1 being no crinkling and distortion and 9 being severe crinkling and distortion.

[3]Means with a column followed by the same letters do not differ significantly at the 5% level (LSD test).

[4]Average of 29 plants. 3 plants had aborted terminal tips. Although probably due to treatment, averages from the other plants in their respective replication and treatment were used in place of the missing values resulting in a downward biased F value.

[5]Average of 26 plants. 4 plants had aborted terminal tips. Although probably due to treatment, averages from the other plants in their respective replication and treatment were used in place of the missing values resulting in a downward biased F value. Averages from others in their replication and treatment were also used for missing values due to 1 plant broken by mechanical damage, and 1 plant with a flower that never reached the 7 cm stage.

TABLE IV

NUMBER OF LATERAL BUD BREAKS AT 90 DAYS AFTER POTTING[1]

| Treatment | Lateral Bud Breaks |
|---|---|
| 1. Natural Light Control | 0.0a[2] |
| 2. 6 Weeks Cooling | 0.06a |
| 3. 6 Weeks HPS Lighting | 3.34b |
| 4. 3 Weeks HPS Lighting and 3 Weeks Cooling | 2.62b |
| Error Mean Square | 0.84 |
| Degrees of Freedom | 9 |

[1]Average of 32 plants.

[2]Means within a column followed by the same letters do not differ significantly at the 5% level (LSD test).

TABLE V

NUMBER OF LATERAL BRANCHES GREATER THAN ONE CM AND LESS THAN THREE CM, AND GREATER THAN THREE CM AT MATURITY[1]

| Treatment | Lateral Branches Greater Than 1 And Less Than 3 Cm | Lateral Branches Greater Than 3 Cm |
|---|---|---|
| 1. Natural Light Control | .59a[2] | 4.0b |
| 2. 6 Weeks Cooling | .56a | 4.12b |
| 3. 6 Weeks HPS Lighting | 1.28a[3] | 1.06a[3] |
| 4. 3 Weeks HPS Lighting and 3 Weeks Cooling | 1.38a[4] | 3.78b[4] |
| Error Mean Square | 1.82 | 1.75 |
| Degrees of Freedom | 9 | 9 |

[1]Average of 32 plants unless otherwise noted.

[2]Means within a column followed by the same letters do not differ significantly at the 5% level (LSD test).

[3]Average of 29 plants. 3 plants had aborted terminal tips. Although probably due to treatment, averages from the other plants in their respective replication and treatment were used in place of the missing values resulting in a downward biased F value.

[4]Average of 26 plants. 4 plants had aborted terminal tips. Although probably due to treatment, averages from the other plants in their respective replication and treatment were used in place of the missing values resulting in a downward biased F value. Averages from others in their replication and treatment were also used for missing values due to 1 plant broken by mechanical damage, and 1 plant with a flower that never reached the 7 cm stage.

for branches between these lengths. The 6 weeks of HPS lighting resulted in plants with significantly fewer branches greater than 3 cm in lengths at maturity compared to the other 3 treatments.

The mean height and number of nodes before the treatment period showed no significant differences among the 4 treatments (Table VI). At the end of the 6 weeks treatment period, plants receiving 6 weeks of HPS lighting were significantly taller (129.47 mm) when compared to the other 3 treatments (Figure 6 and Table VI). Also at this time, plants cooled for 6 weeks were significantly shorter (64.78 mm) when compared to plants of the other 3 treatments (Table VI). Also plants that received 3 weeks HPS lighting plus 3 weeks of cooling were significantly shorter (89.03 mm) than the control(109.95 mm, Table VI). Plants treated with 6 weeks of cooling had significantly fewer nodes after the treatment periods when compared to plants in the other 3 treatments (TableVI). Also plants given 3 weeks of HPS lighting plus 3 weeks of cooling had significantly fewer nodes compared to the control plants and the 6 weeks of HPS treated plants. Plants illuminated for 6 weeks with HPS lamps did not have a significant difference in the number of nodes at the end of the 6 weeks treatment period compared to the control.

Due to an earlier flowering date, plants given 6 weeks of HPS lighting had significantly fewer nodes and shorter plant height at flower maturity when compared to the other

## TABLE VI

### PLANT HEIGHT AND NUMBER OF NODES BEFORE TREATMENTS, AFTER TREATMENTS, AND AT MATURITY[1]

| TREATMENT | BEFORE TREATMENTS | | AFTER TREATMENTS | | AT MATURITY | |
|---|---|---|---|---|---|---|
| | Height | Nodes | Height | Nodes | Height | Nodes |
| 1. Natural Light Control | 54.18a[2](mm) | 3.84a | 109.95bc(mm) | 5.88ab | 307.28b(mm) | 12.03b |
| 2. 6 Weeks Cooling | 56.28a | 4.00a | 64.78a | 4.44a | 282.00b | 10.84b |
| 3. 6 Weeks HPS Lighting | 57.50a | 3.84a | 129.47c | 6.25b | 178.38a[3] | 7.53a[3] |
| 4. 3 Weeks HPS Lighting and 3 Weeks Cooling | 56.41a | 3.88a | 89.03b | 5.25ab | 278.88b[4] | 11.47b[4] |
| Error Mean Square | 107.39 | 0.25 | 223.36 | 0.82 | 819.79 | 1.49 |
| Degrees of Freedom | 9 | 9 | 9 | 9 | 9 | 9 |

[1] Average of 32 plants unless otherwise noted.

[2] Means within a column followed by the same letters do not differ significantly at the 5% level (LSD test).

[3] Average of 29 plants. 3 plants had aborted terminal tips.

[4] Average of 26 plants. 4 plants had aborted terminal tips, 1 plant was broken by mechanical damage, and 1 plant had a flower that never reached the 7 cm stage.


Figure 6. Representative Plants From the Four Treatments on January 21, 3 Days After the 6 Weeks Treatment Period and 74 Days After Potting, Left to Right-Control, 6 Weeks HPS Lighting, 3 Weeks HPS Lighting Plus 3 Weeks Cooling, and 6 Weeks Cooling.

3 treatments (Table VI). Also control plants were significantly taller than the other 3 treatments and had significantly more nodes than plants receiving 6 weeks of HPS lighting and plants given 6 weeks of cooling.

Plants receiving 6 weeks of HPS lighting had visible buds on all but 3 of the 32 plants by 90 days after potting (Table VII). Table VII results, also helps demonstrates the sporadic flowering nature of the 3 weeks of HPS lighting and 3 weeks of cooling treatment.

Daytime light measurements at 1:30 pm during the 6 weeks treatment period (December 6 - January 18) averaged 1558[1] ft-c on the control side of the greenhouse and 1690[2] ft-c under the HPS lights. After the 6 weeks treatment period all plants received an average of 1099[3] ft-c during late January, February, and March; 3859[4] ft-c during April, May, June, and early July.

Light intensity at night under the HPS lights averaged 585 ft-c (Figure 7) while light intensity in the growth chamber averaged 50 ft-c[5] for the 6 weeks treatment period. Leaf temperature at night averaged 23.1° C.[6] under the HPS

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[1]Average of 372 measurements.

[2]Ibid.

[3]Average of 168 measurements.

[4]Average of 264 measurements.

[5]Average of 64 measurements.

[6]Average of 38 measurements.

light and 21.2$^{o}$ C.[7] on the control plants. Each HPS light used an average of 12 kilowatt hours of electricity per 24 hour period.

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[7] Ibid.

TABLE VII

NUMBER OF PLANTS WITH VISIBLE FLOWER BUDS AT 30 DAYS INTERVALS[1]

| Treatment | Days From Potting 90 | 120 | 150 | 180 | 210 |
|---|---|---|---|---|---|
| 1. Natural Light Control | 0 | 0 | 0 | 6 | 32 |
| 2. 6 Weeks Cooling | 0 | 0 | 0 | 3 | 32 |
| 3. 6 Weeks HPS Lighting | 29 | 29 | 29 | 29 | 29[2] |
| 4. 3 Weeks HPS Lighting and 3 Weeks Cooling | 0 | 1 | 3 | 4 | 26[3] |

[1]Each figure represents the number of plants with visible buds at a given date. Significant at the 1% level of the Chi-square test. Validity of the 2 x 4 is reduced however due to the presence of cell values less than 5.

[2]Average of 29 plants. 3 plants had aborted terminal tips. Although probably due to treatment, averages from the other plants in their respective replication and treatment were used in place of the missing values resulting in a downward biased F value.

[3]Average of 26 plants. 4 plants had aborted terminal tips. Although probably due to treatment, averages from the other plants in their respective replication and treatment were used in place of the missing values resulting in a downward biased F value. Averages from others in their replication and treatment were also used for missing values due to 1 plant broken by mechanical damage, and 1 plant with a flower that never reached the 7 cm stage.

HPS LAMP

| | | | | | | |
|---|---|---|---|---|---|---|
| Plant Positions. . . . . | 1 | 2 | 3 | 4 | 5 | 6 |
| Light Measurements . . . | 572 | 570 | 595 | 575 | 598 | 610 |
| | 7 | 8 | 9 | 10 | 11 | 12 |
| | 578 | 585 | 595 | 592 | 592 | 592 |
| | | 13 | 14 | 15 | 16 | |
| | | 545 | 578 | 615 | 562 | |

Over-all average - 585 ft-c

Figure 7. Light Intensity Measurements During the Night at Plant Tops for Each Pot Position Under the HPS Lamps. Average of 4 Night Measurements (One Per Replication) at Each Plant Position.

# CHAPTER V

## DISCUSSION AND CONCLUSIONS

Plants treated with 6 weeks of HPS light flowered much earlier and more evenly than the control plants (Table I). The 6 weeks of HPS lighting, also resulted in plants with more lateral bud breaks at 90 days after potting but fewer larger lateral branches (greater than 3 cm), smaller stem diameters, more crinkling and distortion of leaves, and shorter plant heights at maturity compared to the control. Both the 6 weeks of HPS lighting and the 3 weeks of HPS lighting plus the 3 weeks of cooling had a small percent of blind terminal shoots. This phenomenon warrants further research to determine its specific cause (Table I and VII).

Cooling at $10^{\circ}$ C. and 50 ft-c of incandescent light, and a combination of 3 weeks HPS light followed by 3 weeks cooling, proved to be non-benefical in hastening flower initiation or reducing flowering span compared to the natural light control. Also, of the other variables investigated at maturity only the plant height of these 2 treatments and the number of nodes of the plants cooled for 6 weeks showed any significant difference when compared with the natural light control.

Length of the experimental treatments was 6 weeks, therefore cheesecloth shading was restored to all plants immediately following the 6 weeks period. If the plants had not been shaded with the cheesecloth after the 6 weeks treatment period it is likely that the control plants would have flowered somewhat earlier than they did in this experiment.

The 10° C. cooling treatment investigated in this study may have been conducted at a light intensity that was too low (50 ft-c) to result in a reduction in flower production time and less sporadic flowering. The natural winter illumination used by Christensen and other researchers (15, 22, 31) in combination with a 10° C. cooling period may be necessary to induce more rapid flower initiation.

Only 46 days were required from the start of treatments until the first flower buds were visible in the plants given 6 weeks of HPS lighting. This is less than half the flower production time required compared to the 110 days that Christensen (15) reported for the same visible bud stage to be reached from the start of a 10° C. cooling treatment under natural low winter lighting. He also found that when starting with plants having 3 nodes, the cultivar 'Dania' had 7-8 nodes at flowering time and a plant height of 25 cm after the 10° C. cooling treatment. This compares to an equivalent number of nodes (7.5) and a shorter plant height average (17.8 cm) found in this report for treatment 3. It is the author's opinion that the more compact plant with the same number of leaf pairs has a superior appearance.

More research is warranted to determine the optimum distance from light to plants, the best spacing, and the optimum light treatment time. A closer plant spacing and a greater distance between light and plant could be used probably to induce flowering with less leaf crinkling and distortion, also allowing more plants under each light and thus a reduction in a production cost. The 4 weeks establishment period could possibly be reduced or eliminated.

At 2¢ per KWH and the spacing used in the research, 11¢ per pot for electricity must be added to the cost of production for 6 weeks of HPS light-treated plants. If the approximate $250.00 cost of fixture, Luminary and installation cost were depreciated over 10 years (17) and the lights were in use from September thru May 15, $.045 per pot additional production cost must be added at this pot spacing. The bulbs last an average of 20,000 hours when continuously burned (4) or an additional $.027 production cost per pot. Therefore the total additional cost for the above would be $.182 per pot. If 9.4% of the plants were blind, as was the case in this research, an additional $.017 per pot must be included to the cost of production to compensate for the loss of plants. However, the additional fifteen weeks ($.84 per pot additional cost when calculated at 10¢ per sq.ft. per week) that was necessary for the control plants to reach the 4 cm flower length compared to the HPS light treated plants, by far makes up for this additional production cost. This difference in production time would probably be less if full natural light was used throughout the winter production period.

Due to both a shorter flower production time and a more even flowering span, high pressure sodium lamps would allow the commerical grower to produce flowering plants of Aphelandra squarrosa Nees 'Dania' the year around more easily.

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# VITA

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