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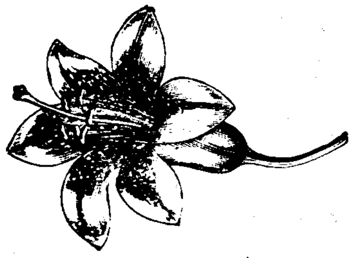

EASTER LILY PRODUCTION FOR 1994

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I. Introduction

Easter lilies are the third largest flowering pot plant crop in value grown in the United States with 8 to 10 million plants produced annually. Lily forcing information has improved dramatically during the last few years. This outline is offered as a guide and reference for Easter lily forcing with emphasis on new forcing information.

The date of Easter varies each year. Easter is the first Sunday following the first full moon, which falls on or after the vernal equinox. Dates of Easter vary from March 22 to April 25 (Table 1). Easter falls on April 3rd in 1994. Palm Sunday is on March 27th.

II. General Considerations

Flower Induction: Flower induction in the Easter lily can be achieved with cold temperatures or long photoperiods. In its native environment, the Easter lily is probably induced to flower by a combination of both cool temperatures and long days, (LD) i.e. days longer than 12 hours. Wild plants typically flower in August.

Commercial flower induction of the Easter lily is accomplished by cooling bulbs for 6 weeks in a moist medium. A short long day treatment after emergence is often used to insure complete induction has occurred.

It is very important that the media around a bulb is moist. If media is dry, the bulb will not perceive the cold treatment and flower induction will not occur.

If media is dry, the bulbs will not fully perceive the cold treatment and flowering will be delayed.

Table 1. Dates of Easter Sunday from 1994 to 2002.

Year	Date
1994	April 3
1995	April 16
1996	April 7
1997	March 30
1998	April 12
1999	April 4
2000	April 23
2001	April 15
2002	March 31

It is very important that the media around a bulb is moist. If media is dry, the bulbs will not fully perceive the cold treatment and flowering will be delayed. The cool, moist treatment is referred to as a vernalization treatment.

Bulbs cooled using methods 1 and 2 generally produce a plant with longer lower leaves and a higher bud count than those produced using methods 3 and 4.

Cooling Methods: There are 4 commercial cooling techniques which are used to induce Easter lilies to flower. The techniques are:

1) natural cooling
2) controlled temperature forcing (CTF)
3) home case cooling
4) commercial case cooling

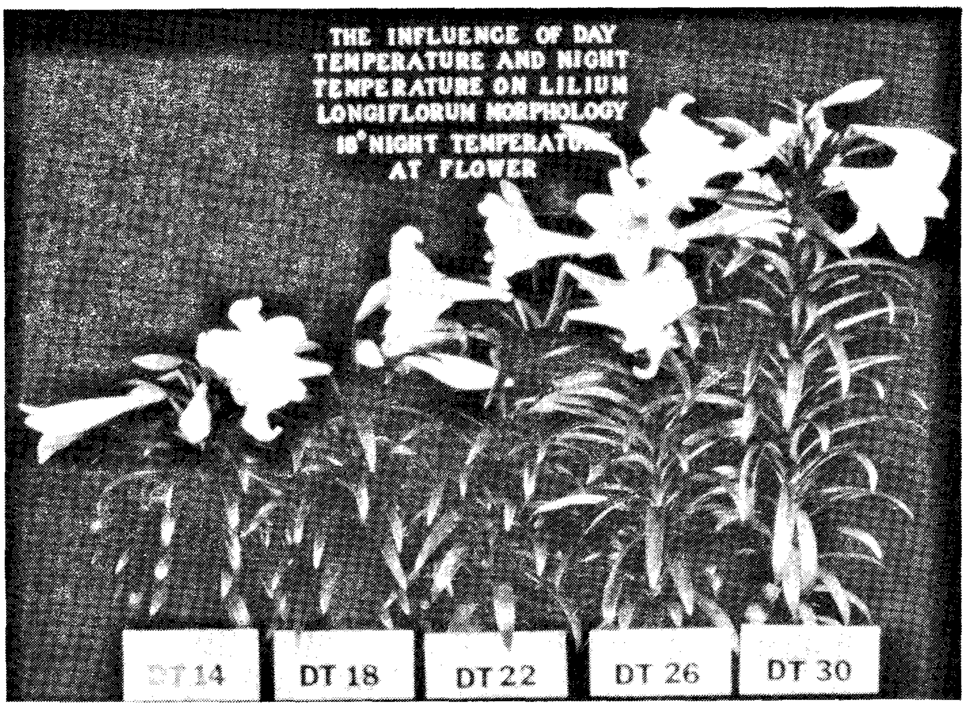
Methods 1 and 2 cool bulbs in a pot. In contrast, methods 3 and 4 cool bulbs in a packing case.

There are differences in the appearance of plants forced under the different techniques. Bulbs cooled using methods 1 and 2 generally produce a plant with longer lower leaves and a higher bud count than those produced using methods 3 and 4. The higher quality of lilies potted prior to cooling is believed to be associated with allowing the bulb to root prior to shoot emergence.

The length of the cooling period is critical. As the length of the vernalization, or cooling period increases:

- shoot emergence occurs earlier
- shoot emergence becomes more uniform
- the time from shoot emergence until flower decreases
- leaf number decreases
- leaf length decreases at the base of the plant

Figure 1. The influence of increasing day and night temperature on *Lilium longiflorum* morphology with a 18°C (64°F) night temperature.



- internode length increases
- flower number decreases

The optimal length of the cooling period is 6 weeks or 1000 hours. Therefore, do not cool over 6 weeks! Overcooling tends to decrease plant quality.

Cultivars: There are 2 cultivars of Easter lily which are commonly forced: 'Ace' and 'Nellie White'. The cultivars vary in their appearance at flower. In general, compared to 'Ace', 'Nellie White':

- is shorter
- has fewer leaves
- has wider leaves
- has more basal leaves
- has 1/2 to 1 less flower/bulb
- is less prone to tip burn

The cultivars also have different optimal temperatures for cooling. 'Ace' should be cooled at 40°F. 'Nellie White' should be cooled at 40-45°F. The lower temperature for 'Ace' is to prevent premature shoot emergence.

Media: The planting medium must be well drained and well aerated. Most forcers grow lilies in a soilless media containing peat and vermiculite. Do not use perlite. Perlite contains fluoride which can cause 'leaf scorch' or tip burn. Some forcers add 10-20% soil to a soilless medium. Advantages to adding soil are:

1) media cation exchange capacity or the ability of the media to retain nutrients is increased.
2) the media is better suited for watering with subirrigation systems.
3) the media is more buffered. Therefore, change in media pH over time is often slower.

Disadvantages of adding soil to media are:

1) the media has less aeration. Therefore, the risk of root rot may be greater.
2) media weight increases.

The optimal length of the cooling period is 6 weeks or 1000 hours.

Most forcers grow lilies in a soilless media containing peat and vermiculite. Do not use perlite. Perlite contains fluoride which can cause 'leaf scorch' or tip burn.

Table 1. Yearly average number of leaves on plants from 'Ace' and 'Nellie White' 8-9 inch bulbs from 1970 to 1992 cooled in the case or with controlled temperature forcing (CTF). Assembled by Dr. Harold F. Wilkins, Former Professor of Horticulture, University of Minnesota.

	Cooled in case		Cooled by CTF	
Year	Ace	Nellie White	Ace	Nellie White
1970	92.3	89.6	104.3	90.5
1971	94.8	69.6	104.0	89.6
1972	96.3	70.3	105.5	90.0
1973	85.0	67.8	94.5	83.0
1974	90.5	80.0	98.8	87.3
1975	83.3	73.8	79.6	77.4
1976	83.5	71.9	87.2	82.3
1977	66.5	56.3	67.0	65.1
1978	71.3	65.6	77.2	74.5
1979	*	*	84.4	79.3
1980	*	*	89.3	69.7
1981	*	*	82.5	76.8
1982	*	*	90.1	70.8
1983	*	*	91.3	76.8
1984	*	*	98.1	83.2
1985	*	*	103.6	93.6
1986	*	*	94.2	86.6
1987	90.0	82.0	101.0	93.0
1992	*	*	85.0	78.0
Average	85.3	72.7	92.5	82.0

Maintain medium pH between 6.0 and 7.0.

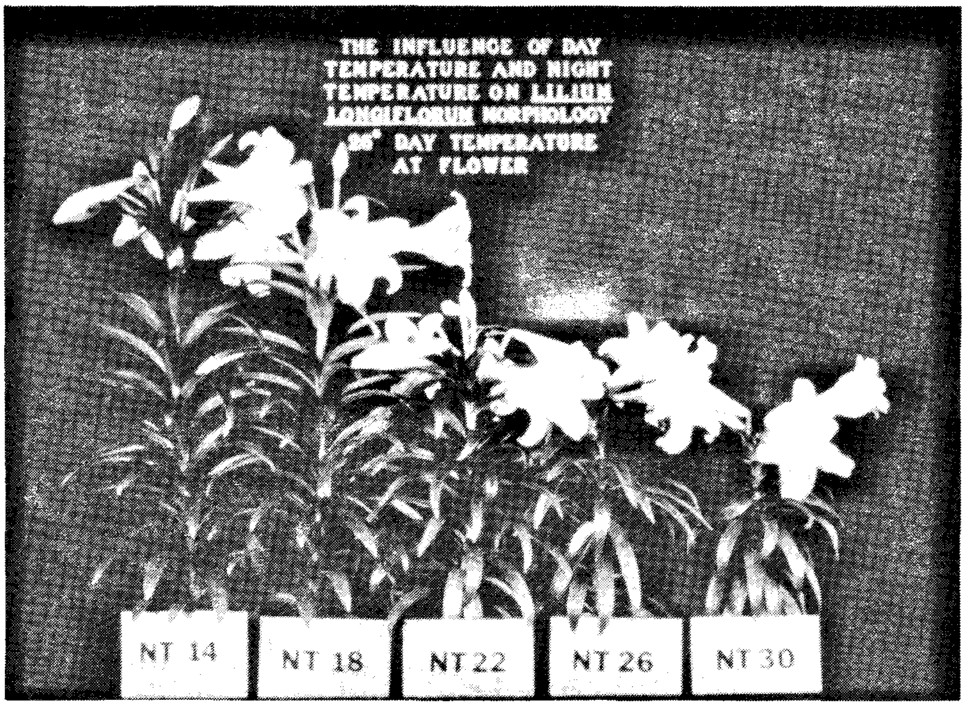


Figure 2. The influence of increasing night temperature on *Lilium longiflorum* morphology at a 26°C (79°F) day temperature.

3) ammonium may tend to build up to toxic levels if a fertilizer which contains ammonium is used.
4) media must be sterilized.

Fertilize with a 200-0-200 ppm (N-P-K) solution.

Nutrition: Maintain medium pH between 6.0 and 7.0. If fluoride is in your water, maintain a higher pH (6.5-7.0) to 'tie up' as much of the fluoride as possible.

Fertilize with a 200-0-200 ppm (N-P-K) solution. Do not use fertilizers which contain ammonium under cool, dark conditions.

Do not add superphosphate to the media because it contains fluoride.

Do not add superphosphate to the media because it contains fluoride. Supply phosphorus through a starter fertilizer. Adequate phosphorus can also be added to the medium through phosphoric acid treatments if the water pH is being amended with this acid.

III. Cooling to Flower Initiation Stage

a) Plants should receive a LD treatment for up to 3 weeks to ensure flower induction has occurred when shoots emerge from the medium. One week of LD treatment is normally used on early emerging plants. Three weeks of LD treatment are normally used on late emerging plants, especially when Easter is early. This may require some sorting of plants, but will improve crop uniformity. A LD treatment is usually delivered by lighting plants with 'mum lighting' (10 footcandles) from 2200-0200 hr each night. Both fluorescent and incandescent lamps are effective to ensure flower induction, however, incandescent lamps tend to promote stretching.

b) During the stage from flower induction to emergence, temperatures should be controlled based on media temperatures. Media temperatures of 60° to 62°F are typically used on years with late Easters. Media temperatures of 62° to 65°F are used on years with early Easters. Temperatures lower than 60°F result in reduced root development and potentially reduced flower number.

c) It is important to establish a good root system to minimize flower bud abortion and/or lower leaf yellowing.

d) Flower initiation should occur by January 18, 1994 for wholesalers and January 23, 1994 for retailers. Plants should be 3-4 inches tall at this stage. To determine if flower initiation has occurred, look at the shoot apex under magnification. If the apex has distinct bumps on it, flower initiation has occurred. Flower initiation has not occurred if the apex is round. Leaf count at least 5 of your lilies from each group of plants. Leaf number varies between plants from year to year, between cultivars and between plants cooled with different techniques. The average leaf numbers of 'Ace' and 'Nellie White' lilies which have been case cooled and CTF are shown in Table 2. The specifics of leaf counting are discussed in one of the following articles.

e) Applying growth retardants during the transitional stage from vegetative growth to flowering may reduce flower number, i.e. from December 13, 1993 to January 18, 1994 for wholesalers and from December 17, 1993 to January 23, 1994 for retailers.

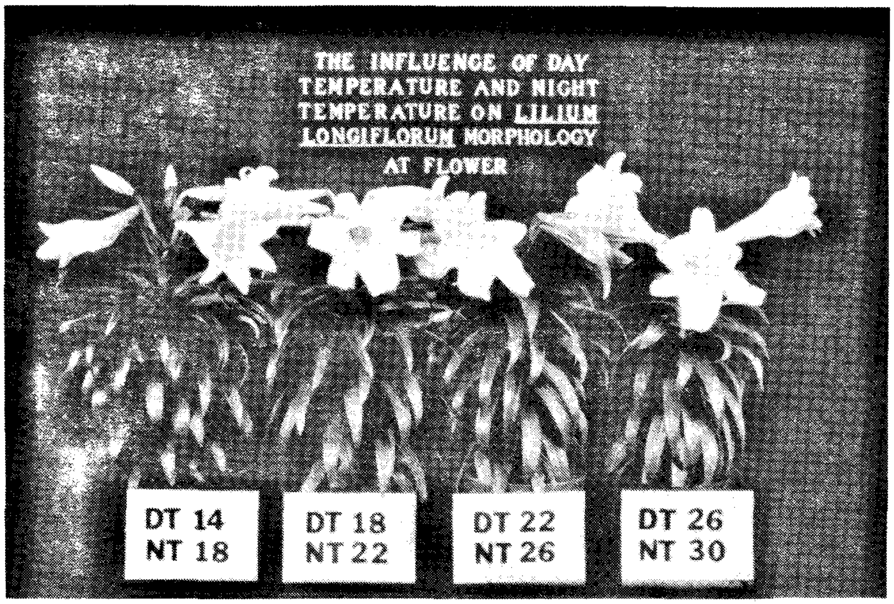
f) Greenhouse temperatures will vary depending on the desired rate of plant development needed to flower plants on time. During the phase from flower initiation to visible bud, the grower has the greatest flexibility in determining the flowering date and the plant appearance at flower. Temperature has the greatest influence on the rate of Easter lily growth during this phase. The majority of your lily population should be at visible bud by February 18, 1994 for wholesalers; February 23, 1994 for retailers, or 31 days after flower initiation. Keep on top of your temperatures!! Use the leaf counting technique to ensure proper timing of a lily crop.

g) Refer to the following article on 'Tracking Easter Lily Height with Graphs' to deter-

Flower initiation should occur by January 18, 1994 for wholesalers and January 23, 1994 for retailers.

Applying growth retardants during the transitional stage from vegetative growth to flowering may reduce flower number.

Figure 3. Appearance of *Lilium longiflorum* Thunb. cv. Nellie White at anthesis when grown under four temperatures regimes with day temperatures (DT) 4°C (7°F) cooler than night temperatures (NT). Plants grown at higher average temperatures flowered earlier than plants grown at cooler average temperatures. As plants grown at higher temperatures reached anthesis, they were placed in a cooler (4°C (39°F)) until plants grown at cooler temperatures reached anthesis. Stem elongation did not occur in the cooler. When all plants had reached anthesis, the photograph was taken. Reprinted from: Erwin, J.E., R.D. Heins and M.G. Karlsson. 1989. Thermomorphogenesis in *Lilium longiflorum*. Amer. J. Bot. 76(1):47-52.



During the phase from flower initiation to visible bud, the grower has the greatest flexibility in determining the flowering date and the plant appearance at flower.

Use the leaf counting technique to ensure proper timing of a lily crop.

mine the average daily temperature which you will need to flower your crop on time. Also consider tracking your height to insure that you produce a lily crop of a desired height.

IV. Flower Initiation to Visible Bud

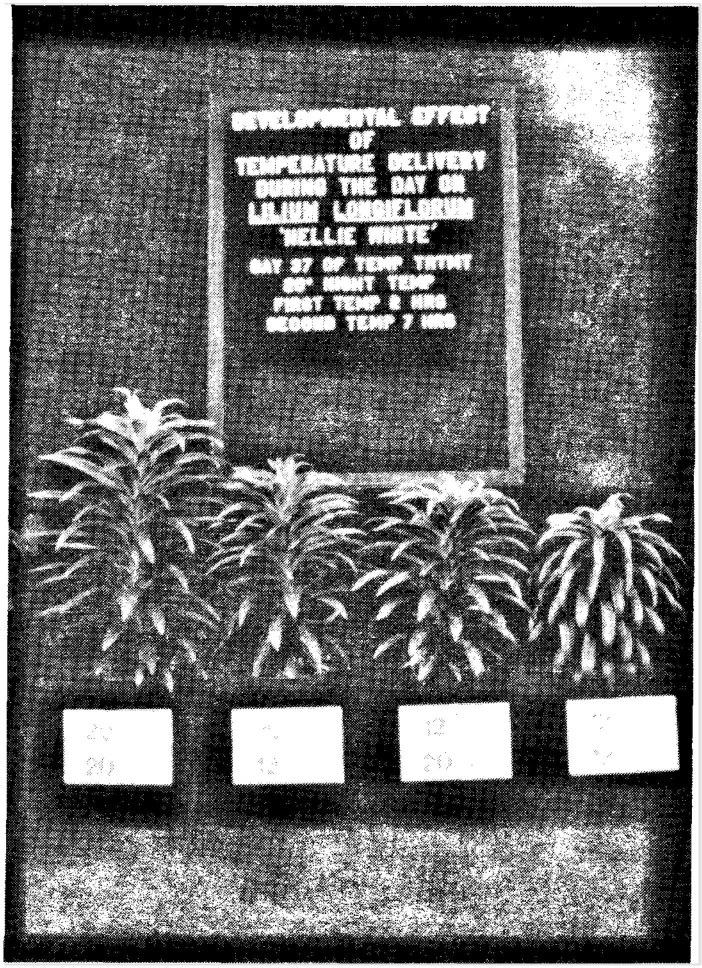
a) Day and night temperatures during the flower initiation to visible bud stage greatly influence final plant morphology (how the plant looks).

b) Plant height increases as day temperature increases (Figure 1). In contrast, plant height decreases as the night temperature increases (Figure 2).

The difference (DIF) between day and night temperatures (day temperature-night temperature) determines final plant height.

c) The difference (DIF) between day and night temperatures (day temperature-night temperature) determines final plant height. Plants progressively become taller as the difference between day and night temperature increases from a negative value (cool day and warm night) to a positive value (warm day and cool night). Plants with an equal difference between day and night temperatures will have similar plant height at flower irrespective of the absolute day and night temperature, grown between 55° and 85°F (Figure 3).

Figure 4. The influence of using cool temperature pulses during the first 2 hours of the morning on *Lilium longiflorum* plant height. The numbers on the top of the cards (below) represent the temperature for the first 2 hours of the morning, the bottom numbers represent the temperatures for the remaining 7 hours. Temperatures are 12°C (54°F) and 20°C (68°F). Reprinted from: Erwin, J.E., R.D. Heins, R.B. Berghage, B.J. Kovanda, W.H. Carlson and J.A. Biernbaum. 1989. Cool mornings can control plant height. Grower Talks 52:(9).



Lily stem elongation is most sensitive to cool temperatures during the first 3 hours of the morning.

d) Lily stem elongation is most sensitive to cool temperatures during the first 3 hours of the morning (Figure 4). One way to maintain a high rate of leaf unfolding, but still control height using temperature, is to dip temperatures below the night temperature for only the first 3 hours of the morning.

e) Leaf orientation, defined as the position of the leaf tip relative to the leaf base, also increases as DIF increases (Figure 5).

The elongation response of lily stems to day and night temperature is rapid.

f) The elongation response of lily stems to day and night temperature is rapid. Therefore, day and night temperatures can be altered to stimulate or slow elongation on a daily basis.

Lily leaf unfolding rate is dependent on the average daily temperatures a crop is grown under.

g) Lily leaf unfolding rate is dependent on the average daily temperatures a crop is grown under. Leaf unfolding rate increases with average daily temperature to an optimum then decreases as temperature increases

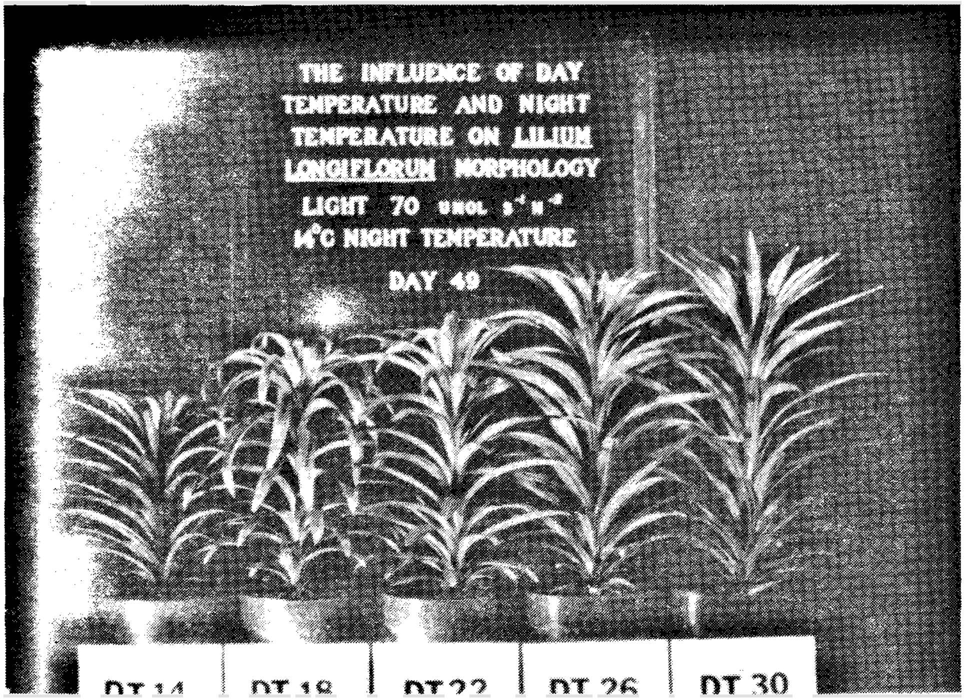


Figure 5. The influence of increasing day temperature on *Lilium longiflorum* leaf orientation at a 14°C (57°F) night temperature.

Leaf length increases as night temperature decreases from 85° to 55°F.

Leaf chlorosis occurs whenever night temperature is greater than day temperature.

(Figures 6a and 6b). Figure 6a plots leaf unfolding rate versus average daily temperature. Figure 6b shows the response of lily leaf unfolding rate to average daily temperature in the linear range only.

h) Many combinations of day and night temperature can be used to achieve a particular leaf unfolding rate; each combination will result in a different plant height (Figure 7). To use Figure 7, determine your required leaf unfolding rate by leaf counting and dividing by the time left to VB. Find the line that represents this leaf unfolding rate on the plot, then pick a day/night temperature combination that will give you your desired leaf unfolding rate yet control your crop height.

i) There are several ways to select the right day/night temperature combination. One method is graphical tracking. See the article on page 19 for more information on graphical tracking.

j) Leaf length increases as night temperature decreases from 85° to 55°F. In one experiment, as night temperature decreased from 85° to 55°F, leaf length increased from 12 to 18 cm (4.7 to 7.1 inches).

k) Similarly, flower length increases as night temperature decreases from 85° to 55°F.

l) Leaf chlorosis occurs whenever night temperature is greater than day temperature. The degree of chlorosis increases as the night temperature increases relative to the day temperature (Figure 8). The leaf chlorosis is not permanent. Plants will either grow out of the chlorosis by flower, or the chlorosis can be reversed by decreasing the night temperature to below the day temperature.

m) Light intensity does not influence the rate of Easter lily development. However, it does influence plant morphology. As light intensity increases, final plant height decreases. In addition, as light intensity decreases to very low levels, more flower bud abortion occurs.

n) Light quality influences lily plant morphology. As the amount of far-red light

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Light quality influences lily plant morphology.

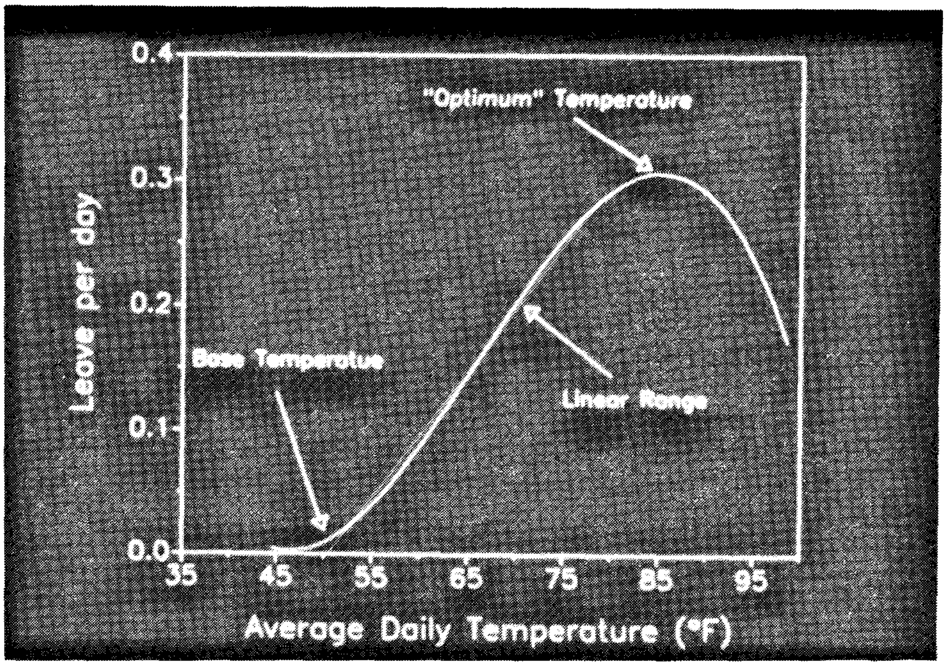


Figure 6a. The influence of average daily temperature on *Lilium longiflorum* leaf unfolding rate. Leaf unfolding rate increases with average daily temperature to an optimum then decreases as temperature increases.

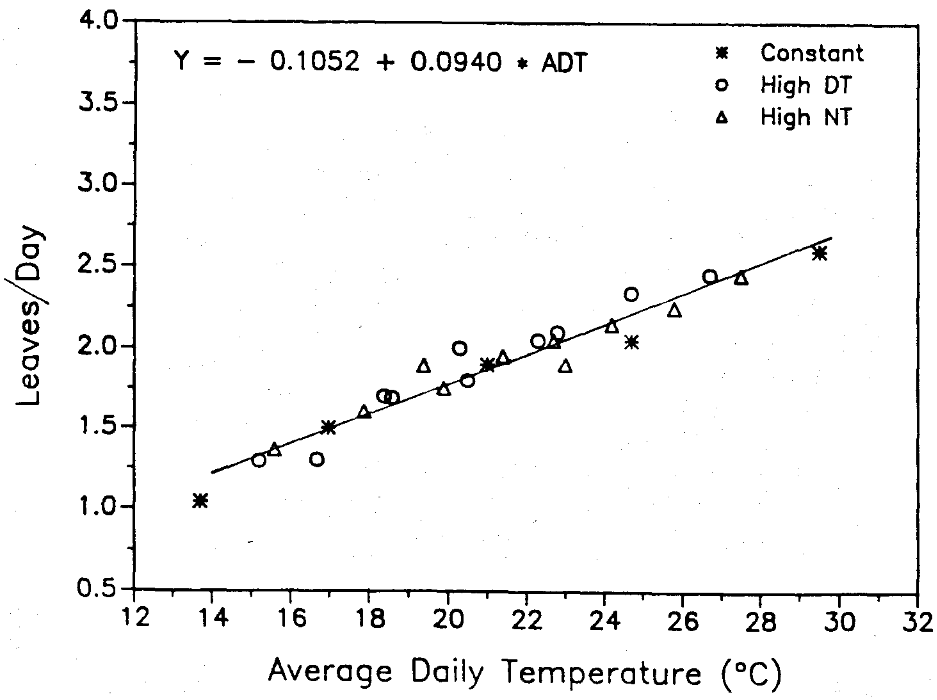
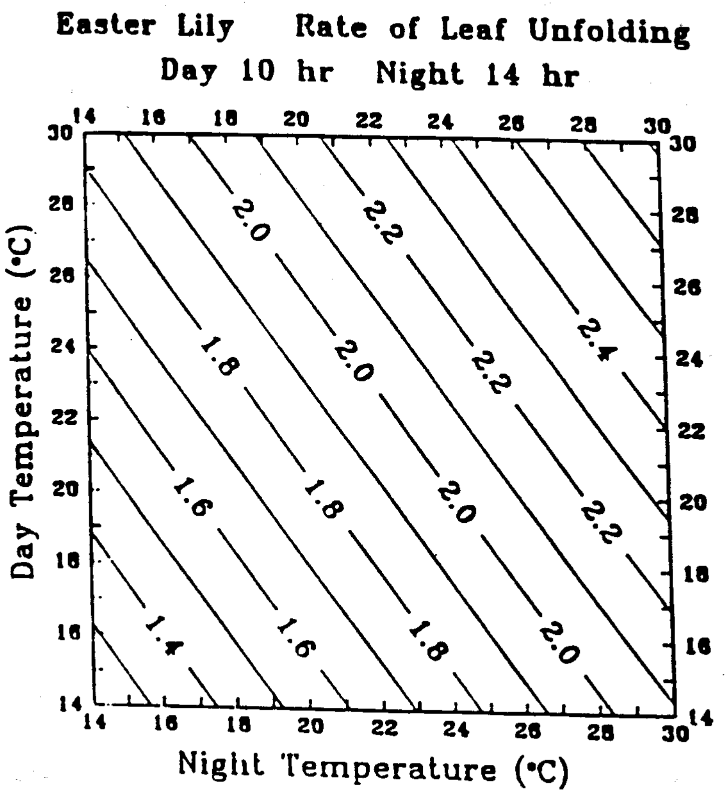


Figure 6b. Number of *Lilium longiflorum* cv Nellie White leaves unfolded per day with a higher day than night temperature, with a higher night than temperature and with the same day and night temperatures. The regression equation was calculated using treatment means averaged over counting periods and average daily temperature (ADT) as the independent variable. Reprinted from: Karlsson, M.G., R.D. Heins and J.E. Erwin. 1988. Quantifying temperature-controlled leaf unfolding rates in 'Nellie White' Easter lily. J. Amer. Soc. Hort. Sci. 113(1):70-74.

Figure 7. Combinations of day and night temperatures used to determine leaf unfolding rate of *Lilium longiflorum*.



which a plant is exposed to increases relative to red light, plant height increases, leaf color becomes a lighter green and leaf thickness decreases. Therefore, do not expose lilies to incandescent light (high far-red source) after flower initiation unless an increase in plant height is desirable. Also, do not crowd plants as this will increase the amount of far-red light which expanding internodes will be exposed to.

o) Photoperiod influences plant height. Plants are shorter when grown under short days compared to long days.

V. The Phase from Visible Bud to Flower

a) The time from visible bud (VB) to flower ranges from 24 days when plants are grown at constant 85°F to 42 days when plants are grown with constant 57°F. The affect of average daily temperature on the rate of lily development from the visible bud stage until flower is not linear (Table 3) (Figure 9). Instead, the benefits from increasing temperature decrease as average daily temperature increases. Therefore, increasing the temperature from 55° to 60°F is more effective in reducing the time from VB to flower than increasing the temperature from 75° to 80°F.

b) Very little benefit, or reduction in the time from VB to flower, is realized by raising temperatures above 75°F. The reduction in predicted days to flower by increasing temperatures during the VB stage is shown in Table 3.

c) Many forcers find plant height doubles from VB to flower. The increase in plant height from the visible bud stage to flower is influenced by DIF (Figure 10). Therefore, forcers have some control of the increase in plant height after visible bud.

VI. Growth Regulators

a) Lilies respond to Ancymidol (A-Rest) ap-

Table 3. The reduction in predicted days to flower with increasing temperature.

Temperature (°F)	Days from VB to Flower	Decrease in Days from VB to Flower Due to a 5°F Increase in Temperature
55	42	
60	38	4
65	34	4
70	31	3
75	27	4
80	25	2
85	24	1

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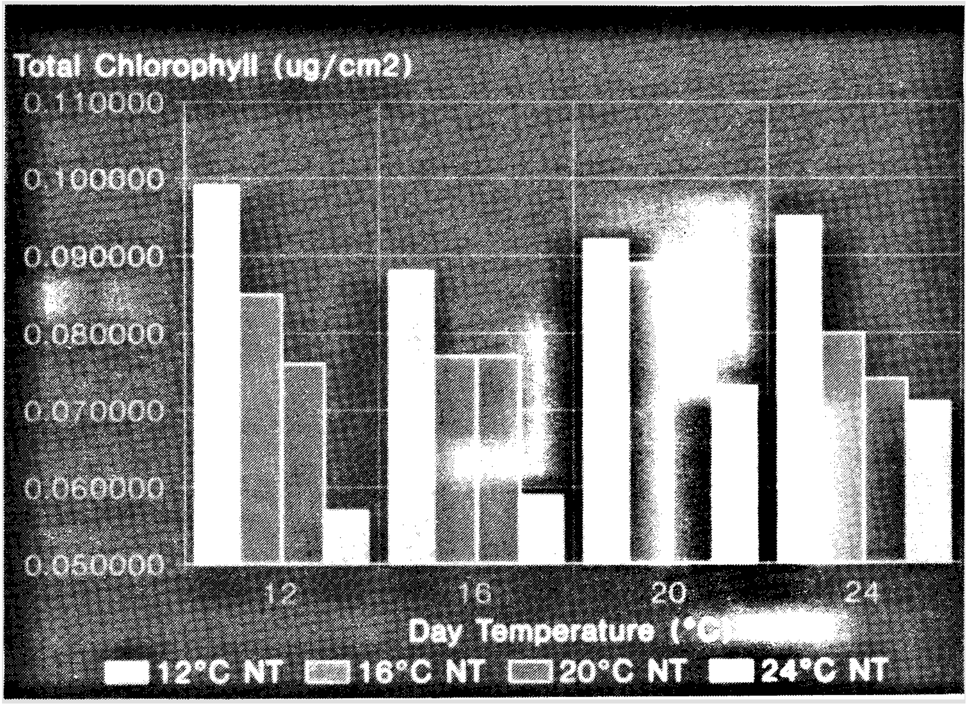

Figure 8. The influence of night temperature on *Lilium longiflorum* leaf chlorosis. The degree of chlorosis increases as the night temperature increases relative to the day temperature. The leaf chlorosis is not permanent.

plied as a spray or drench.

b) Do not apply growth regulators during flower initiation (normally mid- to late January) since a reduction in flower number may occur.

c) In general, drenches of A-Rest are twice as effective as sprays in reducing shoot length per mg active ingredient.

d) Ancymidol effectiveness is greatly decreased when applications are made as drenches in a bark medium or when the medium pH is low. The effectiveness of an A-Rest application is also reduced when the day temperature is cooler than the night temperature, because, elongation is already being suppressed by the negative DIF.

e) Calculations

- 1 quart of A-Rest contains 250 mg active ingredient (a.i.)
- A typical soil drench is 0.25 mg of A-Rest in 6 oz. of water per 6-inch pot.
- 1 quart of A-Rest will drench 1,000 plants at a 0.25 mg/pot rate.
- A typical spray application is 0.50 mg A-Rest in 10 ml (1/3 oz.) of water. This will treat 500 plants per quart of A-Rest.

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VII. Pest Management

Insects: The bulb mite, *Rhizoglyphus robini*, can severely damage the lily bulb during development. Dip bulbs for 10-15 minutes in 1 and 1/3 pound of 35% wettable Kelthane powder per 100 gallons of water (do not use emulsifiable concentrates). If Kelthane is unavailable, Avid as a soak or drench (0.15 EC - 4 oz./100 gal.) or Vendex as a drench (50 WP - 10 oz./100 gal.) appear effective in controlling bulb mites. Few materials are labeled and effective on lilies during the forcing stage. Therefore, do not take a chance, dip or drench your bulbs! Use protective gloves for all operations. Call your state entomology specialist if you have questions.

Aphids can also infest Easter lilies. Use an insecticide - do not wait for aphids to become a problem. A good time to apply is mid-January to early February. Dithio or nicotine sulfate smokes may be safe when flower buds are present, provided plants are dry and temperatures are not above 75°F. Tame and Maverick are effective on aphids. Many other chemicals will damage buds and open flowers. In large numbers aphids cause leaf and flower distortion. Aphids are often most damaging at the visible bud stage.

Fungus gnats are occasionally a problem when the growing medium stays wet for extended periods of time. Larvae of the fungus gnat can cause root damage when present in large numbers. Use an insecticide drench (e.g. Gnatrol, Diazinon 50 WP or Oxamil 10 G) to control this pest.

Pathogens: There are 3 major diseases which you as a lily forcer should be aware of: *Botrytis*, *Rhizoctonia* and *Pythium*.

Botrytis (*Botrytis elliptica*) is a fungal disease that can cause loss in quality of product in a number of ways. Initial symptoms appear as small faded

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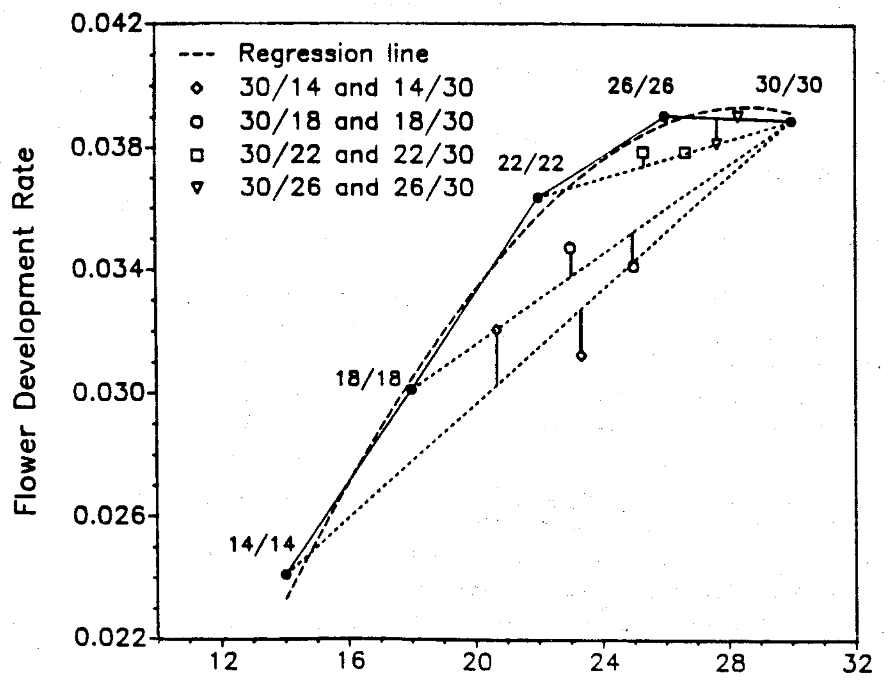
Figure 9. *Lilium longiflorum* cv. Nellie White bud development rate per hour as a function of temperature. The regression line is based on the function: Daily rate = -0.103658E-1 + 0.2615E-2 * [(HDT * DT) + (HNT * NT)]/24 -0.408527E-6/10 * HDT * DT^3 -0.66292E-6/14 * HNT * NT^3 (r^2 = 0.96). HDT and HNT are hours of day and night temperature, respectively. The bars associated with data points represent deviation between observed and expected flower development rate. Reprinted from: Erwin, J.E. and R.D. Heins. 1990. Temperature effects on lily development rate and morphology from the visible bud stage until anthesis. J. Amer. Soc. Hort. Sci. 115(4):644-646.



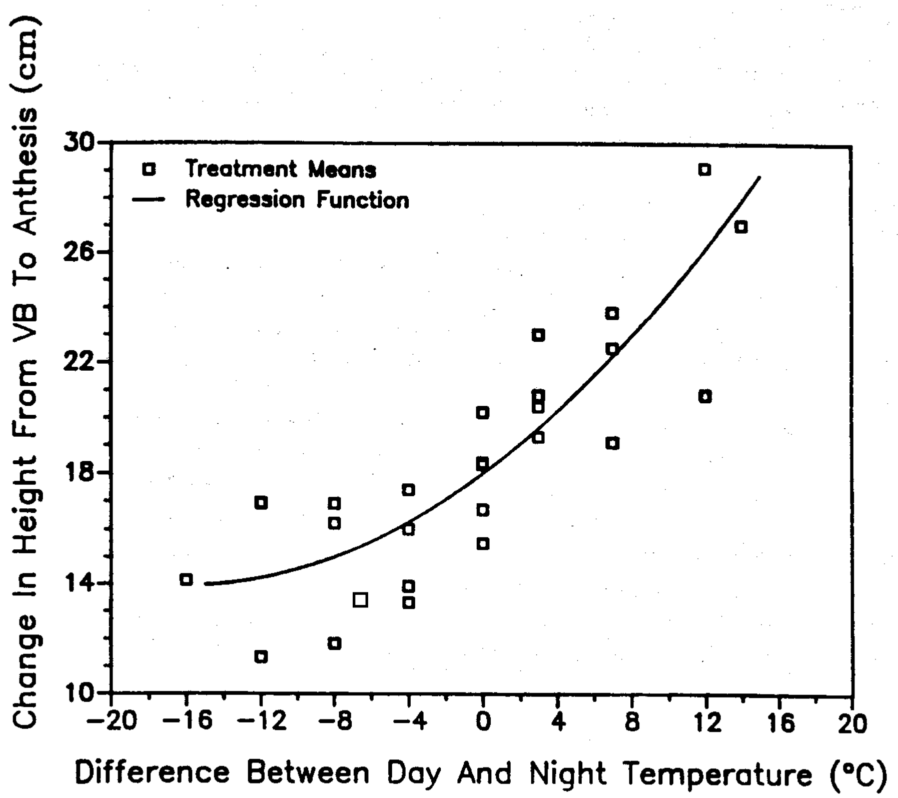


Figure 10. Relationship between *Lilium longiflorum* cv. Nellie White height increase during phase III and the difference between the DT and NT (DT-NT). Squares represent the mean change in plant height after visible bud for each temperature treatment as determined from five plants. The solid line represents the function: Height increase after visible bud = (0.496946*DIF) + (0.150561*DIF^2) + 18.01 (r^2 = 0.77). Reprinted from: Erwin, J.E. and R.D. Heins. 1990. Temperature effects on lily development rate and morphology from the visible bud stage until anthesis. J. Amer. Soc. Hort. Sci. 115(4):644-646.

Botrytis (*Botrytis elliptica*) is a fungal disease that can cause loss in quality of product in a number of ways.

spots which soon turn light brown on the leaves and/or flowers. Disease infestation is favored by cool temperatures and high humidity. If cool moist conditions are present, a grey mold will develop on the infected tissue. Botrytis requires free moisture and high humidity to develop on the plants. Therefore, one method of control for Botrytis is to ventilate to keep plants dry. In addition, plant debris should be removed to eliminate a source of inoculum. If lilies are to be stored in a cooler, reduce humidity if possible to prevent Botrytis from developing on the flower buds.

Root rot is caused by several soil-borne fungal diseases which can be difficult to control.

Root rot is caused by several soil-borne fungal diseases which can be difficult to control. *Pythium* spp. and *Rhizoctonia solani* are usually involved in destruction of lily roots. In general, any discoloration of roots from a yellowish white to a brown/black color suggests a root rot problem. It is usually advisable to assume that the potential for root rot always exists, because, lily bulbs are never sterile. These diseases are controlled by various fungicides applied as soil drenches. The following combinations of fungicides should be applied every 4 weeks: Benlate (50% DF - 16 oz./100 gal.) plus Truban (30% - 8 oz./100 gal.) or apply Banrot (40% WP - 8 oz./100 gal.) only. Alternatively, use Benlate (50% WP-Benlate - 8 oz./100 gal.) and Subdue (Subdue 2E - 0.5 oz./100 gal.). Subdue is a systemic fungicide and should be used early in forcing. Precaution: do not apply more than 1 fluid oz./100 gal. water on lilies and only make one at planting application. Plants have a propensity to develop root rot problems from visible bud onward, especially with high temperature forcing. Higher rates of Subdue can result in leaf tip burn. Always read and follow label instructions prior to use of any fungicide. Call your state plant pathologist if you have any questions concerning disease control.

BUD DEVELOPMENT METER