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Easter Lily Production

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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).

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 brief 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 fully perceive the cold treatment and flower induction will not occur. The cool, moist treatment is referred to as a vernalization treatment.



Table 1. Dates of Easter Sunday from 1995 to 2003.

Year	Date
1995	April 16
1996	April 7
1997	March 30
1998	April 12
1999	April 4
2000	April 23
2001	April 15
2002	March 31
2003	April 20

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.

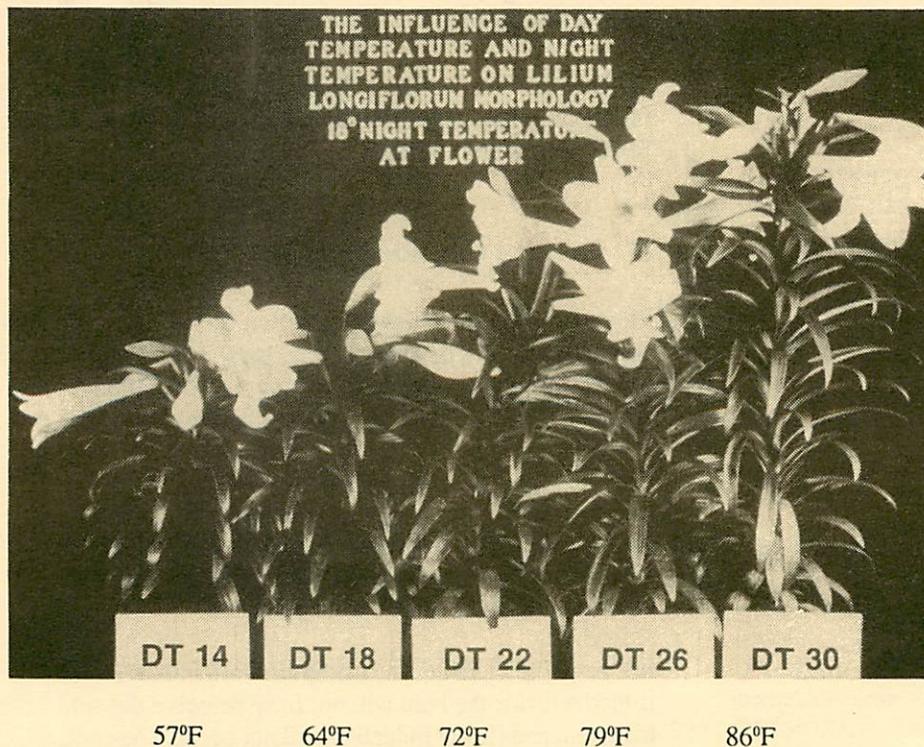
The length of the cooling period is critical. As the length of the vernalization, or cooling period increases:

- 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
- 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':

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



- is shorter
- has fewer leaves
- has wider leaves
- has more basal leaves
- has 1/2 to 1 less flower per 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.
- 3) ammonium may tend to build up to toxic levels if a fertilizer which contains ammonium is used.
- 4) media must be sterilized.

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.

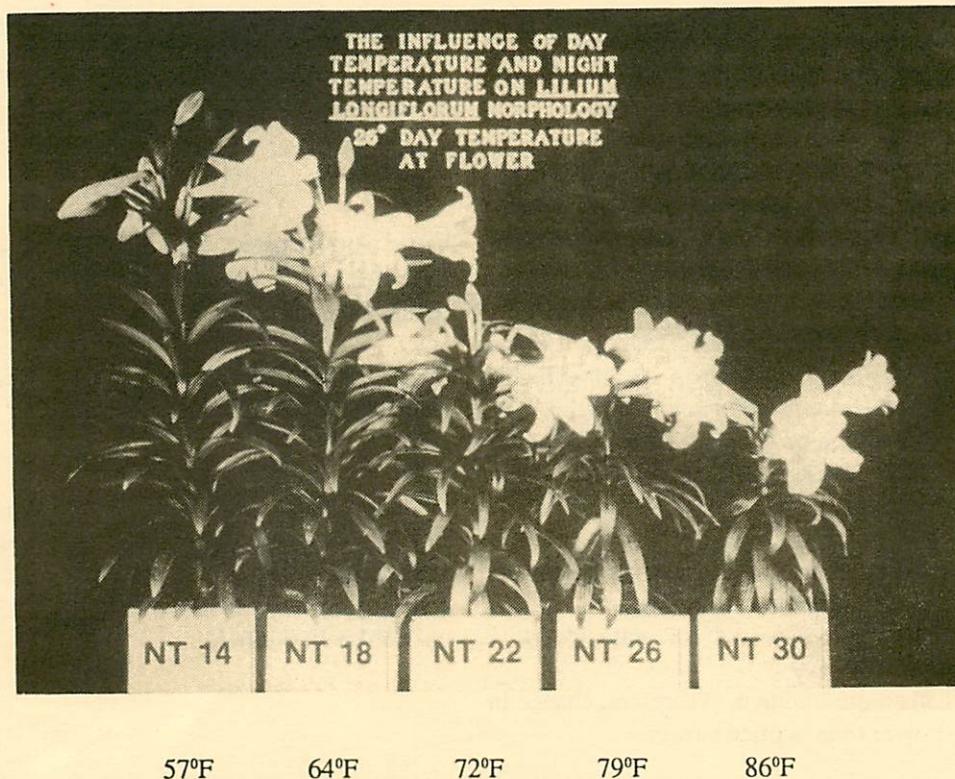
Fertilize with a 200-0-200 ppm (N-P-K) solution. Do not use fertilizers which contain ammonium under cool, dark conditions.

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

Table 2. 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.

Year	Cooled in case		Cooled by CTF	
	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

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



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 foot candles) 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 22, 1996 for wholesalers and Jan. 27, 1996 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 14, 1995, to January, 1996 for wholesalers and December 21, 1995 to January 29, 1996 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 the phase. The majority of your lily population should be at visible bud by February 22, 1996 for wholesalers; February 29, 1996 for retailers, or 36 days after flower initiation. Keep on top of your temperatures!! Use the leaf counting technique to ensure proper timing of a lily crop.

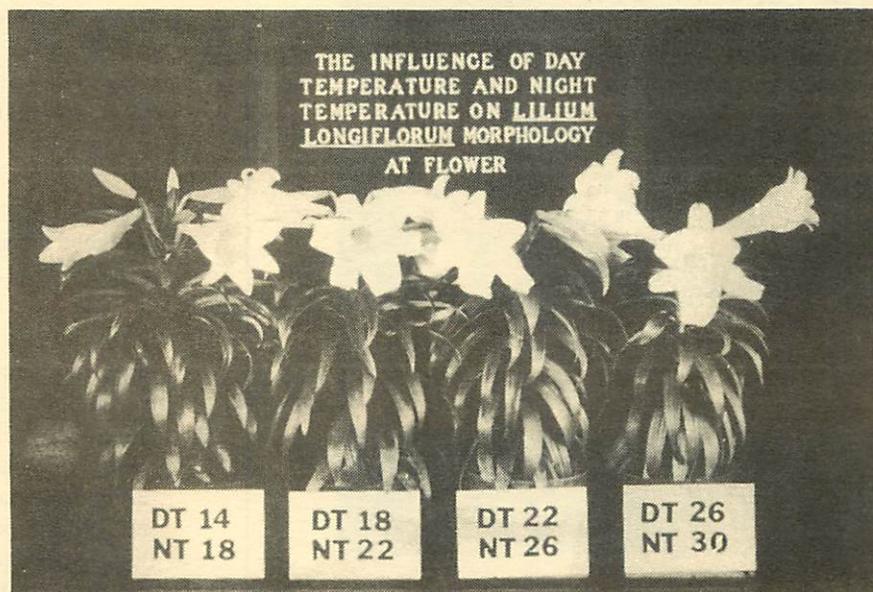
- g) Refer to the following article on 'Tracking Easter Lily Height with Graphs' to determine the average daily temperature which you will need to flower your crop on time. Also consider tracking your height to insure that you produce a lily crop of a desired height.

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).
- 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).
- 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 temperatures for only the first 3 hours of the morning.

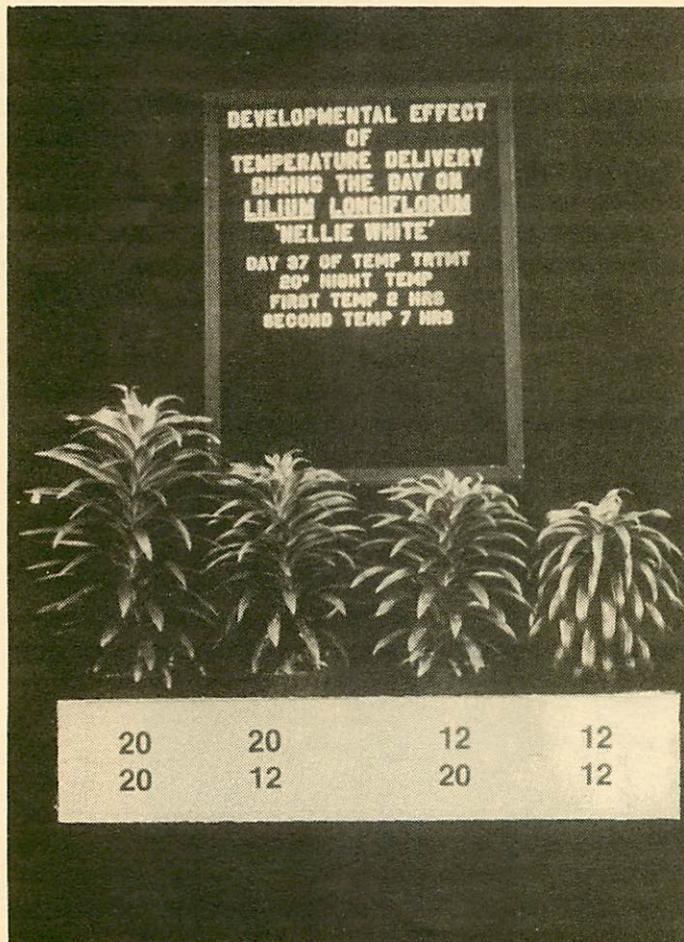
Figure 3. Appearance of *Lilium longiflorum* Thunb. cv. 'Nellie White' at anthesis when grown under four temperature regimes with day temperatures (DT) 4°C (7°F) cooler than night temperatures (NT). Plants grown at higher average temperatures flowered earlier than plants grown at cooler average temperatures. 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.



57°F	64°F	72°F	79°F
64°F	72°F	79°F	86°F

- e) Leaf orientation, defined as the position of the leaf tip relative to the leaf base, also increases as DIF increases (Figure 5).
- 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.
- g) **Lily leaf unfolding rate is dependent on the average daily temperatures under which a crop is grown.** Leaf unfolding rate increases with average daily temperature to an optimum then decreases as temperature increases (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.

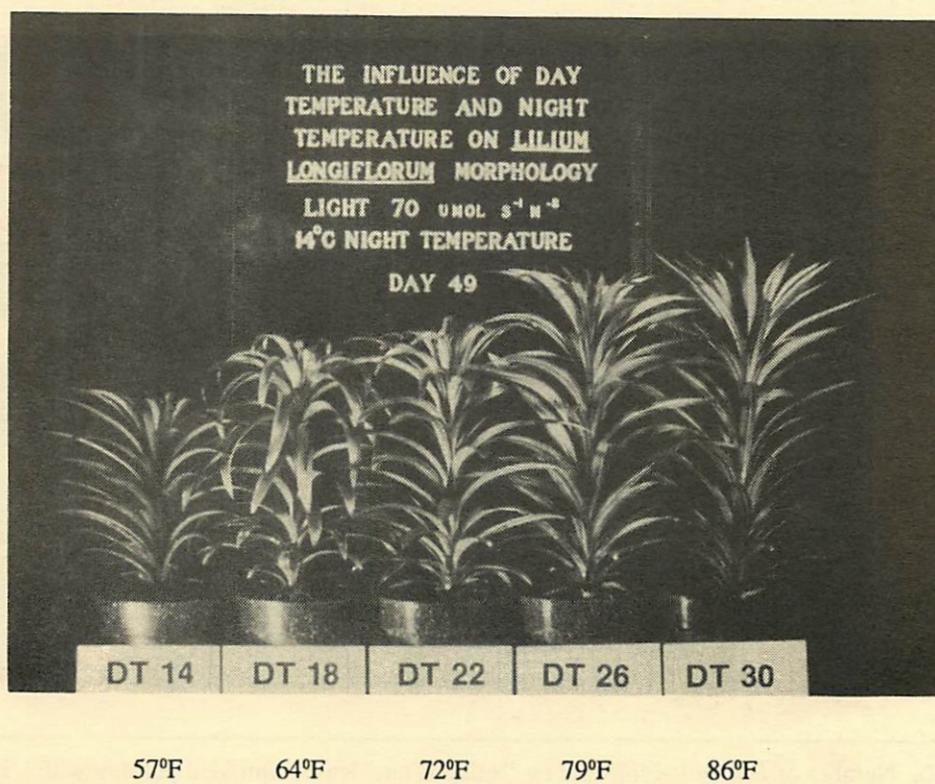
Figure 4. The influence of using cool temperature pulses during the first 2 hours of the morning on *Lilium longiflorum* plant height. The numbers on the top of cards (below) represent the temperature for the first 2 hours of the morning, the bottom numbers represent the temperatures for the remaining 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.



68°F	68°F	54°F	54°F
68°F	54°F	68°F	54°F

- h) Many combinations of day and night 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 visible bud (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 24 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.

Figure 5. The influence of increasing day temperature on *Lilium longiflorum* leaf orientation at a 14°C (57°F) night 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 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 to which expanding internodes will be exposed.
- 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 con-

stant 57°F. The effect 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) applied as a spray or drench.

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.

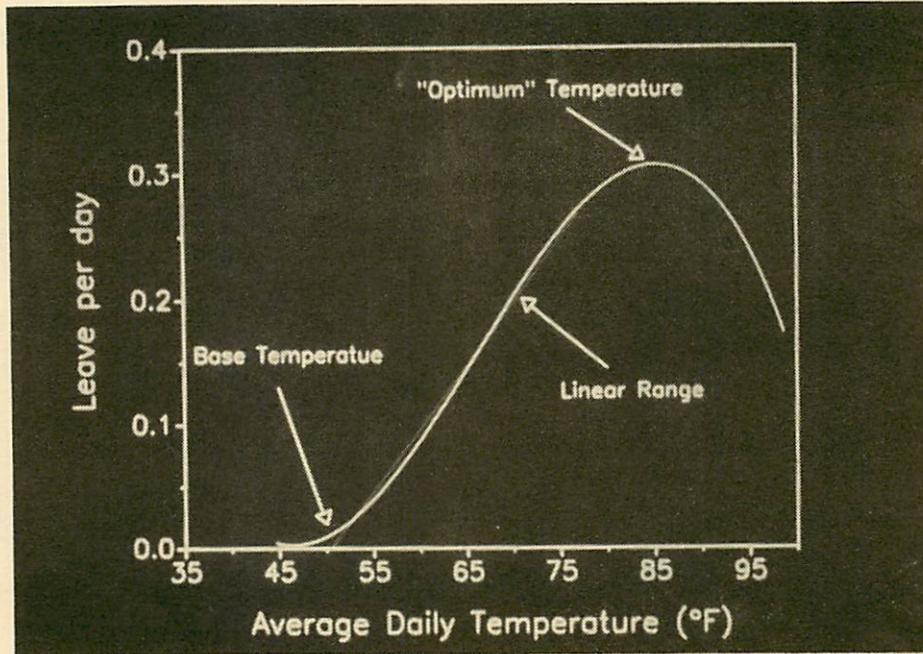


Figure 6b. Number of *Lilium longiflorum* cv 'Nellie White' leaves unfolded per day with a higher day than night temperature, with a higher night than day temperature and with the same day and night temperatures. The regression equation was calculated using treatment means averaged over counting periods 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 'NellieWhite' Easter lily. *J. Amer. Soc. Hort. Sci.* 113(1):70-74.

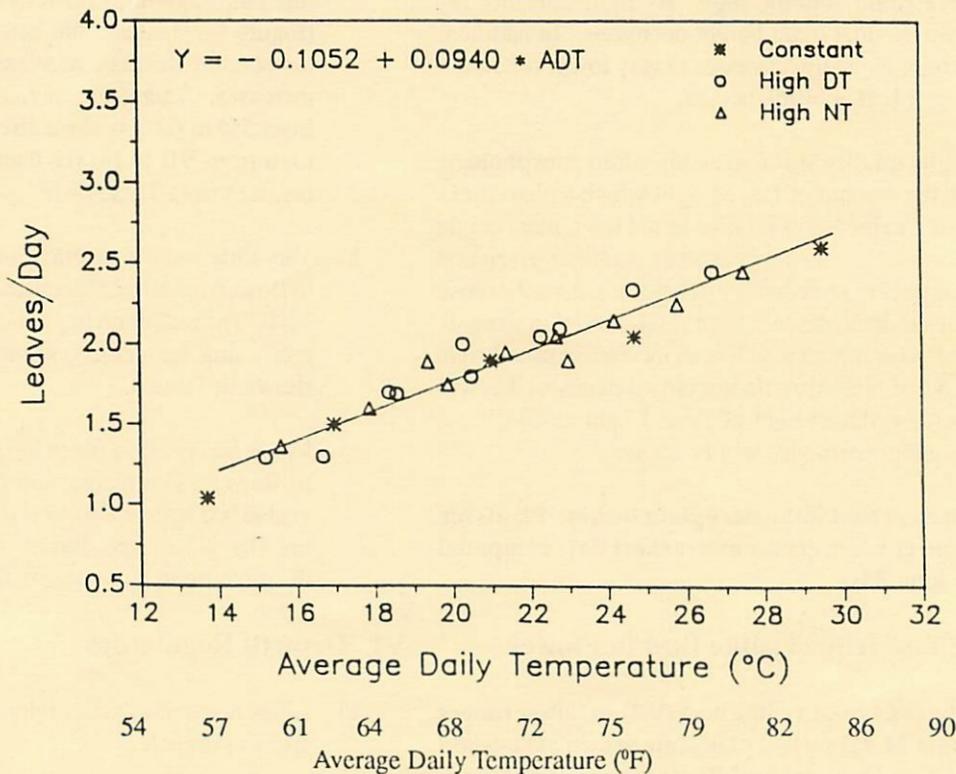
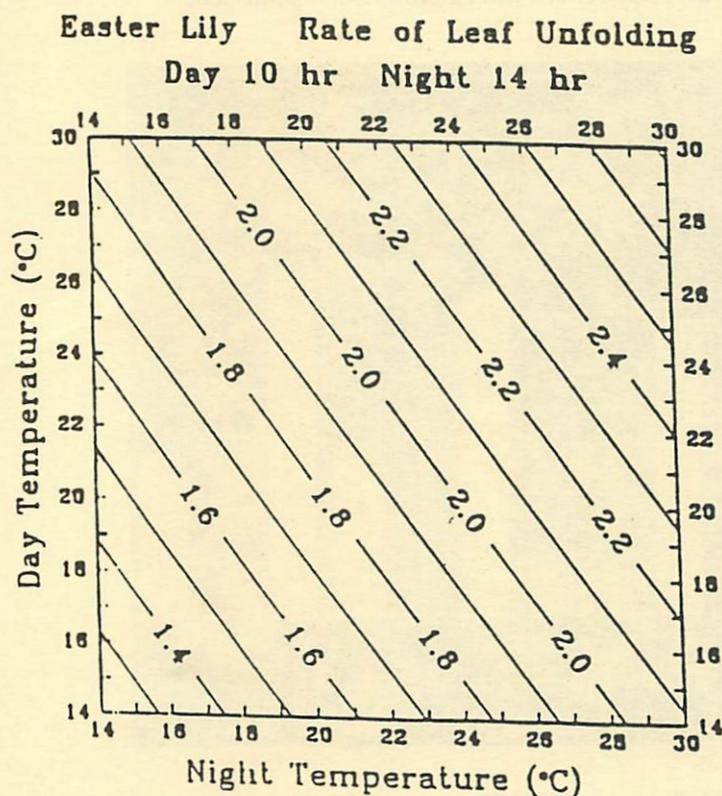


Figure 7. Combinations of day and night temperatures used to determine leaf unfolding rate of *Lilium longiflorum*.



- 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.

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.

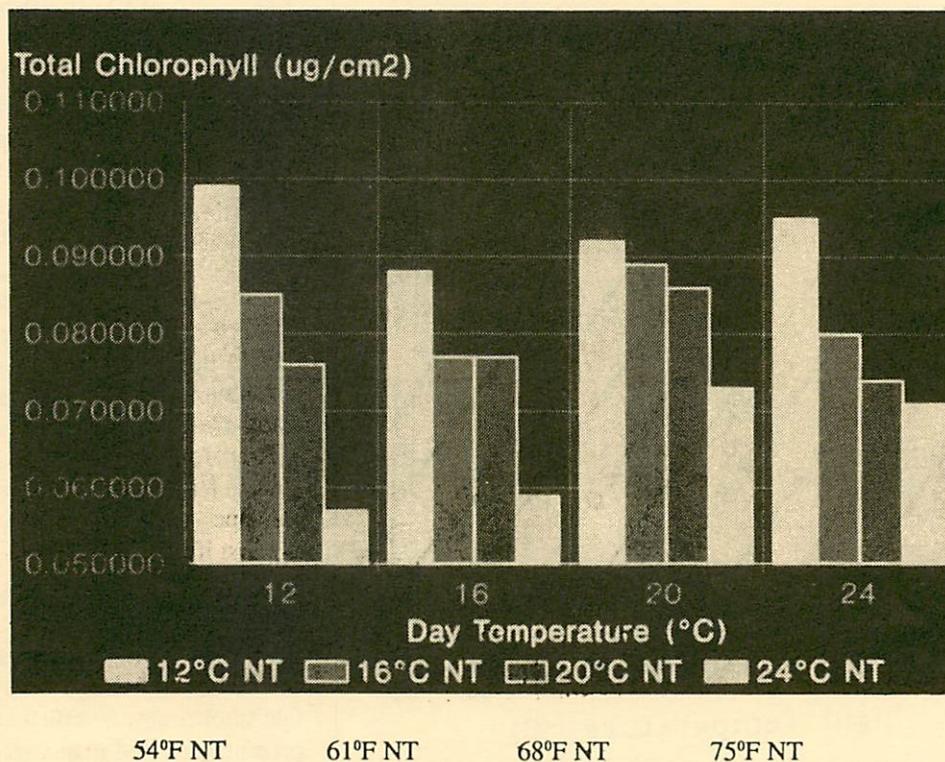
Aphids can also infest Easter lilies. Use an insecticide - do not wait for aphids to become a problem. A good time to apply is mid-January to early February. Dithio or nicotine sulfate smokes may be safe when flower buds are present, provided plants are dry and temperatures are not above 75°F. Tame and 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.

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

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.



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 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 soilborne 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.

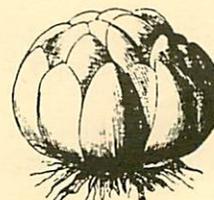


Figure 9. *Lilium longiflorum* cv 'Nellie White' bud development rate per hour as a function of temperature. The regression line is based on the function: Daily rate = $-0.103658E-1 + 0.2615E-2 * [(HDT * DT) + (HNT * NT)]/24 - 0.408527E-6/10 * HDT * DT^3 - 0.66292E-6/14 * HNT * NT^3$ ($r^2 = 0.96$). 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.

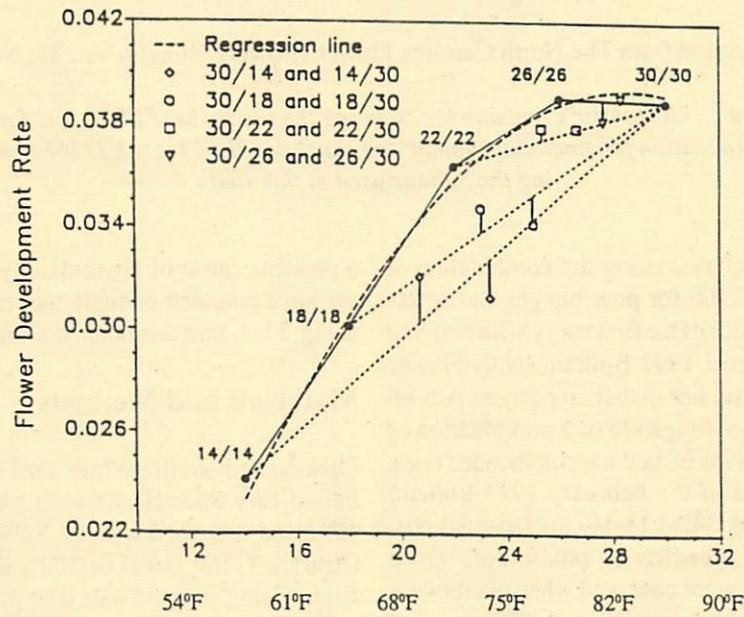
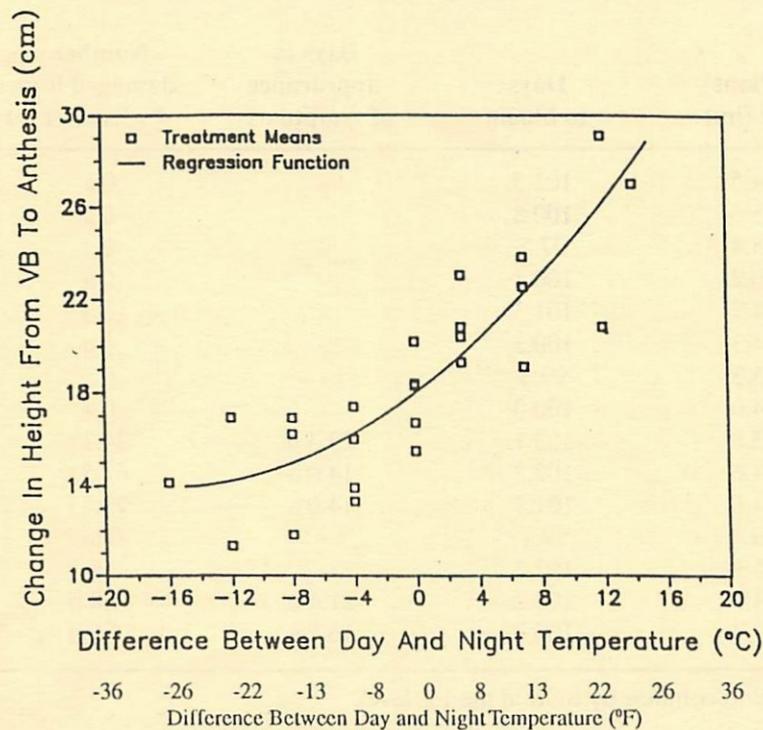


Figure 10. Relationship between *Lilium longiflorum* cv 'Nellie White' height increase during phase III and the difference between the DT and NT (DT-NT). Squares represent the mean change in plant height after visible bud for each temperature treatment as determined from five plants. The solid line represents 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.



DRENCHING DILEMMAS III: EASTER LILIES

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We wish to thank the Fred C. Gloeckner Company for donating the lily bulbs; Fafard, Inc. for donating the substrate; W.A. Cleary Chemical Corporation for financial support and supplying the Cleary's 3336F; and Ciba-Geigy for supplying the Subdue used in this study.

This is our third set of tests evaluating the combination of Subdue 2E and Cleary's 3336F for possible phytotoxic effects; this time on Easter lilies. Our first study with bedding plants, reported in the August 1992 Bulletin (N.C. Flower Growers' Bul. 37(4):1-3) did not detect any phytotoxic effects of drenches with either fungicide or a combination of both even after two applications of 3x the recommended rates. The second study, reported in the February 1993 Bulletin (N.C. Flower Growers' Bul. 38(1):14-16) investigated possible phytotoxic effects of drenches on poinsettias. Once again, no phytotoxic effects were observed when plants were treated at the recommended concentrations. We undertook these studies because growers were warned against mixing two liquid fungicides together back in 1991 (Powell, 1991). In the article by Powell, concern was raised over the possibility of damage due to high salts, especially under high temperature conditions; wetting agents were also implicated as

a possible cause of phytotoxicity in the article. Hopefully, we have amassed enough data to give growers comfort in using this liquid fungicide combination at the labeled rates.

Materials and Methods

Case-cooled 'Nellie White' (8/9's) bulbs were planted into Fafard Lily Special in 6 inch plastic pots on 7 December 1992 and drenched with 1x Subdue 2E (1 fl oz/100 gal) + Cleary's 3336F (20 fl oz/100 gal) after the bulbs and substrate were "watered in." The pots were placed in a 62°F/75°F (night/venting temperature) glass greenhouse here at N.C. State and forced into bloom using standard production procedures.

On 9 February 1993, each pot was drenched with 8 fl. oz. of one of 15 solutions: 1) clear water; 2-6) 20, 60, 200, 600 or

Table 1. Reaction of 'Nellie White' Easter lilies to Cleary's 3336F and Subdue 2E.*

Treatment	Plant ht (in.)	Days to bloom	Days to appearance of symptoms	Number of damaged leaves 4 wks after trt	Number of damaged leaves at anthesis
Check	24.5	101.5	-	0 a	0 a
Cleary's 1x	25.6	100.8	-	0 a	0 a
Cleary's 3x	25.4	97.5	-	0 a	0 a
Cleary's 10x	26.2	100.4	-	0 a	0 a
Cleary's 30x	24.7	101.3	-	0 a	0 a
Cleary's 60x	24.3	100.3	-	0 a	0 a
Subdue 1x	25.3	99.5	-	0 a	0 a
Subdue 3x	24.0	100.0	-	0 a	0 a
Subdue 10x	23.8	103.1	23.3 b	24.2 c	46.8 c
Subdue 30x	24.6	102.2	14.0 a	61.5 e	70.1 d
Subdue 60x	24.6	101.1	14.0 a	73.4 f	80.6 e
C + S 1x	25.4	99.1	-	0 a	0 a
C + S 3x	25.9	102.7	-	0 a	0 a
C + S 10x	24.9	102.2	21.4 b	17.8 b	36.0 b
C + S 30x	23.7	100.7	16.5 a	54.5 d	68.6 d

*Mean separations within columns by SNK at the 1% level.

1200 fl. oz. Cleary's 3336F per 100 gal; 7-11) 1, 3, 10, 30 or 60 fl. oz. Subdue 2E per 100 gal; 12) 20 fl. oz. Cleary's 3336F + 1 fl. oz. Subdue 2E per 100 gal; 13) 60 fl. oz. Cleary's 3336F + 3 fl. oz. Subdue 2E per 100 gal; 14) 200 fl. oz. Cleary's 3336F + 10 fl. oz. Subdue 2E per 100 gal; or 15) 600 fl. oz. Cleary's 3336F + 30 fl. oz. Subdue 2E per 100 gal. These treatments equate to an untreated control, 1x, 3x, 10x, 30x and 60x the recommended concentrations of each of the two fungicides and a 1x, 3x, 10x and 30x combination of the two fungicides. There were ten pots per treatment, and the plants averaged 12.9 ± 1.4 inches tall at time of treatment. The ten replications were arranged in a randomized block design on greenhouse benches.

Results

Cleary's 3336F caused no measurable phytotoxicity at any rate (Table 1). Subdue caused injury only at the 10x, 30x and 60x rates. The injury was more severe as the rate increased. The injury appeared as a light brown leaf tip and brown marginal leaf burn. Leaves that are actively expanding/growing immediately after application were affected the most, but damage eventually extended up and down almost the entire plant. Similar injury was observed in the combination treatments containing 10x and 30x rates of Cleary's 3336F and Subdue 2E, but plants treated with the combina-

tions had no more injury than corresponding Subdue treatments. Therefore, no synergistic effect on the plants from the fungicide combination was evident. Injury from Subdue 2E was not observed at 3x or 1x rates. Symptoms first appeared on the 60x Subdue treated-plants 12 days after treatment and was evident on all of the 30x and 10x Subdue-treated plants by 31 days after treatment.

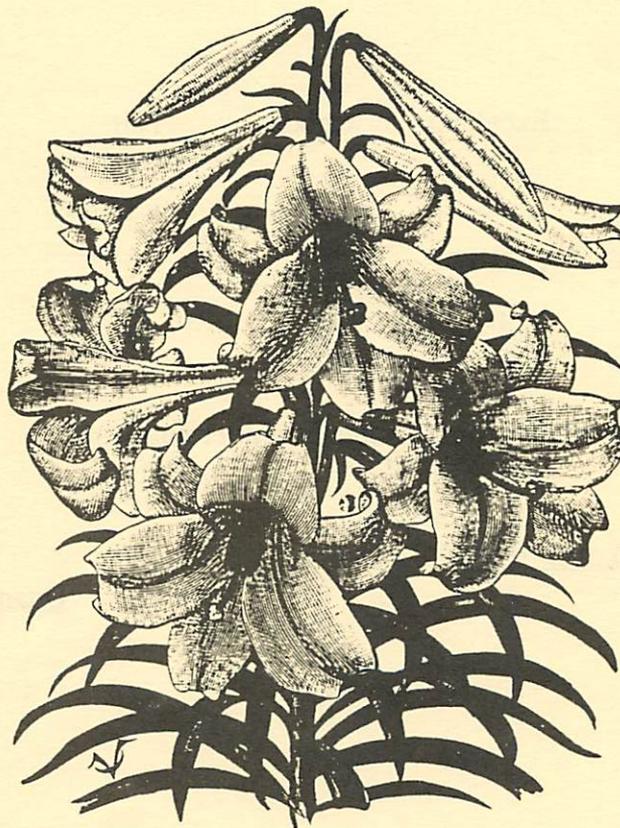
There were no differences between any of the treatments on plant height or flowering dates. This may be due to the late treatment. If the treatments would have been made at planting, there may have been differences, particularly at the very high rates of Subdue where phytotoxic effects were evident.

Conclusion

At the labeled rates of Subdue 2E and Cleary's 3336F, the combination of Subdue 2E and Cleary's 3336F appears to be safe, based on these test conditions. Even at 3x the recommended rates, a one-time application did not result in any measurable/perceivable phytotoxicity.

Literature Cited

Powell, C.C. 1991. Drenches on potted crops: watch the formulations. Ohio State Growers' Hotline No. 3.



Easter Lily Crop Log 1995-1996

Easter is on April 7, 1996

Introduction:

This form was designed to provide factual information to the forcer, jobber, grower and extension agent when/if problems occur with an Easter lily crop. The forcer should accept full responsibility to document cultural steps imposed on his her lily crop and report problems immediately to the jobber. These records are invaluable references for future crops to aid a forcer in making future cultural conditions.

I. Basic Information:

Date of Arrival	
Bulb Source	
Number of Cases	
Bulb Size	

II. Bulb Inspection:

	Excellent	Good	Fair	Poor
Roots				
Basal Plate				
Scales				
Peat Condition	Moist	Dry		
Sprouting	Yes	No		

If there are any serious problems here, contact your jobber.

III. Soil Composition and Test:

<u>Media Item</u>	<u>Quantity</u>

Absolutely conduct a FULL soil test and place it on file.

IV. Bulb Planting:

Bulb planting date _____

Did you soak bulbs (15 minutes) in Kelthane (1- 1 1/3 lbs. 35% WP/100 gallons)?

Yes

No

V. Programming Method:

- a) case cooled by commercial firm
- b) case cooled by yourself
- c) potted and naturally cooled
- d) potted and controlled temperature forcing

Half the total leaf number is already formed in the bulb when you plant the bulb. The remainder of the leaves are formed between planting and the time of flower initiation.

Easter lily bulbs must be cooled a total of 1000 hours at 42-44°F. Do not over cool! Remember; media surrounding bulbs must be moist in order for the bulb to perceive the cooling treatment.

Maintain soil temperature at 68°F. Start bulb cooling immediately if shoots emerge above the media surface. Remember, that sprouted bulbs must be lit with fluorescent lamps if bulbs are cooled in a cooler to reduce excessive shoot elongation.

VI. Cooling to Flower Initiation:

Record both media and air temperature daily from completion of cooling until February 1. Media should be 65°F to maximize root development and flower number after cooling until flower initiation is complete. Air temperatures should never exceed 70°F as flower initiation could be delayed.

Date of First Emergence _____

Date of Last Emergence _____

It is advantageous to sort your crop into early, mid, and late emergers. Different populations should be placed in different locations with late emergers going in the warmer location to hasten development to 'even' the crop.

Test media completely every 2-3 weeks to monitor nutrient levels, pH, and soluble salts from completion of cooling until flowering!

VII. Fungicide Applications:

Apply fungicides at planting, and every 30 days until flowering except when plants are being cooled. Bulbs should be drenched with fungicides to control BOTH *Pythium* and *Rhizoctonia*.

Case Cooled:

- 1) at planting
- 2) January 14
- 3) February 14
- 4) March 14

Controlled Temperature Forcing:

- 1) at planting
- 2) December 14
- 3) January 14
- 4) February 14
- 5) March 14

Actual Materials Applied:

	Date	Material
1)	_____	_____
2)	_____	_____
3)	_____	_____
4)	_____	_____
5)	_____	_____

Make sure fungicide reaches the bottom of the pot. This may require that you 'double' drench each pot.

VIII. Flower Initiation and Leaf Unfolding:

During the third week of January select 3-5 plants from each bulb size and source count leaves under a magnifying glass and observe if reproductive buds are evident. Count leaves again the following week if flower initiation has not yet occurred. Flower initiation should be complete by the end of January.

Refer to the following article by Royal Heins on leaf counting procedures for specifics.

Total leaf number _____

Days to Visible Bud _____

Calculated Leaves per Day
Needed to Flower
Plants on Time _____

Average leaf numbers vary with year and bulb size from 65 to 105 leaves. Adjust air temperatures as needed to hasten or slow leaf unfolding to flower plants on time. Remember that leaf unfolding rate is dependent on the average daily temperature plants are grown under when temperatures range between 50 and 90°F.

IX. Pest Control:

Insecticides:

	Date	Insect	Material
1)	_____	_____	_____
2)	_____	_____	_____
3)	_____	_____	_____
4)	_____	_____	_____
5)	_____	_____	_____

X. Final Developmental Data:

Average final leaf number _____

Average date of visible bud _____

Average flower number _____

Average date of first flowering _____

SCHEDULES 1996

John Erwin
University of Minnesota

Schedule 1, Natural Cooling, Easter 1996

General:

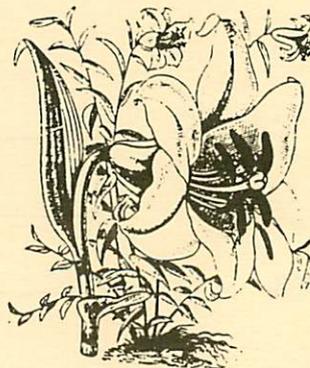
- a) Uncooled bulbs are used. Bulbs should arrive during the third week of October. Dip bulbs for control of bulb mites. (See Pest Control section.)
- b) Pot bulbs 1/2 to 1 inch from the bottom of the pot. Drench with a fungicide for control of *Pythium* and *Rhizoctonia*. Keep soil moist and at a temperature of 63°-65°F for optimal rooting. The rooting period is responsible for longer lower leaves and the higher flower bud counts.

Cooling:

- a) Potted bulbs should be placed on a substrate such as gravel to elevate the base of the pot above the surface of the field, covered frames, shed or uncooled greenhouse. Potted bulbs are then exposed to naturally occurring, fluctuating temperatures. Exact temperature records must be kept. Record temperatures daily. Use thermometers inserted in pots next to the bulbs. Bulbs require 1000 hours of temperatures between 35° and 45°F. Two hours of temperature between 45° and 50°F should be counted only as one hour of cooling. The medium should not be allowed to freeze. Keep the medium moist, but not wet. A light mulch or shading over the top of the pots aides in maintaining uniform temperatures and moisture levels.

Start of Forcing:

- a) Greenhouse forcing can start after 1000 hours of cooling. Do not overcool! The inability to achieve desired media temperatures during any time during the cooling period will delay the beginning of the greenhouse forcing stage.
- b) Media temperatures should be maintained between 63° and 65°F until the shoot meristem is above the soil surface. A warmer media temperature will hasten emergence. The bulk of your lily population should be emerged by December 28, 1995 if you're a wholesaler or January 4, 1996 if you're a retailer. Lower temperatures may limit root development. Higher temperatures may delay flower initiation or negate the vernalization treatment entirely. Maintain 65°F air temperature between emergence and initiation. Flower initiation should occur by January 22, 1996 for wholesalers and January 29, 1996 for retailers.
- c) At shoot emergence you may want to place plants under long day conditions to insure that plants have been induced to flower. Expose emerged shoots to long days by placing plants in an area where they will receive 10 foot candles of night interruption lighting from 10:00 p.m. to 2:00 a.m. Because of the potential for shoot elongation when night lighting with incandescent lamps, we recommend that you light for only 1 week unless plants received less than 6 weeks of cooling. Fluorescent lamps are preferable to incandescent lamps and are equally effective.



Schedule 2, Controlled Temperature Forcing (CTF), Easter 1996

General:

- a) Uncooled bulbs are used. Bulbs should arrive during the third week of October. Dip bulbs for control of bulb mites. (See Pest Control section.)
- b) Pot bulbs 1/2 to 1 inch from the bottom of the pot. Drench with a fungicide for control of *Pythium* and *Rhizoctonia*. Keep media moist and at a temperature of 63°-65°F for optimal rooting. The rooting period is responsible for longer lower leaves and the higher flower bud counts.

Cooling:

- a) Start cooling on November 2, 1995 for wholesalers or November 9, 1995 for retailers. Drop the soil temperature to 40° for 'Ace' and 40-45°F for 'Nellie White' bulbs. Place thermometers in the media next to the bulbs. Record temperatures daily. Make sure the media is moist at all times; the bulb will not perceive the cooling treatment if the media is not moist.

Start forcing:

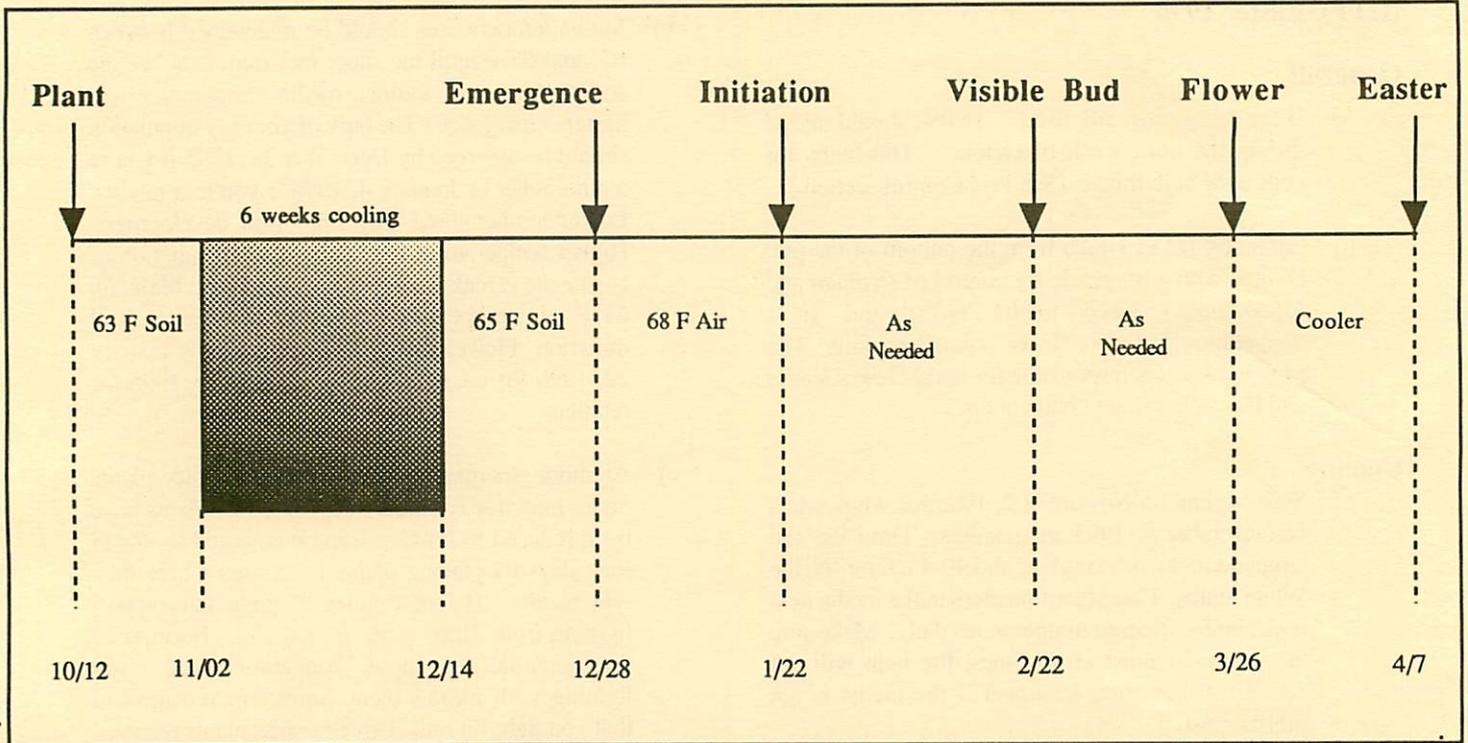
- a) Bring potted bulbs out of the cooler after 42 days (1000 hours). This year potted bulbs should be brought into the greenhouse on December 14, 1995 for wholesalers and December 21, 1995 for retailers.

- b) Media temperatures should be maintained between 63° and 65°F until the shoot meristem is above the soil surface. A warmer media temperature will hasten emergence. The bulk of your lily population should be emerged by December 28, 1995 if you're a wholesaler or January 4, 1996 if you're a retailer. Lower temperatures may limit root development. Higher temperatures may delay flower initiation or negate the vernalization treatment entirely. Maintain 65°F air temperature between emergence and initiation. Flower initiation should occur by January 22, 1996 for wholesalers and January 29, 1996 for retailers.
- c) At shoot emergence you may want to place plants under long day conditions to insure that plants have been induced to flower. Expose emerged shoots to long days by placing plants in an area where they will receive 10 foot candles of night interruption lighting from 10:00 p.m. to 2:00 a.m. Because of the potential for shoot elongation when night lighting with incandescent lamps, we recommend that you light for only 1 week unless plants received less than 6 weeks of cooling. Fluorescent lamps are preferable to incandescent lamps and are equally effective.



Lily Schedule 1995/96 - Wholesale

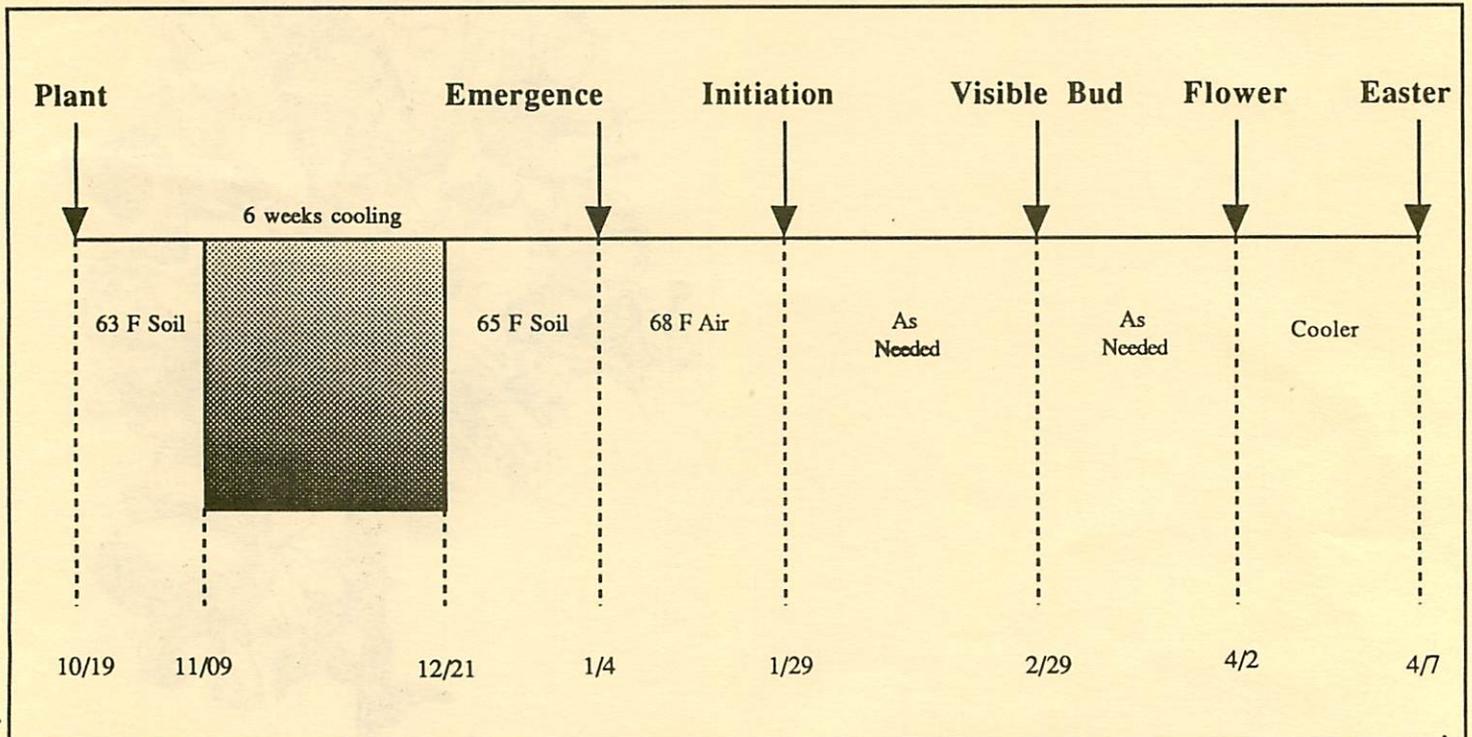
Controlled Temperature Forcing



This schedule is an example. Temperatures are based on an Easter lily which has 90 leaves with 35 leaves unfolded at flower initiation. Forcing temperatures are shown. Actual temperatures will depend on the leaf number per plant of your Easter lily crop and the ability of your greenhouse to maintain temperatures.

Lily Schedule 1995/96 - Retail

Controlled Temperature Forcing



This schedule is an example. Temperatures are based on an Easter lily which has 90 leaves with 35 leaves unfolded at flower initiation. Forcing temperatures are shown. Actual temperatures will depend on the leaf number per plant of your Easter lily crop and the ability of your greenhouse to maintain temperatures.

Schedule 3, Home Case Cooled Bulbs, Easter 1996

Start of Forcing:

General:

- a) Uncooled bulbs are used.
- b) Bulbs should arrive during the third week of October. Make sure that the peat in the crate is moist. If dry, moisten the peat. The peat must be moist for the bulbs to perceive the cooling treatment.

Cooling:

- a) Place the packing crate in the cooler immediately.
- b) Drop the soil temperature to 40° for 'Ace' and 40-45°F for 'Nellie White' bulbs. Place thermometers in the crate next to the bulbs. Record temperatures daily. Make sure the media is moist at all times; the bulb will not perceive the cooling treatment if the media is dry. Check the bulbs every week for evidence of shoot emergence. If shoots begin to emerge, lower temperatures to 36° to 38°F.
- c) **Bring potted bulbs out of the cooler after 42 days (1000 hours).** This year potted bulbs should be brought into the greenhouse on December 11, 1995 for wholesalers and December 18, 1995 for retailers, assuming cooling starts on October 30 and November 6 respectively. If cooling begins earlier, adjust the forcing time accordingly.

- a) Dip bulbs for control of mites. Pot bulbs 1/2 to 1 inch from the bottom of the pot. Drench potted bulbs with a fungicide for control of *Pythium* and *Rhizoctonia*.
- b) Media temperatures should be maintained between 63° and 65°F until the shoot emergence. High media temperatures promote shoot emergence before adequate rooting. Poor rooting results in short lower leaves. After shoot emergence, media temperature should be maintained about 63° to 65°F until the meristem is above the media surface. The bulk of your lily population should be emerged by December 28, 1995 if you're a wholesaler or January 4, 1996 if you're a retailer. High air temperature may delay flower initiation or negate the vernalization treatment entirely. Maintain 68°F air temperature between emergence and initiation. Flower initiation should occur by January 22, 1996 and January 29, 1996 for retailers.
- c) At shoot emergence you may want to place plants under long day conditions to insure that plants have been induced to flower. Expose emerged shoots to long days by placing plants in an area where they will receive 10 foot candles of night interruption lighting from 10:00 p.m. to 2:00 a.m. Remember that both cooling and long days can induce an Easter lily to flower. Because of the potential for shoot elongation when night lighting with incandescent lamps, we recommend that you light for only 1 week unless plants received less than 6 weeks of cooling. Fluorescent lamps are preferable to incandescent lamps and are equally effective.



Schedule 4, Commercially Case Cooled Bulbs, Easter 1996

General:

- a) Uncooled bulbs are used.
- b) Bulbs should arrive by mid December. Make sure that the peat in the crate is moist. If dry, moisten the peat. The peat must be moist for the bulbs to perceive the cooling treatment. Dry peat suggests that bulbs may not have been cooled adequately and/or have been cooled unevenly.

Start of Forcing:

- a) Dip bulbs for control of mites. Pot bulbs 1/2 to 1 inch from the bottom of the pot. Drench potted bulbs with a fungicide for control of *Pythium* and *Rhizoctonia*.
- b) Media temperatures should be maintained between 63° and 65°F until the shoot emergence. High media temperatures promote shoot emergence before adequate rooting. Poor rooting results in short lower leaves. After shoot emergence, air

temperature should be maintained about 63° to 65°F until the meristem is above the media surface. The bulk of your lily population should be emerged by December 28, 1995 if you're a wholesaler or January 4, 1996 if you're a retailer. High air temperature may delay flower initiation or negate the vernalization treatment entirely. Maintain 68°F air temperature between emergence and initiation. Flower initiation should occur by January 22, 1996 and January 29, 1996 for retailers.

- c) At shoot emergence you may want to place plants under long day conditions to insure that plants have been induced to flower. Expose emerged shoots to long days by placing plants in an area where they will receive 10 foot candles of night interruption lighting from 10:00 p.m. to 2:00 a.m. Remember that both cooling and long days can induce an Easter lily to flower. Because of the potential for shoot elongation when night lighting with incandescent lamps, we recommend that you light for only 1 week unless plants received less than 6 weeks of cooling. Fluorescent lamps are preferable to incandescent lamps and are equally effective.

A-REST APPLICATION RATES

Adapted from Minnesota State Florists Bulletin, October 1984 article by Harold F Wilkins and Kevin L. Grueber

A-Rest is the trade name of the chemical Ancymidol. A-Rest is sold as a 0.0264% (264 ppm) solution with 250 mg a.i. per quart. Application solutions should be prepared with water and without any additional wetting agent. Even application is essential for uniform growth response; for sprays this means wetting all foliage evenly and avoiding dripping into the potting medium, while for drenches the medium should be uniformly moistened before application.

Soil Drenches

One pint of A-Rest in 16 gallons of water. This amount is to drench 500, 6-inch pots (4 oz. of the mixture per pot). This results in application of 0.25 mg (25ppm) active ingredient (a.i.) per pot. To avoid over application you may want to apply as 2 or 3 drenches at lower levels. For example 2 drenches at 0.125 mg a.i./6-inch pot or even 3 drenches at 0.083 mg a.i./6-inch pot spaced over the forcing period.

Plant Sprays

Usual recommendations call for 0.5mg a.i. (50 ppm) per plant in a 6-inch pot. Because 1 pint of A-Rest contains 125 mg a.i., 1 pint in 2 or 5 gallons of water will treat 250 plants,

depending on the size of the plants. If the plants are small use 2 gallons to spray 250 plants; if plants are larger, use 5 gallons to spray 250 plants. Whatever volume of water is used (2 to 5 gallons), the entire mixture must be sprayed on the 250 plants. As with drenches, multiple sprays of low application rates may be used. Spraying at 0.25 mg a.i./6 inch pot shortly after emergence and again as needed is practical. Three or more low concentration sprays during forcing is also a possibility, with the sum of A-Rest applied per plant during the forcing season being not greater than .5 mg a.i.

Bulb Dips

If a forcer perennially finishes with a crop which is too tall, or grows in a bark based medium, a low level A-Rest dip of only 2 oz./gal/ for 30 minutes may be more appropriate than a full concentration dip of 6 oz./gal. This way repeated (3 to 5) sprays of .1 mg a.i./6-inch pot may be used at emergence in conjunction with the bulb dip. Bulb dips should be used with caution since once the application is made, the forcer has to "live with" the treatment.

TRACKING EASTER LILY HEIGHT WITH GRAPHS

Easter lily response to temperature during forcing

Royal Heins, John Erwin, Meriam Karlsson, Robert Berghage, William Carlson and John Biernbaum

Reprinted from: *Greenhouse Grower* 6(9):32-37.

Timing and height - how can you control these two vital elements in producing potted plants? At Michigan State we've researched the effects of light and temperature on lily, chrysanthemum and poinsettia timing and height. The result is a system called "graphical tracking" which shows you how to manipulate temperature to get your crops to bloom on time at the height you want.

The key to making this system work is knowing your crop's specific reactions to temperature. Lilies, for example, react differently depending on their stage of development. Before visible bud, their leaf unfolding is directly proportional to increases in average daily temperature. After visible bud, however, this is no longer true. Instead, the higher the initial average daily temperature, the less it helps to increase the temperature further.

While average daily temperature influences how fast lilies grow, the difference between day and night temperatures affects the way they look. Warm days with cool nights produce tall plants with upright leaves; cool days with warm nights produce short plants with horizontal or downward curling leaves.

What is an "isopleth plot"?

"Isopleth" means "equal quantity". An isopleth plot is a graph that shows how two variables relate to a constant quantity of another variable. A contour map which shows lines of equal elevation is an example of an isopleth plot. Our isopleth plots show which day and night temperatures result in the same rate of lily development.

Figures 1a and 1b show combinations of day and night temperatures which result in the same rate of leaf unfolding (Figure 1a for a 10-hour day and Figure 1b for an 11-hour day). Figure 2 shows combinations of day and night temperature that result in the same number of days from visible bud to flower.

Some of these temperature combinations will produce tall plants (warm days/cool nights) and other combinations will produce short plants (cool days/warm nights).

What can "graphical tracking" do for you?

Graphical tracking is a procedure used throughout development where actual plant height is plotted and compared with desired plant height.

This article will explain how to construct a graph like the one shown in Figure 3 showing the "tracking window". This "window" represents where your plants should be if they are to bloom on time at the desired height. If their actual measurements do not fall in the "tracking window", you can adjust their development by means of temperature changes - or growth regulator applications.

To construct the "tracking window" graph, draw a graph like the one shown in Figure 3, with height up the side and days to flower across the bottom. Let's assume that you need your lilies ready for shipping by April 1 and the final desired lily height is 22" to 24". (Subtract 6" for the pot, leaving 16" to 18" actual plant height.) We know from experience that a lily typically doubles in height from visible bud to flower, so visible bud height should be 50% of final height or 8" or 9" (14" to 15" including the pot). Connect your beginning height (0") with these desired minimum and maximum heights at visible bud and flower to form your "tracking window".

From emergence to flower initiation, we recommend growing lilies at 62° to 65°F (17° to 18°C) soil temperature, with constant air temperature a degree or two warmer. Keep day and night temperatures about the same.

Around the beginning of February, you should be able to count the leaves and figure out how many are yet to unfurl.

Divide the number of leaves yet to unfurl into the number of days before your projected visible bud date to get the number of leaves that must unfurl each day to meet that deadline. Let's assume it's 1.6 leaves.

Check Figure 1a to find all the combinations of day and night temperatures which will unfold 1.6 leaves per day. Pick out a day temperature and draw a horizontal line to the 1.6 line; the night temperature directly below the point where those lines cross is the corresponding night temperature.

Figure 1a. Isopleth plots of lily leaf unfolding rates for a 10-hour day and 14-hour night.

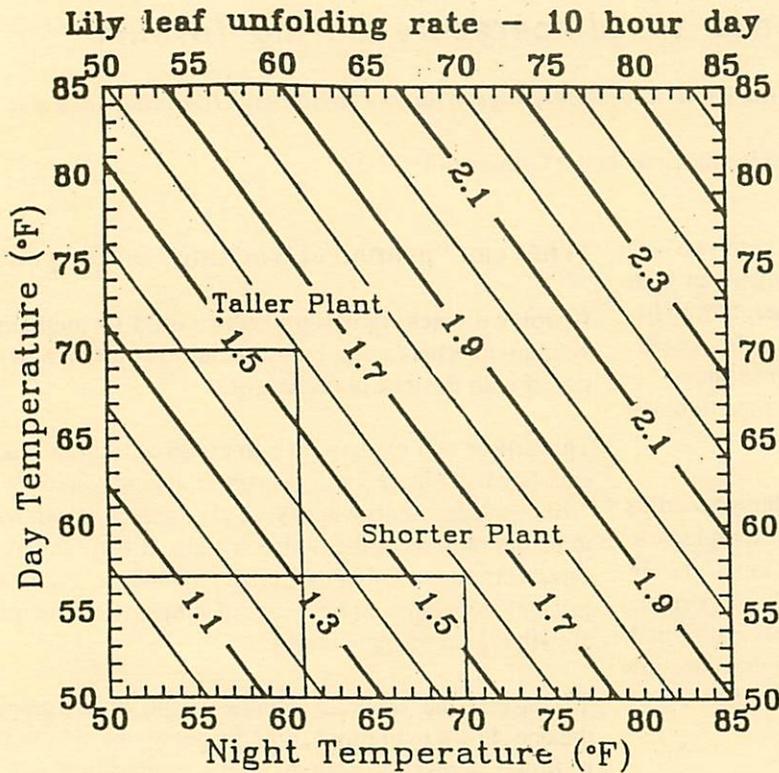
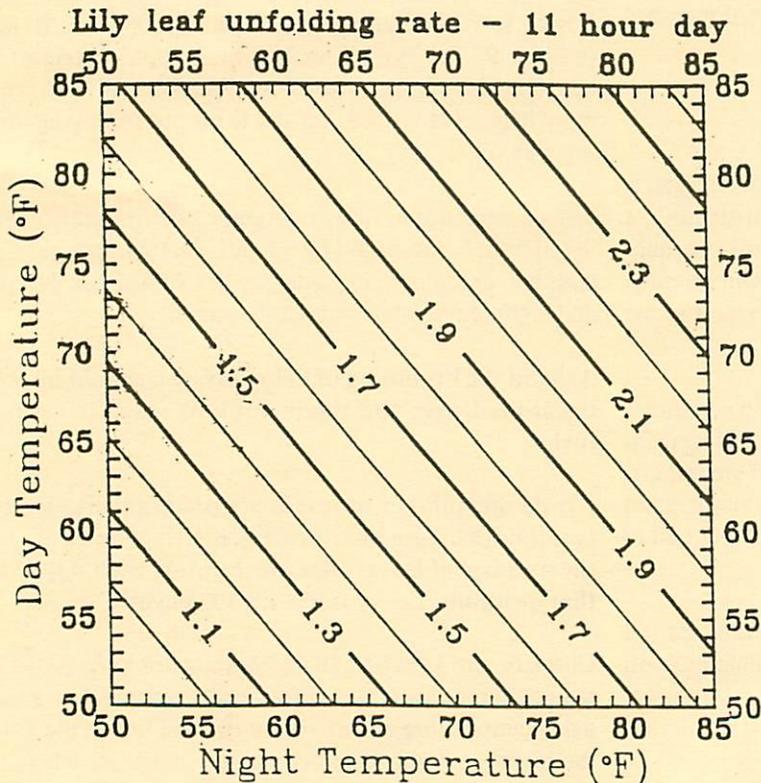


Figure 1b. Isopleth plots of leaf unfolding rates for an 11-hour day and 13-hour night.



In January and early February, when days are short, use the 10-hour-day graph (Figure 1a); in mid to late February, when the days are longer, use the 11-hour-day (Figure 1b).

Measure the height of your plants every 4 to 5 days to see if they are within your "tracking window". Remember that warm days with cooler nights produce tall plants and cool days with warmer nights produce short plants. If your plants are too tall, choose a cooler day/warmer night combination of temperatures; if they're too short, choose a warmer day/cooler night combination.

The more extreme the differences in day and night temperatures, the more extreme the effect in stretching or slowing down the elongation of your plants. However, as long as you choose one of the combinations along that same 1.6-leaves-per-day line, your lilies will stay on your desired growing schedule.

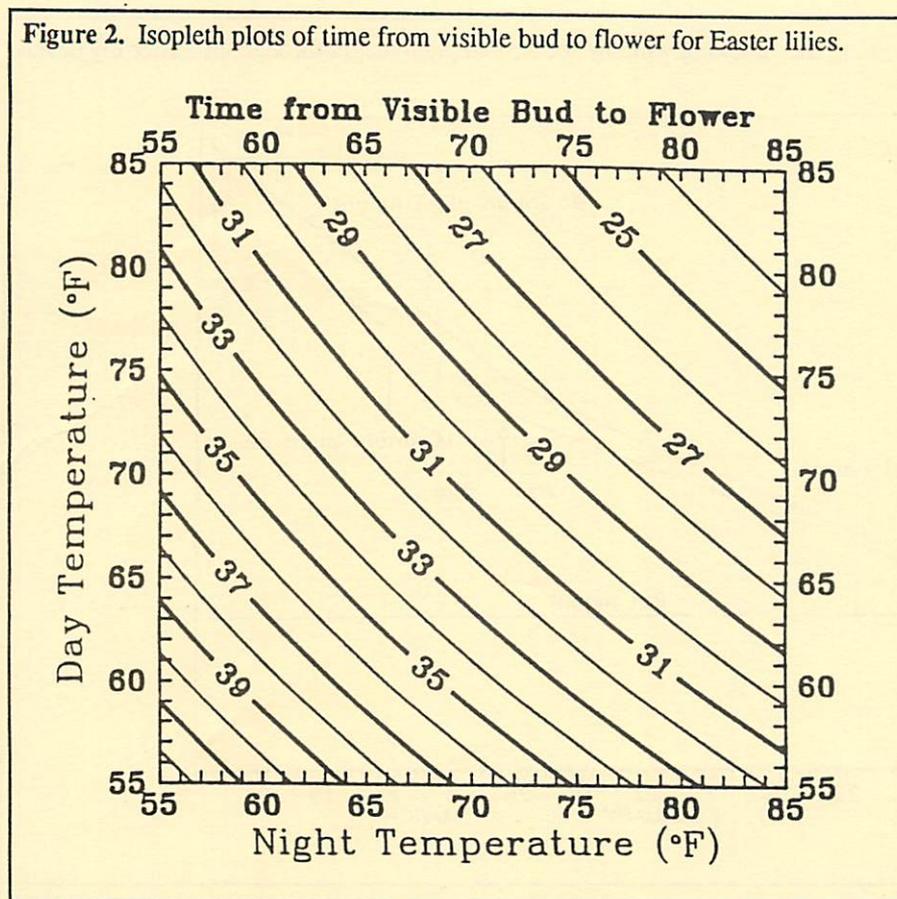
After lilies reach visible bud, use the isopleth plot shown in Figure 2, showing number of days from visible bud to flower. Keep measuring your plants and adjust your temperatures as you did before, if your plants are too tall or too short for the "tracking window".

How does it work?

Figure 4 shows an actual example of graphical tracking in a commercial greenhouse. Before flower-initiation, plants were grown at 62°F (16.5°C) both day and night. On January 27, the grower noticed that his plants were getting too tall for the "tracking window" and chose a warmer night/cooler day combination of temperatures (63°F night and 53°F day; 17°C night and 12°C day). Stem elongation decreased dramatically.

On February 10, the grower became concerned that the plants would soon drop below the "tracking window", so he adjusted the temperatures in the op-

Figure 2. Isopleth plots of time from visible bud to flower for Easter lilies.



perature conditions reduce the effectiveness and benefit of A-Rest.

These are the tools

Any procedure you apply to your plants - from basic watering on up to these more "scientific" procedures - is just another tool to help you control your crops. Once you understand how a tool works, it can make your work easier - and that goes for "isopleth plots" and "graphical tracking", too.

posite direction, to 56°F night and 64°F day (13°C night and 18°C day). This increased the stem elongation while keeping the leaf unfolding rate at a constant 1.3 leaves per day

On February 17, the grower chose to increase leaf unfolding rate to 1.5 leaves per day, by adjusting the temperatures to 65°F night and 60°F day; (18°C night and 15.5°C day). He maintained this temperature past visible bud and then increased it twice more to hasten development.

Informed use of the "isopleth plots" and "graphical tracking" allowed this grower to produce his lilies on time, and at the desired height - without the use of growth regulators.

Growth Regulators

Not all lily growers have light and outdoor temperature conditions that allow precise temperature control throughout lily development. If you can't keep your lilies in the "tracking window" by means of temperature control alone, growth retardants may be necessary.

When using the growth retardant A-Rest, keep in mind that its effectiveness decreases under cool day/warm night conditions and increases under warm day/cool night conditions. So if you are combining A-Rest with the shortening effect of cool day/warm night conditions, keep in mind that these tem-



Figure 3. Graphical tracking plot showing the "tracking window" of desired plant height throughout Easter lily development.

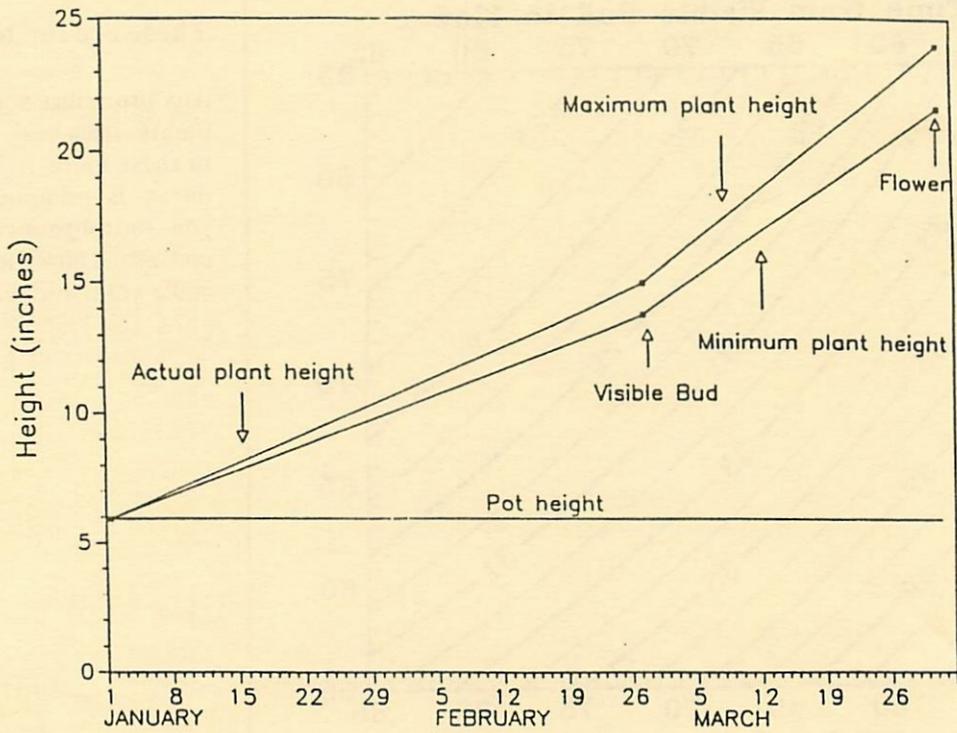
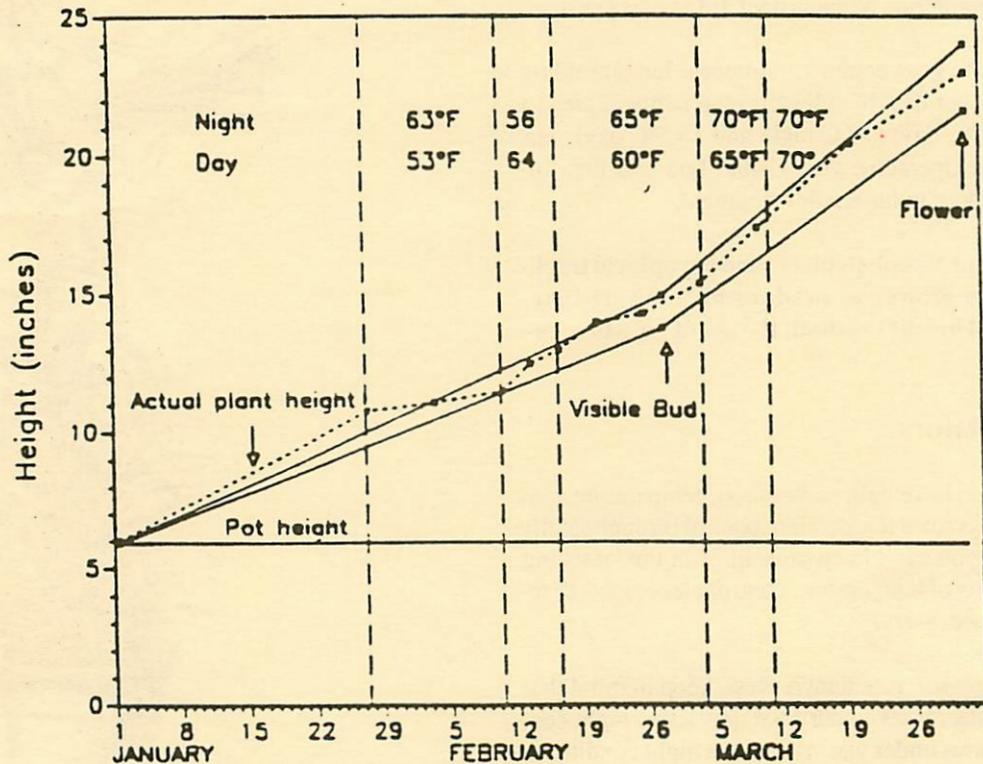


Figure 4. Example application of graphical tracking to a lily crop. Actual plant height plotted and compared to the desired height shown in the "tracking window".



LILY LEAF COUNTING TECHNIQUE AND TIME SCHEDULE

*Royal D. Heins
Michigan State University*

Here are suggested dissecting and counting techniques and schedules for the Easter 1996 forcing schedule.

Leaf counting is a technique used to insure proper timing of a lily crop. Once a lily shoot initiates a flower bud, no more leaves will form. At visible bud, all the leaves have unfolded. Therefore, if one knows how many leaves have yet to unfold on a plant before the visible bud stage, one can calculate how many leaves must unfold each day (or week) in order to reach the visible bud stage by a particular date. By knowing the number of leaves which must unfold each week and by making a count of leaves which actually unfolded the previous week, one can determine if a crop is slow fast or on time. Subsequently, the air temperature may be increased or decreased to hasten or delay plant development for proper crop timing. The following describes how to leaf count a lily crop.

1. **Leaf counting is usually started 3-4 weeks after emergence or when plants are 3-4 inches tall.** The first plants are examined to determine if flower initiation has occurred. If the first plants examined are still vegetative, a new set of plants is examined 4-5 days later
2. **A minimum of 3-5 plants for every bulb source and bulb size should be taken to estimate the average leaf number of the crop.** Count how many leaves have unfolded and how many leaves have yet to unfold on each plant. Unfolded leaves are normally defined as those leaves which are at an angle equal to or greater than 45° with the plant stem. Leaves yet to unfold are defined as those leaves which have an angle of less than 45° with the plant stem. The actual leaf angle is less important than consistency between countings. A large needle and a magnifying glass will help you remove small scale-like leaves near the shoot apex. The embryo-like flower buds will be present on reproductive plants. An estimate of the future bud count can be made on these plants.
3. **Divide the number of leaves already unfolded by the number of days from emergence until the present date.** This will tell how many leaves have unfolded each day to date.
- 4) **Determine the visible bud date.** The visible bud date is normally 30-35 days prior to the expected flower date (often the week prior to Palm Sunday). February 25, 1996 is 35 days before March 31, 1996. It takes 30 days from visible bud to flower at 70°F (21°C) and 35 days at 65°F (18°C). Not all plants reach visible bud the same day.
5. **Divide the number of leaves which have yet to unfold by the number of days from the day of leaf counting until the expected visible bud date.** This figure tells you how many leaves must unfold each day to achieve visible bud at the desired time.
6. If the number of leaves to unfold each day is greater than the number of leaves unfolded each day from emergence until the day of counting, then the average greenhouse air temperature should be increased. In contrast, if the number of leaves to unfold each day is smaller than the number of leaves unfolded each day prior to leaf counting, the average air temperature should be decreased to slow development.
7. In the greenhouse, mark the last unfolded leaves on several representative plants of each lot and bulb size. Different methods can be used. They include marking each unfolded leaf with a magic marker or hole punch or by placing a wire hoop above all expanded leaves on the shoot but below the yet unexpanded leaves. We recommend the use of a wire hoop.
8. Every 3 to 4 days (twice a week) count and record the average number of leaves unfolded, calculate the daily unfolded rate. Compare the days and determine if the leaf number was higher or lower than that which was necessary for proper timing. Adjust greenhouse temperatures accordingly.
9. **The rate of leaf unfolding is a linear function of the average temperature delivered to a lily crop over time.** In other words, the increase in the rate of leaf unfolding resulting from 55° to 60°F is the same as that from 70° to 75°F.

SUMAGIC ON EASTER LILIES

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Height control of Easter lilies has been a concern of growers since Easter lily forcing began. Growers are encouraged to maximize environmental factors that help prevent excessive stretch—avoidance of overcrowding, proper temperature control, use of DIF, when possible—as the first line of defense in lily height control and then use chemical height control as needed. Sumagic has been shown to be an effective height control chemical for Easter lilies, and we commented on the use of Sumagic for Easter lilies in the December 1991 issue of the Bulletin (Consider sumagic for your Easter lilies, N.C. Commercial Flower Growers' Bul. 36(6):12-13. For the past two years, we have conducted chemical height control studies on Easter lilies in a commercial greenhouse to help "fine-tune" rate recommendations for North Carolina conditions. For the sake of space, we will only discuss the results from our 1993 tests.

Materials and Methods

'Nellie White' (9/10's) bulbs were potted into 6" pots in Fafard lily special on 23 October 1992 and grown following commercial CTF procedures (allowed to root in 63°F greenhouse, placed into a 40°F cooler on 9 November 1992, then placed in the greenhouse for forcing on 21 December 1992). Each pot was subjected to one of eight height control treat-

ments: 1) untreated control; 2-3) sprayed once or twice with 50 ppm A-Rest; 4) sprayed once with 10 ppm Sumagic; 5) sprayed once with 10 ppm then with 20 ppm Sumagic; 6-7) sprayed once or twice with 20 ppm Sumagic; or 8) drenched once with 0.09 mg a.i. Sumagic. All spray treatments were applied using 2 quarts of spray solution per 100 sq ft of bench area. The drench treatment was applied in a 4 fluid ounce solution per 6" pot. The first treatments were made on 15 January 1993. Plants averaged a shoot length of 3.5 ± 0.4 inches at the time of first application. On 2 February 1993, shoot length was measured for all plants, and plants slated to receive two sprays were given a second application of growth retardant. Plants were forced into flower for the Easter holiday, and final data was taken on shoot length (from the top rim of the pot to the top of the inflorescence), date of anthesis (when pollen was first shed) and total number of flower buds per plant.

Results

There were already significant differences in plant height by 2 February 1993, when second applications were made for treatments 3, 5 and 7 (Table 1). By the second treatment date, Sumagic treated plants had less elongation than A-Rest treated plants. There was no significant difference in flow-

Table 1. Effects of A-Rest and Sumagic on Easter lilies.*

Treatment	Plant height on 2/2/93** (inches)	Plant height on 4/8/93** (inches)
Control	6.0 ab	20.7 a
1x 50 ppm A-Rest spray	6.2 a	20.6 a
2x 50 ppm A-Rest spray	6.3 a	20.8 a
1x 10 ppm Sumagic spray	5.5 bc	20.8 a
10 ppm + 20 ppm Sumagic spray	5.2 c	15.0 c
1x 20 ppm Sumagic spray	4.9 c	18.9 ab
2x 20 ppm Sumagic spray	5.3 c	14.4 c
1x 0.09 mg a.i. Sumagic drench	5.4 bc	16.9 bc

*Mean separations within columns by SNK at the 1% level.
**Plant height was measured from the top rim of the pot to the top of the inflorescence.

ering date; 1 April 1993 was the average date of anthesis for the first flower per plant. Treatments did not affect the number of flower buds per plant, and plants averaged 7.5 ± 1.2 buds. Final plant height measurements were made 8 April 1993, and treatments did affect shoot elongation (Table 1). The untreated controls; 1x and 2x 50 ppm A-Rest; and 1x 10 and 1x 20 ppm Sumagic spray-treated plants did not differ statistically in shoot elongation, though the 1x 20 ppm Sumagic -treated plants tended to be shorter than the other treatments in the list. The 10 ppm + 20 ppm Sumagic spray, 20x 20 ppm Sumagic spray and the 0.09 mg a.i. Sumagic drench treatments all resulted in plants significantly shorter than the controls or A-Rest-treated plants. The 10 ppm + 20 ppm Sumagic treatment was originally intended to be a 2x 10 ppm Sumagic treatment. The second application at the higher concentration was due to "operator error" on our part. Still this treatment did not result in excessively short lilies (nor did any other treatment we used in this study).

Conclusions

The desired height for your lily crop should be based on customer preference. We advocate growing plants to the height that will sell best in your market. If past experience indicates your Easter lilies require chemical height control, you may want to consider using Sumagic in place of A-Rest. Based on average costs for the two chemicals (\$46/quart for

A-Rest and \$80/quart for Sumagic) and pot-to-pot spacing, your chemical cost per plant for two 50 ppm A-Rest sprays (which was not very effective in our study) would be 8.71¢ and would be 3.20¢ for two 20 ppm Sumagic sprays (the most effective treatment in our experiment).

The amount of Sumagic or A-Rest you will need will be dependent on your growing conditions, the amount of bark in the substrate, and your targeted plant height. A good starting rate for Sumagic sprays under our growing conditions and with a high percentage of bark in the substrate would be 15 ppm, applied when plants average 3 inches in shoot length. Make the decision about a second application when plants average 6 inches. Adjust the rate up or down as needed. If your substrate has little or no bark, use a starting rate of about 8 ppm for a Sumagic spray. Our experiences and those of other researchers suggest that multiple applications at lower rates result in a more attractive product (and offer more flexibility in height control) than a single application at a higher rate. The 0.09 mg a.i. rate would be a good drench rate to use for Sumagic on Easter lilies. Using the Sumagic price given previously, the chemical cost per pot for this treatment would be 1.52¢. Again, the target height for your crop will vary, and we are not suggesting you need to grow 20.4" (plant + pot height) lilies. Grow what will sell for you! One final note: if you decide to trial Sumagic as a chemical growth retardant treatment this year, make sure you include an untreated control to serve as a check.

FLOWER BUD DEVELOPMENT RATE FOR THE EASTER LILY IS TEMPERATURE DEPENDENT

H.F. Wilkins¹

From visible bud to open flower is the third and final phase of forcing an Easter lily crop. A lily bud development meter was developed (Figure 1) from temperature data accumulated by several graduate students at the University of Minnesota.

Flower buds less than 6 cm (4 inches) grow slower than those 6 cm (2.5 inches) or greater. Further, flower buds less than 6 cm (2.5 inches) have a greater growth rate at a constant 27°C (80°F) than at 24°, 21°, 18° or 15° (75°, 70°, 65° or 60°F). Once flower buds are greater than 10 cm (4 inches), there were no differences in growth between constant 15°C (60°F) to 27°C (80°F). Note however, we do not recommend this high temperature of 27°C (80°F) or 24°C (75°F).

Recent work from Michigan State University states that 22°C (72°F) is the maximum rate for flower bud development from visible bud to open flower. Earlier work by Roh and Wilkins

showed that a constant 21°C (70°F) or any 12-hour high/12-hour low temperature average of 21°C (70°F) was the maximum temperature needed to force a lily bud from visible bud to open flower. In other words there were no significant differences between a constant 32°C (90°F), flowering in 24 days, and a constant 21°C (70°F), flowering in 28 days. Some other data are plants in constant 27°C (80°F) flowered in 25 days, at 32°/15°C (90°/60°F), in 28 days 27°/15°C (80°/60°F), (average of 21°C (70°F)) in 30 days.

It is my wisdom that I would force a crop of lilies, if maximum speed is the requirement, at constant 21°C (70°F). Again, a word of caution, temperatures above the 21°C (70°F) constant or above on average temperature of 21°C (70°F) increased flower bud abortions and plant heights.

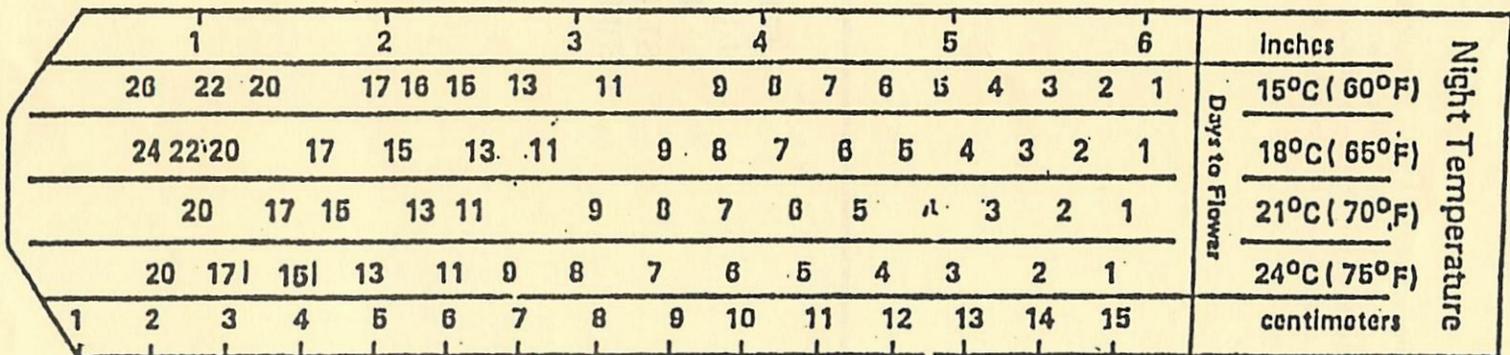
¹ Professor, current address: Nurserymen's Exchange, 2651 Cabrillo Highway North, Half Moon Bay, CA 94019.

1996 EASTER LILY SCHEDULE

Controlled Temperature Forcing (CTF) (for Case Cooled bulbs see pages 21 and 23)

Wks to Easter	Date	Event
24	10/23	Plant Easter lilies on arrival - wholesaler
24	10/30	Plant Easter lilies on arrival, no later than today - retailer
23	11/2	Drench, after first fertilization, to control <i>Rhizoctonia</i> and <i>Pythium</i> - wholesaler
23	11/9	Drench, after first fertilization, to control <i>Rhizoctonia</i> and <i>Pythium</i> - retailer
22	11/2	Start cooling - wholesaler
22	11/9	Start cooling - retailer
16	12/14	Start forcing - wholesaler - Drench lilies to control <i>Rhizoctonia</i> and <i>Pythium</i>
16	12/21	Start forcing - retailer - Drench lilies to control <i>Rhizoctonia</i> and <i>Pythium</i>
14	12/28	Shoot emergence - wholesaler
14	1/4	Shoot emergence - retailer
12	1/14	Drench lilies to control <i>Rhizoctonia</i> and <i>Pythium</i> - wholesaler
12	1/14	Drench lilies to control <i>Rhizoctonia</i> and <i>Pythium</i> - retailer
11	1/22	Flower initiation - wholesaler
11	1/26	Start counting leaves
11	1/26	Flower initiation - retailer
8	2/14	Drench lilies to control <i>Rhizoctonia</i> and <i>Pythium</i> - wholesaler
8	2/14	Drench lilies to control <i>Rhizoctonia</i> and <i>Pythium</i> - retailer
6	2/22	Visible bud - wholesaler
5	2/29	Visible bud - retailer
4	3/14	Drench lilies to control <i>Rhizoctonia</i> and <i>Pythium</i> - wholesaler
4	3/14	Drench lilies to control <i>Rhizoctonia</i> and <i>Pythium</i> - retailer
2	3/26	Flower - wholesaler
1	3/31	Palm Sunday
1	4/1	Flower - retailer
0	4/7	Easter

BUD DEVELOPMENT METER



Place tapered end of meter at the base of the flower bud. Observe where the tip of the bud falls on the meter. Where the tip of the bud falls, corresponds to the number of days to flower at the specified temperature.

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