A Grower's Guide for Producing Easter Lilies'
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August 1980
8 pages

MSU Ag Facts — Extension Bulletin E-1406, August 1980, FILE 26.22

A Grower's Guide For Producing Easter Lilies[1]

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Lilies are the third largest pot flower crop grown by Michigan greenhouse producers. In 1978, 579,000 plants were sold with a wholesale value of $2.3 million. The technology has changed dramatically within the last few years. This outline is offered as a guide and reference for lily forcing.

I. INTRODUCTION

A. *Lilium longiflorum is native to the Ryukyu Islands of Southern Japan, Okinawa, Amami and Erabu.*

B. *The latitude of the Erabu Island is 30°N which coincides with New Orleans. The photoperiod varies from 14 hr 13 min to 10 hr 14 min.*

C. *The mean temperature of Erabu is 21°C. The mean temperatures for Dec., Jan., and Feb. are 17°C, 14.5°C, and 15°C.*

D. *The plant was first reported in England in 1819. Production of bulbs was centered in Bermuda from 1853 to 1898. Virus and nematodes ruined the industry.*

E. *Both Japan and the Southern U.S. produced bulbs after the Bermuda production faded. World War II eliminated the bulbs shipped to the U.S. from Japan.*

F. *The bulb production industry has developed since World War II in the Pacific Northwest. It currently extends from the Crescent City, California area to Brookings, Oregon.*

G. *Essentially all Easter lilies currently forced in the United States are pot plants for Easter sale. In Western Europe and Japan, most lilies are sold as cut flowers over an extended season.*

II. CULTIVARS, CLONES, BREEDING, DEVELOPMENT

A. *The two most important lily cultivars in the U.S. are 'Ace' and 'Nellie White'. The largest production is still 'Ace' but 'Nellie White' is rapidly becoming more important.*

B. *Compared to 'Ace', 'Nellie White':*
1. Grows shorter.
2. Has fewer leaves.
3. Has wider leaves.
4. Has a fuller group of leaves at the base of the plant giving better plant picture.
5. Produces ½ to 1 less flower bud per plant growing from the same size bulb.

C. *'Croft' had been the most popular cultivar for many years up until about 15 years ago. 'Croft' was replaced by 'Ace' due largely to leaf-tip burn difficulties.*

D. *Presently about 8 million bulbs are produced annually. All have a white-colored trumpet flower.*

III. FLOWER INDUCTION REQUIREMENTS

A. *L. longiflorum will eventually flower at temperatures below 70°F. At temperatures above 70°F, the plant will not flower.*

B. *For forcing to bloom at Easter, plants must be given a cold treatment or a long photoperiod treatment.*

C. *Both a cold treatment and long days influence plant and population development. They:*
1. Induce bolting (stem elongation).
2. Reduce the number of leaves formed before flower formation.

[1]Contributions of information to this outline have been made by Dr. August DeHertogh, North Carolina State University and Dr. Harold F. Wilkins, University of Minnesota.

3. Reduce the total number of flowers formed.
4. Hasten the rate (time) of flowering.
5. Even out the time for flowering, i.e., reduce the time from which the first plant flowers in the population to the last plant.
6. Reduce the plant height.

D. *Cold also:*
1. Evens out the date of emergence (first to last).
2. Shortens the basal leaves.
3. Induces greater internode elongation.

E. *Cold and long photoperiods are identical in their effect on flowering.*
1. One week of cold has the same influence as one week of long photoperiods.
2. Half cold and half long photoperiod equals all cold or all long photoperiod.

F. *The optimum temperature for cold depends on cultivar.*
1. 'Ace'—35°-40°F.
2. 'Nellie White'—40°-45°F.

G. *Low intensity night lighting (10 p.m.-3 a.m.) at 10-15 foot candles (ft c) results in maximum photoperiodic response during short photoperiods of winter.*

H. *Lily plants require 6 weeks of either a cold temperature treatment, long photoperiods or any combination of both for rapid forcing.*

I. *Floral initiation occurs during the last week of January and the first week of February. Further differentiation and development occurs with anthesis 8-12 weeks later.*

J. *For early Easters or for bulbs (plants) which have not received an adequate cold treatment, a long photoperiod treatment (The Insurance Policy) can be used to insure flowering plants by Easter.*
1. After shoots have emerged, they are exposed from 10 p.m. to 3 a.m. with low intensity (10-15 ft c) lighting for 1-2 weeks.
2. This treatment insures proper flower induction of the plants.
3. Temperatures must be below 70°F during the lighting.

K. *Commercially, several programming methods are employed to insure that plants are induced to flower by Easter. They include:*
1. Natural Cooling Method
   a. *Non-cooled bulbs are used.*
   b. *Bulbs should arrive from October 15 through 25.*
   c. *The bulbs should be potted immediately. Place the bulbs deep in the pot and keep medium moist at all times. The cold treatment cannot be perceived by the bulb in dry soil.*
   d. *Potted bulbs should be placed in covered frames or sheds and exposed to naturally occurring, fluctuating temperatures. Exact temperature records must be kept by inserting thermometers in the pots. Bulbs require 1,000 hours (6 weeks) of cold treatment.* Record temperatures daily. *'Ace' bulbs should be cooled as near 35° to 40°F (2° to 5°C) as possible while 'Nellie White' bulbs should be cooled at 40° to 45°F (5° to 7°C). The soil should not be allowed to freeze.*
   e. *If bulbs lack adequate cooling because of unusually warm weather conditions, the young plants, upon emergence, should be given 2 or 3 weeks of long days at 15 ft c from 10 p.m. to 3 a.m. (5 hr). Long days (interrupted nights) substitute for the cold treatment on a day-for-day basis.*
   f. *Move potted bulbs into the greenhouse between December 15 and 30, depending upon when the cold requirement is completed and the date of Easter. Keep records of the soil temperature.*
   g. *Soil temperature in the greenhouse should not drop below 60°F (15°C) or rise above 65°F (18°C) until January 21-26. Lower soil temperatures may limit root development and cause a low flower count. High temperatures at this stage may delay flowering. Forcing at any air temperature above 70°F (21°C) should not commence until after February 2-9. Flower buds do not develop until plants are 4-6 in. (10-15 cm) tall. Until this time, temperatures of 70°F (21°C) and above may delay flowering.*
   h. *Make the initial leaf count between January 21 and February 2 for scheduling forcing temperatures and leaf unfolding rates of the plants.*

2. Control Temperature Forcing (CTF)
   a. *Non-cooled bulbs are used.*
   b. *Bulbs should arrive from October 15 through 25.*
   c. *The bulbs should be potted immediately. Place the bulbs deep in the pot and keep medium moist at all times. The CTF method and cold treatment perception cannot be accomplished in dry soil.*
   d. *Keep the soil temperature at 63°-65°F (17°-18°C) to allow roots to develop. Maintain this temperature for up to 3*

weeks depending upon potting date and Easter date.

e. About November 10, drop the soil temperature to 35°-40°F (2°-5°C) for 'Ace' and 40°-45°F (5°-7°C) for 'Nellie White'. Place thermometers in the soil next to the bulb and record temperatures daily in pots at several locations.

f. After 42 days of cooling, raise the temperature before you bring the potted bulbs into the forcing greenhouse.

g. Soil temperatures should not be below 60°F (15°C) or above 65°F (18°C) until January 21-26. Lower temperatures may cause decreased flower count and limit root development. Higher temperatures at this stage may delay flowering. Do not force at air temperatures above 70°F (21°C) before February 2-9. Flower buds do not develop until plants are 4-6 in. (10-15 cm) tall. Until this time, temperatures near 70°F (21°C) and above may delay flowering.

h. Upon shoot emergence, the long day Insurance Policy could go into effect. For early Easters, we suggest 2 weeks of lighting, while 1 week should be adequate for late Easters. However, if inadequate cooling has taken place, use long days immediately upon shoot emergence for 2 weeks at 15 ft c from 10 p.m. to 3 a.m. (5 hr). The slow, late emerging bulb population may be lighted for 2 weeks in order to even out the crop.

i. Make initial leaf count between January 21 and February 2, for scheduling forcing temperatures and leaf unfolding rates of the plants.

3. Home Case-Cooled Bulbs (Do-It-Yourself)

a. Non-cooled bulbs are used.

b. Bulbs arrive from October 15 through 25.

c. Check the cases to insure the peat is moist and place them in the cooler immediately. 'Ace' bulbs should be cooled at 35°-40°F (2°-5°C) and 'Nellie White' bulbs at 40°-45°F (5°-7°C). A 40°F (5°C) temperature is the compromise temperature if both cultivars are cooled in one location.

d. Insert thermometers into the packing cases at several locations and record the temperatures daily.

e. Cool bulbs for 6 weeks. Remove from storage and pot immediately.

f. Place the bulbs deep in the pot and in a well-aerated, porous planting medium.

g. From potting to about December 22, keep the soil at 63°-65°F (17°-18°C). Temperatures above 70°F (21°C) may delay flower bud initiation and flowering. Temperatures below 60°F (15°C) may cause a lower flower count and limit root development.

h. For late Easters, we suggest 1 week of lighting, while 2 weeks should be used for early Easters. However, if cooling has been inadequate, the long day Insurance Policy can go into effect by lighting immediately upon shoot emergence for 2 weeks with 15 ft c from 10 p.m. to 3 a.m. (5 hr).

i. From December 22 to February 2, force at temperatures between 65°-70°F (18°–21°C). Do not permit the temperature to go above 70°F (21°C) until after February 2-9 or after plants are 4-6 in. (10-15 cm) tall and flower buds are formed.

j. Make the initial leaf count between January 21 and 26 for scheduling forcing temperatures and leaf unfolding rates of the plants.

4. Commercial Case-Cooled Bulbs

a. Cooled bulbs are used.

b. Bulbs arrive approximately November 26 to December 3.

c. Pot the bulbs immediately. If bulbs can't be potted immediately, place cases in a cooler or an area where the temperature does not go above 60°F (15°C).

d. Place the bulbs deep in the pot and use a well-aerated, porous planting medium.

e. For three weeks after potting, keep the planting medium at 62°-65°F (16°-18°C) for good root formation. High temperatures at this stage may delay flower bud initiation.

f. If you suspect inadequate cooling, use long days immediately upon shoot emergence for 2 weeks at 15 ft c from 10 p.m. to 3 a.m. (5 hr).

g. Until about January 1, force at a temperature between 65°-70°F (18°-21°C). Do not permit temperatures to go above 70°F (21°C) until February 2-9, or until plants are 4-6 in. (10-15 cm) tall and flower buds are formed.

h. Make initial leaf count between January 21 and 26 for scheduling forcing temperatures and leaf unfolding rates of the plants.

IV. ENVIRONMENTAL REQUIREMENTS

A. Light

1. Light influences timing, plant height and floral bud abortion.

a. *Light influences timing since long photoperiods effectively induce flower initiation.*
   (1) A night break from 10 p.m. to 3 a.m. with 10-15 ft c of incandescent light applied to the shoot is effective in floral induction.
   (2) One night of long photoperiod is equivalent to one day of a cool-moist treatment.
   (3) Long photoperiods can be used to insure flower induction on immature or improperly cool-moist programmed bulbs. This treatment has been called the Insurance Policy.
   (4) The Insurance Policy is applied just after the shoots have emerged from the soil. Lighting is generally applied for 1 to 2 weeks.

b. *Light can affect plant height in two ways.*
   (1) An 8 hr photoperiod can be used to produce short lilies. Apply black cloth from 4 p.m. to 8 a.m.
   (2) Low light intensity during the day can cause lilies to stretch. It is possible to "stretch" the lily by applying 20 ft c of light from 10 p.m. to 2 a.m. from February 1 to March 10. The Insurance Policy properly applied does not cause tall lilies.

c. *Low light intensity during the day from February 1 to flowering can cause floral bud abortion.*

B. *Temperature*

1. Temperature requirements during programming have already been discussed.
2. Temperatures during the greenhouse phase determine when the plant will flower and contribute to plant quality at flowering (number of flowers present vs. aborted, green foliage vs. yellow and height of plant).
3. When plants are first moved into the greenhouse, soil temperature is the critical temperature to measure. Until January 22-29, soil temperature should not go below 60°F or above 65°F. Lower temperatures may cause lower flower count and limit root development. Higher temperatures may delay flowering.
4. Do not force plants at air temperatures above 70°F before February 5 as high temperatures may delay flowering.
5. Temperatures after February 5 are determined by the date of Easter and developmental stage of the plants. The temperature required is based on information received from leaf counting, described in section V.E.
6. After visible bud, fastest flower development rate is at an average temperature of 70°F (21°C). Temperatures averaging higher than 70°F do not hasten flowering and induce stem elongation resulting in tall plants.

C. *Water*

1. Lilies require adequate moisture for optimal development.
2. Plants should not be allowed to dry out as the lower leaves may yellow and/or, under severe stress, flower bud abortion may occur.
3. Excess water results in root rot and related problems.
4. During programming, the medium surrounding the bulb (either in the case or the pot) must be moist for the bulb to perceive the cold treatment.

D. *Nutrition*

1. Proper nutrition is essential to produce a high quality plant. Regular fertilizer applications will not increase plant height but excessive levels will decrease height due to soluble salt accumulation.
2. High phosphorus levels have been associated with leaf scorch in 'Croft' and recently 'Ace'. Whether the problem is strictly a P relationship or a fluoride toxicity (from the superphosphate) has not been established. Some phosphorus is required for lily growth and if no superphosphate is added to the planting medium, phosphorus should be applied in a soluble form.
3. With P added to the planting medium, N and K are the major concerns. Several feeding programs can be used which are adequate.
   a. *A neutral mix could be: 1 part ammonium sulfate and 4 parts sodium or calcium nitrate combined and added at 1 oz per 2 gal water every 2 weeks. Potassium chloride is applied in alternate weeks.*
   b. *For acid soils, calcium nitrate (1 oz per 4 gal H_2O) and potassium nitrate (1 oz per 8 gal H_2O) applied weekly until flower buds are ½ in. long is effective. Thereafter, apply calcium nitrate (1 oz per 3 gal) only weekly.*
   c. *Apply 25-0-25 at 1 oz per 3 gal H_2O (620 ppm) every week or as a 200 ppm N solution at every watering.*

E. *Gases*

1. Carbon dioxide should not be used on lilies; the plants can grow too tall.

V. CULTIVATION

A. *Plant material*

1. 'Ace' and 'Nellie White' are sold in the following bulb circumference (inches) sizes.

Ace	Nellie White	Bulbs per case
6½-7	Not sold	300
7-8	7-8	250
8-9	8-9	200
9-10	9-10	150
10-up	10-up	100

In general, the larger the bulb size, the easier the bulbs are to force and more flowers are produced.

2. The Easter lily will produce either one shoot (single-nosed bulb) or two shoots (double-nosed bulb). In general, the larger the bulb size, the more double-nosed bulbs that will be present. In the past, these two types were sold separately, now they are mixed.

B. *Medium and planting*

1. The planting medium should be well-drained and well-aerated. A 1:1:1 soil, peat and sand or vermiculite medium is acceptable.
2. The pH should be adjusted to 6.5 to 7.0 and soluble salts should be low.
3. Bulbs should be planted near the bottom of the pot so that as the shoot grows, stem roots can develop.
4. A single lily bulb is generally planted in a 6 in. clay or plastic pot. Sometimes two bulbs are planted in a 7 in. pot.

C. *Spacing*

1. Lilies are sometimes grown pot to pot. This, however, induces stretch and yellow lower leaves.
2. A final spacing of two to three 6 in. pots per square foot is generally used.

D. *Growth Regulators*

1. Lilies respond to an Ancymidol spray or drench. Application of 0.25 mg (drench) or 0.5 mg (spray) per 6 in. pot should be made when lilies are 3-6 in. tall.
2. Do not apply from January 23 to February 7 as it may reduce bud count.
3. A-Rest is not effective as a drench at these concentrations if a bark planting medium is used.
4. Temperatures above 70°F and night lighting after application negates the effect of A-Rest.

E. *Leaf Counting—Leaf counting is a technique used to help time a crop of lilies for Easter. Once a lily shoot initiates a flower bud, no further leaves form. Therefore, if one knows how many leaves have yet to unfold on a plant before one sees visible buds, one can calculate how many leaves must unfold each day (week) in order to see flower buds on a particular day. By knowing the number of leaves which must unfold each week and by making count of how many leaves actually unfolded the previous week, one can determine if the crop is slow, fast, or on time. The following description tells how to leaf count to time one's lily crop.*

1. Record the average date of shoot emergence.
2. When the plants are 4-6 in. tall, flower buds should be initiated and the total leaf complement should be present. At this time, the last week of January, cut off 10 random shoots at soil level for every 2,000 bulbs from each cultivar and bulb source.
3. Take these shoots to a well-lighted area, count the leaves, record and average the total number of leaves per sample lot. A large needle and magnifying lense (reading glass) will help you remove small, scale-like leaves near the growing point. The embryo-like flower buds should be present. An estimate of the future bud count can be made at this time.
4. Randomly select and mark 10 average plants in the greenhouse that will correspond to individual sample lots whose total leaf counts were just determined. Count and average the number of leaves that have unfolded to a 45-degree angle on these plants. A bamboo stake with a paper label wired to it will help in marking these plants and in recording weekly individual leaf data.
5. Count and record the number of leaves unfolded to a 45-degree angle from the stem once each week. The last individual leaf counted can be marked weekly with a paper-punch hole to avoid repetitious counting. Then, only unfolded leaves above the most recently marked leaf need be counted each week.
6. Subtract the average number of leaves that have unfolded from the predicted average leaf total. This will tell how many leaves are yet to be unfolded.

7. 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 been unfolding each day.
8. Determine the visible bud date. This is 30 to 35 days before Palm Sunday. It takes at least 30 days to develop an open flower from the time first buds are observed.
9. Divide the number of leaves left unfolded by the number of days left from the date of counting to 30 days before Palm Sunday (visible bud date). This figure tells how many leaves must unfold each day to make the estimated visible bud date.
10. Each week, count, record and determine the average number of leaves unfolded daily the previous week. Compare the data and determine if the leaf number was higher or lower than the number required to keep the crop on time.

VI. PROBLEMS

A. *Diseases*

1. Botrytis *(Botrytis elliptica)* is a fungal disease. Well-ventilated greenhouses and sanitary conditions will normally prevent this disease. When observed on leaves or foliage, it can be controlled by a number of fungicides. If plants are to be stored prior to marketing, it is essential to use preventive measures.
2. The root-rot-complex is an extremely difficult disease complex to define. It is best to assume that the potential for root rot always exists. Thus, the use of preventive soil drenches is advised; these should start immediately after the beginning of the greenhouse phase.
3. There are a number of viruses which infest Easter lilies, e.g., fleck, cucumber mosaic, etc. Normally, the forcer cannot do anything to control them. The best advice is to purchase bulbs from a reliable source and to control aphids, if present, to prevent the spread of the infection.
4. Twist is another disease which is not well defined. If present, it will appear when plants have unfolded 40-50 leaves. A half-dozen or so leaves will twist into a semi-circle. There is no known control but the plants normally grow out of this disease and become marketable.

B. *Insects*

1. The major greenhouse insect pest on Easter lily is the aphid. In large numbers, the feeding aphids can cause deformed or discolored leaves and/or buds. Control with an insecticide.
2. The bulb mite, *Rhizoglyphus echinopus,* has recently been implicated in some damaged lily plants. The mites were thought to only feed on dead or weakened tissue. Dissection of lily bulbs and stems severely infected with mites showed mites feeding on healthy tissue or the interface of healthy and dead tissue. For some growers, the mite has caused severe damage.
3. Fungus gnats are occasionally a problem when the growing medium stays wet for extended time periods. Larvae of the gnat can cause severe root injury. An insecticidal drench has proved effective in control.

C. *Physiological*

1. Leaf scorch is a disorder characterized by a die-back of the leaf tips. Sometimes it is confused with *Botrytis* infections. The exact cause is not really known. There is some evidence that high P is a cause. This is the reason why low P fertilizers are generally used. Some recent work has suggested fluoride toxicity or a boron excess.
2. Yellowing of lower leaves can be due to the development of the root-rot-complex, poor aeration of the planting medium or improper fertilizer levels. All possibilities must be checked.
3. Many factors can be involved in floral bud abortion. Among them are ethylene, root-rot-complex, low light intensity and high temperatures.

D. *Others*

1. The 'no-show' lily is a failure of the shoot to emerge from the bulb. This is usually due to basal rot either to stem pull injury or development of root-rot-complex.
2. Failure to make Easter is probably due to improper programming and/or greenhouse phase control.

VII. HARVESTING, HANDLING, MARKETING

A. *Lilies are sold when the first flower is open. Most plants will not sell if the flower is not open.*

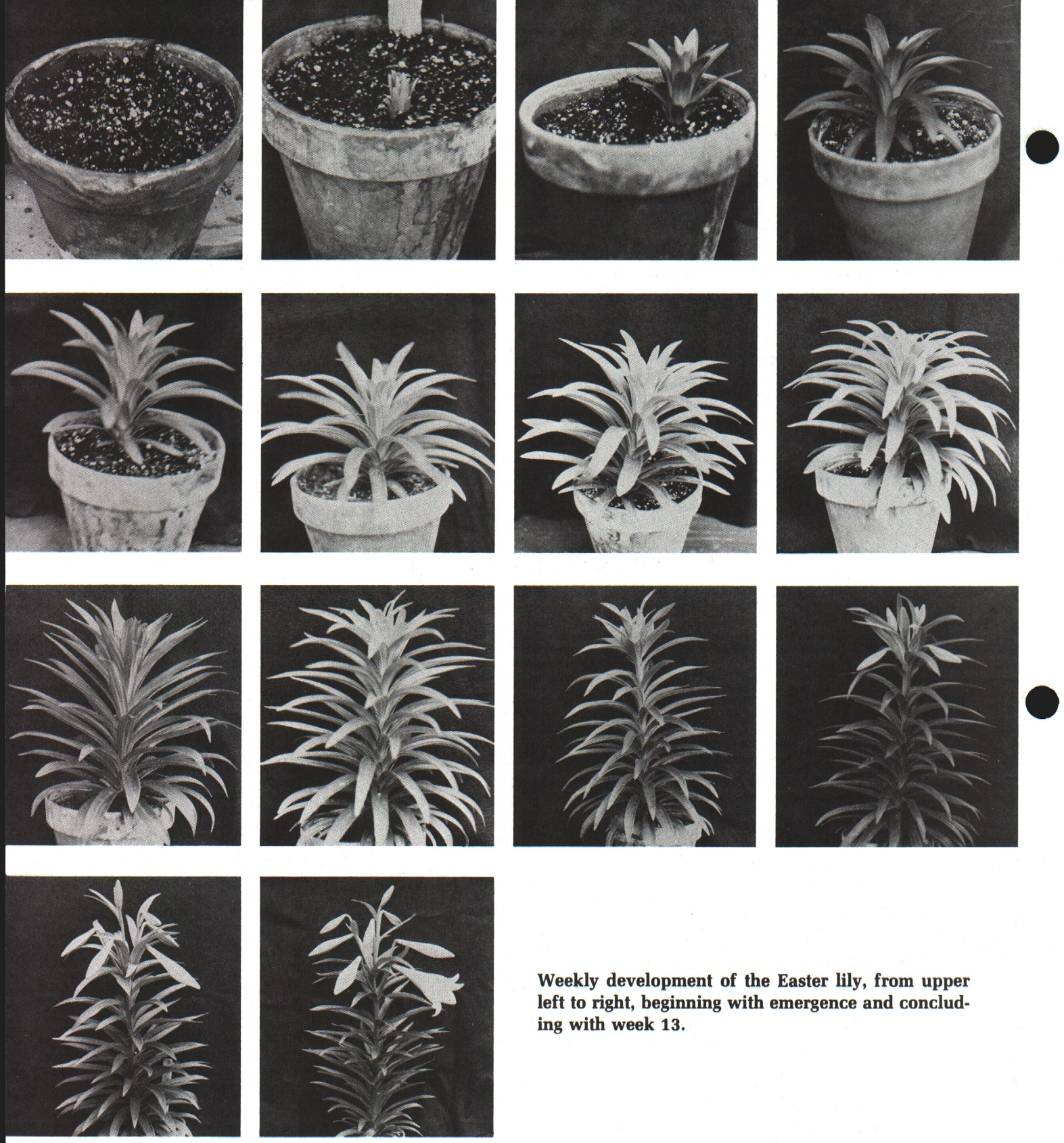
B. *Storage of the Marketable Plants*

1. At times, it is necessary to store the Easter lily plant prior to marketing. When this has to be done, the plants should be removed from the greenhouse when the first flower is beginning to open (puffy stage). This usually means inspecting the crop several times a day. They should be treated with a fungicide to protect against *Botrytis* infection. The best storage temperature is about 40°F.
2. When the plants are removed from cold storage, the shoots will warm up more quickly than the roots. In most cases, this results in a temporary wilting of the plant. One system to overcome this wilting is to remove the plants from the cooler late in the evening, water them with 60°F water, and place them in a cool (55°F) place overnight prior to packing. If this is not possible, advise customers to place the plants in the store late at night (9-10 p.m.) and water with warm water. This will give them time to recover prior to store opening the next day.

VIII. SCHEDULING

A . Typical CTF Production Schedule

Date	No. of Weeks	Cultural Practice	Temperature
Mid-October	3 weeks	Pot bulbs and root	63°F (soil temp)
Second week November	6 weeks	Cool plants	35-40°F 'Ace' 40-45°F 'Nellie White' (soil temp)
Mid-December	3-4 weeks	Bring into greenhouse Start forcing	62-63°F (soil temp) 1-2 weeks of long photoperiod can be provided
January 21-29	6-8 weeks	Begin forcing by air temp Monitoring	Air temp depends on crop development relative to the date of Easter. Do not force at temps averaging greater than 70°F.
First Sunday of Lent	4-5 weeks	Visible bud	At a constant 70°F, 30 days from visible bud to open flower
1 week before Easter (Palm Sunday)	—	In flower	—



Weekly development of the Easter lily, from upper left to right, beginning with emergence and concluding with week 13.

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