Easter Lilies - Present and Future
Part II*

T. Weiler and R. W. Langhans
Department of Floriculture
Cornell University

In the first article we discussed the factors affecting the Easter lily crop before the bulbs reach the East Coast; field culture, bulb maturation-field vernalization-bulb harvest, and shed storage and transportation. In this article we want to consider the problems of the bulb jobbers and plant growers—bulb storage and forcing.

BULB STORAGE

Often when bulb storage is mentioned temperature and/or time in storage immediately come to mind, however, much more is involved than just these two factors. Moisture content of the packing medium, moisture changes in the packing medium (and, therefore, the bulbs) during storage, and the gas content of the atmosphere (e.g. oxygen, carbon dioxide, and nitrogen) are extremely important. Research has demonstrated the influence of these factors, however, more studies must be made.

Vernalization Temperatures

Much of our work has involved temperature and length of storage. We found 70°F was a non-vernalizing temperature, i.e., 'Ace' lilies would not flower in a 70° greenhouse unless vernalization was applied before or during growth (figure 1).

(continued on page 2)

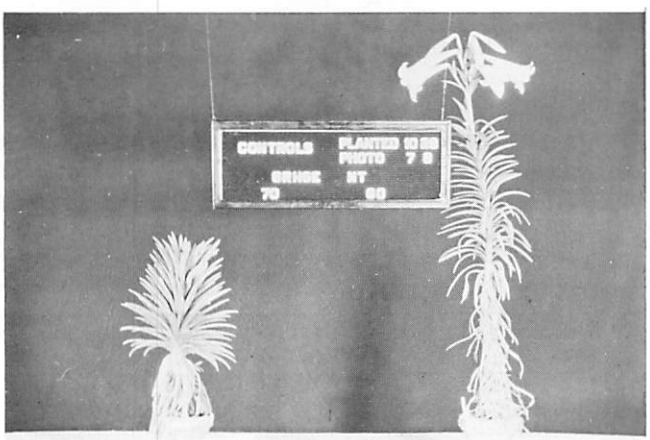

FIGURE 1. 'Ace' plants from unstored bulbs grown in a 60°F minimum temperature greenhouse (right) or a 70° minimum temperature greenhouse (left). Sixty degrees was a vernalizing temperature. The plants grown at 70° did not flower.

* Part 3, the last of this article, will be presented in a future bulletin.

Easter Lilies

(continued from page 1)

Temperatures below 70° had a vernalizing effect, but some temperatures were more effective than others. For example, we would estimate under winter and spring conditions (short daylengths) Easter lilies would flower in 120 days after 6 weeks of 35° to 50°, 8-10 weeks of 60°, and more than 10 weeks of 65° storage. Storage temperatures lower than 35° (i.e. 31° and 32°) usually have to be applied longer than 6 weeks to obtain rapid flowering. Temperatures of 35° to 50° are the most efficient vernalizing temperatures, i.e. they give the greatest vernalizing effect in the shortest length of time.

Storage at 31° to 32°F has been used for "holding." If the bulbs are to be stored for more than 6 weeks, 31° to 32° storage is often used to reduce the undesirable effects of long 35° to 50° storage. Warm "holding" temperatures (greater than 50°) have the advantage of being less effective in vernalization (i.e. long periods of cold storage reduces flower number whereas warm temperatures do not), but warm temperatures have the disadvantage of allowing rooting and sprouting in storage.

The optimum temperature range for rapid vernalization of Pacific northwestern bulbs has been shown again and again to be 35° to 40°F. In the past, 35° was preferred; 40° storage has recently been said to be best. While there are perhaps differences between plants from 35° storage versus 40° storage, the differences are slight. We feel the present preference for 40° storage over 35° is unfounded. There are no experimental results under commercial growing conditions which have compared 35° and 40° storage. There was no difference between 35° and 40° storage when we compared these temperatures in a 70° greenhouse.

Fifty degree Fahrenheit storage for Northwest bulbs was slightly less effective in vernalization than 35° to 40°, but the differences, while observable, were small. Bulbs stored at 50° for 6 weeks may require 7 to 10 days longer to flower than bulbs stored for 6 weeks at 35° to 40°.

Warm Temperatures

Holding the bulbs at 70° to 90°F prior to cooling has caused flowering delays and sometimes improves plant quality. One of the reasons for our experimentation has been to determine whether these flowering delays were the result of a devernalization of field vernalization. Devernalization is the removal of vernalization (i.e. the removal of the effects of cooling). Our results indicate 70° to 90° storage did not devernalize 'Ace' Easter lilies, although it did cause flowering delays. For example, as shown in Table 1, bulbs receiving 6 weeks of 35° storage flowered in 84 days and those receiving 6 weeks of 70° prior to 6 weeks of 35° storage flowered in 101 days (a flowering delay), both treatments required 6 weeks of vernalization (cool storage) for 100 percent flowering. Our recent experiments with an improved, more sensitive technique also indicated warm temperatures cause flowering delays, but not devernalization.

Since devernalization has not been demonstrated in 'Ace' we can either question that the bulbs were significantly vernalized in the West Coast fields, sheds, and refrigerated trucks; or the question can be raised if a devernalization phenomenon occurs at all in Easter lilies. Preliminary results indicate a devernalization phenomenon does not occur in 'Ace'. For example, we have applied known amounts of cooling before the heat treatment, but have not been able to remove the vernalization (i.e. change the flowering percentage) with warm storage, although flowerings delays usually occur.

Table 1. The effect of storage on the growth and development of 'Ace' lilies grown in a 70° greenhouse.

Storage Treatment	Days from Planting to Flowering	Percent of Plants Flowering per Treatment
6 weeks 35°	84	100
6 weeks 70° + 6 weeks 35°	101	100
12 weeks 35°	74	100

If in the final analysis Easter lily bulbs cannot be devernalized (and our work would indicate this), there will be no hope of removing field vernalization or vernalization received during shed storage or refrigerated transport. Devernalization would be very desirable for it would make possible the application of exact amounts of vernalization. Many of today's problems are caused by unknown quantities of vernalization. However, warm storage may still be desirable, for there is usually a definite improvement in plant quality after a short period of warm holding before vernalization. This phenomena we have called the "heat effect" as opposed to devernalization. The heating of the bulbs (70° to 90°) for a few weeks does not affect the length of vernalization required to get flowering, but does cause a delay in flowering with a resultant improvement in quality. The improved quality is manifested in more flowers and longer basal leaves which improves plant form. The appearance of the heat-treated plants is very similar to those from "cold framed" treatments, a subject to be discussed later in this article.

Daylength

Daylength has recently been shown to affect the vernalization requirement. When applied during forcing, daylength determines the amount of vernalization (cool storage) required for rapid flowering. For example (Table 2), plants under long daylength require 4 weeks of cool-

Table 2. The effect of daylength on the flowering responses of 'Ace' Easter lilies grown in a 70° greenhouse.

Weeks 40° Storage	Days from Planting to Flowering		% of Plants Flowering per Treatment	
	LD[1]	SD[2]	LD[1]	SD[2]
0	98	–	10	0
2	97	–	80	0
4	89	107	100	90
6	81	87	100	100

[1] Plants under long days received 8½ hours of sunlight plus 4 hours of incandescent light from 10 pm to 2 am.
[2] Plants under short days received 8½ hours of sunlight.

(continued on page 3)

(continued from page 2)

ing for 100 percent flowering, while plants under short daylengths require 6 weeks of cold storage. It is now incorrect to say bulbs require 6 weeks of 35° to 40° storage for 120 day flowering, since this would only be true under short daylength conditions. Under long days (not naturally found during December and January) the required length of storage would be less than 6 weeks. In addition to the factors of temperature and length of storage, carbon dioxide build-up and drying during storage should be emphasized as a factor to consider. High carbon dioxide concentrations in Easter lily storage were shown more than 30 years ago to cause bulb damage and make the vernalization treatment ineffective. Drying of the bulbs during storage by using a low moisture content packing medium or by permitting desiccation of the packing medium also reduces the effectiveness of vernalization.

Coldframing

Coldframing Easter lily bulbs instead of conventional refrigerated cooling for vernalization has been shown again and again to produce superior quality plants. Many reasons are probably involved: higher average temperature, fluctuating temperature, better moisture conditions, atmospheric gaseous conditions (no carbon dioxide build-up or oxygen depletion), etc. No one will deny the benefits of coldframing, yet from the research point of view, the environmental conditions during coldframing are not easily controllable. For example, while 6 weeks of 40°F storage yields a specific result year after year, 6 weeks of coldframing this year may not be, and probably will not be, the same as 6 weeks of coldframing under next year's weather conditions. The grower must be alert to this fact and be ready to make temperature changes during the forcing period. Hopefully when we understand all of the factors influencing the Easter lily and their relationships under controlled conditions we will be able to translate this information into more desirable commercial practices.

Our present knowledge of bulb cooling sometimes appears to be in a state of turmoil, but more is known about this area than many others. In the next 2 years we hope to fill in some of the missing links that will tie the whole story together.

FORCING

Since the subject of forcing has been dealt with in depth in the Lily manual and articles in this Bulletin, we will not review this information.

One point, however, should be emphasized and that is that the grower can greatly affect the quality of the plant. When the bulbs reach the plant forcer, we often think the forcing characteristics and quality have already been determined. This is not true! The plants will flower faster (with fewer flowers) if the bulbs are cooled further by the forcer, or flowering delays can be produced by high temperatures while the bulbs are in the cases or during the early stages of growth. If the force does not alter the vernalization status of the bulbs, he still may reduce the flower number, affect plant height, and produce unsightly foliage by improper light intensity, spacing, fertilization, watering, temperature control and root rot disease control.

Early Easter

The assumption that pre-cooled bulbs will force in 120 days can usually, but not always be made. For example, with an early Easter (e.g. March 22), the bulbs would arrive on the East coast by October 15 and forcing would have to begin about November 18 to allow 120 days for forcing time. The bulbs would receive 3 to 4 weeks of cool storage. The bulbs arrived on the East coast at a temperature of 55-60°, therefore, it would be at least one week before the temperature would reach 35°. Four weeks of cool storage is 2 to 3 weeks too few for rapid forcing under winter conditions (short days). In this situation, starting growth in a 50°F greenhouse for the first 4 weeks would remedy the situation as would growing under long daylength. The 50° growing temperature is cool enough to be a fairly good vernalization temperature so the bulbs would actually be receiving cold or vernalization while growing. (This happens to a coldframed bulb). Long photoperiod during this period would also be beneficial in that less weeks of vernalization are needed when the plants are grown under long days rather than short days (while long daylengths early in forcing will hasten flowering, applying long daylengths after flowering initiation only increases height.) The natural reaction in a situation where growth is slow because of too little cooling would be to raise the temperature, speed up the growth; but in actual fact high temperature would further delay flowering. This occurred a few years ago and the growers who raised the temperature too soon did not have flowering plants for Easter even though they forced at extremely high temperature. High forcing temperatures might be used in late February and March for rapid growth but not until that time.

Late Easter

On the other hand, when Easter is late (i.e. April 25), and the bulbs are shipped to the East coast by October 15, forcing would probably begin about December 26. The bulbs would receive 10 weeks of cool storage. (In practice, with late Easter the bulbs are usually dug later so the bulbs would receive somewhat less than 10 weeks of cool storage .) Since Easter is late the grower would place the bulbs in a cool (50°) greenhouse and this would again act as vernalization and the bulbs would become over-vernalized. Too many weeks of cool temperature causes the plants to force very rapidly, reduces bud count, and reduces plant quality by lessening the leaf number and causing the lower leaves to be short. The bulbs for late Easter probably should be forced immediately in a 60° greenhouse and cooled to slow growth after the flower buds have been initiated (when there is no longer a chance of over-vernalization). The essential point remains, however, that the cool storage received by bulbs for early Easters is marginal and is excessive for late Easters and the forcer must recognize the problems involved.

(continued on page 6)

(continued from page 3)

SUMMARY

Perhaps we can conclude our remarks on the problems of the bulb jobber (bulb storage) and the plant grower (forcing) with the comment that while both the jobber and forcer do everything possible to produce quality Easter lilies, they, like the bulb grower, have difficulty determining what is the best procedure for any particular Easter. The question of when bulbs are vernalized sufficiently for rapid forcing and low to maintain plant quality will be answered by further research.

In the last article of this series we will comment on the possible future results of research and the implications of these results for commercial Easter lily production.