

RESEARCH NEWSLETTER



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Figure 1. Which is better? Gibberellin4+7 sprays counteract damaging effects of cold storage of 'Star Gazer' oriental hybrid lilies. These plants were stored in a dark cooler at 4C for 2 weeks. The plant on the right was sprayed with 100 ppm Fascination. The control plant (sprayed with water) is on the left. Photo taken after 12 days in 21C postharvest room after cold storage.

One from the Archives: Postharvest Leaf Yellowing and It's Control in Oriental Hybrid Lilies

William B. Miller
Cornell University

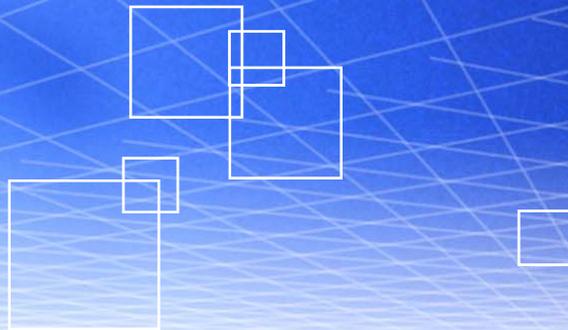
I have entitled this article as "One from the archives..." to highlight a couple of points. The first being that a full report of this research has not appeared in a Research Newsletter, and secondly, that results from the Flowerbulb Research Program continue to be beneficial for many years after the work is done.

In an earlier Research Newsletter (July 2005), a short version of the story of hybrid lily leaf senescence and the postharvest benefits of gibberellin4+7 (GA4+7) on oriental hybrid lilies was presented. GA4+7 is available in at

least two commercially products, Fascination (Valent, USA) and Fresco (FineAmericas). Both products are mixtures of the cytokinin, benzyladenine (BA), and GA4+7. The material was originally a product used on apples and was sold as Promalin (and, still is, for the fruit market). In lilies, the GA component of Fascination has specific effects on leaves, keeping them green and in many cases, totally eliminates leaf yellowing that might occur in the greenhouse (especially for Easter lilies), or after postharvest cold storage (all lilies). Fascination is also highly effective in prolonging flower life of most lilies, in many cases by 25-30%. Growers forcing oriental hybrid lilies in pots are now commonly spraying their crops with 50-100 ppm GA4+7 within 2 weeks of flowers opening. Such a treatment allows cold storage of the plants at 4C for up to 14 days, without leaf yellowing. After storage, flowers will continue to open and with good color. While growers should always be advised to cold-store hybrid lilies for as short a time as possible, Fascination has proven to be an excellent tool to improve plant quality in an increasingly tough marketplace.

Review

The story of gibberellin use on oriental hybrid lilies began with our research at Clemson University in the mid-1990's. We were concerned with lower leaf yellowing on Easter lilies. We identified two kinds of leaf yellowing. The first was called "gradual leaf yellowing", where the lower leaves slowly lost green color while growing in the greenhouse. Gradual yellowing is essentially due to nitrogen deficiency in lower leaves, and can be caused by low nitrogen fertilization, low nitrogen status of the soil mix, or by reduced nitrogen uptake resulting from weak, injured, or otherwise nonfunctional roots. Since nitrogen is highly mobile within plants, if a nitrogen deficiency begins, the plant calls upon the older leaves to "give up" nitrogen for the benefit of the young leaves and developing flower buds; thus the deficiency shows as yellowing older leaves. In fact, our research showed that on a typical Easter lily plant, leaves from the lower part of the stem have only 1/3 the nitrogen concentration of upper leaves. Thus, lower leaves will always be more prone to nitrogen deficiency than upper leaves.



There is a second form of leaf yellowing in Easter lilies (and is most related to the sometimes serious leaf yellowing problems in Oriental hybrid lilies). Termed “postharvest or catastrophic leaf yellowing”, it is a dramatic and rapid yellowing of leaves seen during postharvest shipping, handling, and retail display. Seemingly good quality lilies can be boxed and shipped, only to rapidly lose chlorophyll and senescence within 3 to 4 days in the retail outlet. Our work demonstrated that the major causes of this type of leaf yellowing are stresses that reduce both plant carbohydrate and gibberellin level, including growth regulator drenches, large negative DIF’s (that is, very warm night temperatures and lower day temperatures, used for height control) in the greenhouse, long cold storage of budded plants and lengthy, warm, dark shipping. Each of these stresses can greatly reduce leaf carbohydrate level. Additionally, heavy applications of growth regulator or large negative DIF’s most likely reduce leaf gibberellin level. In our early work, some benefit was seen from gibberellic acid sprays (GA3, from Pro-Gibb), but Pro-Gibb could not overcome the stress of both heavy A-Rest applications and cold storage. Additional benefits were longer-lasting flowers, a long-known effect of gibberellins on lilies. Eventually, GA4+7 was tested, and found to be much more effective in reducing leaf yellowing, and, ultimately, Fascination became a legal product for improving quality of lilies. The next step was to apply this knowledge to Oriental hybrid lilies.

Oriental Hybrid lilies and Cold Storage

Oriental hybrids do not tolerate cold storage very well, and as a group tolerate cold storage much less than Easter lilies. In the late 1990’s forcers in the US were experiencing major losses from quality loss in the retail chain. Leaves would rapidly turn yellow brown and fall off, and buds would not open, open poorly, or fall off. See the nearby figure for a ‘Star Gazer’ plant that was dark-cold stored at 40F (4C) for 2 weeks when plants had reached the puffy bud stage. The photo was taken after 12 days in a 21C postharvest room. The plant on the left illustrates the “state of the art” at the time. A similar effect is seen for ‘Mona Lisa’, but it is even worse! Table 1 shows the effects of cold storage (Expt. 2) on a variety of cultivars. Without cold storage, most cultivars show little leaf yellowing. If cultivars are cold stored, then a significant amount of leaf yellowing can occur, and ranged from 10 to 64%, depending on the cultivar.

Optimum Storage Temperature

Temperature in the cooler plays a vital role in storability of Oriental hybrid lilies, and lower is not better, as can be

seen in Figure 2. Storage at 1C (33-34F) caused more than 60% leaf yellowing and death within 6-8 days in the postharvest room, whereas the onset of leaf yellowing at 4, 7, or 10C (40, 45 or 50F) occurred much later. Actually, if one considers only leaf quality, the warmest temperatures we tested, 45-50F, are optimum for ‘Star Gazer’, as there was slightly less leaf injury at 45-50F than at 40F. But, since flower life span is reduced as temperatures move above 40F (more respiration of carbohydrates at a warmer temperature), a lower temperature is needed, and we decided to find ways to better store hybrid lilies at 4C (40F).

Lights in the Cooler?

In our early work, we determined several treatments that are highly effective at maintaining leaf quality after cold storage at 4C. For example, illuminating plants in the cooler for 24 h/day with more than 20 $\mu\text{mol m}^{-2} \text{sec}^{-1}$ light (approximately 200 ft. c.) allows ‘Star Gazer’ to be held at 4C for at least 2 weeks (Figure 3). At 4C, dark stored plants, and those held with 10 $\mu\text{mol m}^{-2} \text{sec}^{-1}$ light were of poor quality after 10-16 days postharvest. Increasing light levels in the cooler also improved flower longevity, and allowed opening of more flower buds, as seen in the photo. We hypothesize this effect is due to maintenance of adequate levels of carbohydrate in leaves of plants illuminated with higher levels of light. While effective, this is probably not a commercially viable treatment.

An Easier Way: GA Sprays

While the above results are encouraging, an easier approach would be hormone (gibberellin) sprays. Although there are now a number of commercially labeled products containing gibberellin and benzyladenine (Table 2), at the time of our early research we used the product Promalin which is a mixture of BA and GA4+7, each at 1.8%. Results from our early experiments indicated that sprays of Promalin (Fascination or Fresco) and Provide (100 ppm GA4+7) allowed dark cold storage of ‘Star Gazer’ plants for at least 2 weeks at 4C whereas Pro-Gibb (100 ppm GA3), and ABG-3062 (100 ppm BA) had no effect. Accel (100 ppm BA and 10 ppm GA4+7) was intermediate in effectiveness (Figure 4). This work proved that it is the gibberellin4+7 in Fascination, and not the benzyladenine, that is most important ingredient for controlling leaf yellowing and for improving flower life.

After a number of trials, the following have been developed as basic use guidelines on Oriental hybrid lilies. Plants should be sprayed with 50-100 ppm of GA4+7

from Fascination, Fresco or similar product (see Table 3 for mixing directions). The entire plant should be sprayed, including all leaves, buds and the stem. This is a critical point and full coverage is necessary for the best postharvest life. Unlike Easter or LA hybrid lilies, Oriental lilies have finished all their height growth by the last 2 weeks of the crop, so no elongation will occur from whole plant sprays on these hybrids! Oriental hybrids may be sprayed at any time within 2 weeks of sale or cold storage, giving a great deal of flexibility in terms of labor scheduling. If cold storage is necessary, a temperature of 4C (40F) is recommended for 2 weeks or less, but only if plants have first been treated with GA4+7. Cultivars vary greatly in their level of leaf yellowing from cold storage, but all cultivars respond favorably to GA sprays (Table1).

How do the hormone sprays work?

Our work with both Easter and hybrid lilies has shown that GA4+7 is the key component of the Fascination (Promalin) and Accel products in reducing leaf senescence and abscission, since when sprayed at comparable rates, the product Provide (which contains only GA4+7) gives as much effect as Fascination (Promalin) which contains both gibberellin and BA. Also, it is important to distinguish between ProGibb and Provide, as ProGibb has a different gibberellin (GA3), and has much less beneficial effect, as seen in Fig. 4. Currently, Fascination (Valent USA) and Fresco (Fine Americas) are both labeled for use on lilies in the US.

So, how do these treatments work? The details are not important here, but we have done research suggesting that the gibberellins reduce chlorophyll breakdown by maintaining intact cell membranes, by improving the "oxidative stress" status of the plant, and by maintaining higher levels of carbohydrates in leaves and flower buds. Research has shown that individual lily leaves treated with GA or BA have reduced respiration rates, which would tend to conserve leaf carbohydrate, thus supporting the hypothesis.

Acknowledgments

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Sidebar

Quick guidelines for using gibberellins to improve post-harvest performance and allow short-term cold storage of potted oriental hybrid lilies

- Only use labeled products containing GA4+7, such as Fascination or Fresco.
- Plants should be sprayed in the last 2 weeks of the crop
- Use a concentration of 50-100 ppm
- Spray the whole plant, including leaves, buds and stems
- After spraying, plants can be cold stored at 4C for 2 weeks or less
- Correctly treated plants will show less leaf yellowing and exhibit 20-30% longer flower display life
- Do not follow these guidelines for LA or asiatic hybrids!

Cultivar	Expt. 1			Expt. 2		
	No cold storage	Cold storage		No cold storage	Cold storage	
		No GA	100 ppm GA		No GA	100 ppm GA
Berlin	—	51	5	2	46	9
Muscadet	—	53	4	3	52	10
Tom Pouce	—	8	2	0	10	3
Star Gazer	—	54	4	6	64	10

Table 1. Cultivar differences exist for leaf yellowing susceptibility. At the puffy bud stage, potted plants were sprayed with 100 ppm GA4+7 from Fascination or left unsprayed. Plants were sprayed, allowed to dry, then placed in the cold storage the same day. In year 1, all plants were cold stored at 4C for 2 weeks. In year 2, plants were cold stored, or not, to see the effect of cold storage.

Product	Formulation	BA:GA ratio
Fascination or Fresco	1.8% w/w benzyladenine 1.8% Gibberellins 4+7	1:1
Accel	1.8% w/w benzyladenine 1.8% Gibberellins 4+7	10:1
Pro-Gibb	4% Gibberellic acid (GA3)	n/a
Provide	2% Gibberellins 4+7	n/a
Configure	2% Benzyladenine only	n/a

Table 2. Currently available products containing gibberellin and/or cytokinin.



ppm GA4+7 needed	ml Fascination per Gallon (3.7 liters) of water	ml Fascination per 10 gal (37.8 liters) of water
25	5.3	53
50	10.5	105
75	15.8	158
100	21.0	210

Table 3. Since Fascination has a 1:1 ratio of BA and GA4+7 and contains 1.8% active ingredient of each component, calculations can be a little tricky. The table below gives recipes to prepare 25 to 100 ppm GA4+7 solutions from Fascination (or Fresco, each containing 1.8% GA4+7).

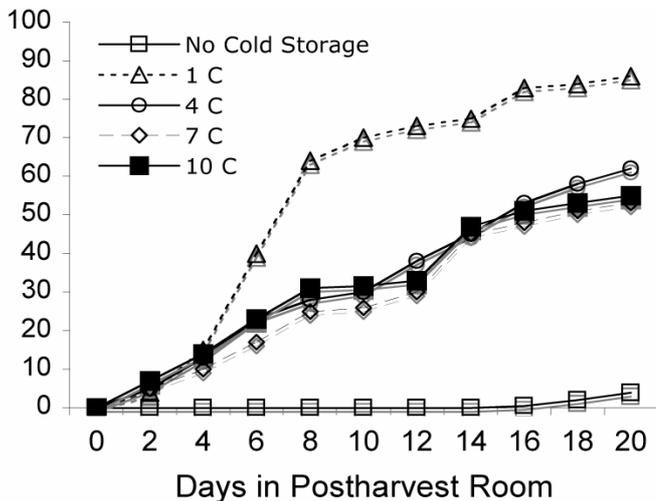


Figure 2. Effect of temperature on leaf yellowing (percent, on the y-axis) during dark storage on 'Star Gazer' Oriental hybrid lilies. Plants were stored for 2 weeks at the indicated temperatures (1, 4, 7, or 10C), then placed into the postharvest room. Control plants were not stored, and were put into the postharvest room immediately from the greenhouse.



Figure 3. Light in the cooler also dramatically helps postharvest quality of 'Star Gazer' lily. At the puffy bud stage, both plants were placed in a cooler for 2 weeks at 4C. The plant on the right had 40 $\mu\text{mol m}^{-2} \text{sec}^{-1}$ light for 24 hours/day, the plant on the left was kept in the dark. Photo taken after 12 days in a 21C postharvest room (after cold storage).

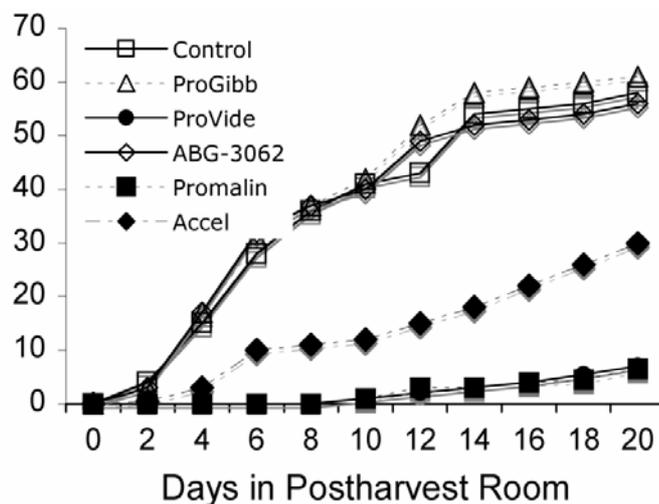


Figure 4. Effects of pre-cold storage sprays of ProGibb (100 ppm GA3), ProVide (100 ppm GA4+7), Promalin (100 ppm each BA and GA4+7), Accel (100 ppm BA and 10 ppm GA4+7), or ABG-3062 (100 ppm BA) on leaf yellowing (percent, on the y-axis) of 'Star Gazer' Oriental hybrid lilies. Plants were sprayed to runoff, allowed to dry 2 hours, placed in a dark cooler at 4C for 2 weeks, then moved into a 21C postharvest room.



Address:
Dept. of Horticulture
Cornell University
134 Plant Science Building
Ithaca, NY 14853
USA
Phone: + 1 0016072272780:
Fax: + 1 0016072559998:
wbm8@cornell.edu

Address:
Anthos
Weeresteinstraat 12
P.O Box 170
2180 AD Hillegom
Phone: +31 252 53 50 80
Fax: +31 252 53 50 88
secretariaat@anthos.org

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