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RESEARCH NEWSLETTER

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Cut Lily Postharvest: Something Old, Something New

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Considering their economic importance, there has been relatively little research published on postharvest handling of cut lilies. Complicating this is the diversity of cultivar groups---asiatics, orientals, LA hybrids, OT hybrids, longiflorum and others. And, the diversity within each group is large and constantly growing as new cultivars are released. Cultivation practices and production location (northern Europe vs. the US west coast vs. Florida vs. China vs. Japan) can be expected to impact postharvest quality and performance.

In recent years, we have received many questions about postharvest handling of cut lilies. The answers to some questions are simple and straightforward, others are more complex. Some require new research and trials to answer. In this newsletter, some thoughts on lily postharvest handling will be presented. In no way is this the final word, nor are all topics covered. This information is based partially on work within the Flower Bulb Research Program, but much also comes from established industry practice, which has been validated by years of successful experience.

The Major Postharvest Lily Problems

While there are relatively few postharvest problems with lilies, they can be severe and can result in significant quality and economic loss. For all of these, cultivar differences are important and each can vary due to cultural situation (pre-harvest factors) and treatment after harvest. Perhaps the largest problem is leaf yellowing, a problem that is increased from cold storage of harvested stems. While we would like to believe cut flowers spend a minimal time from cutting to retail purchase, the reality is that 7-10 days or more is not uncommon. Figure 1 shows an example of cut lily flowers showing leaf yellowing. A second problem is bud blasting (death) as seen in Fig. 2. This can happen from cold storage, and also by ethylene exposure, and probably interactions of the two. A third problem is seen in long-stored flowers or ones exposed to ethylene: premature bud opening (Fig. 3). Finally, reduced flower life, in an overall sense, can be a result of many factors. These will be discussed below.

Fig. 1. An oriental hybrid cultivar showing lower leaf yellowing. Image 7198.

Fig. 2. Ethylene injury to a young bud on an LA hybrid lily cultivar. Image 0900.

Fig. 3. Prematurely opening bud, from ethylene exposure. Image 0908.

Leaf Yellowing (Chlorosis)

Factors affecting leaf yellowing in cut lilies:

- Cultivar differences
- Cold storage increases leaf yellowing, longer is worse
- Storage temperature (depends a lot on the cultivar)
- Pre-harvest nutrition: low nitrogen increases leaf yellowing

Table 1 shows variability in the amount of leaf yellowing as affected by cultivar and cold storage. It is clear that individual cultivars can be extremely susceptible, and that cold storage dramatically increases the yellowing.

Table 1. Examples of the range of leaf yellowing found in several hybrid lily cultivars. After harvest at the puffy bud stage, stems were stored dry for 2 weeks at 3C, then evaluated for postharvest quality in a constant temperature room (20C).

		Percentage leaf yellowing		
Cultivar	Type	No cold storage no GA4+7	Cold storage, with GA4+7	Cold storage, GA4+7
'Colosseo'	As	6%	28%	10%
'Sorpressa'	As	0	6	2
'Springfield'	As	1	10	0
'Tresor'	As	0	11	2
'Vermeer'	As	0	2	2
'Algarve'	LA	2	8	0
'Cebeco Dazzle'	LA	1	19	4
'Daytona'	LA	2	15	6
'Fangio'	LA	1	7	2
'Printal'	LA	0	7	0
'Royal Parade'	LA	0	8	1
'Royal Perfume'	LA	2	31	2
'Samur'	LA	1	10	1
'Berlin	Or	2	46	9
'Muscadet'	Or	3	52	10
'Sissi'	Or	2	30	6
'Star Gazer'	Or	6	64	10
'Tom Pouce'	Or	0	10	3

Reducing Leaf Yellowing

Another critical step should be the application of GA_{4+7} to the stems. Quite a lot of background information on using GA_{4+7} on lilies can be found from the May 2008 Research Newsletter, seen at http://www.flowerbulbs.cornell.edu/newsletter/No.16 2008 May Hybrid lilies and Fascination.pdf

For cut lilies, GA_{4+7} is generally applied by stem uptake using the labeled Chrysal product, BVB (Dutch for Bulb Pretreatment). There may be other labeled products on the market as well. $Gibberellin_{4+7}$ treatment is very important for two main reasons. First, the gibberellin maintains green leaves throughout the consumer phase. The leaves of many cultivars can turn yellow in the vase, especially if they had been cold storage prior to sale. Second, the GA_{4+7} dramatically improves flower life. This can be seen in Table 2. Stems of the LA hybrid, 'Algarve' were harvested and pretreated in BVB for 12 hours in darkness at 4C at the recommended rate. The effect of BVB was dramatic, increasing the life of individual flowers from 5.6 to 7.2 days, an increase of 28%. BVB has two ingredients, gibberellin and benzyladenine. The active ingredient of BVB, as far as lilies are concerned, is the $gibberellin_{4+7}$. The other ingredient in BVB, 6-benzyladenine, is for all intents and purposes ineffective on lilies (at the concentrations used) and basically "goes along for the ride". So, $gibberellin_{4+7}$ products such as Fascination (Valent) and Fresco (FineAmericas), while not labeled for use, will give equal effects when used in the same manner.

$Gibberellin_{4+7}$ can also be given to cut lilies in other ways. Some years ago, we evaluated a number of cultivars and GA_{4+7} application methods. For all cultivars tested, positive effects in terms of reduced leaf yellowing and longer flower life was seen by pre-harvest sprays (Table 1) and also if given in the vase solution. To my knowledge, there are no labeled materials for use in the consumers' flower vases, but it is interesting that GA_{4+7} can work as a pre-plant spray, a post-cut pulse or as a vase solution. In my opinion, the use of GA_{4+7} is an absolutely essential step for improving cut lily postharvest quality.

Table 2. Effect of $gibberellin_{4+7}$ pretreatment (as Chrysal BVB, 12 h, 4°C in darkness) on flower life of the LA-hybrid 'Algarve'.

Pretreatment	Vase solution	Flower life span (days)
BVB	Water	7.2
Water	Water	5.6

Flower Bud Blast

Some buds, especially the smallest ones, will fail to open in the vase (Fig. 2). This problem is very cultivar specific, but Asiatic and LA-hybrid cultivars are more likely to show this problem than oriental or OT cultivars. In some cases, buds do not die outright, and will still open weakly, and at a much earlier stage than normal (Fig. 3). Another common symptom of ethylene damage in lilies (cuts and pots) are "exserted stamens" (pollen protruding out of non-opening buds (Fig. 4).

Fig. 3. Prematurely opening bud, from ethylene exposure. Image 0908.

Fig. 4. LA-hybrid lily with a commonly seen ethylene symptom, where the anthers protrude out from the petals. Essentially, the ethylene reduces petal growth more than anther and filament growth. Im-

Causes of failure of buds to open (blast), or of premature opening can be:

- Preharvest conditions of warmer temperature of lower light levels
- Cultivar variation
- Ethylene exposure before or during shipping
- Longer cold storage after harvest

For most cultivars ethylene has little to no effect on how long a lily flower will last. Many studies have exposed lily stems to ethylene at different times and ways, and the clear result is that young unopened buds can be very sensitive to ethylene (with symptoms as described above), and larger buds usually show little response to ethylene. Open flowers are usually non-sensitive (although, there are always cultivar differences and exceptions). For example, the cultivar 'Trebbiano' showed severe damage following ethylene exposure in trials at Cornell. Fig. 5 shows petals where the bases have collapsed (a normal plant is in Fig. 6). But, clearly, on the whole, lily flowers are less sensitive to ethylene than flowers like carnations and larkspur (*Consolida),*

For this reason, ethylene inhibitors such as 1-MCP (EthylBloc or Ethylene Buster) are primarily useful to maintain viability of smaller buds on stems that are to be stored for longer periods.

Fig. 5. Ethylene injury to a Trebbiano (LA-hybrid) flower. Note collapse and water-soaking of the petal bases. Image 9282.

Fig. 6. Normal Trebbiano flower. Image 9284.

There is usually little value of 1-MCP on large buds or nearly open flowers, but exceptions always exist (for example, Trebbiano). The largest value of 1-MCP comes in maintaining viability of small buds, especially on stems that are destined for storage, for example before a holiday distribution.

Even so, for some cultivars, the effect can be dramatic. In Fig. 7, 'Trebbiano' stems exposed to ethylene (3 days, 2.5 ppm) quickly lost flowers from early bud death and bud blast, whereas plants pre-treated with 1-MCP had healthy flowers and an excellent display long after the non-protected plants lost all consumer appeal (Fig. 7).

Fig. 7. Ethylene injury and prevention by 1-MCP. Left: Trebbiano, treated with 2.5 ppm ethylene for 3 days at puffy bud. Right: Trebbiano treated with 1-MCP gas overnight before ethylene treatment. Images 9306 and 9308.

The Importance of Cut Flower Food

The floral postharvest industry offers a variety of products designed to promote longevity of cut flowers. There are many recipes offers, varying by company and crop. In general, "cut flower food" is mainly sugar with additions of acidifiers (to promote water uptake), and perhaps a biocide (to reduce bacterial growth to aid water uptake and to keep vase water clean and attractive). The general concept is that sugar increases vase life as it replaces carbohydrates that are no longer available after the flower is cut from the mother plant. Handling, storage shipping and retail and consumer display in low light areas all lead to reductions in flower carbohydrate level, and presumably shorter vase life.

The importance of "fresh cut flower food" is well established within the cut flower industry. Lilies are no exception. It is hard to imagine an easier, yet more important, technique to improve cut lily vase life. The major cut flower companies offer packets of lily food to package with bunches (all are proprietary, but most contain sugar, some type of biocide and perhaps a water acidifier). We did experiments evaluating the effect of sugar concentration in the vase and found longer flower life as sugar increased up to at least 5%, well beyond the "normal" sugar concentration of about 2% that is aimed for by the manufacturers (Table 3). But, most beneficial effect is seen at about 2%, with a 20-25% increase in flower life between the controls and 2% sugar. Sometimes, leaf yellowing can increase as sugar level increases. In our work, we did see this (Table 3), where the "SPAD" readings, a measure of leaf greenness, decreased a little as the sugar level increased. We tested a number of commercial products offered for use as lily vase solutions (Table 4), and while there were small differences among them (on a limited selection of cultivars), *all of them* performed much better than a non-sugar containing control.

People have also wondered if lily stems could be "pulsed" with high concentrations of sugar in the flower warehouse, and whether this might improve store-ability or retail/consumer performance. We did experiments with the LA-hybrid 'Pirandello', but saw no positive effect of sugar pulsing (Table 5).

Table 3. Effects of vase sucrose on flower life and leaf SPAD reading (when last flower senesced) of 'Lake Michigan' and 'Pirandello' hybrid lilies.

Sucrose concn. (g/L)	Flower life (days)	SPAD reading
'Lake Michigan' (Oriental hybrid)		
0	5.7	---
10	6.8	---
20	7.2	---
30	7.3	---
40	8.1	---
50	7.6	---
'Pirandello' (LA-hybrid)		
0	7.4	54.4
10	8.1	54.7
20	8.3	49.2
30	8.8	45.9
40	9.0	45.9
50	9.0	44.4

Table 4. Effects of commercial sugar-containing vase treatments on flower life of two lily cultivars. The treatments are commercially supplied, consumer products, often supplied as "sachets" with cut flower bunches, and were made according to printed directions.

Vase treatment	Flower life (days)
***'Algarve'* (LA hybrid)**	
Company 1	9.2 a
Company 2, product A	8.1 b
Company 2, product B	7.1 c
Water	5.6 d
'Lake Michigan' (Oriental hybrid)	
Company 2, product A	9.5 a
Company 2, product B	9.4 a
Water (+Clorox)	5.7 b

Table 5. Effect of sucrose pulsing (30 h 4°C in darkness plus 11h 20°C in light) on flower life of 'Pirandello' LA hybrid lily. After pulsing, stems were held dry at 4°C in darkness for 7 d, then placed in a postharvest room for evaluation.

Pulse treatment	Individual flower life (days)
Water	6.4
1% sucrose	6.5
5% sucrose	6.8
10% sucrose	6.8
Significance	NS

Cold Storage After Harvest

This is an area where a lot of work still needs to be done and we need more knowledge of the permissible duration of cold storage as well as the temperature itself. Some lilies are susceptible to "Bud Necrosis", a disorder that occurs in the cooler, during storage. Injured buds show prominent tan or brown streaks and blotches on the petals. While injury develops while stems are in the cooler, depending on how often they are checked, it may only be noted upon removal from the cooler. The temperature of cold storage is critical to this problem, with temperatures approaching 0-1C being more problematic than slightly warmer temperatures. Figures 8 a, b and c show 'Sorbonne' that were stored for 10 days at 1, 4 or 7C.

Fig. 8a. Bud necrosis, caused by, and happening during post-harvest cold storage. 'Sorbonne' stems stored at 1C for 10 days. Image 0344.

Fig. 8b. Bud necrosis is much less at slightly warmer temperatures. 'Sorbonne' stems, from the same experiment, stored 10 days at 4C. Image 0348.

You can clearly see massive injury on buds stored at 1C, much less at 4C, and none at 7C. In this particular experiment, larger, nearly open buds did not develop injury but smaller ones did. Bud necrosis is a problem related to specific cultivars, and it seems to be more of a problem when stems are moved directly into cold coolers from hot greenhouses. In earlier work with 'Mona Lisa', we showed that "pre-cooling" at 7-9C for 24 -48 hours before further storage at 4C was beneficial, and significantly reduced bud necrosis compared with plants immediately put at a colder temperature.

Fig. 8c. Bud necrosis is eliminated by storage at 7C. 'Sorbonne', stored 10 days. Image 0355.

Effect of Cold Storage on Flower Life

Generally speaking, cold storage after harvest reduces flower longevity. With the LA-hybrid 'Pirandello', 2 weeks storage at 1, 4 or 7C reduced flower life relative to non-stored control stems, but there was, interestingly, no difference between the three temperatures (Table 6). We have noticed a large effect of storage temperature on performance of buds of different sizes. Basically, larger buds (the lowest ones that are the first to open) are adversely affected by warmer (7C) storage, and perform better with colder (1 or 4C) storage. Conversely, the upper, small buds perform much better with warmer (7C) storage. We think much of this is due to continuous (although slow) growth of the bottom buds that happens at 7C. Our studies indicate a rapid loss of starch (a storage carbohydrate) from buds that is probably related to the loss of bud lifespan. As far as smaller buds, the warmer temperature probably also allow continued development so that the buds are large enough when removed from the cooler to "compete" for sugars coming up the stem from the vase. Cold storage (1C), stops bud growth and probably reduces the ability of these smallest buds to compete for sugar when stems are placed in a warm room, leading to their death. Ultimately, the particular temperature chosen for cold storage of cut lilies and the exact handling methods depends on the cultivar, season of harvest, intended use, planned duration of storage, transportation, etc.

Other Issues: Bucket Water and Harvest Stage

I have been asked about dirty bucket water, and whether it is necessary to clean buckets frequently. I have not done any research on this and am unaware of any published work that would suggest that poor sanitation is acceptable with cut lilies. In the absence of any research to the contrary, forcers and handlers should always use proper sanitation and wash and sanitize buckets on a regular basis. Perhaps since lilies are relatively easy to hydrate, and even severely wilted plants can be readily rehydrated, people assume dirty water is OK. I would not make this assumption.

The optimal harvest stage will vary by cultivar. Some can to be harvested at an earlier stage, and these would be good cultivars if longer storage or longer transportation is anticipated. Cultivars that need to be harvested with more bud color would be good candidates for minimal storage and local sales.

Table 6. Effect of two weeks of cold storage on individual flower life of LA-hybrid 'Pirandello'. Harvested stems were held at 1, 4 or 7°C, then evaluated in a postharvest room.

Storage	Temperature (°C)	Individual flower life (days)
Not stored	---	8.7
2 weeks	1	7.8
2 weeks	4	7.1
2 weeks	7	7.2