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# RESEARCH NEWSLETTER

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## Causes and Control of Cold-Storage-Induced Bud Necrosis in 'Mona Lisa' Lilies

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Oriental hybrid lilies are an important crop in the international floriculture industry with a wholesale value of more than $65 million in the U.S alone. When crops are finished earlier than market demands, cold storage is often inevitable before marketing. Common disorders associated with cold storage of potted hybrid lilies are accelerated leaf yellowing, flower abscission, and bud abortion. While the leaf yellowing problem has been substantially solved by the registration and use of Fascination (a gibberellin and cytokinin-containing product from Valent USA), in recent years we have heard increasing reports from growers about a new cold-storage problem in Oriental hybrid lilies. Since the disorder is characterized by sunken, darkened or brownish areas on unopened buds (Fig. 1), we have adopted the term 'bud necrosis' to describe it. Based on comments from growers, bud necrosis is most common when plants are finished in hot summer periods then placed directly in cold storage. 'Mona Lisa' (Fig. 2) is a particularly susceptible cultivar, but many other pot and cut cultivars are also susceptible.

While bud necrosis occurs in storage, we were interested in whether greenhouse growing conditions (for example, heat or intense light or possibly both) play a role in bud necrosis, or whether the sudden temperature drop from the greenhouse to the cold storage is responsible. Therefore, we manipulated growing temperature, light intensity, and cold storage temperature to figure out the causes of bud necrosis problem. The following is a summary of Cornell research (generously supported by Group 1 of Anthos) looking into the causes, development and control of postharvest bud necrosis in oriental hybrid lilies.

### What We Did

We grew 'Mona Lisa' lilies in a glass greenhouse maintained at 17C under natural sunlight with a standard fertilizer regime and moved them to various growing temperatures (17C, 21C, or 26C) and light conditions (full sun, 25%, 55% or 85% light reduction from black shading cloth) about a week before cold storage. At the puffy bud stage (the most mature bud of the inflorescence showing full color, but not open), they were moved to 3C or 7C dark cold storage, or to 7C for two days, followed by 3C. Plants were held in cold storage for 2 weeks to observe how bud necrosis develops. We were able to develop a rating system to indicate the amount of visual injury to the buds (Fig. 3). Bud size was measured before and during cold storage.

### When does bud necrosis develop?

Susceptible plants develop initial symptoms within a day or two in cold storage (3C). Symptoms gradually increase over the first week in the cold storage, but stops in the second week. Thus, if an individual bud does not develop bud necrosis in the first week of cold storage, it will not become necrotic during the rest of storage period. Therefore, it is important to control the development of bud necrosis during the first couple of days in cold storage.

### Factors affecting bud necrosis

1. Bud size Bud size at the time of cold storage is an important factor for susceptibility to bud necrosis. In 'Mona Lisa', light green- to white-colored-buds, 5 to 10 cm long, are the most susceptible, while buds smaller (green buds less than 5 cm long) or larger (fully developed puffy buds) than this are not affected. Fig. 4 shows various sizes of buds along the flo-

wer stem. Completely green upper buds or lower buds at the puffy bud stage or at fully developed white-colored-bud stage don't get bud necrosis. It is the intermediate-sized buds that are at risk of developing bud necrosis.

At the end of normal forcing, the intermediate-sized buds happen to be in the middle of the inflorescence, so it was an open question as to whether bud position on the stem was also a casual factor. Therefore, we ran a series of experiments with different bulb sizes and suppliers. The results indicated that regardless of the number of buds on the stem or bud position (top, middle, bottom), buds size ranging from 5 to 10 cm are in fact the most sensitive to bud necrosis. The position of the bud along the stem is not important.

We measured the change in bud size over time during cold storage to find out why certain size classes of buds are more susceptible. Our results show that the buds at high risk of getting bud necrosis are more actively growing right before and after cold storage compared to smaller or larger buds. Therefore, if they are moved to a cold storage while they are in a "growing mode", their growth may be disturbed and necrotic spots or areas are generated on those actively growing region, such as bud tip or tepal fringes. The greenhouse cultural practices we have found effective in reducing bud necrosis (reduced temperature and light) also act to reduce bud growth rate.

2. Light intensity High light intensity is also an important factor for bud necrosis. For this research, we grew 'Mona Lisa' lilies over many months, so we set up high (26C) temperatures and supplemental lights to simulate hot summer days. The basic light intensity was approximately 600 uM.m-2.s-1, and we gave 0%, 25%, 55% or 85% shade cloth about a week before cold storage. As shown in Table 1, high light increased the incidence of bud necrosis (despite cold storage temperature), and shade reduced it.

3. High growing temperature To test the effect of growing temperature, we moved plants to a 26C greenhouse (without supplementary lighting) about a week before cold storage. Exposure to a high temperature (26C) just for one week (at the end of forcing) induced severe bud necrosis in the cooler, as shown in Table 1.

4. Sudden temperature drop in cold storage Buds of 'Mona Lisa' lily will get bud necrosis when directly moved to a 3C cold storage even if they are grown at a greenhouse temperature (17C) that does not encourage bud necrosis. It seems possible that the sudden temperature drop from the greenhouse to a cold storage causes a temperature shock, especially on the most susceptible, actively growing buds.

Based on our findings, bud size, greenhouse temperature and light level and cold storage temperature all interact to induce bud necrosis during cold storage. Each of these factors is important. When susceptible cultivars are grown under both intense light and high temperature, and moved directly to low temperature cold storage, bud necrosis can be severe and cause serious economic loss! Now that we have basic information on the causes of bud necrosis, we can suggest solutions to prevent the problem.

How can we prevent bud necrosis?
1. Reduce light intensity during production Putting up a heavy shade cloth (85%) at least one week before finishing the crops will reduce the incidence of bud necrosis. In one experiment, lilies that received shade only in the last 3-4 days all got bud necrosis regardless of shade level or cold storage temperature. Therefore, the shade duration at finishing should be longer than a week.

It would be also possible to reduce greenhouse temperature to a lower level (optimally 17C) for the last week of forcing, then gradually reduce temperature after plants are in cold storage. If the facility has automated shade cloth, however, this might be the easiest option depending on outside temperatures.

A warning: some lily cultivars are susceptible to flower abortion from low light, and this must be evaluated on a case-by-case basis.

2. Gradually reduce temperatures in cold storage If feasible, we recommend to initially store susceptible

lilies at 7C for two days, then reduce the temperature to 3C after 2 days. While this staged temperature reduction is not for reducing bud necrosis, as shown in Fig. 4, buds continue development at the warmer temperature, and may even bloom, becoming unmarketable. Therefore, for longer storage, it is important to bring the cold storage temperature down to 3C after two days at 7C. To avoid leaf yellowing, a Fascination treatment should be applied before cold storage.

3. What about a chemical remedy? DPA (diphenylamine) is an antioxidant that is used in the apple industry to reduce 'superficial scald', a chilling injury in apple that, much like bud necrosis, develops in cold storage. In our work, we grew plants in a continuous 26C greenhouse with intense light and sprayed them with 100 ppm DPA before cold storage. We found that DPA reduced bud necrosis but did not completely inhibit it. Calcium has also been used to reduce chilling injuries in other crops, but neither calcium nitrate nor calcium chloride sprays prevented bud necrosis problem in our trials. We have not found a better remedy other than altering cultural or storage practices.

Table 1. Incidence of bud necrosis (% of total buds showing necrosis) on 'Mona Lisa' lilies after 1 week of cold storage. Plants were grown at 17C and moved to various temperature and shade levels one week before cold storage (at different temperatures). Incidence of bud necrosis was calculated based on the percentage of the number of buds with bud necrosis versus total number of buds used in each treatment. (Note that values given here do not show how significant the bud necrosis was).

| | | Cold storage temperature | | |
|---|---|---|---|---|
| Growing temperature | Shade level | Continuously kept at 3C | Move from 7C to 3C after 2 days | Continuously kept at 7C |
| 26C | 0% | 88% | 68% | 52% |
| | 25% | 75% | 27% | 44% |
| | 55% | 39% | 13% | 22% |
| | 85% | 7% | 7% | 0% |
| 26C | 0% | 67% | 73% | 69% |
| 21C | 0% | 63% | 12% | 7% |
| 17C | 0% | 59% | 0% | 0% |

**Fig. 1. Bud necrosis on 'Mona Lisa' lilies.**

**Fig. 2. Bud necrosis affects many Oriental hybrid lilies such as 'Mona Lisa'.**

**Fig. 3. Various stages of bud necrosis on 'Mona Lisa' buds. Top, left to right: No necrotic lesions (0%) to 40% necrosis along the tepal. Bottom, left to right: 50 to 100% necrosis along the length of the bud. Any rating greater than 2 (necrotic area longer than 1 cm around the tepal fringe; middle bud on the top) is noticeable and considered unmarketable.**

Fig. 4. The three buds indicated with the bracket are particularly susceptible during cold storage. These buds are actively growing at the time of cold storage and sudden temperature drop in cold storage can induce severe bud necrosis.


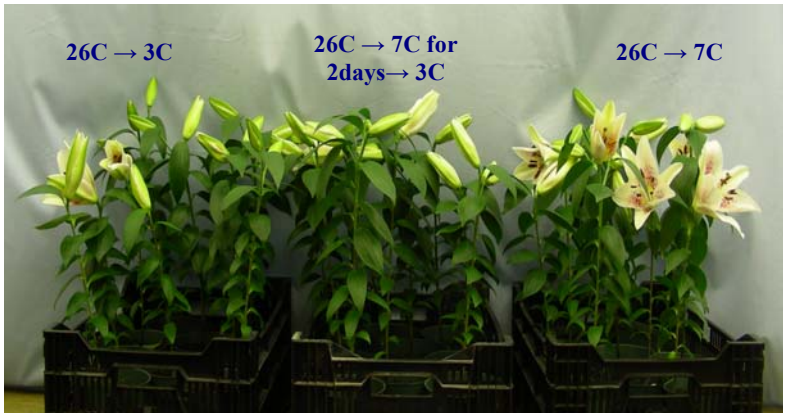


Fig. 5. Two days acclimatization at 7C can reduce bud necrosis in 'Mona Lisa' lilies. All plants grown at 26C in the greenhouse. Top, left to right: held at 3C cold storage (control), acclimatized at 7C for 2 days before moving to 3C, or held at 7C. The acclimatization (7C to 3C) and warmer (7C) storage treatments greatly reduced bud necrosis. Storage at 7C, however, allowed further growth of the buds, resulting in unwanted flowering during cold storage. Bottom: Close-up of the upper part of the plants. Left, held at 3C cold storage (control); right, acclimatized at 7C for 2 days before moving to 3C.

Fig. 6. Using heavy shade cloth (85%) can greatly reduce bud necrosis in 'Mona Lisa' lilies. All of the plants were grown at 26C and moved directly to 3C cold storage. Top, left to right: grown in full sun (control), under 55% shade cloth, or 85% shade cloth for a week before cold storage. Bottom: Close-up of the upper part of the plants. Left, grown in full sun (control); right, 85% shade cloth for a week before cold storage.

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