Ask the Doctor

Stephen A. Carver, Ph.D., OFA

Yao-Chien Chang and Bill Miller have written an excellent series of articles describing the work they have done at Cornell University's Department of Horticulture. The latest article appeared in the September 2005 issue of the *Journal of the American Society for Horticultural Science*. Complete citations for this and the other articles are listed at the end of this review. In addition to being the basis of this issue's Research Review, these articles will also provide the material for "Ask the Doctor," because they present a problem common to oriental lilies, along with the authors' efforts to identify the cause, the conditions under which it occurs, and management techniques to help manage the problem. Because this review can only touch on the high points of their efforts, you are encouraged to read these articles for yourself.

There is a problem observed on many cultivars of oriental lilies including 'Star Gazer'. The authors have named the problem "upper leaf necrosis" (ULN). It can be found affecting oriental lilies in all regions of the United States, in the Netherlands, and elsewhere. ULN can be observed at any time the lilies are grown. It has been seen on oriental lilies grown under glass and under plastic. The symptoms are typically confined to the leaves at the top of the plant. When severe, they can be seen as a necrosis or death of leaf margins and tips. Occasionally, the leaf necrosis will be accompanied by a curling and distortion, which means the value of the crop is compromised.

Based on the symptoms and their similarity to known problems on other crops, the authors postulated that a calcium deficiency might be involved. They tested the hypothesis in several ways. Chang and Miller re-examined the nature and location of the symptoms on the plant, the pattern of symptom development during the course of production, and the impact environmental and cultural conditions had on the incidence of injury. They reviewed the function of calcium in crop development, its movement in plants, factors that can limit its availability in any portion of a plant, and the symptoms that typically develop. Finally, they ran tissue analysis of affected and healthy tissues, manipulated cultural and environmental conditions that would directly affect calcium availability in injured leaves, and observed the impact of calcium treatments on symptom development and leaf calcium content.

Symptoms & Complicating Conditions

- While symptoms of ULN may be observed on any of the top 15 or so leaves of the plant, they are usually most severe on the two leaves just below the bottom bud.
- Symptoms may be seen as tiny depressed spots (which may be hard to see) on the leaf undersides along the margins. The spots may be accompanied by a yellowing (chlorosis) of the leaf margins.
- In severe cases, early symptoms appear as water-soaked areas that can be almost an inch long along the leaf margins. The injured tissue quickly turns brown. This dead tissue can cause the leaf to curl or distort as leaf growth continues. In more severe cases, dead (necrotic) areas developed inwards from both margins to the center, causing leaf tip death. Severely affected leaves may not fully expand and may occasionally be purplish in color.
- In the authors' studies, symptoms typically developed 30 to 50 days after planting. They note, however, that bulb cold treatments can affect the number of days for stems to emerge following planting. Bulbs used by the authors typically emerged in six to eight days after planting and were grown on at about 62°F target temperature, day and night.
- Flower buds were rarely affected by ULN, even though they were associated with highly distorted leaves.
- Symptoms can begin developing in "susceptible" leaves starting up to three days prior to their unfolding. The sides of the unfolded leaves typically overlap each other before the flower buds become visible.
- Symptoms were more significant on lilies grown under shade. There is some data that indicates supplemental lighting during the winter increases leaf calcium content and may diminish ULN. There is also some evidence that lilies grown under conditions of higher relative humidity will have more significant symptoms.

Calcium in Plants

- Calcium is an essential macronutrient in plants. It is a component of plant cell walls. In addition, it helps maintain cell membrane stability and cell integrity. Membranes of calcium deficient tissues become leaky, i.e. cell "fluids" can escape, resulting in cell death.
- Calcium moves "up" in plants in the xylem or water conducting vessels. Once calcium ions leave the xylem and move to the cells, they are "tied-up" and become unavailable for redistribution to other parts of the plants. Numerous studies have shown that calcium content in leaves, flowers, or fruit is tied closely to the level of transpiration from the organ. Thus, the higher the rate of transpiration, the greater the movement of calcium into the leaf, flower, or

Ask the Doctor

fruit. Fruits and young leaves typically have low rates of transpiration.

The Authors Found That:

- Scales of the 16- to 18-cm bulbs that the authors used generally had a low calcium concentration which couldn't meet the demand of expanding upper leaves.
- Transpiration rates from the unfolded leaves were significantly reduced because, until the flower buds appeared, the leaves tightly overlapped each other.
- Manually unfolding the leaves prior to flower bud appearance reduced symptoms of ULN. The practice also increased transpiration and calcium content.
- The authors found that ULN is not a significant problem on plants grown from smaller bulbs. But when these smaller bulbs are planted in a calcium-free nutrient solution in sand culture, ULN symptoms developed.
- Foliar analysis revealed a six-fold drop in calcium content in injured leaves compared to that found in similar leaves from healthy plants. The amount of calcium in ULN-affected leaves was below levels considered sufficient for Easter lilies and, presumably, oriental lilies.
- Daily calcium chloride or calcium nitrate foliar sprays to run-off of the upper foliar at 25 mM were very effective in minimizing ULN, especially when accompanied by 5ml of the spray directed at the shoot apex. Spray applications were begun 30 days after planting and continued for 14 days. Bulb soaks, however, were not.

The authors concluded that there are two primary mechanisms that lead to symptoms of upper leaf necrosis. "The first is a very low bulb calcium content that cannot meet calcium demand when the upper leaves are expanding. The second is that young expanding leaves of *Lilium* 'Star Gazer' are highly overlapped before flower buds are visible. This leaf 'enclosure' reduces transpiration of young leaves and encourages the development of ULN."

Yao-Chien Chang and Bill Miller shared some strategies for minimizing ULN.

"As a result of this research, growers interested in using calcium foliar sprays to reduce this problem could be advised to spray calcium nitrate or calcium chloride at no more than 25 mM daily, for 14 days starting 30 days after planting. Furthermore, an effort to direct spray into the congested leaves should be made. Whether or not this is an economically viable treatment would need to be determined by the individual grower."

They also noted that observations imply that reducing the relative humidity and providing supplemental lighting (both of which can enhance transpiration rates) may help reduce the severity of upper leaf necrosis.

References:

- Chang, Y.C. and W.B. Miller. 2003. Growth and calcium partitioning in *Lilium* 'Star Gazer' in relation to leaf calcium deficiency. J. Amer. Soc. Hort. Sci. 128:788–796. Abstract can be read at the following web location: http://www.electronicipc.com/JournalEZ/detail.cfm?code=04200011280602&CFID=440755&CFTOKEN=7E661BC0-491C-490F-939FF63A2885DFA8
- Chang, Y.C., K. Grace-Martin, and W.B. Miller. 2004. Efficacy of exogenous calcium applications for reducing upper leaf necrosis in *Lilium* 'Star Gazer'. HortScience 39:272–275. Abstract can be read at the following web location: http://www.electronicipc.com/JournalEZ/mo/detail.cfm?code=04200020390203&CFID=440755&CFTOKEN=7E661BC0-491C-490F-939FF63A2885DFA8
- Chang, Y.C. and W.B. Miller. 2004. The relationships between leaf enclosure, transpiration, and upper leaf necrosis on *Lilium* 'Star Gazer'. J. Amer. Soc. Hort. Sci. 129:128–133. Abstract can be read at the following web location: http://www.electronicipc.com/JournalEZ/detail.cfm?code=04200011290120&CFID=440755&CFTOKEN=7E661BC0-491C-490F-939FF63A2885DFA8
- Chang, Y.C. and W.B. Miller. 2005. The development of upper leaf necrosis in *Lilium* 'Star Gazer'. J. Amer. Soc. Hort. Sci. 130:759–766. Abstract can be read at the following web location: http://www.electronicipc.com/JournalEZ/detail.cfm?code=04200011300517&CFID=440755&CFTOKEN=7E661BC0-491C-490F-939FF63A2885DFA8

ofa