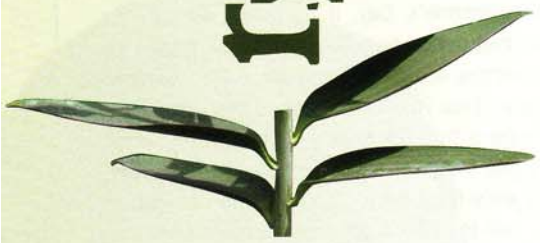
By Yao-Chien Chang and William B. Miller

Upper leaf necrosis on Oriental lilies: A calcium deficiency disorder



Upper leaf necrosis (ULN) affects many popular Oriental hybrid lilies, such as Star Gazer (shown here), reducing their aesthetic appeal and economic value. Only leaves associated with flower buds and those immediately below the buds are susceptible.

Oriental lily growers, especially growers of Star Gazer, are familiar with upper leaf "burn." Characterized by curled, distorted or dead upper leaves, the disorder is found in greenhouse-grown Oriental hybrid lilies worldwide. We call this problem "upper leaf necrosis," or ULN. Described in Asiatic lilies nearly 20 years ago in the Netherlands, ULN was thought to be caused by rapid changes in the greenhouse environment, specifically by bright sunny weather following periods of cloudy, dark days. Our work shows instead that ULN is caused by calcium deficiency. The problem occurs long before you see brown leaf margins and is unrelated to light changes in the greenhouse.

Symptoms

ULN occurs only on the leaves associated with flower buds and the several leaves immediately below the flower buds, with no necrosis on the lower leaves nor on the buds themselves. ULN is hard to understand because the obvious visible symptoms (brown upper leaves) develop as many as 25 days after injury occurs in the leaf cells, meaning the problem often goes unnoticed until very late in its development. Very careful observation will reveal symptoms on young expanding upper leaves about 30 to 35 days after planting, when the plant is about 30- to 35-cm tall. A lightly infected leaf will exhibit tiny depressed spots on the lower surface. On a severely affected leaf, the initial symptom is water-soaked tissue.

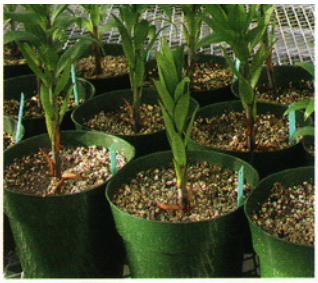
Symptoms most commonly start on the leaf margin and are easily missed. Although the result of calcium deficiency persists for the remainder of the crop, the period the plant or an individual leaf is susceptible to calcium deficiency is relatively brief. Star Gazer plants grown from 16/18 cm bulbs begin to exhibit symptoms about 30 days after planting; plants grown from larger bulbs might take as long as 45 days. Once flower buds are visible, the danger of developing additional necrosis is minimal. Since early growth rates vary depending on the length of cold storage, growing temperature, etcetera, another indicator is plant height. Plants from 16/18 cm bulbs begin to exhibit early necrosis symptoms when they are about 25 cm tall.

ULN is a calcium deficiency disorder

In bulbous plants, there are two sources of calcium: 1) calcium in the scales and in the young shoot inside the bulb and 2) calcium that is absorbed from the soil by the roots during active growth. The calcium concentration in Star Gazer bulbs is very low (about 0.04%). Bulbs provide a limited amount of calcium to lower leaves, but not enough for upper leaves. ULN occurs when the shoot enters the rapid growth phase, when the calcium supply from the bulb and roots cannot meet the demand of the leaves.

Another important cause of ULN is leaf enclosure on the shoot apex. As plants grow, roots absorb calcium that is moved upwards in the xylem or "transpiration stream" and deposited in actively transpiring leaves. Since young, expanding leaves are physically enclosed by outer (older) leaves, transpiration of the young leaves is restricted. Since transpiration is required for plants to move calcium from the soil to the leaves, "leaf enclosure" reduces calcium

translocation to young leaves, with calcium deficiency and ULN as the result.



Star Gazer lilies become susceptible to ULN when about 75% of the plants have begun to unfold their leaves and plants are about 25 cm tall.

ULN is affected by many factors

Cultivar. To avoid ULN, plant non-susceptible cultivars. Star Gazer, Acapulco and Muscadet are susceptible to ULN; Sissi, Alliance, Berlin, Helvetia and Tom Pouce are not.

Bulb Size. Small bulbs (12/14) rarely show ULN, but when larger bulbs (e.g. 16/18 cm) are used, the risk of upper leaf necrosis is greatly increased.

Light intensity. We do not agree that ULN occurs when bright, sunny days follow a prolonged period of dark, cloudy weather. Calcium deficiency injury occurs long before symptoms are visible. When brown leaves occur during or immediately after bright or dark days, the abrupt change may not be the cause. Instead, the high light might cause it to develop more rapidly or more intensely than if the environment remained dark and cloudy.

Humidity. High humidity reduces transpiration and calcium movement and commonly increases calcium deficiency.

Growth rate. Physiologically, calcium disorders such as ULN occur when crop growth rate is high and when the calcium supply cannot meet the high demands of leaves. Greenhouse production protocols are optimized for rapid crop production, but in this case, rapid growth causies ULN. During the susceptible period (25 to 50 days after planting for 16/18 cm Star Gazer), reducing growth rate without sacrificing transpiration can help reduce ULN. Preliminary experiments indicate that reducing greenhouse temperature during this period can reduce upper leaf necrosis to some extent.

How to control ULN

Calcium deficiency usually results from uneven calcium distribution in the plant, often when there is plenty of calcium available to the plant in the soil. In general, properly prepared greenhouse mixes have adequate calcium for Star Gazer lilies and adding extra calcium to them will not reduce ULN. Greenhouse practices promoting young leaf transpiration can help eliminate ULN.

Luckily, lilies are not susceptible through the whole crop cycle. With Star Gazer we saw that in the first 25 days after planting the bulb itself supplies sufficient calcium. Once all leaves are unfolded (not touching other leaves) they are no longer susceptible. With 16/18 cm Star Gazer, the critical period is from 25 to 50 days after planting or from the time plants are 25 cm tall until flower buds are visible. When plants begin to unfold leaves after shoot emergence, pay attention to reducing upper leaf necrosis.

Other key methods to reduce the risk of ULN include 1) using overhead fans to increase transpiration, 2) reducing the growth rate and 3) spraying calcium solution.

Overhead fans. Additional airflow drastically reduces upper leaf necrosis. Horizontal airflow fans, in their normal configuration, do not provide enough airflow to reduce ULN. To be effective, air must blow directly onto the plants.

Artificial light. ULN is increased with light reduction. We routinely see more ULN in crops planted in the winter or very early spring than when planted in higher light periods. In northern production areas, artificial lighting can help increase transpiration, thus reducing ULN.

Avoid overhead irrigation. Water accumulation on foliage increases humidity around the plants, reducing transpiration and increasing the risk of ULN. Avoid getting water on the upper, unfolding leaves; strive for a "dry" greenhouse.

Calcium sprays. Calcium sprays are effective if done correctly, but may be non-effective (or even phytotoxic) if done incorrectly. Both calcium nitrate and calcium chloride are effective sources. Daily sprays are needed from day 30 to 43 because the individual leaves are growing rapidly and the calcium solution must touch each new leaf in sequence before it develops its own calcium deficiency.

What is the future of this work? In our current research, we are evaluating cost effective methods to manipulate leaf unfolding at specific points during the crop. We believe it will be possible for a single treatment to substantially control ULN and also provide most, if not all, of the needed height control for pot plant production of Oriental hybrid lilies. ■

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TIPS FOR REDUCING UPPER LEAF NECROSIS ON ORIENTAL HYBRID LILIES.

- Use non-susceptible cultivars
- Use small bulbs such as 12/14 and 14/16 cm
- Increase vertical airflow onto plants by overhead fans
- Use assimilation lighting in the winter
- Foliar calcium sprays
- Keep lily leaves dry
- Keep greenhouse dry
- Reduce growth rate during the susceptible period (25-50 days after planting, or 25 cm tall to flower bud visible)
- Avoid high soluble salt levels in the substrate
- Ensure a good root system

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