no. 6 / April 2005

RESEARCH NEWSLETTER

This Flower Bulb Research Program Newsletter is published by the Royal Dutch Wholesalers Association for Flowerbulbs and Nurserystock in cooperation with Dr. Bill Miller of Cornell University.

Controlling Upper Leaf Necrosis on 'Star Gazer' Lilies

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Dedication. This project is dedicated to the memory of Mr. Piet Borst of Van Zanten, who passed away in Holland on July 23, 2003. Piet was a member of our Group 1 research committee, and a tireless promoter of lilies, especially on the west coast. We appreciated his thoughtful criticism, involvement, and support of the Flowerbulb Research Program at Cornell.

Fig. 1
Upper leaf necrosis (ULN) affects many popular Oriental hybrid lilies, reducing their aesthetic appeal, and economic value. Shown here: 'Star Gazer'.

In the previous Newsletter, we reported on Cornell research on upper leaf necrosis, a calcium deficiency disorder that occurs in many Oriental hybrid lily cultivars. In oriental hybrids, the leaves on the upper stem, and those associated with the flower buds are susceptible (Fig. 1). Leaves lower on the stem are not susceptible. In our work, we have shown that 'Star Gazer' bulbs have very low levels of calcium (about 0.04%), and that the overlapping of young leaves before and during leaf unfolding are key factors in the development of the calcium deficiency that leads to the disorder.

However, the problem is not always consistent, and the severity of ULN can vary from crop to crop. Even under controlled experimental conditions, ULN severity in our own work would vary between experiments. For each crop, plants can respond differently even when the same cultivar and bulb size are used, and even when grown in the same greenhouse. Since ULN is affected by so many factors, including cultivar, it is important to be aware of them to maximize control of this problem.

In this Newsletter, we will give examples of some of the factors we investigated, discuss others that are commonly associated with calcium deficiency disorders, and provide methods to commercially apply the results.

Fig. 2. Bulb size has a significant impact on susceptibility to upper leaf necrosis. The plant on the left was grown from a 16/18 cm bulb, and has necrosed upper leaves. Plants grown from smaller bulbs (14/16 cm, middle; 12/14, right) are much less susceptible to upper leaf necrosis.

Bulb Size. Bulb size is a very important factor for upper leaf necrosis. Small bulbs (12/14) are much less susceptible to ULN. When larger bulbs are used, such as 16/18 cm and larger, the risk of having upper leaf necrosis is greatly increased. Fig. 2 shows no necrosis on 'Star Gazer' grown from 12/14 and 14/16 cm bulbs, and severe symptoms from 16/18 cm bulbs. The downside of smaller bulbs is the lower bud number (bud numbers typical of the different sized bulbs are clearly visible in Fig. 2). Using smaller bulbs will result in fewer buds; depending on your marketing strategy and product requirements, choose smaller bulbs if possible. Our results suggest the higher growth rate and a more enclosed shoot apex (which reduces leaf transpiration) on the plants grown from larger bulbs are important causes of the high incidence of upper leaf necrosis (Fig. 3). Table 1 lists the expected necrosis incidence when 'Star Gazer' of varying sizes are planted. This information is based on our trials during both spring and summer. When growing 'Star Gazer' lilies in the winter, the incidence is expected to be higher.

Light intensity. It has been commonly said that an abrupt change in greenhouse light can cause upper leaf necrosis. The scenario often described is that ULN occurs when the sunny days follow a prolonged period of dark, cloudy weather.

If plants were held in place in "shuttle trays", and with a bit of practice and control, we imagine that this could be an effective treatment, whereby enough "disruption" to the upper leaves could be achieved without causing physical injury to them. We suggest that overhead fans blowing vertically downward offer a practical means for controlling upper leaf necrosis. Plus, for pot plant growers, some measure of height control will also be realized as a result of the mechanical perturbation of the plant (see Fig. 6).

Artificial lighting is suggested for winter plantings. In our shading trials, we found upper leaf necrosis was increased with light reduction, and this was related to a reduction in transpiration in the shaded plants. We also 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 be useful to increase transpiration and thus reduce upper leaf necrosis, and improve overall quality.

Overhead watering is not recommended. We conducted an experiment where we misted the foliage once or twice a day. We found that upper leaf necrosis was increased when misting was applied. Plants misted twice a day had more severe symptoms than with one misting. Some growers may choose overhead watering as their irrigation method. However, water accumulation on the foliage will increase the humidity around the plants, and lead to a reduced transpiration (Fig. 8). Reduced transpiration means less calcium will be distributed to the leaves. Therefore, when watering, try to avoid getting water on the upper, unfolding and work to keep the greenhouse 'dry.'

Calcium sprays. As discussed in the previous Newsletter, we feel that calcium sprays are not the best approach for combating this problem as we found daily sprays were needed to significantly reduce ULN. If grower trials are to be conducted, we recommend a pressurized sprayer and a directed the spray to the young enclosed leaves. If calcium solution is not directed to the enclosed shoot apex, satisfactory results may not be achieved. Also remember to add a surfactant; it will increase the efficiency of calcium sprays. It is not necessary to spray calcium to the lower leaves, since they are not susceptible to ULN.

Other factors. Root pressure is another important factor that can increase calcium transport to young tissues during the night. Root pressure is built up in the dark when the humidity is both high in the air and in the soil. Practically, optimum leaching and keeping the medium moist will help root pressure build up, and high salt levels act to reduce root pressure. While it is obviously important to ensure a vigorous stem root system, experienced 'Star Gazer' growers know that this cultivar is a very "slow rooter". A good root system is necessary for the plant to acquire adequate calcium from the soil as well as for the root pressure to build up during the night.

When the above factors are considered, upper leaf necrosis is not difficult to predict or understand. Upper leaf necrosis is the result of high growth rate, insufficient calcium supply from the bulb and root system, and leaf overlap or "enclosure". From the results discussed above, we know bulb size, humidity management, and growth rate manipulation are important factors to control this disorder. Environmental manipulations that decrease humidity during the day will reduce the risk of upper leaf necrosis. Airflow directed onto the upper leaves offers an inexpensive and practical solution for many occurrences of this problem.

Fig. 8. Water residing in the shoot apex may result in severe upper leaf necrosis, bud abnormality, or even shoot apex death. Always keep the foliage dry!!

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Fig. 3 A

Fig. 3 B

Fig. 3. Appearance of the young leaves at the apex of 'Star Gazer' oriental hybrid lily stems grown from (L to R): 12/14 cm, 14/16, and 16/18 cm bulbs. The apex of the 16/18 cm plant has many more buds and leaves than those of smaller bulbs. This leads to a reduction of transpiration from the young leaves, as their overlap and "enclosure" reduces water loss and calcium movement into the leaf.

Bulb fresh weight (g)	Commercial grade (cm)	Estimated necrosis incidence (%)
47.0	14/16	10
50.3	14/16 or 16/18	20
52.8	14/16 or 16/18	30
55.0	16/18	40
57.2	16/18	50
59.5	16/18	60
62.0	16/18	70
65.2	16/18	80
69.7	16/18	90

Table 1. Estimated correlation between bulb fresh weight and necrosis incidence on 'Star Gazer' lilies.

We do not agree with this assertion. As discussed in the previous Newsletter, the calcium deficiency injury itself occurs much earlier than the moment symptoms become visible. Seeing browning leaves during or immediately after bright or dark days doesn't mean the abrupt change is the cause, but it is possible that the high light might cause the problem to show more rapidly or more intensely that it would had the environment remained dark and cloudy. In our work, we were not able to show any relationship between ULN and the amount of light the crop received in the days before symptoms first showed. Low light, however, does promote ULN, probably by reducing transpiration and therefore calcium movement to the leaf. Fig. 4 shows that shading increases upper leaf necrosis. The more light was reduced, the more severe were the necrosis symptoms.

Fig. 4. Low light levels increase upper leaf necrosis. From left to right: Control (full sun), 30% light reduction, and 55% light reduction. These plants were planted 18 Sept. and the photo taken 22 Dec.

We have done research on upper leaf necrosis throughout the year, and typically observe the most severe necrosis on winter crops.

Leaf orientation. We did a series of experiments to demonstrate that "leaf enclosure" promotes the occurrence of ULN. We applied a technique we call "artificial leaf unfolding" (ALU) to 'Star Gazer' lilies during the susceptible period (25-50 days after planting). ALU is the gentle, manual bending of leaves to a horizontal position

Fig. 5. Artificial leaf unfolding (ALU) was used to investigate if leaf enclosure of the shoot apex promoted upper leaf necrosis. ALU was done by bending leaves to a horizontal position in order to place them in an "unfolded" position several days earlier than normal. After ALU, leaf enclosure was minimized and the shoot apex was much more open (plants on the right). Plants on the left are controls, with leaves in the normal position.

in order to "unfold" them several days earlier than normal. After ALU, leaf enclosure and overlap was minimal and the shoot apex was exposed as shown in Fig. 5. Plants receiving ALU had almost no upper leaf necrosis. Table 2 and Fig. 6 show typical results of our ALU experiments. In the control group, 87% of the plants had severe upper leaf necrosis. In the treatment that plants received one ALU per day, only 3% of the plants had light necrosis, and no necrosis was found in the treatment where we unfolded leaves twice per day. The purpose of applying ALU was to increase the transpiration of upper leaves and therefore increase calcium movement to young leaves. Although artificial leaf unfolding is not feasible for commercial growers, the striking results emphasize the importance of upper leaf transpiration for reducing the risk of upper leaf necrosis.

Unfolding frequency (times/day)	Plants with upper leaf necrosis	
	Number	Percentage
0 (Control)	26	86.7 %
1	1	3.3 %
2	0	0.0 %

Table 2. Artificial leaf unfolding successfully controls the occurrence of upper leaf necrosis on 'Star Gazer' lilies. Artificial leaf unfolding was applied 0, 1 or 2 times a day. For each treatment, 30 plants were potted.

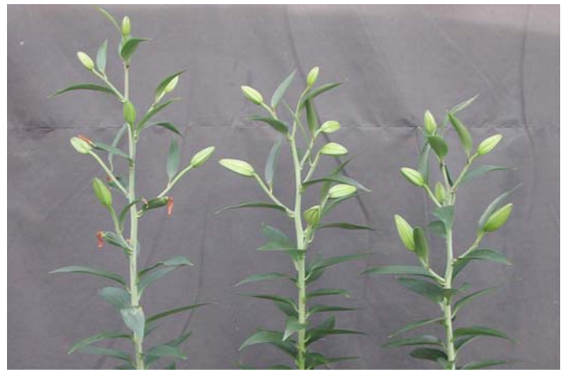

Fig. 6. Artificial leaf unfolding (ALU) successfully suppressed the occurrence of upper leaf necrosis. Plant on the left is a control; plant in the middle received ALU once a day; and plant on the right received ALU twice a day. No necrosed leaves were found on plants receiving ALU twice per day. Note plants are shorter with ALU.

Growth rate. Physiologically, calcium disorders such as ULN occur when crop growth rate is high and/or when the calcium supply cannot meet the high demands of leaves (or fruit, in the case of tomatoes). The fact that larger bulbs result in more upper leaf necrosis is a good example of this relationship (larger bulbs have more leaves, buds, more shoot weight, and therefore a higher calcium demand at the moment the injury occurs).

Greenhouse production protocols are optimized for rapid crop production, but in this case, rapid growth brings troubles to lilies. During the susceptible period, which is 25-50 days after planting for 16/18 cm 'Star Gazer', reducing growth rate (without sacrificing transpiration) would help to reduce ULN. For example, reducing greenhouse temperature during this period will reduce upper leaf necrosis to some extent.

The use of overhead fans reduces upper leaf necrosis. We conducted a number of experiments where we installed fans to blow air vertically down onto the plants. We could vary airflow by changing the fan speed or distance from the plants. Plants receiving additional air had greatly reduced upper leaf necrosis. We also found the higher the airflow, the lower the necrosis (Fig. 7). The airflow delivered down to the plants was about 30 inches (0.75 meter) per second (ca. 150 feet per minute) on low speed, and about 30% more on high speed. We realize that most growers do not have the equipment to measure wind speed, so a user-friendly approach would be to ensure that enough airflow is occurring to cause slight movement of the upper leaves.

Fig. 7. The use of overhead fans offers a very promising method to combat upper leaf necrosis. Plant on the left (the control) received no additional airflow, and several necrosed upper leaves are seen. The plant in the middle was treated with additional airflow ("low speed" setting on the fan), and the plant on the right received "high speed" airflow. Necrosis on the plants subjected to direct airflow was reduced to a satisfactory level.

Practically speaking, overhead fans (blowing vertically down) can be easily installed in the greenhouse. Another possibility might be to use fans mounted on a movable boom. With such a system, fewer fans might be able to "treat" more plants as the fans move above the crop. We imagine the airspeed might need to be greater in such a moveable system. Another suggestion proposed by a grower is to use an electric leaf blower.