MARYLAND COOPERATIVE EXTENSION
UNIVERSITY OF MARYLAND
COLLEGE PARK•EASTERN SHORE

Fact Sheet

Fact Sheet 687

Production of Hybrid Lilies as Cut Flowers

Introduction

Hybrid lily production is well suited for specialty cut flower growers selling to retail florists or at farmers' markets. High quality fresh cut lilies have a distinctive competitive edge over lilies grown out-of-state. Local growers are able to harvest lily stems with one flower open and store them in water to deliver a fresher product. Boxed lilies, however, are harvested with only one large well-colored flower bud to avoid damage during shipping. Also, ethylene build-up in shipping boxes decreases the shelf life of most lilies grown out-of-state by 5 to 7 days.

The commercial production of bulbs sold to cut flower growers requires a cool environment, which is not found under East Coast climatic conditions. For this reason, most bulbs used for cut-flower production are grown in the Netherlands, Chile, New Zealand, South Africa, France and the northwestern United States in Oregon and Washington State.

The five main groups of lilies are Asiatic, Oriental, OT, LO and LA hybrids (see photos 1 and 2). Although Asiatic and Oriental lilies are well known to the general public, there have been many new releases of LO, LA, and OT hybrid lilies brought onto the market. These new hybrids provide an opportunity to introduce the public to new possibilities in stem length, flower shape, size, color, and scent. Growers can expect to see many more new and exciting cultivars in coming years.

Hybrid lilies are a result of genetic crossings between lily species, making newer lily cultivars difficult to classify into conventional groupings. The OT hybrids are a cross between Oriental and Trumpet lilies. Oriental and OT lilies have fragrant flowers with some cultivars having stronger scented flowers than others. For customers sensitive to strong odors, LA hybrids may be a better choice. The LA hybrids are a cross between *L. longiflorum* and Asiatic lily. The LA hybrids are increasing in popularity compared to the Asiatic hybrids. LA hybrids generally have a larger flower size and the flowers are more clustered at the top of the stem and are more upward facing than Oriental lilies. The LO hybrids are a cross between *L. longiflorum* and Oriental lily. LO hybrids are the newest addition of lilies and will provide unique flower shapes, sizes and colors.

1. 'Royal Sunset'- LA Hybrid.

Table 1. Bulb Shipping Quantities.

Lily Group	Bulb Size (cm)	Number of Bulbs per Crate
Asiatic	12/14	400
LA	14/16	300
Orientals	16/18	200
OT	18/20	150
LO	18/20	125

Note: For smaller quantities, some suppliers pack bulbs in bags of twenty-five. Also, the shape of the bulb influences how many bulbs are packed in a plastic crate. For example LO hybrid lilies have a shape that differs from the OT hybrids, making packing tighter for OT compared to LO hybrids.

Table 2. Asiatic Hybrid Lilies.

Color	Cultivar	Bud Count (bulb size 12/14 cm)	Height (cm)	Forcing Time in Greenhouse (days) at 50-55°F Night Temperature	Flowers Upward-facing (U) or Side-facing (S)
Deep Red	Black Out	3–6	90	85	U
Red	Monte Negro	3–5	90	75	U
Orange	Brunello	4–6	90	85	U
	Lyon	3–5	95	80	U
Orange/ Maroon	Loreto	2–5	85	75	U
Pink	Vivaldi	3–5	90	85	U
	Toronto	5–7	120	90	U
Salmon	Cannes	3–5	85	95	U
	Farfalla	4–7	105	90	U
White	Navona	4–7	105	85	U
	Sorpressa	2–4	110	90	U
Pink/White	Vermeer	2–4	100	90	U
White/Pink	Renoir	4–7	90	90	U
Pink/Yellow	Corrida	4–6	90	85	U
Yellow	London	4–6	90	75	U
	Gironde	4–7	90	90	U

Table 3. LA Hybrid Lilies.

Color	Cultivar	Bud Count (bulb size 14/16 cm)	Height (cm)	Forcing Time in Greenhouse (days) at 50-55°F Night Temperature	Flowers Upward-facing (U) or Side-facing (S)
Pink	Algarve	4–6	110	90	U
	Brindisi	3–5	90	85	U
Yellow	Dazzle	5–8	100	90	U
	Glow	5–8	90	85	U
Red	Fangio	3–6	115	85	U
	Original Love	3–5	105	90	U
White	Litouwen	4–6	110	85	U
	Timaru	3–5	100	95	U
Salmon	Menorca	3–6	105	85	U
	Salmon Classic	3–6	80	70	U
Orange	Madrid	4–6	90	85	U
	Royal Trinity	3–6	110	85	U
White/Pink	Samur	3–5	85	85	U
Pink/Yellow	Royal Sunset	4–6	95	85	U
Lime Green	Courier	3–5	95	85	U

Table 4. LO Hybrid Lilies.

Color	Cultivar	Bud Count (bulb size 18/20 cm)	Height (cm)	Forcing Time in Greenhouse (days) at 58-62°F Night Temperature	Flowers Upward-facing (U) or Side-facing (S)
White/ Raspberry	Triumphator	5–7	100	95	S
White	White Heaven	5–7	105	100	S
	White Elegance	5–7	100	95	S

Table 5. Oriental Hybrid Lilies.

Color	Cultivar	Bud Count (bulb size 16/18 cm)	Height (cm)	Forcing Time in Greenhouse (days) at 58-62°F Night Temperature	Flowers Upward-facing (U) or Side-facing (S)
Dark Pink	Acapulco	4–6	110	85	U
	Mero Star	4–7	105	115	U
	Tiber	4–6	100	100	U
	Star Gazer	4–7	95	100	U
Dark Red	Dordogne	3–5	105	100	U
	Tropical	5–9	85	110	U
Pink/Yellow/ Red	Bergamo	6–10	130	105	U
White/Yellow	Legend	3–6	105	100	U
White/Yellow/ Pink	Maryland	3–7	115	110	U
Pink	Lombardia	5–7	115	100	U
	Sorbonne	3–6	100	105	U
White/Pink	Marco Polo	3–6	110	85	U
	Muscadet	3–6	80	105	U
White	Casa Blanca	3–5	130	110	S
	Siberia	4–8	100	110	U

Table 6. OT Hybrid Lilies.

Color	Cultivar	Bud Count (bulb size 18/20 cm)	Height (cm)	Forcing Time in Greenhouse (days) at 58-62°F Night Temperature	Flowers Upward-facing (U) or Side-facing (S)
Yellow	Conca d'Or	4–6	100	105	S
	Yelloween	6–8 (bulb size 16-18 cm)	130	90	U
Pink	Gluhwein	4–9	120	90	U
	Maywood	5+	110	100	U
Yellow/Red	Nymph	5+	110	100	U
Red/Yellow	Shocking	4–6	120	110	U
Red	Visaversa	6–9	110	100	U

Table 7. Recommended Temperatures.

Lily Group	Night Temperature	Day Temperature
LAs and Asiatics	50–55°F	62–65°F
O, OTs, LOs	58–62°F	65–68°F

Note: OT, O and L0s show decreased performance below 55°F.

Cultivar Selection

Recommended Bulb Sizes

Bulbs are measured by circumference (cm) in a horizontal plane at the middle height of the bulb. Selecting smaller bulbs produces weaker stems and fewer flowers. Very small bulbs often result in no flowers being produced. Size does matter!

Bulb Storage and Handling

Lily bulbs ready for production are available year round from bulb suppliers. Suppliers precool the bulbs for 6 to 8 weeks at 34 to 36°F to ensure that they flower more evenly. Once the bulbs are precooled, suppliers freeze them in peat moss at 28 to 29°F for storage (see photo 3). Freezing the bulbs prevents sprouting, reduces loss of bulb energy reserves, and minimizes disease occurrence.

Growers should open the shipping boxes immediately upon arrival. Uncover the bulbs to let them air out and allow them to thaw before planting if they are still frozen. Bulbs can be stored in a cool room overnight at

2. 'Sorbonne'- Oriental lily.

3. Lily bulbs in cold storage.

temperatures no higher than 60°F. If planting must be delayed, bulbs can be held for up to two weeks in a cooler at 34 to 36°F. Do not refreeze the bulbs or the flower buds may not develop properly.

After bulbs have been precooled, they should not be exposed to temperatures above 36°F for periods longer than 8 to 12 hours or premature sprouting will occur. If the shoots of unplanted lilies have grown beyond 2 inches, the bulbs are worthless. Oftentimes lily bulbs available through local garden centers or large chain stores are held in heated retail areas, reducing the quality of the lily bulb. Although these bulbs are adequate for a homeowner's purpose, professional growers are not advised to use them for cut flower forcing.

Production Methods

There are several production methods available when growing lilies as a cut flower crop. Lilies can be grown in raised beds in the field, in high tunnels, and in greenhouses. Lilies can also be grown in crates in greenhouses. Before choosing a production method, or a combination of methods, growers should consider factors such as facilities and resources available, the types of lilies to be grown, and the time of year for growing the lily crop.

Fall and early spring production of lilies requires the use of high tunnels. High tunnels extend the season by allowing growers to start 6 weeks earlier in mid-February and by allowing them to plant Asiatics and LA hybrids up until early August to obtain a fall harvest. Growers can plant precooled LA bulbs in the field from March through June. For early

4. Greenhouse crate production of three-week-old bulbs.

spring and late fall production of Oriental and LO hybrids, it is recommended to grow them in a heated greenhouse to maintain minimum optimal night temperatures (Table 7). Heated greenhouses allow for year-round production. Winter production in the greenhouse takes around 5 weeks longer than in the spring and also requires the use of supplemental lighting. Maintaining proper air circulation using horizontal air flow (HAF) fans and top vents is very important for reducing disease problems in greenhouse production systems.

Field Site Selection and Management

Select a site that receives a minimum of 6 to 8 hours of sun daily to allow the flowers and foliage to dry off by evening, which decreases the chance of *Botrytis*. Choose a loam soil with 2 to 5 percent organic materials that is at least 6 to 8 inches deep. The soil should be well drained and have a pH of 6.3–6.8. Apply a pre-emergent herbicide soon after planting. The following chemicals are labeled for use around lilies: isoxaben (Gallery) and S-metolachlor (Pennant Magnum). Use Round-up in late winter as a post-emergent weed control.

Raised Beds

Raised beds are useful for lily production because they help to improve drainage and prevent disease problems caused by root rots. An indoor raised bed can be constructed using pressure treated wood to create a 6-inch high side. When constructing the raised beds in a high tunnel or greenhouse, consider the space between the beds for maneuvering equipment. During the heat of the summer when a greenhouse is not in use, plastic covers can be used to solarize the soil for 4 to 6 weeks. Solarizing the soil helps to reduce weed and disease problems the following season.

Greenhouse Crate Production

Lily bulb shipping crates can be reused for production in the greenhouse (see photos 4 and 5). Place newspaper on the bottom of the crates to prevent losing substrate. Use a well-drained commercially available soilless substrate. Your own mixture of leaf compost,

Table 8. Number of Bulbs per Crate.

Lily Goup	Low Lighting	High Lighting
O, OTs, LOs	10 to 12	12 to 15
Asiatics, LAs	12 to 15	15 to 20

Note: Spacing is dependent on individual varieties. Tulip crates are too shallow for lilies to develop an adequate root system. Additional shipping crates can be purchased separately from your bulb supplier.

coarse peat, and perlite or sand in a 1:1:1 ratio could also be used.

Place a 2-inch layer of substrate at the bottom of the crate, lay the bulbs out, fill the rest of the crate with substrate, and water well. Keep the crate in a cool area between 50 and 55°F for 7 to 20 days before placing it in the greenhouse to keep the bulbs from developing shoots before establishing an adequate root system. It is important to take the trays out of the cool area and into the light, whenever sprouts have developed 2 to 3 inches in height.

Irrigation

In raised beds, place drip tape with emitters at 8-inch intervals. For crate production you can use two trickle tapes over each row of crates. However, growers should take into consideration how often the crates will need to be moved before deciding to install an irrigation system. Lack of frequent watering produces smaller flowers and shorter stems, so do not allow soil to dry out. Irrigate plants after cutting to maintain bulb vigor in field production situations.

Fertilization

Proper fertilization for lilies used as cut flowers is important. With a pH/soluble salt meter, monitor the pH and electrical conductivity (EC) of the soil using the 1:2 dilution method. The soil pH should be in the 6.3 to 6.8 range for optimum nutrient uptake and plant growth. This pH range is good for growing lilies both in the ground and in soilless substrate in the greenhouse. For greenhouse production of lilies, soil samples should be taken every week during the growing season

5. Full-grown lilies in crates before harvest.

Table 9. Recommended Rates of Calcium Chloride.

Type of Calcium Chloride	Percentage of Calcium	Gallons of Water	Ounces of Calcium Chloride	Rate of Calcium (ppm)
Dihydrate	27	3	0.5	325
Anhydrous	39	3	0.4	357

and the soluble salt and pH monitored using a portable pH and EC meter. Acceptable EC readings for production in containers should be between 1.0 and 1.5 ms/cm. High soluble salt levels can cause soft stems, leaf burn, and reduced plant height because of inadequate root development.

In greenhouse and high tunnel production systems fertilization should begin at shoot emergence, using a fertilizer with a 2:1 ratio of calcium nitrate to potassium nitrate. Weekly application of this ratio can be used or 250 to 300 ppm of N should be applied. The use of slow or controlled release fertilizers is not recommended as the stems will be harvested before most of the nutrients are released.

In field production systems fertilization should begin at shoot emergence. If applying a granular fertilizer use one that has 30 to 50 percent water insoluble nitrogen (WIN) so fertilizer will be supplied throughout the growing season. Apply 1 to 1.5 pounds of nitrogen per 1,000 square feet. If the lilies are left in ground for a second season then test and adjust the pH as necessary during the fall/winter period. If phosphorus levels are low and the phosphorus level needs to be increased avoid the use of superphosphate as it may lead to leaf scorch damage from fluoride. Commercially available substrates, well water, and pond water are generally fluoride free, but municipal water may contain fluoride.

When growing lilies in soilless substrate, the bulbs should be discarded after harvest. Do not re-use the substrate because of the increased chance for root rot diseases. When lilies are grown in the field, the bulbs will produce marketable flowers for 2 to 3 years before flower production drops in yield and flower size. Do not rotate flower bulb crops into a lily field for 5 years.

Supplemental Lighting

Lilies are given supplemental light from late September until early April to extend the day length to 16 hours. The number of hours of lighting necessary to manipulate the day length to 16 hours will vary depending upon the exact time of year. Increased light levels will also help to avoid bud abortion and keep the plants from leaning south. Start lighting plants when the foliage emerges. Initially you can use 2,500 watts of halogen lighting or one high intensity discharge (HID) light per 100 ft^2 placed 6 to 8 ft above the crop. The use of HID lights is preferable to incandescent or fluorescent lamps because of high efficiency, uniform light distribution, and a lower amount of shading. Based on 2006 figures, a 30 x 48 ft greenhouse used three 1,000 watt fixtures, which cost $350 each and an automatic timer that cost $60.

Harvesting

Cut stems may be sold when flowers are open for local markets, but harvesting in the bud stage to allow the flowers to open after the customer has taken them home is preferred. Harvest lilies when the first, lower-most bud shows full color but has not yet opened (see photo 6). If lilies are harvested at an earlier stage, buds may take longer to open, may not open completely, or may be misshapen. Remove the anthers on open blooms to prevent pollen from soiling the flower or any surfaces on which it might fall. The best time to cut lilies is when temperatures are below 80°F. Handling the flowers in temperatures above 80°F will bruise the flowers. Harvest and place stems into water using clean plastic buckets. Do not use galvanized buckets for harvesting any type of cut flowers because the coating on the bucket creates an oily residue in the water that clogs the stems.

6. Harvesting stage with one bud showing color.

Post Harvest Handling

Place cut lily stems in water in a cooler at 35 to 41°F an hour after harvesting to avoid shocking the flowers. Handle lily blooms carefully at all times because the flowers bruise easily. Remove the bottom one-third of the foliage and grade the stems by size. Depending upon the market, grading can be done by the stem length or by the number of flowers per stem. Lilies may be bunched into desired quantities and sleeved, again, depending upon the market.

Cut lily stems should be transported in water to prolong the vase life. Freshly harvested lilies have a vase life of 9 to 14 days, depending upon the cultivar and the environment (see photo 7). The vase life of freshly harvested lilies can be extended by the final customer if they are re-cut and placed in a solution containing a floral preservative. Floral preservatives can also be added to the water used for storage prior to shipping, upon receipt at the retail level, and in floral arrangements. Hybrid lilies are sensitive to ethylene; keep them away from ripening fruit, maturing foliage and flowers, or any other ethylene source. Anti-ethylene treatments are effective on many lily cultivars, especially on Asiatic lilies.

Cultural Problems

Calcium Deficiency

Calcium deficiency is occasionally a problem in greenhouse production. Some Oriental lilies are susceptible to a condition known as "upper leaf necrosis" (ULN), which causes distortion and necrosis of the upper leaves. Problems with ULN have been reported primarily on 'Star Gazer' lilies, which have a low calcium content in the shoot and bud scales of the bulb.

The bulbs have enough calcium to supply the lower leaves of the plant, but the rest must come from the soil. Growers can improve nutrient uptake by monitoring for root rots and soluble salts. Calcium deficiencies can develop even when there is an adequate amount of calcium in the soil. In those instances, adding calcium to the soil would not be beneficial because the deficiency is a result of uneven distribution within the plant.

Calcium is taken up by the roots and translocated only to transpiring tissues. Calcium will not move into the young leaves of the plant if they are not actively transpiring. A low transpiration rate due to high humidity or low light intensity increases the likelihood of lilies developing ULN.

Transpiration rates can be raised by increasing light intensity and decreasing humidity.

7. Lily bouquet in vase.

Avoid growing plants under shady conditions and provide supplemental lighting during the winter months. Keep the leaves and the greenhouse as dry as possible. Overlapping leaves can also restrict transpiration. On Oriental lilies, the leaves associated with the flowers are overlapped by older leaves before the buds develop. These are the same upper leaves that display symptoms of ULN.

Symptoms of upper leaf necrosis appear long after the actual damage has occurred, so most growers catch the problem after it is too late. Some preventative measures include using a calcium nitrate fertilizer and applying foliar sprays of calcium chloride. Use caution; foliar sprays can be phytotoxic if applied improperly.

Bud Abortion

Bud abortion is the first sign of lilies growing in a stressful environment. Lilies will forego flower buds as a survival technique. Stress occurs from excessive heat and/or inconsistent watering practices. Lilies need consistent and thorough hydration, especially in the summer time. Light levels below 460 foot-candles ($60 umol \cdot m^{-2} \cdot s^{-1}$) can also cause bud abortion in the winter.

Pests

Aphids

Aphids can rapidly become a major pest on lilies if left unchecked. Because aphids feed on the plant fluids within the phloem of leaves and green stems, heavy populations may measurably reduce plant vigor. Aphids spread many plant viruses. They excrete large quantities of sugar-rich honey dew on which sooty mold fungus may grow. Before any attempt is made to control aphids, the species should be identified. Submit samples of aphids to your local Cooperative Extension office for identification. After the species is identified, familiarize yourself with its biology on a particular lily crop. Note whether it prefers particular species or cultivars of lilies, if it feeds selectively on certain parts of the plant, and how rapidly it reproduces.

Lily Aphid

The lily aphid, *Neomyzus circumflexus* (Buckton), is a crescent-marked lily aphid, and is one of the common aphids to attack lily plants in the field and greenhouse (see photo 8). Reported food hosts in addition to lily include *Adianthum, Cineraria, Cyclamen, Fuchsia,* and *Zantedeschia*.

The immature or nymphal form of lily aphid is pale greenish white and does not have the dark crescent bands found on the adult. Adult aphids may be either apterous (without wings), or alate (with wings). The apterous female is whitish to pale bright green, shiny and 1/18 to 1/12 inch long. The tip of the abdomen usually has a dark brown to black horseshoe-shaped patch. The antennae are pale with black joints and about 1/10 the length of the body. Legs are pale brownish yellow and slightly darker at the tips. Eyes are dark red.

The alate female is pale green with a black head and thorax. The body is slightly longer than the apterous form. The antennae are longer than the body and black. Legs are long, thin, and dark. The wingspan is about 1/3 inch and similar in shape and structure to those found on other aphids.

8. Lily aphids with crescent markings.

Aphid Control

Insecticidal soaps offer some control against aphids. Applications should be applied at regular intervals for maximum efficacy. Growers with aphid problems can apply foliar or soil drenches of a labeled neonicotinoid. Check the *Total Plant Management for Greenhouse Crops* manual for a recommended systemic pesticide. Many Dutch suppliers of lily bulbs treat the lily plants in the field with a systemic neonicotinoid insecticide that greatly reduces the chances of growers experiencing lily aphid populations in the first year after purchasing from suppliers.

If you grow lilies in greenhouses, check plants before moving them indoors to make sure they are free of aphids. Control weeds under greenhouse benches and outdoors in areas adjacent to the greenhouse to prevent aphid populations from developing. Aphids can be prevented from migrating into the greenhouse by covering vents and doors with a 300 holes-per-inch mesh screening.

Grasshoppers

Grasshoppers often are the most common insect invaders of cut flower production fields and among the most difficult pests to control. For a variety of reasons, grasshopper populations cycle naturally from season to season, causing extensive damage during outbreak years. Annually, grasshopper problems tend to increase as summer progresses and usually continue even after the first frost. Grasshopper populations often build up in weedy and tall grass areas near cut flower fields.

Grasshopper Control

It may be useful to leave an uncut barrier strip of grass to concentrate grasshopper populations. Treat these barrier strips with insecticide for greater control. The insecticides Acephate (Orthene) and a synthetic pyrethroid can be applied to control grasshoppers.

Guinea hens and chickens may be used to supplement grasshopper control in some cut flower operations. Guinea hens are very efficient in reducing grasshopper populations. They are known as a "watch dog" bird and can be rather noisy. Consider this characteristic if your operation is located in a residential area.

Nosema locustae, a disease-causing protozoan, is available to control grasshoppers. The protozoan is on a grain carrier. The material is applied to tall grassy and weedy areas where grasshopper populations are building up. The material needs to be applied in early to mid summer to keep grasshopper populations low. *N. locustae* applications may cause some reduction in grasshopper numbers in a few days or weeks, but in general it is a slow-acting and debilitating disease of grasshoppers that takes at least a whole season to affect grasshopper populations. This protozoan is not effective against all grasshopper species and is much more effective against young grasshoppers. Combinations of insecticides for rapid knockdown and *Nosema* for long-term control may be useful.

Lily Leaf Beetle

The lily beetle is one of the greatest threats to lily producers. This insect is an invasive species that is native to Europe and northern Africa and was first reported near Montreal, Canada, in 1945. It is suspected that it came from Europe on a delivery of lily bulbs. In 1992 the beetle was found in Cambridge, Massachusetts. By 2005, growers in New Hampshire, Maine, Ontario, and Massachusetts reported that it was devastating their lily plants. Fortunately, it has not been found yet in Maryland. Lily growers must remain alert to detect this pest if it is accidentally shipped into Maryland. If you find a beetle in a shipment of lilies, contact the Maryland Department of Agriculture or your local Cooperative Extension office.

The lily leaf beetle is in the family Chrysomelidae (leaf beetles). Its Latin name is *Lilioceris lilii*, which tells you it loves to feed on lily plants. It does not confine its feeding just to lily. It has been found feeding on solomon's seal, bittersweet, hollyhock, hosta, and even the common potato. It does not attack daylilies.

Lily Leaf Beetle Identification

The adult beetle has a shiny, scarlet-colored body and black legs, head and antennae. If you flip over the beetle you will see that its underside is black. The beetle is small compared to other beetles, varying from 1/4 to 3/8 in length. If squeezed lightly, this

beetle will give off a slight squeak by using the wing cover and an abdominal stridulating body part.

The larvae of this beetle are slug-like with a swollen body and black head capsules. Their bodies can be orange, yellowish, or green colored. Lily leaf beetle larvae tend to place their excrement on their backs. The early instar larvae feed on the underside of the foliage and can go undetected unless you are examining the underside of the foliage regularly during the summer. The later instar larvae feed on the underside and top of the foliage. They also feed on the flower buds and stems of the plant. After feeding in the last instar, larvae migrate to the soil to pupate.

The pupal stage is a shocking florescent orange. You can easily pick up this brightly colored beetle pupa if you probe through the soil. The pupal stage lasts a little over 2 weeks and then the adults emerge to start a new generation. Adult beetles overwinter in the leaf litter and appear to be able to survive the cold New England winters nicely. The adults emerge in early April in most northern states to start a new generation. Female lily leaf beetles are prolific egg layers. A healthy female lays up to 450 eggs in irregular lines on the underside of the foliage. The beetles are active throughout the summer into the fall with up to 3 generations in northern states.

Lily Leaf Beetle Control

There are several control options for the lily leaf beetle. For light infestations, remove larvae and beetles by hand. Look for the eggs on the undersides of the foliage and make sure you cut off leaves with eggs and get them out of the area. If this method is too time consuming, then consider applying a soil drench of imidacloprid, which will provide 8 to 12 weeks of control. If you want to try a botanical insecticide, then use a neem-based insecticide such as Azatin, Aza-Direct, or BioNeem. Neem works best on early instar (young) larvae. There are four parasitic wasps that are used for biological control in France and Switzerland. One species of European parasitoid has been released in the Boston area and in Cumberland, Rhode Island. The efficacy of this biological control is still being evaluated.

Diseases

The major diseases of lilies in the mid-Atlantic region are gray mold (*Botrytis*), nematodes, viruses, root/bulb rots, and southern blight (*Sclerotium rolfsii*). Cultural practices are the foundation for disease prevention. Lily bulbs should be purchased from a reputable source. This will reduce the risk of bringing nematodes and virus in with the bulbs because most large bulb producers index propagation stock and periodically fumigate production fields.

Botrytis

Three species of the *Botrytis* fungus may attack lilies: *Botrytis elliptica*, *B. liliorum*, and *B. cinerea*. The symptoms and conditions required for infection are similar for all species. The first symptoms are pale tan spots on leaves, stems, or petals. The spots enlarge rapidly, producing general blight and collapse of tissues (see photo 9). In very humid weather or in the early morning, a gray velvety or fuzzy mold may be seen on the blighted plant parts. A film of water is required for infection. *Botrytis* can infect over a wide range of temperatures, from just above freezing to about 86°F. Thus, *Botrytis* can damage plants at all stages of growth and in transit or in coolers.

Botrytis can enter your production area on the lily bulbs as small dark resting structures that can persist in the soil called sclerotia. The key to preventing *Botrytis* damage is sanitation and cultural management. Keep production, cutting and flower storage areas clean and free of plant debris. *Botrytis* can grow readily on debris such as dropped petals. The "gray mold" is composed of many microscopic infective spores. Spores are carried on air currents throughout the production area. Once spores settle onto leaves and flowers they can remain viable for several weeks until a film of water is present to facilitate infection. Thus, the key to prevention is to keep foliage and flowers as dry as possible at all times. Space plants to allow good air circulation. During periods of overcast, humid weather, vent the greenhouse in the evening, then heat the cooler air from outside to prevent dew formation during the night. Keep horizontal air flow

9. *Botrytis* on lily foliage.

(HAF) fans going at all times. The fans will prevent a moist high humidity microclimate from developing around the plants. Avoid overhead watering: water the substrate, not the leaves.

The *Botrytis* fungus has developed resistance to many fungicides commonly used in greenhouses. Consult the current recommendations for effective fungicides if you experience active *Botrytis* in your production area.

Viruses

Reputable bulb producers take pains to reduce the chance of virus infection. Propagation stock is periodically tested for virus, and only healthy stock is used. It is rare to see virus during the first year in hybrid lilies. However, once the plants are in the field, viruses can invade. Several aphid-transmitted viruses can damage lilies. Some lily cultivars are available with resistance to some of these viruses. Symptoms of viral infection include foliar mosaic (bright to faint yellow mottling and streaking), rings (dark or yellow), abnormal flower size, color-break (streaks of color in what should be a solid color flower), stunting of random plants, and distorted leaves. Cucumber mosaic virus is common in the mid-Atlantic region and can be brought into lily plantings by several aphid species. Color break virus can spread from infected tulips by aphids.

Rogue out symptomatic lilies promptly. Cucumber mosaic remains from year to year in perennial weeds, so good weed control will help reduce virus transmission. Other viruses can be transmitted by soil nematodes or mechanically in handling the plants.

If many plants show virus-like symptoms, specimens should be sent to a testing lab (one such lab is Agdia, visit on the web at Agdia.com) to determine the specific virus. Only by using specific serological (e.g., Enzyme Linked Immunosorbent Assay or ELISA) or molecular (e.g., Polymerase Chain Reaction or PCR) lab tests can the virus be identified. Symptoms are not diagnostic because many different viruses display similar symptoms. Once infected, the plant cannot be cured and should be destroyed. Damage from herbicides or spray injury can be confused with virus.

Nematodes

The root knot nematode can infect lilies. This nematode (several species in the genus *Meloidogyne*) dwells in the soil and infects roots. Infected roots have swellings (knots), which house the female root knot nematode. If you notice swellings on the roots, have the soil and bulbs tested to determine if root knot nematode is present. This nematode can be a persistent problem because it can feed on a wide variety of plants including weeds. In commercial production soil is periodically fumigated to control root knot. For smaller plantings a fallow period, rotation with nematode suppressive "green manure" crops, and crop rotation out of susceptible crops are effective.

Lilies can also be infected by two nematodes that feed in the bulb, stems, and foliage. The foliar nematode (*Aphelenchoides* spp.) produces discolored streaks in lily foliage and will cause the bulbs to decline. The stem and bulb nematode (*Ditylenchus dipsaci*) causes individual bulb scales to rot, and eventually can kill the bulb. As with the root knot nematode, these nematodes can infect a wide variety of crops and weeds, so once introduced into a production field, they will persist. Sanitation and crop rotation are effective controls. Lab tests are required to identify the nematodes.

Root and Bulb Rots

Lilies can be attacked by several root rots. Both *Pythium* and *Rhizoctonia* are common. *Pythium* is favored by wet, slow draining soil. Lilies should be grown in a site that has good internal soil drainage. Raised beds are often used. *Rhizoctonia* usually is more active during warm/hot weather. Lab tests are required to determine which fungus is causing root rot. *Pythium* often causes the root cortex to slough off, leaving the vascular cylinder exposed (growers call these "hair roots"). *Rhizoctonia* usually produces tan dry, sunken lesions on roots and bulbs, eventually blighting the bulb. Both of these fungi can be present in your field soil or can be introduced on field-grown bulbs. Fungicide drenches can be used to prevent these root rots. Aliette, Subdue Maxx, and Terrazole are some fungicides effective against *Pythium*. Medallion, Banner Maxx, Heritage, Compass, and many other fungicides are effective against *Rhizoctonia*.

Bulbs can be rotted by blue mold (*Penicillium* spp.) and by the Southern blight fungus, *Sclerotium rolfsii*. Inspect bulbs closely and reject shipments that show sunken lesions with powdery blue or blue-green fungus sporulating on damaged bulb parts. Blue mold is an indicator of poor bulb quality.

Southern blight attacks only during hot summer weather. The fungus produces white mycelium at the stem, and small, tan spherical bodies called sclerotia on the white mycelium and on the rotting plant tissues. Infected plants will stop growing, wilt, and die. The fungus remains in the soil as the dormant sclerotia, and is only active during hot, moist weather. Three techniques can be used to reduce losses from Southern blight. One is to rogue out infected plants (wilting, dying plants showing mycelium and sclerotia) and the soil and mulch immediately surrounding each plant. This will remove the sclerotia that are the persistent stage for this fungus. The other method is fungicide applications as a "spot treatment" when you know your field is infested. Some fungicides registered to control Southern blight on ornamental plants include Heritage and Compass. The third method is deep tillage prior to planting into an infested field; this will bury the sclerotia, and separate them from the crop. The fungus is active only in well-aerated hot soil, so it is most active only in the upper 5 inches of soil/mulch.

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