MARYLAND COOPERATIVE EXTENSION
Fact Sheet

Fact Sheet 770

Production of Lisianthus as a Cut Flower

Introduction

Lisianthus has performed well in planting trials in Maryland and has been well received in local flower markets. Lisianthus has the qualities of an "ideal cut flower" (attractive flowers and long vase life) and should continue to increase in popularity throughout the next century. Plant breeders have done a wonderful job of developing outstanding flower colors and introducing single- and double-flowering forms, adding to the beauty of this flower. The flower is elegant in form and easily mistaken for a rose. *Eustoma* is native to the Western continental United States where it is known as the prairie gentian.

Field Production

Culture

Eustoma grandiflorum is a perennial plant that is treated, in most cases, as an annual. The seed is relatively small (19,000 seeds/gm or 545,000 seeds/oz) and is hard to handle in field plantings. Because of this small size, seedlings are generally started in plug trays and transplanted into the field. A plug size of 288 or 392 has been successful for commercial producers. Plants are moved to the field when they have developed 2 to 3 sets of true leaves (approximately 3 months from seeding time). Although for some vari-

eties terminal cuttings are used, plants from seed are much more common.

Lisianthus is marginally hardy in zone 7. For best survival in this zone, plant in the field in spring, cut back in fall when plants are well established, and place a floating row cover over the plants. Then place a thin layer of relatively weed-free straw mulch over the floating row cover. Uncover plants in spring after danger of heavy frost is over. In Maryland, growers who have been successful in overwintering lisianthus plants report that stem length and stem diameter is greater in overwintered plants, compared to plugs planted in the field in spring.

Methods for Starting Plants

It is generally advisable for most cut flower growers to purchase plugs from a greenhouse grower who specializes in plug production. (If starting seedlings yourself, see the section on greenhouse production starting on page 5.) Grow plants in the greenhouse for 3 months and then move them out into the planting field after danger of frost has passed. Larger-sized plugs (288-plant plug trays) will generally have a higher survival rate in the field since they do not dry out as fast as smaller plugs. Some growers have increased plant survival and shortened the time to harvest by planting plugs into 48 cells per tray cell packs and growing them for 2–3 weeks in a greenhouse. This increases the plant size before moving the plants into the field and generally results in harvestable flowers 4–6 weeks after moving the plants into the field.

Transplant seedlings before they become root-bound. Any growth restriction in the seedling stage decreases stem quality. Try to avoid damaging roots during transplanting; damaged roots can delay maturity or stunt plants. Avoid planting plugs too deeply in the soil or root rot is likely.

An alternative to starting plants from plugs or seeds is to start plants from tip cuttings, which will require temperatures of 22–23° C (75–77° F) and a misting system. Cuttings should root in 2–3 weeks. Some varieties produce more vigorous plants with greater flower production when grown from seed, compared to rooted cuttings.

Space the plugs at 60–84 plants/m^2 in field sites. Use the lower number of plants per m^2 for low-light growing situations. Use the higher density spacing per m^2 when growing during the high light levels of summer.

Site Selection

Lisianthus grows best in soil with good fertility, high organic matter, and excellent drainage. Choose a site in full sun with well-drained soil having a pH of 6.0–7.0. Plant in raised beds, 10–20 cm (4–8 in) high, to insure that excess moisture drains away. Plants grown in sandy soil tend to be shorter than plants grown in loam soil and to reach lower levels of production unless organic matter levels are kept above 5% and watering is maintained on a consistent schedule throughout the production cycle. The site should have water for irrigation and wind protection. Some growers choose to pinch out the first flower to open on every main stem to encourage uniform flowering of the side shoots. Recent breeding has produced varieties with more uniform flowering, which do not require this extra labor. After a short rest period, plants will produce additional flower stems to be harvested 6–8 weeks later. Yield on a second harvest averages 20–30% of the earlier summer harvest.

Support and Use of Shade Cloth

Lisianthus has been grown successfully without netting, but it is not recommended. A summer rainstorm will easily flatten the plants, destroying the quality of the flowers. A layer of plastic netting is desirable for keeping flower stems straight. Netting with an opening of 4 x 6 in (15 x 20 cm) is typically used by growers. The netting is placed at 30 cm (12 in) above the ground. Some growers have benefitted from using two layers of netting, with the second placed several inches above the first. In California, lisianthus grown in the field is often covered with 40–50% shade cloth during summer months to increase stem length; the number of flowers produced is unaffected. In Maryland, when the Central Maryland Research and Education Center (CMREC) used 50% shade cover, no significant stem length increase was found, compared to plants grown in full sun. During humid summers, the use of shade

cover may increase the incidence of *Botrytis*. Plants established in spring will produce flowers in mid to late summer.

Irrigation for Field Production

Adequate soil moisture is essential for production of lisianthus. In the Mid-Atlantic region, periods of drought frequently occur during the growing season. Moisture stress reduces yield and quality of the flower stems. However, excessive irrigation increases a plant's susceptibility to soil-borne fungal pathogens. Maintaining uniform soil moisture is highly desired. Irrigate and use soil moisture monitoring equipment to achieve maximum return

Overhead irrigation may be useful for the first 2–3 weeks after planting to establish plants. However, trickle irrigation that places water into the root zone without wetting the foliage or interfering with the harvest has many advantages. Problems from *Botrytis*and other foliar diseases will be lessened.

After the first set of flower stems have been cut, reduce water for 2–3 weeks until a second set of flower stems has started. Maintain uniform moisture as the second set of flowers develop in September and October.

Trickle rowcrop tubing works well on fairly level ground. The water is discharged slowly from small "emitters" spaced 5–30 cm (2–12 in) apart along the tubing. A circular wetting space is formed as water moves laterally and vertically. Seek professional design assistance for setting up the system.

For plants growing on a wide raised bed or in several closely spaced rows, place two or three lengths of trickle rowcrop tubing across the width of the bed. For single or double rows, one length of tubing can be placed down the middle. Coarse soils require more tubing than fine soils because coarse soils reduce the lateral movement of water. Install tubing under plastic mulch.

Water frequently to maintain adequate and uniform soil moisture. The crop will use more water as it matures. Avoid overwatering. Monitor the soil moisture with a sensor, such as a tensiometer, to determine when to irrigate. One tensiometer placed at a depth of 15 cm (6 in) and a second one placed at a depth of 30 cm (12 in) covers the root zone. If the deeper tensiometer indicates a very wet soil, irrigation water and nutrients may be moving below the root zone where plants are unable to use it.

Trickle irrigation systems require clean water, which should be filtered through a 100- to 140-mesh screen filter to prevent clogging. A screen filter works well for well water, but a disk filter or a media (sand) filter is needed for surface water containing organic matter or soil particles. For uniform water application use a pressure regulator to ensure the proper operating pressure; many systems operate at 8–10 psi. Hilly or rolling terrain requires extra care in system design. (See References for Extension publications about trickle irrigation and soil moisture sensors.)

Nutrition

Take a soil test before the growing season, to establish proper pH and to determine the amount of nutrient to apply to establish optimum fertility levels. Begin fertilization 1 week after transplanting. Soluble fertilizer can be injected into the irrigation water weekly to maintain plant nutrition. Water-driven fertilizer injectors are available, which add concentrated dissolved fertilizer into the irrigation water. Use 100–150 parts per million (ppm) of nitrogen from a complete fertilizer for mineral-based soil in the field. The nitrogen should be predominantly in the nitrate form; keep the potassium level equal to the nitrogen level. Decrease nitrogen-containing fertilizer and increase potassium-containing fertilizer when flower buds are initiated. For optimum growth, Lisianthus also needs high calcium levels and adequate phosphorus.

If plants are not fed with liquid fertilizer, side dress plants with 1 pound of a complete fertilizer (10-5-10 or 10-6-4) per 100 square feet of production area. Another alternative is to apply a 3-month slow-release fertilizer over the soil surface immediately after transplanting.

Diagnosis of Nutrient Toxicity and Deficiency

Major nutrient deficiencies are expressed through reduced growth and foliar chlorosis. A deficiency of calcium results in tip burn of immature foliage, bud drop, and weak stems.

An improper pH level will reduce plant vigor because nutrients will not be readily available for plant use. Interveinal chlorosis may result from zinc toxicity or low pH levels. If interveinal chlorosis is detected, run a soil and tissue test to determine pH and zinc levels.

Cultivars

Cultivars are divided into single- and double-flowering lisianthus. Single-flowering lisianthus are appealing in form; however, there appears to be a strong customer preference for double-flowering varieties. Doubles have 10–20 flower petals that present a rose-like appearance when fully open. The single-flower form is similar to a poppy.

Although color preference differs from season to season, the bicolors, white with blue rim and white with pink rim, appear to enjoy wide appeal in Maryland. In addition, some of the pure-whites to ivory cultivars appear to be in strong demand. Other colors worth working into your production include pink, pink blush, bicolor pink, rose, blue blush, dark blue, yellow, and other pastel shades. Most lisianthus breeding has focused on introducing new colors and flower forms. Also important, however, are new varieties being introduced that feature better seedling vigor, stem length and caliper; flowering uniformity; and resistance to disease.

Double-Flowering Lisianthus

Balboa Series. The Balboa series (available only as plugs) has performed well in Maryland and appears to enjoy strong market appeal. Balboa has been bred to flower during the lengthening days and warm temperatures from spring through summer. Results of trials conducted at CMREC from 1997–98 on the Balboa series rank it as outstanding for field-produced cut flowers. Harvest time ranges between 11 and 14 weeks after transplanting. The average stem length is 50 cm (22 in) with 31 flower buds per plant and four stems per plant. Colors available are blue, blue rim, and blue blush.

Catalina Series. The Catalina series (available only as plugs, like Balboa and Mariachi) is a double-flowering lisianthus also bred to flower during the long days and high heat of summer. Harvest time ranges between 11 and 14 weeks after transplanting. Colors available are blue blush and yellow.

Echo Series. The Echo series is one of the most commonly grown double-flowering lisianthus. This series is best grown in early spring when the longest stems are produced. Stems tend to be too short in Maryland when Echo is grown during summer. Echo tends to have weak stems and a long crop time under lower light levels. A range of colors is available—various shades of blue and pink and a clear white.

Mariachi Series. The Mariachi is a double-flowering series (available only as plugs) that performed well in Maryland trials at CMREC and the Wye Research and Education Center. Flower petals are slightly recurved, creating a pleasant appearance for viewers looking down on the open flowers. Optimal plant growth and flower formation during summer make Mariachi best suited for summer production. A range of colors including white, pink, pink blush, blue blush, and blue are available. During trials conducted at CMREC, stems averaged 48 cm (20 in) with 21 flower buds and 4 stems per plant.

Single-Flowering Lisianthus

Flamenco Series. The single-flowering Flamenco series is intended for flowering during the long days and high temperatures of summer. Flamenco has performed well in Maryland plantings. Flower stems are long and strong, and a range of colors is available in various shades of blue, pink, and white.

Laguna Series. The Laguna series is a single-flowering lisianthus bred for summer production. In trials conducted at CMREC, the Laguna series produced 48-cm (20-in) stems and 3 stems and 25 flower buds per plant. Laguna, which generally takes from 11 to 13 weeks from transplanting to harvest, is available in deep blue, blue blush, deep rose, and pink rose.

Malibu Series. The Malibu series was bred for production during spring and autumn. It is not well suited to summer production in Maryland. Producing harvestable flowers 11–12 weeks after transplanting, Malibu is available in lilac, deep blue, blue rim, white, and rose.

Greenhouse Production

Culture

For lisianthus, growth, crop time, and quality are variety-specific. The optimum light requirement is 4,000 foot candles of natural light. Plants growing in greenhouses in areas of high light during spring and summer may require a shade cloth. A 16-hour day is the optimal length for creating the highest quality plant. During winter months, high intensity discharge (HID) supplemental lighting is required to increase light intensity and day length. Lisianthus is a quantitative long-day plant. Although it flowers faster under long days of 16 hours or greater, it will eventually flower regardless of photoperiod.

For alternative lighting, suspend 100-watt incandescent lights 3 meters apart and 3 meters over the plants. Use this to extend day length by lighting continuously from 10 p.m. to 2 a.m. or to create cyclic lighting by keeping the lights on for 6 minutes out of every hour. Supplemental lighting will strengthen stems and improve stem length.

Start lisianthus plants in a greenhouse. Sow the seeds on top of the substrate and do not cover the seeds. Maintain substrate temperatures at 20–22° C (70–75° F). Germination will take 10–20 days. The range in germination will produce a range of seedling sizes in the plug tray or seedling flat. The plants will grow slowly for the first 3 months. Greenhouse temperatures should not exceed 20° C (68° F) during the growing-on stage. The best growing temperatures are 15–18° C (59–65° F). Great skill and care are necessary to properly manage water and to avoid increasing the susceptibility of seedlings to disease. Because plants are growing slowly, overwatering and overfertilization is a constant concern. Overwatered plants are highly susceptible to water mold fungi. Horizontal airflow (HAF) fans installed in the propagation greenhouse improve air circulation and keep the plug substrate from remaining overly wet after irrigation. Move plants to outside fields once flower stems start to develop. If you plan to produce flowers in the greenhouse, move plugs into large growing containers or into greenhouse production beds.

In general, keep soil on the dry side. Optimal nighttime growing temperatures continue to be 15–18° C (59–65° F), and optimal daytime temperatures are 18–20° C (65–68° F) until harvest. Nighttime temperatures should fall to no less than 15° C (59° F). Temperatures above 86–90° F can induce rosetting in plugs or premature flowering on young plants. Plants grown from seed require 20–23 weeks to flower, whereas plants grown from plugs require 10–13 weeks. Applications of gibberellic acid may be necessary to induce flower stalk elongation if rosetting occurs. Use hot water circulating systems over bench tops and forced-air heating in winter for optimal greenhouse production.

Irrigation for Greenhouse Production

Use overhead watering early in the crop cycle and trickle irrigation once the plants have developed an adequate root system. As seedling plants grow slowly for the first 3 months after germination, handle watering carefully. The lower the light intensity, the less watering plants require. Overwatering and wet growing substrate will make plants susceptible to water mold fungi development. Keep humidity low once buds have formed, to reduce the incidence of *Botrytis*. Good air circulation around plants is essential for removing free moisture from the foliage. Horizontal air flow fans maintain air circulation and reduce the incidence of foliar disease. To maintain plant quality during high temperatures and under strong light, plants may require heavy watering, possibly by overhead irrigation (depending on plant size).

Nutrition

Lisianthus has two distinct growing phases. The first phase is an actively growing seedling stage. This stage of development occurs over a long period. It is important to maintain fertility levels but not to overfertilize. Root systems of these slowly developing plants will be easily injured by high soluble salt levels. Monitor soil soluble salt levels and maintain levels of 1.0–1.2 millimohs. Using a slow-release fertilizer is generally the easiest way to maintain fertility without overfertilizing.

Follow these guidelines to assure proper fertilizing:

- A 3-month slow-release fertilizer can be applied immediately after transplanting.
- Use a nitrogen source in nitrate form.
- Potassium application rate should be equal to the nitrogen application rate (e.g., 15-0-15 fertilizer).
- Supplemental calcium may be required during production unless the substrate has high calcium content.
- Decrease nitrogen and increase potassium when flower buds are initiated.

Double-Flowering Lisianthus

Following is a partial list of commonly planted varieties for greenhouse production:

Avilia Series. The Avilia series was bred to flower under the low light levels and cool air temperatures during winter months. Crop time is 14 weeks from transplanting. Supplemental lighting—cyclic or continuous—increases stem length and shortens crop time. Available colors are ivory, blue rim, deep rose, and purple.

Balboa Series. The Balboa series has been bred to flower as days lengthen and temperatures increase from spring through summer. Balboa is good for summer production in greenhouses. Available colors are blue, blue rim, and blue blush.

Catalina Series. The Catalina series has been bred to flower during the long days and warm weather of summer. Crop time is 11 weeks from transplanting. Colors available are blue blush and yellow.

Candy Series. The Candy series was bred for production under moderate light intensity and the short days of winter. Candy produces double flowers with high uniformity of flowering.

Echo Series. The Echo series has been one of the most commonly grown double-flowering lisianthus varieties. Best grown during early spring when stems are longest, Echo tends to be too short in Maryland when grown during summer. Echo tends to develop weak stems and have a long crop time under low light levels. A range of colors is available in various shades of blue, blue blush, pink, pink blush, and clear white.

Mariachi Series. The Mariachi series, which is double-flowering with flower having a high petal count, is available only as plugs. Flower petals are slightly recurved, giving a pleasant appearance to viewers looking down on the open flowers. A range of colors, including white, pink, rose, and blue, are available.

Single-Flowering Lisianthus

Following is a partial list of commonly planted varieties for greenhouse production:

Flamenco Series. The Flamenco single series is intended for flowering during the long days and high temperatures of summer. Flower stems are long and strong. Flamenco, which has performed well in Maryland, grows in a range of colors—various shades of blue, pink, yellow, and white.

Heidi Series. The Heidi series was bred for production under moderate light intensity and day length. Heidi, which grows in a wide range of colors, is a good series for winter and spring greenhouse production.

Laguna Series. The Laguna series is a single-flowering lisianthus bred for summer production. In trials conducted at CMREC, the Laguna series produced 48-cm (20-in) stems. Plants produce an average of 3 stems and 25 flower buds. Laguna is available in deep blue and blue blush.

Malibu Series. The Malibu series, bred for growing during spring and autumn, is not well suited to summer production in Maryland. Malibu produces harvestable flowers in 11–12 weeks after transplanting and is available in lilac, deep blue, blue rim, white, and rose.

Yodel Series. The Yodel series is a single-flowering lisianthus that produces relatively long stems: 45–50 cm (18–22 in). Yodel is available in blue, deep blue, lilac, pink, rose. and white.

Diseases

Lisianthus suffers most from disease problems during the early stages of production; large established plants do well in field beds in the mid-Atlantic region, provided soil is well drained and irrigated properly. Seedlings have slowly developing root systems that are highly susceptible to root rots. Viruses can be destructive; the risk of virus infection is higher when lisianthus seedlings share greenhouse space with a variety of other crops.

Damping Off

Basic good horticultural practices, sanitation, and optimum conditions for seed germination and seedling growth can prevent most damping-off diseases. Using a media that drains well and watering early in the day so soil drains well before night help control *Pythium* A biological fungicide, SoilGard™, can be added to media to control both *Pythium* and *Rhizoctonia* The fungus *Tricoderma* spp. (RootShield™) has been reported to provide a level of protection from *Rhizoctonia* and some species of *Pythium* root rots. The fungicides Banrot™ and Subdue™ control *Pythium* Many fungicides are registered for *Rhizoctonia* control, including Medallion™, Cleary's 3336™, Terraguard™, and Chipco 26019™.

Root Rots

Three fungi are reported to cause root rots on lisianthus—*Pythium* species, *Rhizoctonia solani*, and *Fusarium solani* and *Fusarium avesaeum*. All root rots produce similar symptoms of stunting, yellowing foliage, wilting, and death. On-site test kits are available (Alert kits from Neogen Inc.) to detect *Pythium* and *Rhizoctonia* Microscopic examination and cultures are needed to confirm *Fusarium*.

Wet soil promotes *Pythium* root rots. The infected roots look tan and water soaked with the outer fleshy cortex sloughing off. Warm conditions are favorable for *Rhizoctonia* and *Fusarium* root rots. *Rhizoctonia* usually causes dry, sunken root lesions. As the fungus grows into the stem, the plant may "melt" down. Under warm, moist conditions the tan mycelium of *Rhizoctonia* may be seen on the surface of soil and stems. When *Fusarium* infects roots they turn soft, brown, and eventually black. As *Fusarium* grows into the stem, you may be able to see tiny cream to light orange lumps erupting from stems; these are the fruiting bodies of the fungus, which contain vast numbers of microscopic spores.

The basis for preventing root rots is sanitation and providing a good culture for the plants. Drainage is critical. Irrigate to maintain proper moisture, but do not leave soil saturated for extended periods. Chemical fungicide drenches or biological fungicides such as RootShield or SoilGard are also helpful.

Viral Diseases

Several viruses are reported to infect lisianthus: impatiens necrotic spot tospovirus (INSV), broad bean wilt (BBWV), bean yellow mosaic (BYMV), tobacco mosaic (TMV), and cucumber mosaic (CMV) can all be destructive. Once a virus infects a plant, the plant cannot be cured; destroy infected plants promptly so they do not serve as a source of virus that spreads to other plants. These viruses can be distinguished only by serology-based testing. If a few plants show virus symptoms, promptly rogue out the plants. If many plants show symptoms, testing may be necessary to determine the cause. Agdia Inc. testing lab tests for viruses on ornamentals (1-800-622-4342).

When lisianthus is grown in the greenhouse with a wide variety of other ornamentals, the risk of INSV increases. The vector for INSV is the western flower thrips. INSV-infected lisianthus stops growing, shows yellow and necrotic mottling and spotting on stems and foliage, wilts, and dies. An on-site test kit is available from Agdia Inc. to detect two common tospoviruses, INSV and TSWV. Aphids transmit BYMV, BBWV, and CMV. Symptoms seen in lisianthus are leaf mottling, ring spots, yellow leaf spots, mosaic, flower break (normal color with lines or patches of white or other abnormal color), leaf curl and other leaf distortions, wilt, and death.

TMV can be introduced into the greenhouse on the hands of smokers and in infected plants that may show few symptoms. TMV causes foliar mosaic symptoms in lisianthus, but if the plants are also infected with another virus, they may exhibit stunting, necrotic spotting, and wilt and then die. TMV can infect a wide range of plants, including many ornamentals, crops, and weeds. TMV is especially bad to have in a greenhouse or cut flower operation because it forms stable crystals that are easily transmitted through plant sap during normal handling; TVM can persist for a long time on tools and surfaces.

Botrytis

The fungus *Botrytis cinerea* is especially serious in the greenhouse, where is causes stem cankers that kill plants. In the field, *Botrytis* can cause flower spotting and blight during

rainy periods. To diagnose *Botrytis*, look for the characteristic gray mold that forms on blighted tissues under moist conditions. The first symptom seen is a dry, tan spot. This will enlarge to cause a girdling stem canker or blight the flower.

The basis for preventing *Botrytis* damage is sanitation and controling both leaf wetness and high humidity. In the greenhouse, water early in the day and vent and heat air in the evening to reduce excessive humidity and formation of dew on plants. Remove blighted material from the greenhouse, and groom plants regularly to remove spent flowers and other debris.

Minor Diseases

The fungus *Phyllosticta* is reported to cause leaf spots on lisianthus. Symptoms include tan spots that have tiny dark fruiting bodies scattered in the necrotic tissues. Wet conditions favor infection, which is seldom of major importance. If leaf spots appear, remove the diseased material.

Insects

The lisianthus we have been growing in Maryland since 1994 has been relatively free of insect pests. When lisianthus is grown in the greenhouse, whiteflies and thrips will feed on the plants.

Whiteflies

Two whitefly species are most common and cause the majority of problems to lisianthus crops grown in greenhouses—the silverleaf whitefly, *Bemisia argentifolia* (also known as strain B of the sweetpotato whitefly, *B. tabaci*), and the greenhouse whitefly, *Trialeurodes vaporariorum*.

Identification. All whitefly life stages are almost always found on the lower surfaces of leaves. Adult whiteflies are small (1–2 mm), white, flylike insects. Wax secreted from the abdomen of adults, and which they cover their bodies with, causes their white appearance. The whitefly's tiny and spindle-shaped eggs usually stand vertically on the leaf surface, attached to the leaf by a tiny pedicel or "stalk" at the base of the egg. The crawler and other nymphal stages of the most common species are oval, greatly flattened, and somewhat translucent with a white, light-green, or light-yellow cast. The four nymphal stages are identified by their relative sizes; length and width increase with each successive molt.

Damage. Whiteflies have sucking (stylet) mouthparts that they use to remove plant juices. Heavy populations of whitefly cause yellowing of the foliage.

Biology . The life cycles of the two whitefly species are generally similar. Eggs are deposited on the underside of leaves, sometimes in a circle or crescent-shaped pattern. The eggs hatch in about 10 days for greenhouse whitefly and 12 days for silverleaf whitefly. The tiny first nymphal stage (crawler) hatches from the egg, crawls a few millimeters, and settles down to feed. They do not move from this spot until they emerge as adults. They pass through three more nymphal stages before emerging as adults. The "pupal" stage (i.e., when the red eye spots of the developing adult are visible through the pupal case) lasts 5 days for both species. A female can begin to lay eggs from 1 to 4 days after emerging as an adult.

Monitoring. Monitor whitefly infestations through a combination of yellow sticky traps and foliage inspection. Use yellow sticky traps to monitor the location and relative numbers of adults. Monitor nymphs by inspecting foliage frequently. Inspecting whitefly nymphs several days after a foliar insecticide application can help determine whether the spray was effective. Dead whitefly nymphs appear to be flattened and dry.

Biological control. Certain tiny wasps are specialized parasitoids of whiteflies. These wasps attack whitefly nymphs, killing them in one of two ways. First, the female wasp uses her needlelike ovipositor to lay an egg within or beneath a whitefly nymph. The egg hatches and the parasitoid maggot feeds on the nymph. Pupation occurs within the nymph. When the adult wasp emerges from the whitefly pupa, it chews a round exit hole through the cuticle at one end of the whitefly pupa. Second, the female wasp punctures the whitefly nymph with her ovipositor, killing the nymph, and feeds from the fluids that exude from the wound, a phenomenon called host-feeding.

Parasitoids for whitefly control. *Encarsia formosa* is a tiny wasp (0.6 mm) with a black head and thorax and pale yellow abdomen. Greenhouse whitefly pupae that have been parasitized by *Encarsia formosa* turn black; silverleaf whitefly pupae turn amber-brown. The adult wasps are rarely noticed. This parasitoid is widely used for biological control of greenhouse whitefly on greenhouse vegetables.

Eretmocerus eremosces (=californicus) (Arizona strain) is an equally tiny wasp, differing from *Encarsia formosa* by having an adult that is entirely yellow. It has green eyes and clubbed antennae. Parasitized whitefly nymphs appear beige.

Pathogens To control whiteflies. Several fungal pathogens will infect whiteflies. *Beauveria bassiana,* a entomopathogenic fungus that attacks insects but is harmless to humans and other animals, is sold under the name BotaniGard (Mycotech Co.) and Naturalis-O (Troy Bioscience Co.). Whitefly nymphs infected with this pathogen will often appear reddish, pinkish, or orangish, especially if humidity is not high. *Beauveria bassiana* can be an effective biological control, especially under humid conditions.

Chemical control. For a complete up-to-date list of chemical control, request the University of Maryland Cooperative Extension Fact sheet on Whitefly Control.

Thrips

Identification. Adult thrips found in greenhouses are small, generally 1–2 mm in length. The bodies of adults are tubular, with narrow, pointed veinless wings that are fringed with long setae (hairs). The wings, which fold flat over the back, are difficult to see when the thrips is at rest. Adult female thrips have a sawlike ovipositor that is used to pierce plant tissue and deposit eggs in protected locations on the plant.

Plant damage. Most thrips are plant feeders with the larvae and adults feeding on flowers, leaves, or buds. Thrips feed by piercing plant cells with a single mandible and sucking out the cellular contents with strawlike stylets (maxillae). The damage to plant cells caused by thrips feeding can result in deformation of flowers, leaves, and shoots. Thrips often leave a silvery streaking and flecking on expanded leaves. Flower petals are often scarred and flower buds may abort during heavy infestations. Thrips often deposit tiny greenish-black fecal specks in areas where they feed.

Monitoring. Monitor plants constantly to detect the first appearance of thrips. They should then be identified. Adults congregate in open flowers and can be easily tapped out of flowers into catch containers. In greenhouses, monitor adult thrips by clipping sticky cards vertically to florist stakes and also just above the canopy of the plants. As the crop grows taller, move the sticky card up, so it remains just above the plant canopy. Although yellow sticky cards will capture thrips, they find blue sticky cards particularly attractive.

Biological control. *Amblyseius (=Neoseiulus) cucumeris* and *Amblyseius (=Neoseiulus) degenerans.* These predatory phytoseid mites appear to be well suited for immature thrips control on greenhouse crops. Similar to thrips, phytoseid mites prefer small niches, where contact between predator and prey is likely even without specific searching. These predators are pollenphagous (pollen feeding) when thrips populations are low. Many questions remain unanswered about the best timing and frequency of releases and the usefulness of these predators on various crops and thrips species. These mites must be introduced before a thrips population has reached damaging levels. The mites establish themselves on leaves—usually on the undersides—and are most effective in attacking young (first instar) larvae of thrips. The limitation of mites is that they are susceptible to many insecticide sprays; growers must use biological control for other pests or be selective by choosing insect growth regulators or biorational chemicals that have minimal impact on predators. Predatory mites can be supplied in shaker bottles. Growers shake the mites and a grain carrier onto the crop.

Chemical control. For a complete up-to-date list of chemicals for thrips control request University of Maryland Cooperative Extension Fact Sheet 762 on thrips control.

Weed Control

An integrated approach combining tactics to control perennial weeds and to reduce the existing seed bed of annual weeds creates a site where weeds are managed during the growing season without a large amount of hand weeding or hoeing. Techniques such as using plastic mulch, planting cover crops for organic mulch, and using nonselective herbicides are but a few possibilities for weed control. Nonselective herbicides can be used either to kill weeds during the fall before planting or to kill emerged weeds during the spring before planting. An herbicide such as Glyphosate will be translocated through the entire plant to kill both above- and below-ground plant parts. The key to successful control is thorough coverage and application when target plants are actively growing in spring or prior to senescence in early fall. This type of application will control perennial weeds; however, if annual weeds are the only problem in the planting area, a contact material such as Finale, Scythe, or Reward may be preferable. These materials will "burn down" the above-ground plant parts but will not kill the roots. If planting can be delayed to allow germination of annual weeds in the field, this type of treatment will provide a period of time to allow the establishment of lisianthus without competition from weeds. However, no residual control of weeds will occur during the season.

Cover crops such as rye or hairy vetch can be established in late summer or early fall and allowed to grow until 1–2 weeks prior to the desired planting date. At that time, mowing or rolling kills the cover crop either with an herbicide application or through mechanical injury of the weeds. The transplants are planted directly into the organic mat, which provides covering over the soil surface, limiting the amount of sunlight that reaches the soil. This reduces germination of annual weed seeds. The cover also preserves soil moisture, and leguminous covers such as hairy vetch fix nitrogen, which can help reduce the need for commercial nitrogen applications. Another advantage of cover crops is that valuable organic matter is added to the soil profile, which can greatly increase soil tilth over time.

Plastic mulches can be used for weed control in the row between the plants. The plastic comes in a variety of thicknesses and is usually applied with a mulch-laying machine, which requires a tractor. The cost of equipment may make the use of plastic more appropriate for large plantings. Plastic mulches tend to raise soil temperatures and control weeds, which can encourage faster plant development than growing plants in bare ground or with organic mulches.

In areas where weed control has been a serious problem, the use of a soil fumigant may be desirable. Basamid is a granular formulation that controls a variety of weed seeds, nematodes, and soil diseases. Careful planning prior to application is required to allow adequate time to elapse between the time of application and planting.

No matter what techniques are employed to control weeds, weeds in the field must not be allowed to go to seed. Hand pulling and hoeing is almost always required to some degree to get excellent weed control in cut flower crops. If the decision to use an herbicide is made, be sure to read and understand all label instructions and restrictions before applying the product.

Postharvest Factors

Things to do:

- Harvest in the morning when sugars are highest
- Harvest when 2 flowers are open
- For fresh market sales, wait for up to 4 flowers to open before harvesting
- Precool cut flower stems to 55° F prior to shipping

Things to consider:

- Lisianthus has good keeping quality with minor flower shattering
- It retains good quality for approximately 2 weeks after being cut
- It is easy to ship
- It is not highly susceptible to ethylene gas

Retail Handling

Things to do:

- Recut stems and place in warm water with a pH of 3.5 and a temperature of 65–75° F, the closer to 65° F the better.

Things to consider:

- Preservatives are highly effective
- Solutions of 2–4% sucrose and anti-microbial agents result in flowers lasting up to 14 days
- Pink and blue flowers tend to fade drastically in low light environments and small buds often fail to open after cutting

Consumer Care

Things to do:

- Recut stems and place in preservative solution to maximize vase life
- Because of flowers' sensitivity, keep them away from temperatures above 75° F and direct air blowing from air vents

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