Lilies as cut flowers and as pot plants

Guidelines for producing lilies as cut flowers and pot plants

Acknowledgements
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Asiatic hybrid

Oriental hybrid

Longiflorum hybrid

LA hybrid

OT hybrid

LO Hybrid

OA hybrid

Asiatic hybrid, pot type

Oriental hybrid, pot type

Chapter 1 - General information

1.1 Ordering

Placing the order to purchase lily bulbs from the importer or exporter has to be done well in advance of planting. This gives you the security of knowing that the next bulbs you receive have been cultivated at the same location and will be of the same quality as the last ones you received. It will also make it possible for the exporter to schedule the delivery of the cultivars you want. The best time to place your order is before the bulbs are lifted.
Be sure to provide all your preferences and information when placing your order. Some of the important points to be included are:
- desired flowering and flower delivery periods
- climate data during scheduled cultivation
- planting location (greenhouse or field)
- directly in the soil or in substrate-filled boxes
- possibilities for screening
- cultivar and bulb size
- transport
- whether you have cooling facilities and what their temperature range is

1.2 Group classification

Traditionally, lilies were classified into the Asiatic, Oriental and Longiflorum hybrids, each with its specific positive and negative characteristics. Interspecific hybridisation has now led to the development of new groups of lilies that exhibit improved characteristics. Meanwhile, the commercially available assortment of Asiatic lilies decreased. Except for certain cultivars, the Asiatic lilies have been replaced by the LA hybrids which were developed by breeding Asiatic lilies with Longiflorum lilies. The LA hybrids have larger flowers and better cultivation and forcing characteristics than Asiatic lilies. LA hybrids are available in a wide range of colours and can be used for flower production starting at bulb size 12-14. The flowers of LA hybrids are unscented. The Oriental hybrids produce large flowers with a beautiful shape, have a stronger fragrance, and need less light but take longer to produce, offer less colour variation, and are susceptible to various diseases. The OT hybrids make up a relatively new group of lilies that were developed by crossing Oriental lilies with Trumpet lilies. Like Oriental lilies, the OT hybrids produce large flowers but offer a broader range of colours including yellow and salmon. The OT hybrids are better suited for long storage and are less susceptible to diseases. In general, the greenhouse forcing period for OT hybrids is also shorter than that of Oriental lilies. The Longiflorum hybrids can be distinguished by their large, calyx-shaped, usually white flowers, their need for a shorter cold period and their good forcing characteristics. Their less positive characteristics are their very limited range of colour and their susceptibility to virus problems. Breeding within the various Longiflorum species has led to cultivars with upright flowers that later open horizontally in the vase. This makes these cultivars easy to process with less bud breakage as a result. After years of breeding activities conducted within these separate groups, it had become nearly impossible to make any more improvements.

New breeding techniques, however, are making it possible to cross hybrids in one existing group with hybrids in another group. The objective is to combine the positive characteristics, such as resistance to disease, that are typical of the separate groups. This development has produced new groups within the lily assortment, each with its own cultivars displaying new shapes, colours and improvements in various respects. In itself, this has been a much-needed development in keeping flower producers interested in producing lilies, but it has done even more to keep consumers coming back for these products.

The following new groups are now considered standard within the lily assortment and are mentioned frequently in the various chapters of this brochure. The year in which the first successful hybrid was produced is given in parentheses.
LA hybrids: Cross between Longiflorum and Asiatic hybrids. (1970)
OT hybrids: Cross between Oriental hybrids and Trumpet lilies. (1980)
LO hybrids: Cross between Longiflorum and Oriental hybrids. (1990)
OA hybrids: Cross between Oriental and Asiatic hybrids. (1995)

It is often necessary to emphasise the dominance of the characteristics of one of the parents over those of the other; this then necessitates inbreeding. Longiflorum hybrids are selected for crossing because of their vigour, while Oriental hybrids are chosen due to the shape of their flowers. The results are then known as LAA, OOT, LLO, TA, LOO and LOOT etc. At this time, more combinations are under development, so we can foresee the lily assortment undergoing plenty of development for a long time to come. This also means that we should expect to see a reduction in the life cycle per cultivar.

As a result of these developments, the Asiatic hybrids are increasingly being replaced by the LA hybrids due to their increased vigour and larger flowers. When it comes to cultivation procedures, both of these groups can be treated similarly.


Pollination

1.3 Storage

If newly harvested bulbs are delivered unpackaged and/or not frozen in and cannot be planted within a month of receipt, they will have to be packaged and frozen in as soon as possible (in any event, by 15 January). Freezing them in later will result in a reduction of quality and frost damage.

There are two types of lily storage: under below-freezing temperatures, and under both below-freezing temperatures and ultra-low oxygen (ULO) conditions. Lily bulbs stored under ULO conditions are frozen in at very low oxygen concentrations. The advantage of ULO storage is that the sugar levels in these bulbs are not reduced as much as the sugar levels in bulbs not stored under ULO conditions. After planting, lilies stored under ULO conditions usually exhibit better stem quality than the ones stored under the more conventional frozen storage method. This is under the condition,

however, that the bulbs are planted within a week of thawing. Sending thawed ULO bulbs by ship over long distances will counteract the positive effect of ULO storage. This eliminates the advantages of ULO storage for flower production in countries outside the Netherlands.

If lily bulbs are to undergo prolonged storage, measures will have to be taken to prevent the bulbs and roots from drying out. This is why they are packaged in lily export crates lined with a bag made of .02 mm-thick plastic (HDPE) film. This plastic bag has around 18 holes measuring 1 cm. in diameter to provide the bulbs with enough oxygen. When filling the plastic-lined crates, the bulbs are mixed and covered with slightly moist peat litter, upgraded black peat or potting soil. The plastic bag is then folded or sealed shut.

Once the bulbs are packaged and the dormancy of the bulbs has been broken, the bulbs are frozen in according to the temperatures listed below and then stored at the given temperature. For the freezing in period itself, the storage room temperature can be dropped temporarily to -3 to -4˚C. It will then usually take a couple of weeks before the lilies are actually frozen in to the proper temperature. Lilies that have been delivered already frozen in can go immediately into storage if the storage room has reached the proper temperature. Once thawed, lily bulbs should never be frozen in a second time. This is because frost damage can occur, the extent of which depends on the cultivar, time period and interim period.

When freezing in the bulbs, all of them, no matter where they are in the crate/stack, must reach the desired temperature within a relatively short period of time (7-10 days). This means that the storage room has to meet certain criteria. The criteria set in the Netherlands are:
- an insulation value for the walls of 0.3 Watts/m²/0°Kelvin
- a cooling capacity of 30-60 Watts/m^3 of rooting room space
- automatically operated, slowly turning fans
- enough room so as to leaf sufficient space between the crates/stacks and to allow approx. 5 cm. between the stacks and walls in the room
- regularly timed air circulation throughout the storage room
- a construction and/or equipment that keeps air moving even into and through the corners of the storage room.

These criteria have been set because it is very important that the temperature be uniform throughout the storage room. Even small differences can cause frost damage or shoot formation. The following room temperatures (not the temperature as measured in the box!) can be applied to the various groups of lilies:

Asiatic hybrids	-2 °C
Oriental hybrids	-1-1½°C
Longiflorum hybrids	-1½°C
LA Hybrids	-1½/-2°C
OT hybrids	-1½°C
LO hybrids	-1½°C
OA hybrids	-1½°C

When lifted, the sprout in a lily bulb has stored a certain amount of sugars. These sugars act as antifreeze that keeps the lily bulb from freezing. Once the temperature during bulb cultivation drops below 10°C, the production of sugars commences and continues after the bulbs are lifted. Once the peak sugar level is reached, the bulbs are ready to be frozen in. Lily bulbs produced in the Netherlands usually reach their peak sugar level during the second half of January. The higher the sugar level, the longer the bulbs can be stored and the lower the temperature at which they can be

frozen in. Since the Asiatic hybrids produce bulbs with the highest peak sugar level, they can be stored the longest and frozen in at the lowest temperature.

Depending on annual, group or cultivar factors, storage problems such as shoot formation, frost damage and black sprouts can start occurring in June/July. Frost damage, however, will occur later (after approx. 8 months of storage) or due to applying storage temperatures lower than those listed above. To prevent frost damage among Oriental hybrids (and hybrids resulting from breeding with Oriental hybrids) and Longiflorum hybrids, the room temperature in the storage room should be raised after six months. This should be done in steps so that the final temperature is –1.2 to –1°C. The occurrence of black sprouts is a phenomenon in which the meristem in the bulb turns black. Black sprouts occur in Oriental and OT hybrids after six months in frozen storage as a result of the low sugar level in the sprout that encourages the sprout to start sprouting. When the bulbs are stored for long periods under below-freezing temperatures, the sugars are consumed and the sprout turns black and rots. Bulbs belonging to the Asiatic hybrids can be stored up to one year without a major reduction in quality. As compared to fresh (unfrozen) bulbs, bulbs that have been frozen in and stored for one year emerge and flower faster and produce stems that are approx. 15 cm. shorter and that have fewer buds.

Oriental hybrids can usually be kept in storage until November/December. Some cultivars with a shorter growing period (e.g., 'Le Rêve') are exceptions and can only be stored until August. This is because the bulbs of this cultivar produce less sugar. The prolonged storage of Oriental hybrids will reduce their quality somewhat and increase the risk of frost damage. Longiflorum hybrids can be stored until early September.

Lilies that have not been frozen in can be stored only for a short period of time. How long this is depends on the temperature of the storage room and the time of year. As an example, fresh bulbs from the Northern Hemisphere can be stored longer at temperatures above freezing during the months of January and February than in the autumn. As a general rule, they can be stored no longer than 2 weeks at approx. 1°C and no longer than a week at 5°C.


Frost damage


Black sprout

1.4 Bulbs produced in France

Due to its warmer climate and greater light intensity, lily bulbs (chiefly Oriental and Longiflorum hybrids) are also produced in France in such locations as the Bordeaux region.

If lifted early, these Longiflorum hybrid cultivars can be planted for cut flower cultivation as early as September. If lifted at the normal time, they can start being planted in mid-December. Bulbs produced in France have stored more energy and the shoot is located more deeply within the bulb. As compared to bulbs produced in the Netherlands, French bulbs root more slowly (early plantings: 7-10 days later) and better and produce a good crop with an average of one additional bud, particularly under warm planting conditions.

Oriental hybrids produced in France can be planted from late May to late August. Here again, rooting takes longer and will therefore be more effective. This then results in longer stems with more volume. These bulbs are also suitable for planting during the indicated planting period in climates with higher temperatures.

1.5 Bulbs produced in the Southern Hemisphere

The lily bulbs produced in the Southern Hemisphere in such countries as New Zealand and Chile are usually Oriental and OT hybrids. The quality of these bulbs can vary according to the cultivation location. In these countries, the bulbs are lifted in June and July and can be planted for flower cultivation from 1 October to late January. This means that these bulbs will have been stored for six months less than bulbs produced in the Netherlands. Their rooting process will thus proceed more slowly and effectively and will produce a better-quality crop. To obtain the same stem quality as the Dutch bulbs that were stored longer, the grower can consider using bulbs that are one size smaller. It would be a good idea, however, for the grower to have first acquired some experience in this regard.

1.6 Number of bulbs per box

The following list provides an indication of the number of bulbs per lily export box so that you can arrive at a more accurate calculation of how many bulbs can be stored in a cold storage room. Your supplier, however, can provide you with exact numbers. Bulbs are always ordered by the box.

Bulb size	Number of bulbs/box
10/12	500
12/14	400
14/16	300
16/18	200
18/20	150
20/22	100-125
22/+	75-100

Chapter 2 – Greenhouse structure and greenhouse equipment

2.1 Greenhouse structure

Producing lilies as cut flowers requires the proper kind of greenhouse; it has to be able to provide a stable greenhouse climate under highly fluctuating conditions. Temperature, air circulation, ventilation and light are factors that have to be controlled very accurately. Optimum climate control is made easier by forcing lilies in greenhouses with a substantial volume. A standard height of 4 to 4.5 metres is customary. This will then provide sufficient room for installing the screening, irrigation and lighting systems. The greenhouse will also have to admit plenty of natural light; this is especially important during the darker winter period. Less light results in bud drop in Asiatic and LA hybrids and reduce the sturdiness of stems. During the other periods of the year, the greenhouse will have to provide for the admission of fresh air in order to reduce the soil and air temperatures in the greenhouse.

Another important condition for producing a healthy lily crop is the RH (relative humidity) of the air in the greenhouse. Achieving optimum growth requires maintaining an RH between 70 and 80%. A higher RH will result in less transpiration. This will mean a reduction in the transport of minerals so that the plant will be more prone to nutrient deficiency symptoms, leaf scorch or papery leaves. At a high RH, the plant will also be more susceptible to damage caused by Botrytis. The RH can rise to high levels particularly during the winter months. It can be lowered by heating and ventilating. Air movement also ensures proper plant transpiration.

Different Greenhouse facilities

2.2 Greenhouse equipment

2.2.1 Heating system

In many regions it will be necessary to have the greenhouse equipped with a heating system. Asiatic and LA hybrids require a minimum greenhouse temperature of 8-14°C; the other groups require 15-16°C. To achieve these temperatures, a norm for the heating systems is approx. 220 Watts/m² of greenhouse volume/hour. Due to better heat distribution and climate control, radiant heat provided by pipes is preferred. Forced-air heaters can be used as well, but care should be taken to ensure proper heat distribution, proper combustion and leak-proof exhaust pipes for transporting combustion gases out of the greenhouse. An improperly calibrated heating system can allow the release of ethylene and CO_2. The release of ethylene into the greenhouse will cause flower bud drop. Heating the crop by means of pipes or hoses (max. temp. of 40°C) located in the beds is also possible and is actually

recommended for achieving a dry crop (for preventing *Botrytis*).

2.2.2 CO_2 system

CO_2 injection benefits the growth and flowering of Longiflorum and LA hybrids and is thus recommended since it produces a sturdier and greener crop. The weight of some cultivars can increase by 10% by applying CO_2 injection. With the help of so called "hanging burners" the gas is supplied from the central boiler or from pure CO_2. Attaining a concentration of 800 ppm is sufficient. Injection is started upon sunrise and can be continued for a few hours to throughout the day on the condition that the greenhouse is closed or little ventilation is carried out and that there is sufficient light for photosynthesis. In the Netherlands, CO_2 injection is used as necessary during the winter and early spring.

When using assimilation lighting, CO_2 injection can be conducted 24 hours a day. Keeping track of the CO_2 requires regular monitoring using a simple monitoring device. Due to the possibility of damage to the crop caused by CO_2 and ethylene, combustion must be optimal. This will thus require security devices that can indicate any deviations promptly.

2.2.3 Irrigation system

The most important requirements for an irrigation system are that it distributes the water uniformly and that the water provided does not damage the soil structure. Regular monitoring of water distribution should begin even before planting. Too much or too little watering will result in uneven, delayed emergence and growth; reduction in stem length; Pythium, Phytophthora, Fusarium oxysporum and Rhizoctonia (by excessive watering); and even flower bud desiccation among certain susceptible cultivars. To prevent damage to soil structure, it is important to keep droplet size small enough and not to provide too much water all at once. It is better to distribute the amount of water being provided over several applications. In general, it would be advisable not to exceed 10 litres of water per square metre per application. Lilies require large quantities of water particularly during stem root emergence. Once the stem roots are well developed, this quantity can be reduced.

A low level irrigation system is preferable. Its use keeps the plants less wet or even entirely dry and thus substantially reduces the risk of damage due to *Botrytis*. This is an important factor particularly when growing *Botrytis*-susceptible cultivars and when the relative humidity is high due to the geographical region or time of year. In addition, plants that grow tall and become top-heavy will have fewer problems with flattening, especially during the winter. If use is made of hoses for drip irrigation, care should be taken to arrange them so that the lily's entire root zone receives water.

The use of overhead sprinklers provides better water distribution and a way to rinse the crop clean. Growers often use this system at the beginning of cultivation and later switch to a low level irrigation system. The best time to provide water is in the morning just before or during sunrise.

For technical criteria that an overhead sprinkler system must satisfy, we refer you to the installer. Important points to consider include soil type, dry spots, soil permeability, stage of crop development, time of year, and pump pressure/type of nozzle.
A system that floods the soil should not be used due to the possibility of damaging soil structure and producing a lack of oxygen that will then result in a higher risk of *Pythium*.

2.2.4 Lighting equipment

Light is a factor in the growth and development of the lily plant as well as its flowering (photoperiodicity). Depending on the time of year, the location of the cultivation site in relationship to the equator, the light admitted by the greenhouse, and the cultivar's need for light, it may be desirable or even necessary to use assimilation lighting during the day to promote photosynthesis or to extend day length.

2.2.5 Assimilation lighting

Insufficient light intensity causes weak growth in plants in general; in lilies, this results in flower bud drop, late flower bud desiccation, a tall and limper crop, a lighter foliage colour, leaf scorch and a reduced keeping quality. Lily plants need sufficient light intensities, particularly for proper flower bud development and sturdiness. During the dark winter period, once flower buds produced by Asiatic and LA hybrids are 1 to 2 cm. in length, they can become pale and drop off (flower bud drop); during a later stage of development, and under the same conditions, they can suffer flower bud desiccation. Within the commercial lily assortment, the Asiatic hybrids (with clear distinctions being made among the individual cultivars) are the most susceptible to flower bud abortion. The next most susceptible are the LA hybrids. Longiflorum hybrids are definitely less susceptible whilst the Oriental hybrids and their related hybrids are least susceptible (the exception is 'Yelloween', an OT cultivar that is susceptible).

For winter cultivation, and depending on the local climate and light conditions, growers will have to be aware of the following points even if they do not need to use assimilation lighting.
- use a clean glass or plastic greenhouse
- use new plastic on the greenhouse
- remove any shade-producing objects from inside and outside of the greenhouse. Growers should be aware that the use of a shade cloth, including the use of plastic film inside the greenhouse, can substantially reduce light intensity.
- use groups and cultivars less susceptible to problems due to lower light intensities
- use a smaller bulb size
- reduce plant density
- use light-reflecting material on the ground and light-reflective paint on the walls.

The minimum light intensity in the greenhouse for Asiatic and LA hybrids is 300 Wh/m² or 190 Joules/cm²/day (in terms of PAR= Photosynthetically Active Radiation). If natural daylight has to be supplemented, it should be started when the buds are 1 to 2 cm. in length. In general, this means the use of special reflectors equipped with 400-Watt SON-T lamps placed so as to cover every 8 to 11 m² of cultivation surface or 600-Watt lamps to cover every 12 to 15 m². The minimum light intensity when measured at crop height is 8-9 W/m² or converted when using the previously mentioned type of lamp to 3200-3300 lux. This light intensity is needed to prevent bud drop. For good stem quality, the use of artificial lighting will have to begin earlier with a light level of 6,000 lux being optimal.

A few more instructions:
- regularly monitor the lighting system
- regularly clean the reflectors to maintain the proper effect of the lamps
- have the installer periodically check the light intensity since it gradually decreases: by 10% after 10,000 hours of use and by 17% after 15,000 hours.
- record the number of hours of use and replace the lamps after they have been used for 10,000 to 15,000 hours.

There are two kinds of reflectors: the narrow-angle reflectors (to be placed no farther than 1.80 m. above the crop) and broad-angle reflectors (to be placed no farther than 1.40 m above the crop). For additional information, we refer you to the local agricultural information service, your installer or your supplier.

For each group of lilies, Table 1 shows the periods in which natural light is insufficient under Dutch conditions, the number of hours a day for which artificial lighting will be required, and the cultivation phases during which artificial lighting will be needed.

Table 1. Assimilation lighting period, number of hours/day, and cultivation phase during which assimilation lighting is required to prevent bud abortion among the various lily groups .

Lily group	Period	Hours/day	Lighting starts	Lighting ends
Asiatic and LA hybrids	15 Oct. – 15 Mar.	20 - 24	flower buds 1 cm. long	end of harvest
Oriental, OT, LO, OA hybrids	5 Oct – 15 Mar.	10 - 16	from emergence, upon leaf unfurling	end of harvest
Longiflorum hybrids	1 Dec. – 15 Jan.	10 - 16	from emergence, upon leaf unfurling	buds 1 cm. long/ 2-3 weeks before harvest

This table shows the minimum light required for preventing bud abortion among Asiatic and LA hybrids. Depending on the level of incoming sunlight, the stems can become too long and too limp if artificial lighting is not started soon enough. To be assured of good stem quality, this is why lilies in the Asiatic and LA hybrids – just like other lilies – should receive artificial lighting from emergence, upon leaf unfurling through to the end of harvest.

2.2.6 Day length lighting

The number of hours of light received by lily plants within a 24-hour period affects their flowering. To advance the flowering of some lily cultivars, they are subjected during the shorter days of the year to artificial lighting that extends the photoperiod (day length). Cultivars responding favourably to the extension of day length belong to the group of Oriental hybrids requiring more than 100 days of cultivation time when using freshly lifted bulbs during a spring forcing period. Extending day length can induce flowering 14 days earlier among certain cultivars. For this reason, artificially lengthening the photoperiod should be done only when using newly harvested bulbs for spring forcing. This procedure also reduces the forcing period during the autumn, but because the lilies react more quickly as the result of long storage at below-freezing temperatures at that time of year anyway, their stems will not be sturdy enough.

Long-day treatment (extending the photoperiod – in this case, to 16 hours) is applied starting from when 50% of the lily shoots have emerged. This long-day treatment is terminated after 6 weeks, or whenever the flower buds become just barely visible within the closed inflorescence. Long-day treatment is achieved by the use of incandescent lamps (installed capacity: approx. 20 Watts/m²) to illuminate the crop before or after the hours of natural sunlight. Cyclic lighting (10 minutes of light, 20 minutes of dark) can also be used but is not as effective.

For Oriental lilies that respond to this treatment, long-day treatment provides a way to market them earlier in the spring than if they had not been treated. On the other hand, stem length can be somewhat shorter and the percentage of flower bud drop can be somewhat higher. Once the natural photoperiod reaches 16 hours, extending the day any longer by artificial means provides little benefit.

Due to the use of supplementary lighting during the day to boost photosynthesis, the use of long-day treatment alone is not used much anymore.

2.2.7 Screening equipment

The use of a screening equipment is recommended for climate control and, during the winter, for saving on energy consumption. A retractable screening system that reduces light intensity very little when not in use is best. Particularly when forcing lilies during the autumn or spring, a retractable system is better than a fixed system because a retractable system can be drawn so as to make optimum use of natural light; even when light intensities are low, this will allow the lilies to respond to higher light intensities and thus produce flowers sooner. A permanently installed shading solution, i.e. spraying a shading compound onto the greenhouse or using a shade cloth (preferably hung on the exterior of the greenhouse) can best be applied once light intensities remain constantly above the minimum desired level and then should be removed in good time in the autumn. A permanent shading solution can also be used during the first 3-4 weeks of cultivation; in this case, a moisture-permeable material would be preferable.

During the summer months, it is also possible to spray a shading compound onto the exterior of glass greenhouses that will filter around 50% of the natural sunlight. Because a shading compound is not easy to remove, it should not be applied too early in the spring nor removed too late in the autumn. Applying the shading compound to the north side of the greenhouse later and then removing it earlier as well makes it possible to be somewhat more prepared for fluctuating kinds of weather. The shading compound can be removed by a high-pressure spray gun using a solution containing chemical agents especially designed for this purpose. Do not use any cleaning agents that contain fluoride because fluoride can discolour leaf tips.

Simple screening system

Chapter 3 – Soil and irrigation water

3.1 Soil

Lilies can be forced into flower in almost any type of soil. Nevertheless, care must be taken to ensure excellent soil structure and retain moisture permeability (no impermeable layers) throughout the entire growing layer (particularly the upper layer of soil) throughout the entire cultivation period. Heavy loam and clay soils are less suitable for the cultivation of Oriental hybrids. For producing other groups of lilies, these soils can be improved by working in substrates containing humus to a depth of 40-50 cm. This improves air permeability and provides sufficient moisture permeability in the upper layer of soil so that even in these soils, sufficient oxygen can be absorbed by the moisture

in the soil. Heavy soils will usually reduce the height of the crop somewhat. In addition to water and nutrients, having enough oxygen in the soil is also essential for a good healthy root system and thus for plant development.
The panning of soil susceptible to compaction should be prevented by applying a mulch after planting. The mulch can consist of with rice hulls, Styromull, rice straw, pine needles, upgraded black peat, etc. A certain amount of care should be taken when mulching due to the possible presence of the fungus *Rhizoctonia solani* in some mulching materials.

3.2 Soil structure

The term "soil structure" refers to both the physical and chemical properties of the soil that will affect the usability of this soil by the plant. Important factors in soil structure are organic matter and pH. It is thus important when growing lilies that the structure of the soil, whether this is the border soil of the greenhouse or field soil, is in order previous to planting. If not, there will be a high risk of root rot. And, although the primary cause of root rot is a fungus known as *Pythium*, the underlying cause in most cases is poor soil structure paired with an insufficient permeability of the soil. Flooding and a lack of oxygen are the result, followed by a weakening and even dying back of the stem roots. When this occurs, the *Pythium* fungus can easily invade these roots and worsen their condition. In addition to Pythium, fungi such as Phytophthora and Fusarium oxysporum can damage lily plants. This is why it is essential to keep track of the structure of your soil and improve it according to schedule by applying the procedures indicated in this chapter. You can also prevent the deterioration of soil structure by not tilling the soil when it is too wet. Do not provide too much water in a single application but distribute irrigation over several applications on soils susceptible to flooding. Also be careful not to make the soil too finely textured when tilling it. Furthermore, make sure that the soil does not become compacted as the result of intensive watering. If necessary, mulch the soil with a few centimetres of rice hulls, peat litter, or similar material.

3.3 Soil structure improvement

Adding organic material, a name given to a wide variety of materials originating from plants or animals, improves the structure and at the same time the water balance, the accessibility of fertilisers, and the aeration of the soil. Fertilisers – but even more importantly, water and oxygen – are essential elements in producing a good root system that will then promote the proper growth of the plant. This makes it desirable to apply organic material to the soil, especially heavy clay soil, in plenty of time before planting. For this purpose, use can be made of:
- rice hulls: 30 kg/100m²
- 1 year old, well-decomposed cow manure: 1 m³/100m². Beware of the fact that manures produced by other animals such as chickens, horses and pigs can contain too much salt and lead to root burn!
- upgraded black peat: 1 m³/100²
- well-composted tree bark

On heavier soils containing more humus, stable manure can often damage soil structure since it makes soil particles stick together. It would thus be better to apply materials such as upgraded black peat, rice hulls and tree bark. Sand or lava sand is also used for this purpose.

Work the organic material thoroughly into the upper 50 cm. of soil. Beware of the fact that excessive amounts of organic material can cause damage. It is better to add this material every year until the soil has attained a good structure and then to adjust the amount provided thereafter in order to maintain the right soil structure.

3.4 pH

Maintaining the proper pH (degree of acidity) in the growing layer is essential for the root development of lily plants and for the proper absorption of nutrients. Soil with an excessively low pH can result in excessive absorption of such elements as manganese, aluminium and iron; an excessively high pH and lead to an insufficient absorption of such elements as phosphorus, manganese and iron (also see the section on deficiency and excess symptoms in Chapter 9).
For growing Asiatic, LA and Longiflorum hybrids, maintaining a pH of 6 to 7 is recommended; for the Oriental, OA, LO and OT hybrids, a pH of 5.0 to 6.5 should be maintained.

To reduce the pH, pH-reducing materials such as unlimed peat products should be worked into the upper layer of the soil. When using artificial fertilisers, pH-reducing fertilisers such as the ones containing ammonium and urea are preferable. To increase the pH, liming materials or liming materials containing magnesium can be worked into the soil previous to planting.
The addition of 1 kg of CaCO/ m^3 of soil will increase the pH value by a factor of 0.3. After having increased the pH value of a soil that has been measured as having a very low pH, planting will have to wait for at least one week. During cultivation, the application of pH-increasing materials such as the ones containing nitrates (N) is preferable.

3.5 Water balance

Because the stem roots of certain lily cultivars grown downward, these cultivars require a layer of 40-50 cm. (the exact thickness depending on the existing soil structure) of well-drained soil. This is even more important when you consider that it is often necessary to leach the soil between cultivation periods to prevent excessively high concentrations of salts.

3.6 Salt sensitivity

Lilies are sensitive to salt. High salt contents will produce roots that are hard, brittle and yellow to brown in colour. A high salt content will also reduce the roots' capacity to absorb water, and this will lead to a reduction in the height of the crop. Excessive salt contents can even result in root damage! In these cases, it is the root hairs in particular that burn (and it is the root hairs that are responsible for the absorption of minerals).

The salt content in the soil is determined by three factors:
- the salt content of the manure and/or artificial fertiliser applied
- the salt content of the water used for irrigation
- the nutrients in the soil and how much of them were absorbed during the previous cultivation period.

Conduct soil sampling at least 6 weeks prior to planting the bulbs in order to obtain a good picture of the pH, the total salt content and the chlorine content, and the presence of nutrients in your soil. The EC of the soil must not exceed 1.0 and the chlorine content must not exceed 3.0 mmol/l. If the EC or chlorine content exceeds these levels, the soil should be leached prior to planting with water having an EC less than 0.5. This will then make it possible to apply fertilisers to produce a good crop of lilies without the danger of increasing the salt content in the soil that would harm them. Always leach in plenty of time prior to tilling in order to prevent damaging the soil structure. Leaching sandy soil will require 30-40 litres/m^2; loam and clay soils will require 50-60 litres of water with an EC not exceeding 0.5 (preferably lower) per m^2. Should you notice during cultivation that the soil contains too much salt (evidence: areas within the crop with shorter plants), provide more water than usual. You should thus be careful with the application of organic fertilisers containing too much salt or the application of too much artificial fertiliser. When overly fresh organic fertiliser is applied, the soil

organisms will have to compost it before planting can take place. To accomplish this, these soil organisms will have to extract a lot of nitrogen from the soil. In lilies, this will result in yellow plants as a result of nitrogen deficiency.

3.7 Basic dressing

To obtain an accurate idea of the nutritional elements present in the soil, taking soil samples far enough in advance of cultivation is essential. If this data is unavailable, a standard application of fertiliser can be conducted according to the following guidelines.

3.7.1 Fertilising without soil sampling data:

The following amounts of fertilisers are spread over the soil and worked into it:

Table 2. Standard fertilising plan

Fertilising agent	Composition		Quantity/100 m²)
Calcium ammonium nitrate	$NH_4NO3 + CaCO_3$	27% N + 12% $CaCO_3$	1.4 kg
Dicalcium phosphate	$CaHPO_4$	35% P	1 kg
Potash magnesia sulphate	$K_2SO_4MgSO_4$	30% K + 10% MgO	1.8 kg
Borax	$Na_2B_4O_7$	11,3% B	0.1 kg
Kieserite	MgSO4	25% MgO	0.5 kg

3.7.2 Fertilising as based on soil sampling data:

Based on the soil sampling findings, you can see whether your greenhouse soil achieves the target values needed for lily cultivation. Table 3 gives these values for each soil type:

Table 3. Target values for the EC, pH and elements (in mmol/l) needed in various types of soil for lily flower cultivation.

Element	Sand	Loam/clay	Peat
EC (mS/cm)	0.9	0.9	0.9
pH	5 to 7	6-7.5	>5
$NH4^+$	0.1	0.1	0.1
K^+	1.3	1.0	1.3
Na^+	-	-	-
Ca^{++}	1.8	1.5	1.8
Mg^{++}	1.0	0.8	1.0
Si^{++}	-	-	-
NO_3^-	3.0	3.0	3.0
SO_4	1.5	1.3	1.3
P	0.15	0.15	0.15

If these target values are met, a basic dressing is not needed. If these values are not met, fertilising will have to be conducted during cultivation, based on the soil sampling findings.
Soils low in nutrients (according to the soil sampling findings), however, will need an application of phosphate and potassium in the form of simple fertilising agents previous to cultivation because these cannot be applied during cultivation. Because lilies are easily subject to dead leaf tips if exposed to fluoride (especially if the soil has a low pH), no use should be made of fertilisers containing this element (examples: super and tri-super phosphate and certain compound fertilisers). Fertilisers low in

fluoride such as dicalcium phosphate are much preferred.

A general warning concerning basic dressing, however, should be given at this point. Lilies require few nutrients, especially during the first 3 weeks of cultivation, to produce flowers. What is more important at this time is not allowing any salt damage to occur. Too much fertilising produces more damage than to little!

3.8 Soil temperature

For the proper emergence of roots, it is important to have the temperature of the soil as close to the optimum values as possible in advance of planting. This is 10 – 12°C for all lily groups. Although this may not always be possible to achieve, the soil temperature will have to be brought to below the ceiling levels of 20 – 25°C.
If the soil temperature exceeds these levels, the following measures should be taken a number of weeks before planting:
- shading: lilies can tolerate shading long after emergence
- ventilate
- apply cold groundwater
- mulch with reflective material

3.9 Pathogen-free soil

Plant the lily bulbs in greenhouses or outside but preferably in a location where few if any lilies have been planted there before. If several greenhouses are available, crop rotation is possible. This means alternating the crops being cultivated per greenhouse. If certain disease problems are expected, a general soil treatment can be conducted and, if necessary, followed up by an additional soil treatment. At facilities where lilies are produced continually, the soil will have to be disinfected once every one or two years.

3.10 Irrigation water

The salt content (EC) of the irrigation water also contributes to the total salt content of the soil and will thus have to be low: 0.5 mS/cm or less. Rainwater, because it has an EC of approx. 0.1, meets this criterion. The EC of water obtained from wells or surface water can increase sharply due to lower levels due to increasing use or summer evaporation. For sprinkling in greenhouses, the maximum allowable chlorine content for irrigation water is 200 mg/litre; outside, this content is 450 mg/litre.

Frequent monitoring of the salt and chlorine contents of the irrigation water is actually quite necessary. If water exceeding these levels is used for irrigating, the soil will have to remain constantly moist in order to prevent salt concentrations from rising should the soil dry out. If irrigation is done only with rainwater, boron deficiency can occur, so you must be alert to this possibility.

Chapter 4 – General cultivation procedures

4.1 Receipt of bulbs

4.1.1 Bulbs that arrive frozen in

If the bulbs are still frozen in upon arrival, the grower can decide to continue storing them under the conditions and temperatures indicated in the section devoted to storage in Chapter 1. If the grower

wishes to plant the bulbs soon, the plastic lining the boxes should be opened (unfolded) and the boxes should be stacked in single stacks and left undisturbed to thaw in a cold storage room that provides them with good air circulation at a temperature of 10-12˚C. Thawing at a higher temperature (> 25˚C) will result in a reduction of quality. Once thawed, bulbs can never be frozen in again due to the risk of frost damage. If the grower wishes to plant the frozen contents of a single box on two different dates, it would be advisable to break apart the frozen mass of bulbs in the box and return the other half to a facility that will maintain below-freezing temperatures.

4.1.2 Bulbs that arrive not frozen in

Bulbs that arrive not frozen in, whether or not short shoots have emerged, can be planted immediately or can be pre-rooted in the crates with the plastic opened (unfolded) at a temperature of 10 to 12°C. To postpone the planting period, store the bulbs in a refrigerated storage room for no longer than 1 to 2 weeks at +0 to 2°C, an RH of 95-98%, and little air circulation.
Bulbs with shoots longer than 5 cm should be planted as quickly as possible.

If newly harvested bulbs without visible shoots are delivered unpackaged and/or not frozen in and cannot be planted within a month of receipt, they will have to be packaged and frozen in as soon as possible (in any event, by 15 January). Freezing them in later will result in a reduction of quality and frost damage.

Higher storage temperatures and/or longer storage periods will result in undesirable shoot growth and, if not packed properly, desiccation of the bulbs. This will be followed by shorter stems and fewer flowers per stem. Eventually, due to increased respiration, the temperature in the boxes will quickly increase to a level far exceeding the surrounding room temperature.

4.2 Bulb size

It is best to use the smallest bulb sizes available from the various groups of lilies during a period when not too much is demanded from the plants: in other words, when they will be grown under conditions of sufficient light and sufficiently low temperatures. In the Netherlands, this is the case when producing Dutch-produced bulbs from December through March. Under conditions of low light (winter), bulbs with a smaller bulb size should be planted at a reduced planting density; during periods of high temperatures (e.g. summer plantings), bulbs with a larger bulb size should be used. Be aware that the use of large bulb sizes when growing certain cultivars in the Asiatic, LA and Oriental hybrids will result in a higher risk of leaf scorch.

The bulb size chosen also depends on the desired number of buds per stem. In general, the smaller the bulb, the fewer the number of buds per stem, the shorter the stem, and the less a stem will weigh. The following list indicates the bulb sizes for each lily group that can be used.

Group	**Bulb size**
Asiatic hybrids	10/12 cm, 12/14 cm, 14/16 cm, 16/18 and 18 cm +
LA hybrids	12-14 cm, 14/16 cm, 16/18 cm and 18 cm +
Oriental, OT, LO, OA hybrids	12/14 cm, 14/16 cm, 16/18 cm, 18/20 cm, 20/22 cm and 22 cm +
Longiflorum hybrids	10-12 cm, 12-14 cm, 14-16 cm, 16/18 cm and 18 cm +

4.3 Cultivation site

Producing lilies for use as cut flowers usually takes place in the border soil or in peat or coir potting soil in containers under glass, plastic or shaded greenhouses. In this way, the grower will have fewer problems due to unfavourable weather conditions, will be better able to control the climate for lily

cultivation, and will have a way of producing lilies year round. Forcing lilies in boxes shortens the greenhouse period.

Planting lilies outdoors can be done only in regions that provide a favourable climate throughout the cultivation period. Before starting outdoor cultivation, a grower will have to consider the possible problems (including *Botrytis*) that can occur as a result of heavy or prolonged rainfall, hail, heavy wind, ground frost and frost periods. Intense sunlight will produce lilies with short stems. For outdoor cultivation, it is particularly important to have rich, moisture-retentive, well-drained soil; an effective irrigation system; and screening to protect the plants from excessive wind and sunlight. The last factor is important for producing long enough stems during the summer months (and so is choosing the right cultivar, i.e. one that will tend to produce long stems as well as many buds).

4.4 Plant procedures and plant depth

Once a lily bulb is planted, it depends for the first three weeks on the bulb roots it has already developed previous to planting for its intake of water, oxygen and nutrients. This is why it is so important that these roots be at least 5 cm in length, vital, not diseased, and not desiccated at the time the bulbs are planted. It is during these first three weeks that the stem roots develop on the part of the stem just above the bulb but beneath the soil level. These stem roots soon take over for the bulb roots and from then on will supply the plant with 90% of its needs for water and nutrients. To produce lilies of excellent quality, this means that the stem roots will have to develop properly. To achieve this, keep the following points in mind:

- plant only in pathogen-free soil (see Chapter 9)
- make sure that the soil is cool enough. Achieve this before planting begins by taking the following measures well in advance: screening, ventilating and applying cold irrigation water.
  Then, after planting, mulch the soil with suitable material such as potting soil, rice hulls, straw, etc. for the purpose of controlling black-body radiation, desiccation and damage to the soil structure.
- during hot weather, plant only in the morning
- during a spell of hot weather, postpone planting for one or a few more days
- prevent the bulbs from drying out during planting by distributing small quantities of bulbs at time onto the bed or by planting directly from the crates. Allowing the scales or bulbs roots to dry out will always lead to a reduction in quality.
- plant the bulbs at a sufficient depth in somewhat moist soil. A good planting depth is achieved by having around 8-10 cm. of soil covering the upper side of the upright bulbs. To prevent damage to the bulb roots, do not use much force in tamping the soil down over the bulbs once planted.

4.5 Planting density

Due to the differences in plant sizes produced by the various groups, cultivars and bulb sizes, the planting density should vary accordingly. Planting density will also depend on the planting period and the type of soil used. For flowering during months with high temperatures and high light intensities, the planting density can be higher. In darker periods (winter) or under conditions of low light, however, the planting density should be lower. On heavy soils such as peat soils, the plants will display denser habits so that a lower planting density should be applied. The following table indicates the maximum and minimum planting densities per net square metre according to group and plant size. In general, lily bulbs are planted in beds 1 metre wide.

Planting by hand

Planting by machine

Table 5. Indication of planting density according to group, type and bulb size per net square metre of bed surface or box area.

Group / Bulb size	10/12	12/14	14/16	16/18	18/20	20/22	22/+
Asiatic hybrids	60-70	55-65	50-60	40-50	35-45		
LA, OA hybrids		45-55	40-50	35-45	30-40		
Oriental hybrids such as 'Star Gazer' that do not produce large leaves		55-65	45-55	40-50	35-45		
Oriental hybrids such as 'Siberia' that produce large leaves			40-50	35-45	30-40	25-35	25-35
OT hybrids		55-65	45-55	40-50	35-45		
Longiflorum hybrids	55-65	45-55	40-50	35-45	30-40		

4.6 Mulching

To prevent damage to soil structure, soil desiccation and an increase in soil temperature, post-planting mulching the soil with rice hulls (20-30kg/100m²), straw, Styromull or potting soil is recommended. The possible disadvantages of mulching are: grain emergence and sometimes the presence of Rhizoctonia solani in the hulls or straw. During the autumn when the temperature in the greenhouse is dropping, mulching can keep the soil temperature higher for a longer period of time.

4.7 Staking

A plant support system may be necessary depending on the cultivation period and cultivar. A crop produced during the winter months will always require support; at other times of the year, cultivars taller than 80-100 cm. will usually need support. If harvesting will involve pulling the stems instead of cutting them, support will be necessary to prevent surrounding plants from falling over. The usual way of providing this support is the use of wire grids similar to those used in chrysanthemum cultivation. These grids are then raised as the crop grows taller. Such a grid can also be used during planting as a way to determine planting density.

4.8 Nutrition

4.8.1 Nutrition without soil sampling data:
With reference to the section on basic dressing in Chapter 3, the following guidelines should be adhered to after planting.
During the first three weeks following planting, good root development should occur, so this means preventing any salt damage during this time. For this reason the weekly alternating applications of the quantities of calcium nitrate and potassium nitrate listed in Table 6 will have to wait until three weeks following planting (and can then continue until 14 days before harvesting). The application of any magnesium in the form of magnesium sulphate (0.15 to 0.20 kg/100 m²) will depend on whether any yellowish discoloration occurs in the lower foliage. (This means that magnesium sulphate should be added in the event of this discoloration.)

Table 6. Application of nitrates in kg per 100 m²

Fertiliser	Composition		Quantity/100 m²
Calcium nitrate	$Ca(No_3)_2$	15.5% N + 26.3% CaO	1 kg
Potassium nitrate	KNO_3	13.7% N + 46.2 % K_2O	1 kg

The application can be made by using sprinkler circuit or by sprinkling among a dry crop. To prevent leaf scorch, application should be followed by a thorough sprinkling of the crop with clean water.

Based on practical experiences and research findings, target values have been developed for fertilising lilies. These values will generally have to be met in order to arrive at an acceptable cultivation result.

4.8.2 Nutrition based on soil sampling data:
Based on the results of the soil sample, a grower has data for creating a basic dressing for lily cultivation as based on the desired target values (see the section on basic dressing in Chapter 3). The grower can then start making additional applications of the fertilisers according to the quantities listed in Table 7 (again waiting until 3 weeks after planting) by means of the sprinkler circuit.

Table 7. Quantities of fertilisers per m^3 of water that will add an EC value of 1.0 to the water.

*Fertiliser	Chemical formula	Percentage	Kilos/m^3 water for EC of 1.0
*Container A			
Calcium nitrate	$Ca(NO_3)_2$	15.5% N	60
Potassium nitrate	KNO_3	13.5% N + 45% K_2O	22
Ammonium nitrate	NH_4NO_3	35% N	5
*Container B			
Potassium nitrate	KNO_3	13.5% N + 45% K_2O	35
Potassium sulphate	K_2SO_4	44.9% K +18.4% S	2.1
Magnesium sulphate	$MgSO_4$	16% MgO	56
Ammonium nitrate	NH_4NO_3	35%	5
Borax	B	10%	0.15

Try to achieve a total EC of 1.5. If the water already measures an EC of 0.5, add this to the EC level provided by quantities of fertilisers to be applied (example: if the water has an EC of 0.8 and the fertiliser has an EC of 1.0, the total EC is then 1.8). Regularly monitoring the EC value of the soil

during cultivation is recommended.
As a precaution to prevent leaf scorch, it would be advisable to sprinkle the crop with clean water following the application of fertiliser solutions.

* The mixing of fertilisers
  Certain fertilisers, if they are in a concentrated form, react with each other when mixed in the same container. (Calcium, for example, reacts with sulphate in a concentrated form to produce gypsum.) This is why two separate containers are needed to store the fertilisers that will be applied simultaneously.
* Elements that affect the absorption of other elements
  When the balance of elements in the soil is disturbed by there being too much of one in proportion to another, this disturbs the absorption of certain elements by the plant. The following table lists the elements that can affect each other in this way.

Table 8. Elements that affect the absorption of other elements.

Too much of this element:	Will reduce the absorption of this element:
NH_4 (ammonium)	Ca (calcium), Mg (magnesium)
K (potassium)	Ca (calcium), Mg (magnesium)
Mg (magnesium)	NH_4 (ammonium)
Mn (manganese)	Fe (iron)
High EC level	Ca (calcium)

4.9 Irrigation

Never plant the bulbs in soil that is too dry. Instead, moisten the soil a few days ahead of planting so that re-rooting can start immediately.
Immediately after planting, water thoroughly several times; this will help to prevent panning and damage to soil structure whilst providing the bulbs with the water they need to develop bulb roots and root hairs quickly. Check to make sure that the water is actually coming into contact with the bulb roots!
Because the stem roots of some cultivars grow not only horizontally but downward, the upper 30-40 cm layer of soil should be kept continuously moist.

If not enough water is provided, the result will be slow emergence, uneven development, shorter stems and early flower bud desiccation. Providing too much water should be avoided as well since this will reduce the oxygen available to the roots and limit their development. The weakened roots will then be susceptible to damage from Pythium and Phytophthora. An excessively wet soil during the period when the stems are growing rapidly will also result in limp stems and/or plants due to an explosive enlargement of the cells. Continuous monitoring is thus essential. It can sometimes happen that soil beneath the growing layer is excessively wet due to poor structure; this can be traced by means of a soil bore.

The quantity of water to provide depends on the following factors:
- the type of soil: e.g., sandy soil retains less water than heavier soils and also reduces the capillary action of rising groundwater.
- the greenhouse climate: e.g. high greenhouse temperatures and a low RH will increase the transpiration of the crop.
- cultivar: leaf mass varies from cultivar to cultivar, and this will have an impact on transpiration.
- crop's development stage: the rate of transpiration changes according to the crop's stage of development
- the salt level of the soil: a higher salt level reduces the plant's water absorption. In such a situation,

be careful not to let the soil become excessively wet. (The soil should have been leached in advance!)

During dry periods, water consumption in lilies can reach 8 to 9 litres/m²/day. To see if the correct quantity of water is being provided, do the following test: squeeze some soil tightly in your hand. If the moisture in the soil almost but not quite drips from your hand, this indicates the proper degree of moistness. Also check the water distribution of your irrigation system on a regular basis.

It is preferable to irrigate early in the morning so that the crop will be dry before evening. If necessary, provide additional heating or ventilation to prevent damage due to *Botrytis*. Use rainwater instead of well water. Well water often contains calcium carbonate, magnesium carbonate or iron; these substances will leaves spots on the leaves. When using a low level sprinkler circuit, it is preferable to apply liquid fertilisers and crop protection agents since these leaves less residue behind! After applying fertilisers, rinse the crop off.

4.10 Weed control

Previous to planting, weeds can be controlled mechanically or chemically. Weeding, hoeing or disinfecting the soil (by steaming, solarisation, or flooding) previous to cultivation are preferable methods. Either pre-emergence or post-emergence chemical weed control by means of spraying chemical weed control agents that are permitted at the grower's location is another possibility. Spray according to current recommendations.

The best way to control weeds after planting is by weeding. A lily crop is extremely vulnerable and, depending on other conditions, can be quickly damaged by a post-emergence application of a chemical control agent. Be extremely careful in applying chemical weed control agents. If in doubt, conduct a test by spraying on a small surface to see how the lily plants react. Use chemical weed control only when really necessary.

weed control important!

4.11 Crop control

Frequent crop control, which also includes checking the soil, is absolutely essential. To be noted are:
- soil: dry spots, wet spots, EC, structure, weed growth, temperature
- crop: crop condition, colour, aphids, thrips, leaf nematodes, Botrytis, Phytophthora, Pythium, Rhizoctonia and Fusarium oxysporum.
- greenhouse: climate, light conditions, staking.

Chapter 5 – Greenhouse environment

5.1 Temperature

To obtain high-quality lily products, proper rooting is absolutely essential. To attain this, it would be best (and therefore worth recommending) to maintain a low temperature (10 to 12°C) for two to three weeks following planting (at least until the stem roots have developed). Lower starting temperatures will unnecessarily extend cultivation time whilst temperatures exceeding 15°C will reduce the quality of the product.
Soil cooling can prove its worth during warmer months. After this time, cooling should be cut back gradually over a period of one to two weeks.
During the rest of the cultivation period, the following temperatures should be maintained for each group in order to obtain optimum quality.

5.1.1 Asiatic and LA hybrids

To obtain the best possible quality, a 24-hour temperature of 14 to 15°C should be maintained. During the day, the temperature may be allowed to reach 20 and even up to 25°C due to incoming sunlight; at night, the temperature can drop to 8 to 10°C (but be sure not to let the RH become too high). This method can save on energy consumption during the spring and autumn seasons yet not have any adverse effects on crop quality and growth rate.
When growing shorter cultivars and when growing during dark periods, it would be advisable to lower the 24-hour temperature from 14 to 15°C by 1 to 1½°C in order to promote stretching and prevent bud drop.

5.1.2 Oriental, OT and OA hybrids

Following the rooting period, the most beneficial greenhouse temperatures are 15˚C at night and 15 to 17°C during the day. The temperature during the day may be allowed to reach 20 to 25°C due to incoming sunlight. OT hybrids can more easily tolerate somewhat higher temperatures. Temperature fluctuations exceeding 10 - 12˚C between day and night temperatures should be avoided in order to help prevent bud deformities. Temperatures below 12°C can lead to leaf drop and leaf yellowing.

5.1.3 Longiflorum and LO hybrids

The best greenhouse temperature for these lilies after the rooting period is a 24-hour temperature of 14 to 16°C. During the day, the temperature may be allowed to reach 20 and even up to 22°C due to incoming sunlight. During darker periods, the greenhouse temperature can be reduced by 1 to 1½°C.

Due to the occurrence of “split calyxes”, a day and night temperature of at least 14°C should be maintained. Split calyxes occur during the autumn and winter when the greenhouse temperature is too low during the period just following planting (the time at which flower initiation takes place). In split calyxes, one of the six petals is missing or deformed. As a result, the trumpet-shaped flowers they produce split along their length.

5.1.4 General information regarding temperature

It is usually no problem to maintain the indicated temperatures during late autumn, winter and early spring. The summer, however, is another story. This is when the temperature will have to be kept as close as possible to the advised temperatures by means of ventilation, shading and the application of cold irrigation water both before planting is done and during cultivation. High temperatures will result in a shorter crop, fewer flower buds per stem, and an increased risk of diseases and physiological disorders.

5.1.5 Negative DIF

Lilies produced under low-light conditions (e.g., late autumn, winter and early spring) can grow too tall and become limp. To limit this vertical growth, it is possible to provide somewhat less water once the bulbs have developed roots. Another measure to enhance sturdiness is to adjust the fertilising regime: provide somewhat more phosphorus and somewhat less nitrogen. Finally, it is also possible to adjust the DIF to limit the height of the crop. DIF is the difference between day and night temperatures. A negative DIF indicates that the night temperature is higher than the day temperature. (A positive DIF indicates that the day temperature is higher than the night temperature.) In many crops, including the lily, a negative DIF will promote the cultivation of shorter sturdier plants. (A positive DIF will promote tallness and, under low-light conditions, a less sturdy crop.) Maintaining a night temperature of 18 - 19˚C and a day temperature of 14 - 15˚C (i.e., a negative DIF of 4˚C) will result in a shorter sturdier crop.

5.2 Relative humidity

The relative humidity in the greenhouse should be kept at 70-80%. It is also important to prevent sharp fluctuations in the RH and to have any changes occur gradually. Rapid changes will cause stress and can produce leaf scorch among susceptible cultivars and when using large bulb sizes. Properly applied cultivation procedures (as described previously), along with screening, and prompt ventilating and watering are measures that should be used to prevent these problems.

On extremely hot days or extremely cold days (freezing cloudless weather) when the RH outside is extremely low, rapid ventilation during the day should not be conducted. It would be better to ventilate early in the morning when the RH outside is higher. Providing a substantial amount of water during the day when the greenhouse climate has a low RH would not be advisable either; here again, the right time to water would be early in the morning.
Mild, dark, windless and/or humid weather will often result in a very high RH in the greenhouse that will necessitate taking measures such as simultaneous heating and ventilating.

5.3 Ventilation

Ventilating is a very important way to control temperature and lower the RH. A grower will have to be careful when ventilating, however, to keep the RH in the greenhouse from dropping too quickly; such rapid removal of moisture can lead to leaf scorch and a reduction in quality.

5.4 Screening

The use of screens can control the temperature, relative humidity and light intensity in the greenhouse. During months of high light intensities, the temperature in the greenhouse can become excessively high in spite of ventilation. To prevent a reduction in crop quality and height, these circumstances call for shading. (For more information, see the sections on screening equipment and lighting equipment in Chapter 2.)
During the summer months when high light intensities are common, shading to reduce this intensity by 70% can be applied for the first two to three weeks. This can be done when producing cultivars

from any group. After this period, the light intensity can be cut by no more than 50%.

5.5 CO_2

CO_2 can have a beneficial effect on the growth and flowering of Longiflorum and LA hybrids. A target concentration would be 800 but not exceeding 1000 ppm. If growers already have a way to provide CO_2, they can do so, but taking extra measures to achieve this would not be immediately necessary.

5.6 Duration of greenhouse period

The length of time required from planting to harvesting is difficult to predict. It depends on several factors such as cultivar, time of year, how long the bulbs have been cooled, and greenhouse temperature. There are also differences between cultivars within the same group. It is for these reason that such a wide range of time is indicated. The number of days was based on the previously given optimum day/night temperatures although it will not be possible to adhere to these during warm periods (and in this case, the greenhouse period will be shortened).

Table 9. The duration of the greenhouse period for the various lily groups over the seasons.

Group	Greenhouse period in days		
	Spring	Summer	Autumn/Winter
Oriental hybrids	90 - 135	75 - 100	80 - 120
Asiatic hybrids	60 - 105	60 - 75	50 - 90
Longiflorum hybrids	80 - 110	70 - 100	70 - 95
LA hybrids	65 - 110	70 - 80	55 - 95
LO hybrids	75 - 105	60 - 90	65 - 90
OT hybrids	90 - 125	60 - 90	90 - 110
OA hybrids	80 - 125	60 - 90	70 - 110

Chapter - 6 Other cultivation systems

6.1 Box cultivation

Forcing lilies in boxes is becoming more and more common, both in the Netherlands and in other countries. The reasons for this are:

- an improvement in crop quality. This is especially so in regard to the Oriental hybrids. One of the factors in this is that tray cultivation makes it possible to control the pH of the substrate to 5.0-6.5.
- less risk of disease due to the use of fresh substrate (e.g. peat or coir potting soil) that has the right structure (good water/air balance) as a planting medium
- the possibility of increasing the mechanisation of cultivation
- the possibility of integrating this cultivation into a more environmentally responsible cultivation system.
- when using a rooting room, this cultivation system provides the following advantages:
    - during the summer: an increase in crop quality, including longer stems, due to the low starting temperature (makes the summer cultivation of ‘Star Gazer’ , etc.)
    - reduces the greenhouse period: this allows making more efficient use of the greenhouse and saves on energy consumption during the winter.
    - enables a distribution of labour and an improvement in labour conditions

- enables cultivation scheduling
- enables mechanisation
- lightens the physical labour involved in planting.

In addition to these advantages, this cultivation method also involves higher investments.

Box cultivation

6.1.1 Rooting medium

The best kind of substrate to use in boxes would be a good moisture and air retentive medium. A commonly used substrate is potting soil: a mixture of peats sometimes combined with Perlite (fluorine-free!) or sterilised rice hulls or garden mould. Effective peat mixtures that are often used in lily cultivation are 40-80% year-old, properly frozen black peat + 60-20% peat litter (white peat type). The pH will have to be adjusted to 5.0-6.5 for Oriental, OT, LO and OA hybrids and to 6.0-7.0 for the other groups. The rule of thumb is that to increase the pH by a factor of 0.4, around 1 kg of calcium carbonate will have to be added to every cubic metre of potting soil mixture. A basic dressing of 0.5 kg. of 12-14-24 compound fertiliser including trace elements should be added to every cubic metre of potting soil mixture.

If the potting soil will be reused for future cultivation periods, it will have to be disinfected by steaming or the application of chemical agents before this reuse. Next, it should be mixed with fresh potting soil until it reaches the original volume. This procedure will prevent a reduction in crop quality due to soil structure and disease problems. The potting soil should be fairly moist during planting.

6.1.2 Planting method

Commonly used for forcing boxes are the lily/tulip storage containers that have a minimum inner depth of approx. 12-14 cm. The bulbs should be planted with at least 1 cm. of potting soil under the bulb and 8 cm. on top of the bulb. It should be remembered that the thicker the layer of soil, the greater the water buffer during cultivation. The soil layer beneath the bulbs is of less importance and serves mainly to support the bulbs during planting for proper distribution over the surface. The noses of the bulbs on the perimeter of the box should be pointed slightly inward to prevent shoots from growing through the sides of the box. Once the plants start to emerge, they automatically distribute their growth over the entire box.
Cultivars chosen should be the shorter varieties. To preserve the boxes, they are placed somewhat apart from each other. This means that the planting density in the box will have to increased.

Planting in boxes

6.1.3 Rooting room

Once planted, the boxes can be put immediately into the greenhouse or stored for one or more weeks in a refrigerated storage room.

Storage:

To distribute labour, the bulbs can be planted during otherwise unremunerative hours and then put into storage at -½ to 2˚C for up to 6 weeks. This will keep the shoots from developing to any degree. The higher the temperature during this storage, the faster development will occur.

Once the bulbs are in boxes, they can also be placed in the rooting room where they will be pre-forced at 10 to 12˚C for 2 to 3 weeks. The emergence of shoots from freshly harvested bulbs (frozen in for up to 5 months) is slow (three weeks). Shoots from bulbs stored for a long period (more than 5 months) will emerge in 2 weeks.

Storage longer than the indicated 6 weeks will later increase the risk of a reduction in quality and fewer buds.

Rooting:

After storage (or immediately after planting), the ideal temperature for an excellent, problem-free development of bulb and stem roots is 10 - 12˚C. Once the stem roots have developed (approx. two to three weeks after planting), the boxes can be placed in the greenhouse. At this time, the visible shoot should be no taller than 8 to10 cm. If this is the shoot growth expected, the boxes should be stacked accordingly. Certain guidelines for the refrigerated storage room / rooting room are:

- ensure a uniform temperature throughout the room
- arrange the boxes in such a way that air can circulate easily around them
- check the shoot length regularly. Do not allow the shoots to grow up into the bottom of the box above. If necessary, reduce the temperature to prevent this.
- do not let the substrate in the boxes dry out. If necessary, sprinkle some water on the floor.
- pay special attention to the boxes under the humidifier since these will dry out faster.

6.1.4 Cultivation procedures

Make sure that the soil on which the boxes are placed is level. Make sure that the soil beneath the boxes has an open structure so that drainage water can escape and no puddles can form. Wet spots beneath the boxes can lead to losses from Fusarium oxysporum and Phytophthora. Once the boxes have been placed in the greenhouse, watering them will require extra attention. This is because the soil in the boxes will dry out faster here and thus require more frequent watering. The outer boxes in particular can dry out faster than the others. Keep the soil constantly moist. Drip irrigation systems such as an in-line system can prove very worthwhile in this regard. The other cultivation procedures are the same as for producing in the border soil of the greenhouse.

6.2 Pre-rooting and pre-sprouting

"Pre-sprouting" is the term used for allowing the delivered boxes filled with lily bulbs to remain undisturbed with the plastic open for a few days at 10-12˚C. This gives the bulb roots and stem roots a chance to start growing. Plant the bulbs before the length of the shoots exceeds 5 cm.

Pre-rooting is a method used when producing during warmer seasons or in warmer climates (including Italy and Japan). A 1 to 2-cm. layer of potting soil is placed in the boxes, and the lily bulbs are placed in a single layer, touching one another, on top of this layer of potting soil. The bulbs are then covered with a thoroughly moistened layer of potting soil approximately 8 cm. thick and placed in a rooting room maintained at 10 - 12˚C for two to three weeks until the stem roots start to develop. Be sure to leave enough space between the boxes. The method of stacking the boxes or the use of additional legs between the boxes can prove helpful in achieving this. Once the stem roots develop, care should be taken when planting the lilies in the border soil of the greenhouse. Another thing to consider when planting, especially once the stem roots have already developed, is that the soil must not be lumpy. Eliminating clods will reduce the risk of damage caused by Rhizoctonia solani because the shoot will not come into contact with greenhouse soil that might be contaminated with this fungus.

Pre-sprouting

6.3 Outdoor cultivation

Lilies can also be planted outside for one-year or multi-year cultivation. If using the latter approach, or when re-using cultivars, the grower will have to pay license fees for any cultivars protected by breeders' rights when using then for another year of cultivation. Be sure to consult your supplier about this.

The results obtained from outdoor cultivation depend very much on weather conditions, type of soil (heavier soils produce shorter stems), cultivar selected, bulb size and the availability of a shading system. The choice between one-year or multi-year cultivation depends on these factors:

- type of soil (light soils limit bulb growth)
- whether the winter period is long enough (14-16 weeks) to provide a break in dormancy
- whether or not there are risks associated with ground frost
- the price of the bulbs: without a cultivation schedule, it could save money to plant new bulbs each year if using cheaper cultivars.
- the assortment: not all cultivars (including short cultivars and ones susceptible to Botrytis) are suitable for this purpose. Consult your supplier!
- bulb size: for proper growth in succeeding years, the bulbs selected must be sufficiently large to begin with. Oriental hybrids must be at least 16/+ and preferably 18/+.
- the distribution of forcing periods without a cultivation schedule: it should be remembered that the

flowering of all lilies being reused for cultivation will occur at practically the same time.
- more labour will be needed for grading due to the greater differences in stem size caused by the development of “double-nosed” bulbs during cultivation.
- The planting density. The bulbs will be larger during their second year. They will then need more space, but will this space be available?

Harvesting outdoors

6.3.1 Planting time

Planting should start in the spring at a time when severe ground frosts are no longer expected. The last planting date depends on the local climate during the cultivation period. For Asiatic, LA and Longiflorum hybrids, harvesting should be done before the average 24-hour temperature drops below 11°C; for Oriental, OT, LO and OA hybrids, this would be 13°C. From experience, we know that bulbs to be used for multi-year cultivation should be planted in the spring since this improves crop quality during the second year. However, planting can be done in the autumn if the plants will not be subjected to any chance of frost damage during the winter and will not be subjected to ground frosts after emergence in the spring. Once emerged, lilies planted in dry soils can suffer damage from even a light ground frost (-1°C or colder). This is why it is important to keep the soil moist and to water lily plants during periods of ground frosts. If the green parts of the plant freeze during a ground frost, water should continue to cover these parts of the plant until they are entirely thawed. In spite of sprinkling, damage cannot be avoided if temperatures drop to -5°C.

6.3.2 Planting method

If a cultivar is not susceptible to leaf scorch, larger bulb sizes (for greater stem length) are preferred. The same applies to multi-year cultivation; this assures the grower of good quality even in succeeding years. If the bulbs are planted during warm weather, there will be more chance of double-nosed bulbs next year. (This depends on cultivar and bulb size and this is particularly the case when using large bulb sizes.) Double-nosed bulbs produce two stems but they are of considerably inferior quality.

For outdoor cultivation, bulbs should be planted so that they will be covered with 10-15 cm. of soil. Planting density depends on the number of years the bulbs will be in cultivation. For one-year cultivation, this should be 10% higher; for multi-year cultivation, it should be reduced by 15-20% from what is indicated in Table 5 for this cultivar, bulb size and greenhouse cultivation season.

6.3.3 Other cultivation procedures

Nutrition for field cultivation is the same as for greenhouse cultivation. If it is not possible to administer fertilisers by means of a sprinkler circuit during cultivation, a greater quantity of fertiliser should be applied as a basic dressing or a slow-release fertiliser should be used (on the condition that the salt content of the soil allows this).

To promote stem length and improve the crop quality of field-produced lilies, the use of 50% shading is highly recommended. This is especially important during the first eight weeks or until the buds become visible. Throughout cultivation, much attention will also have to be devoted to disease control, particularly Botrytis fungus, aphids and viruses. Two factors that will determine the financial results for multi-year cultivation are state of the crop's health and the demand for the selected cultivar. If there is no demand for the cultivar, cultivation will have to cease. For more cultivation procedures, see chapters 3 and 4.

6.4 Net house

As mentioned previously, a net house preferably approx. 4 metres in height offers the potential for summer cultivation or cultivation located at a high enough elevation in a subtropical climate. This gives the grower a way, other than using a glass or plastic greenhouse that includes a shading system, to prevent or limit having the lilies subjected to excessively high temperatures (> 25˚C) over prolonged periods. A net house also offers better means of ventilation because it can be opened on the sides. This improves the quality of the product: brighter colours and heavier stems. The shading percentage is the same for cultivars in all lily groups: 50%.

In the Netherlands (i.e., under Dutch climate conditions), growers also use net houses in the spring; these are moveable and, because they are only approx. 2 metres tall, they are cheaper. Once the buds become visible, the net house is removed. By that time, the objective of good rooting and sufficient stem length has been achieved. A combination of forcing in boxes, including the use of a rooting room and using a net house usually makes a substantial improvement in the quality of lilies produced during the summer.

In climates where light intensities fluctuate during the spring and autumn, a net house with a retractable shade is recommended. This offers a way to reduce or stop shading during darker (< 300 Watt/m²) conditions. This will then prevent flower bud desiccation and flower bud drop, particularly once the buds are easily visible (0.5 – 1 cm). During periods of high light intensities (>600 Watt/m²), particularly when the temperature exceeds 25˚C, total shading can be applied whilst leaving a chink open for the release of excess heat. During the first two or three weeks after planting, this will make it easier provide the shade needed to keep the soil temperature low (preferably 10-12˚C) during sunny weather. Gradually changing the percentage of shading will help to prevent sudden climate changes in the net house and thus avoid leaf scorch.

The use of a net house also has other advantages as opposed to a completely outdoor cultivation since it can prevent damage due to wind and hail and reduce frost to approx. 3˚C. The choice of shading material is also important: meshes that are too coarse will provide little protection against frost whilst meshes that are too fine will promote the risk of *Botrytis* damage.

Different net house constructions

6.5 Pot lilies

Besides using lily bulbs to produce cut flowers, they can also be used to produce pot plants for applications inside the home, on the balcony, in the garden or as a graveside planting. Until not too long ago, the somewhat shorter lilies usually used for cut flower cultivation were used to produce pot lilies. Then came the application of growth regulators such as paclobutrazol (Bonzi) and ancymidol (Reducymol). They could be applied by adding them to the irrigation water and then watering the pot, by spraying them onto the foliage, or by immersing the bulbs in a solution. In this way the plants could be kept short (optimum stem length: 30-40 cm.). But the results were highly unpredictable due to many other factors: cultivation period, the substrate used, cultivation temperature and cultivar characteristics. Nowadays, there are many genetically short lilies (including the Asiatics and certain dwarf Oriental hybrid cultivars) available in many colours that require no growth regulators. Cultivation varies little from that of cut flower cultivation. A few specific cultivation procedures are described as follows.

6.5.1 Planting method

Various bulb sizes can be used for pot plant cultivation. Optimum bulb sizes, although also dependent on the cultivar's total volume of foliage, are given in the following table. The table shows how many bulbs should be planted per pot for the various lily groups. The choice of bulb size should be such that the total number of buds/pot meets the minimum requirement listed in the table. Table 11 also indicates which bulb sizes/pot size can be used when planting 1, 3 or 5 bulbs/pot.

Table 10. Optimum plant sizes for pot lilies per pot when planting 1, 3 or 5 bulbs, including the minimum number of buds/pot.

	Bulbs/pot	**Buds /pot**
	1 bulb/pot	
Asiatic hybrids	14/16 and 16/18	5-7
Oriental hybrids	16/18 and 18/20	4-5
'Star Gazer'	14/16 and 16/18	3-5
Longiflorum hybrids	14/16 and 16/18	3-4
	3 bulbs/pot	
Asiatic hybrids	11/12, 12/14 and 14/16	10-20
Oriental hybrids	12/14 and 14/16	5-10
'Star Gazer'	12/14 and 14/16	6-10
Longiflorum hybrids	12/14 and 14/16	6-10
	5 bulbs/pot	
Asiatic hybrids	14/16 and 16/18	25-35
Oriental hybrids	14/16 and 16/18	10-25
'Star Gazer'	14/16 and 16/18	15-25
Longiflorum hybrids	14/16 and 16/18	15-20

Table 11. Usable bulb sizes for various pot sizes

Pot size (ø)	**Bulbs/pot**	**Bulb sizes (cm)**
10 cm	1	12/16
12 cm	1	12/+
13 cm	3	12/14
15 cm	3	12/16
17 cm	3	14/+
19 cm	5	14/+

When planting Longiflorum hybrids or any cultivars with double-nosed bulbs for cultivation during the summer and autumn, a larger bulb size should be used. The substrate in the pot should be pathogen-free, moisture retentive but also air-permeable, and have a pH of 5.0-6.5 for Oriental

hybrids and 6.0-7.0 for Asiatic, and LA hybrids. Potting soil (see "cultivation in boxes" and "substrate") with a 30% addition of sand or fluoride-free Perlite is a good choice. As a basic dressing, use 1-1.5 kg Osmocote 14-14-14 and 1 - 2 kg potash magnesia sulphate per m^3. The bulbs should be planted in the pot on top of a layer of potting soil 1 cm thick. If more than one bulb is being planted per pot, the noses should be pointed toward the closest side of the pot. Then fill the pot with potting soil. After planting, thoroughly moisten the substrate in the pot.

6.5.2 Cultivation procedures

Keep the substrate in the pot fairly moist. Leaf scorch can occur during cultivation due to cultivar-specific susceptibility, not enough light (i.e., too many pots/m^2), excessively wet cultivation conditions, or damage due to Pythium.

For the desired greenhouse climate, refer to Chapter 5. Research has shown that using the negative DIF method (maintaining a night temperature warmer than the day temperature) can reduce stem length. If feasible, it is also possible to reduce the day temperature (negative DIF) as opposed to the night temperature. This reduces the 24-hour temperature, so this might mean a longer greenhouse period. A reduction of the day temperature during the first two hours after sunrise (morning temperature drop) will have a significant impact on stem length (reduction) in comparison with the same reduction throughout the day. In applying this concept, it should be remembered that for plants, the day begins at sunrise and ends at sundown, but another factor to be considered is fluctuation in climate conditions. Sprinkling with cold water (2 - 10˚C) will also shorten the stem length of Asiatic and Longiflorum hybrids. Trial and error is recommended.

6.5.3 Harvest and post-harvest activities

Pot lilies can be sent off for distribution once the lowest buds are displaying sufficient colour. The distribution chain should be as short as possible in order to prevent bud drop due to lack of light. Shipping these lilies off in an earlier stage of development is unacceptable due to their heightened susceptibility to damage from lack of light. To present these products successfully, it is important to take the following steps before they leave your facility: provide the pot with sufficient water, make sure the pot is clean, remove any yellow leaves, provide the pot with a label that includes product information and consumer tips, and package it in an attractive sleeve. To prevent bud drop, the cold storage of pot lilies should be avoided or kept to a minimum. The temperature maintained during cold storage or during transport should be no colder than + 5°C for most hybrids (Asiatic hybrids may be stored at +3°C). Although flower development will not be halted at these temperatures, lower temperatures will have an adverse effect on the proper opening of the buds after purchase by consumers. To prevent bud drop, the lilies should also receive sufficient light during the selling phase

Chapter 7 - Harvesting and post-harvest treatment

7.1 Flowering and harvesting

For lilies to flower attractively after purchase, it is very important to harvest them when they are sufficiently but not overly mature. The earliest harvest stage for stems with five to ten buds is when at least two but fewer than five buds display colour. Harvested when less mature, the plants will produce small pale flowers and not all buds will open. The failure of buds to open can also be caused by a shortage of water at the end of cultivation. Such a shortage of water will have an adverse effect on the continued growth of the buds and on flowering in the vase. It is thus important to keep providing enough water right up until the end of cultivation!

Harvesting when overly mature, i.e. once a few buds are already open, will cause problems during processing and the distribution process. These problems are stains due to pollen, the bruising of petals, and the rapid maturing of buds and opened flowers resulting from the ethylene produced by previously opened flowers. Remove open flowers as necessary.

Harvesting the stems by cutting them is preferable to pulling. Pulling greatly damages the roots attached to surrounding plants. If a support mesh has not been used, the plants can even fall over. Due to the extensive root development typical of Oriental, OT, OA, LO and Longiflorum hybrids, their stems cannot be pulled. It is better to harvest lilies in the morning to prevent desiccation. For the same reason, limit dry storage in the greenhouse to no more than. 30 minutes.

Harvesting flowers

7.2 Product cooling

Following the harvest of flowers in the greenhouse, the product temperature should be brought to the optimum storage temperature as quickly as possible and maintained throughout processing, shipping and distribution. This is necessary to limit desiccation and bud development. For this reason, take the flowers to the cold storage room as quickly as possible following harvest and keep them there in containers filled with clean water for at least 3-4 hours (no longer than 48 hours) at a room temperature maintained at 1-2°C. Once the product temperature reaches 1-2°C, processing may begin.

At many cultivation facilities, harvesting is immediately followed by bunching, sleeving and placing in water-filled containers kept in a cold storage room. This processing method will not slow down the product-cooling process as quickly as the first mentioned method. During warm weather, the use of pre-cooled water is recommended; this keeps the flowers from maturing so quickly.

Pre-treatment agents such as silver thiosulphate + GA_3 (e.g. 6 ml of Chrysal A.V.B. + 1 tablet of S.V.B. for each 3 litres of water) should be added to the water used for Asiatic and LA hybrids. This improves the keeping quality of these lilies by making them less susceptible to damage by ethylene during the distribution process. The solution can become cloudy but can still be used for up to one week. Using silver thiosulphate for lilies from the other groups can damage them.
When placing lily stems in water, use only properly cleaned containers. This will prevent the growth of bacteria in the water and then inside the stem. When this happens, the absorption of water by the stem is reduced or even blocked entirely

pre-watering

7.3 Brown spots on buds

During the summer months or during periods of high outdoor temperatures, the outer sides of the petals on Oriental and OT hybrid cultivars, and particularly 'Star Gazer', can display brown spots. The most common cause of this problem is that the temperature of the product was reduced too quickly during post-harvest cooling. To prevent this, harvest early in the morning on very hot days and then put the stems in water-filled containers in the processing room for a few hours to let them acclimatise. Next, place them in a cold storage room at a temperature not lower than 6˚C. Temperatures lower than this will dramatically increase the risk of brown spots.

7.4 Grading and bunching

Following product-cooling, the stems are graded according to their number of flower buds, length, the sturdiness of the stems, and any disorders affecting leaves and flower buds. The lily stems are then bunched, part of this process including the trimming off of the lower 10 cm. of stem. This can be done by hand or by using a special leaf-stripping machine. Stripping the leaves improves product presentation and, because it reduces the build-up of bacteria in the water, it improves the keeping quality of the lily stems. Processing also includes the removal of any yellowed and damaged leaves. After bunching, the stems are cut to equal lengths and then wrapped in sleeves that protect both the flower buds and the leaves. To substantially reduce processing time, grading and bunching can also be done mechanically on a flower processing line. And keeping processing time to within one hour will prevent desiccation of stems keep the product temperature from rising. Another point to remember is that people operating a flower processing line must be able to do so ergonomically.

7.5 Storage

After grading and bunching, the lilies can be stored in the cold storage room without placing them in water. The best storage temperature for cut lily stems (except for some, such as 'Star Gazer') when harvesting takes place under warm weather conditions is 1 to 2°C. In addition, storage should always be kept as short as possible since the best storage period is always the shortest.

7.6 Dispatch

Lilies should be shipped in perforated boxes. The perforations are necessary to prevent the accumulation of excessive concentrations of ethylene, a hormone produced by the opened flowers themselves. This hormone causes acceleration in maturation that leads to tightly squeezed buds, bud drop and reduced keeping quality. To prevent the premature forcing of flowers and the development

of fungi, make sure when packaging that the product goes into the box dry. Low transport temperatures (preferably cooled to between 1 and 2°C) are necessary for lilies to prevent flower bud development as well as the adverse effects of ethylene.

For a lengthy period spent in transport, it would be highly advisable to pre-cool the boxes before they are dispatched.Upon arrival at the wholesaler and/or retailer, the lilies should again be trimmed, placed in clean water, and stored at 1 to 5°C.

Chapter 8- Planning and labour

8.1 Planning

Planning is necessary in order to obtain optimum growing, cultivation and commercial results. In this regard, a thorough preliminary examination of sales potential and the expected pricing is extremely important. In general, it can be said that a regular supply of flowers in various colours will create a good sales market. Nevertheless, it will still be advantageous to have more flowers in cultivation during times of high demand. This makes a properly considered plan essential. Other reasons for having a good plan are that it makes it possible to determine the right delivery date for the bulbs, to keep the greenhouses from being empty unnecessarily, and to distribute labour as evenly as possible over the year.

For a good plan, it is necessary to create planting schedules 1½ to 2 years in advance. By planning this far ahead of time, the grower can also be assured of receiving cultivars that are stocked in limited quantities. Creating planting schedules requires data, and the data available from the grower's own company is very useful for this. Data necessary for a drawing up a worthwhile plan and achieving effective operations can be accumulated by means of a registration system.
Important data needed for planning are:
- the net house area available (or, for outdoor cultivation, the net available ground area)
- the cultivar, the length of its cultivation period, its cultivation characteristics, and whether it is available and can be produced year round
- how long the bulbs can be stored; newly harvested bulbs will emerge more slowly (approximately two weeks later) and more unevenly than bulbs harvested longer ago
- when to apply a general soil treatment (if necessary) and how long this will take
- time needed to prepare the soil for planting
- planting date
- planting density
- desired cultivation temperature
- last day of harvesting
- availability of required labour
- expected financial yield

8.2 Labour requirements

Having information about labour requirements for cultivation, particularly in regard to the various cultivation activities, is important when creating a plan. Table 12 provides some information about this.

Table 12. Labour requirements and cultivation activities for Asiatic, LA and Oriental hybrids in percentages/1000 m² of greenhouse space under Dutch conditions.

Cultivation activities	Asiatic and LA hybrids	Oriental hybrids	Oriental hybrids
Cultivar: e.g.	Brindisi	Sorbonne	Robina
	%	%	%
Soil preparation	5	4	4
Planting	15	13	13
Crop care	10	10	12
Harvesting and processing	53	60	58
Shipment, clearing up greenhouse	17	13	13
Total % , total number of hours	100 275/345	100 310/380	100 345/420
Number of bulbs/cultivation period	52,000/72,000	44,000/56,000	21,000/31,500

Around 50 to 60% of labour is taken up by activities performed during and immediately after harvesting. This means that distributing the harvest is also important to prevent excessively high labour peaks. Using a flower processing line will save around 15% on labour for harvesting and processing.

Chapter 9 – Crop protection and diseases

9.1 General soil treatment

The soil should be free of pathogens. This can be achieved by maintaining optimum cultivation conditions during cultivation and by using crop rotation. Should soil pathogens nevertheless prove to be a problem, a general soil treatment can be conducted once a year. Steaming, flooding and solarisation are the options for soil disinfestation.

9.1.1 Steam sterilisation

The factors in effective steam sterilisation are temperature, duration and concentration. For steam sterilisation, a temperature of 70-80°C has to be maintained for at least an hour at a soil depth of 25-30 cm. Steaming with pressure from below is more effective for the control of pathogens than steaming with pressure from above. The soil to be steamed has to be dry. Steam sterilisation will control almost all soil-related problems except for Pythium which will usually remain only partially controlled. A supplementary chemical treatment would be advisable. Steaming soils containing silt that have a low pH can result in an excessively high uptake of manganese by the crop. This can be

minimised by a brief steaming of dry, air-permeable soil that has previously been limed to increase the pH.

steam sterilisation

9.1.2 Inundation

Flooding the greenhouse soil (i.e. inundating it for 6 weeks) effectively controls a number of soil fungi, nematodes and perennial weeds. This method is particularly effective in controlling Botrytis, a fungus that is a great threat to lily flower cultivation. By flooding, soil that contained these fungi will again be made suitable for lily cultivation.
Unfortunately, however, flooding does not provide sufficient control of Rhizoctonia solani and Pythium fungi. Because these soil fungi will then have less competition following flooding, they can sometimes return in increased numbers.

inundation

9.1.3 Solarisation

In regions subject to high temperatures for part of the year (during the summer months), soil

disinfestation can be achieved by means of solarisation. This involves covering the greenhouse soil for 6 to 8 weeks during the hottest time of the year with transparent plastic film (0.5 to 1 mm thick, preferably treated to reduce UV radiation). Using two layers of plastic with air between them helps to increase the temperature. The soil should be level, free of clods, and very wet. Any holes discovered in the plastic should be sealed as quickly as possible. If using this method in the field instead of in the greenhouse, plastic having a thickness of 2-3 mm can be used to prevent damage from wind or other causes.

After solarisation, as well, the greatest of care should be taken to prevent the return of pathogens, particularly soil fungi. Proper greenhouse hygiene and the application of an additional soil treatment will help in this regard!

9.2 Additional soil treatment

Pythium fungus will return so quickly that a general soil treatment once a year will not be enough to control it. This means that an additional soil disinfestation will have to be conducted previous to each planting.

These agents should be mixed evenly through the upper 10-20 cm of soil. When applying by hand, this uniformity can be promoted by first adding sand to the agent. When using the spray method, uniformity can be encouraged by using lukewarm water and a spray nozzle with large holes. In both cases, the agent should be tilled thoroughly into the soil after application. For soils susceptible to structure damage, the agent should be spaded into the soil, to a shallow depth, followed by a light tilling.

> Be aware that most fungicides cannot be applied by using a sprinkler system. For more information regarding the use of the proper agents and how much of them to use, we refer you to your local professional or supplier.

Potting soil can also contain Pythium fungi. Their occurrence will only be sporadic when using fresh potting soil, but the risk is much greater in previously used potting soil. This can be controlled by treating the potting soil with the appropriate fungicide previous to planting. If needed during cultivation, one of these agents such as Aliette can be applied by means of the sprinkling system (see “root rot”).

When producing in boxes filled with potting soil, this potting soil is steamed after each cultivation period and used again without the addition of control agents.

9.3 Bulb treatment

Bulb disinfecting immediately before planting is not used in lily cultivation because this procedure has already been conducted by the supplier previous to packing. For this reason, bulb disinfecting is not addressed here. If you have any questions, consult your supplier.

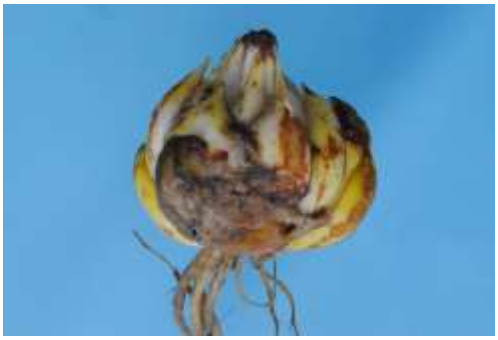
9.4 Diseases caused by fungi

9.4.1 Bulb rot, scale rot and stem spot disease

Bulb and scale rot: Depending on the degree of infestation and the optimum conditions during cultivation, the shoot will fail to emerge or, if it does, the plant will be short, weak and pale green and its buds can desiccate. Slightly or only moderately infested plants will usually produce good results.

Underground, the tips and sides of the scales, as well as where they are attached to the bulb will display brown spots that may later rot (scale rot). If the base plate and the scales growing from the base plate are infested, the disease is referred to as bulb rot.
Stem spot disease: Above ground, this can be identified by the premature yellowing of the lowest leaves that will then turn brown, rot and fall off.
Underground on the part of the stem where the stem roots and underground leaves are attached, orange to deep brown spots appear that will later enlarge and spread to the inside of the stem. Brown discoloration and rotting occur and the plant will die prematurely.


bulb rot


Scale rot


Fusarium stem disease

Cause
Bulb rot, scale rot and stem spots are caused by both *Fusarium oxysporum* and *Cylindrocarpon destructans*. These fungi infest the underground parts of the plants at places where they have been wounded due to the breaking of bulb or stem roots or due to damage caused by other pathogens. Although these fungi could have been present on the bulbs previous to receipt, the bulbs and plants could also have been infested after planting since these fungi can survive for years in the soil. Certain cultivars, and especially the larger bulb sizes of these cultivars, are particularly susceptible to infestation by these fungi.
Infestation does not spread during storage. Conditions that encourage infestation are high soil temperatures, excessively wet soil and excessive fertilising.

Control
- Soil infested or thought to be infested with these pathogens should undergo a general soil treatment for soil disinfestation (see “General soil treatment”)
- Remove bulbs infested by these fungi from the planting material.
- Lots displaying only lightly to moderately infested bulbs should be planted as soon as possible at low soil temperatures. It would be preferable to use these bulbs for planting during December

through March.
- Keep the soil and greenhouse temperature as low as possible during summer cultivation.
- Prevent the soil from becoming excessively wet and do not apply excessive quantities of fertilisers.

9.4.2 Botrytis

Symptoms of *Botrytis* damage can appear on the leaves: grey-brown to dark brown speckles, sometimes with a dark green edge, that measure 1 to 2 mm across. Under moist conditions, the speckles can quickly expand to become larger round or oval sharply delineated spots. These leaf spots can be seen on both sides of the leaves. Sometimes, irregular concentric rings within the leaf spots can be observed. The infestation can begin in the middle of the leaf surface or at the edge where it will be crescent-shaped; the result will be a stunted, malformed leaf. If the leaves are severely infested, the tissue can wither, turn yellow, shrivel and finally become papery. On necrotic tissue, the fungus produces large quantities of light brown to grey-brown spores that easily disperse upon slight contact or falling water droplets. Under the right conditions, the fungus will spread extremely rapidly.

Botrytis can also infest the stems. The exterior layer of the stem turns grey-green to dark brown. The leaves will then yellow, wither and drop off.
Botrytis can also infest flower buds. Buds infested during a very early stage of development display brown raised spots on the outer petals. As they develop, they become malformed and can rot altogether. Flowers that have opened are extremely vulnerable to *Botrytis* damage in the form of greyish, watery-looking, round spots known as “pox”. The common name for *Botrytis* is “fire”.

Infected leaves

Infected buds

Cause

Most “fire” is caused by *Botrytis elliptica*. Under moist conditions, *Botrytis elliptica* generates spores that can spread very quickly to nearby plants when carried by rain and wind. On a dry crop, however, the spores cannot germinate, so this lack of water will keep an infestation at bay. At the end of the season, the fungus on infested and necrotic tissue will form round black sclerotia 2-3 mm in diameter that can survive in the soil for one to two years.

Within the lily assortment, there are substantial differences in susceptibility to this fungus. The Asiatic, the LA hybrids and Longiflorum hybrids are much more susceptible than the Oriental hybrids. Within the Asiatic and LA hybrids, the white and pink cultivars are especially susceptible.

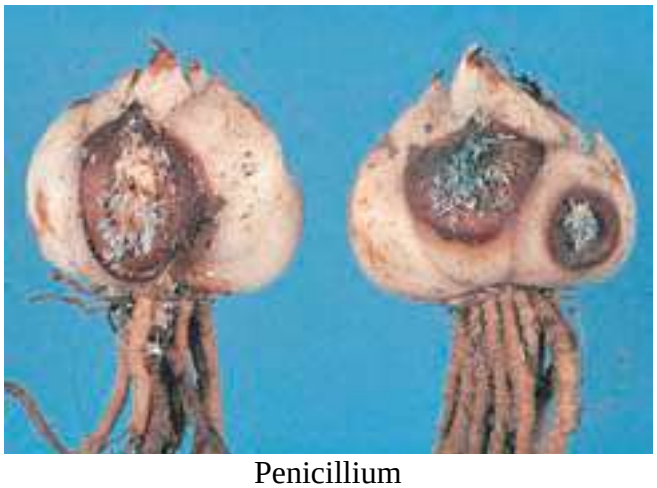
Control
Keep the crop dry by:

- reducing planting density during a period of a high RH
- controlling weeds
- watering the soil in the morning and providing ventilation simultaneously with some heat. The crop should dry off quickly and, in any case, be dry before nightfall.
- not sprinkling during times of little wind or high RH
- preventing condensation in the morning by a starting to increase the temperature about one hour before sunrise.

- If infestation is expected (upcoming period of high RH), fog regularly with alternating Botrytis-controlling fungicides starting in an early stage of development (definitely before the leaf canopy closes).
- Remove infested plants as quickly as possible to reduce the chance of spreading in the greenhouse.
- As the flowering period approaches, a fungicidal smoke agent that leaves no visible residue on the plants can be used.
- Cultivation in a screened greenhouse increases the risk of *Botrytis* infestation; the use of a movable shading system reduces the risk of *Botrytis* infestation.
- Carefully remove crop residues after the completion of cultivation.

9.4.3 Penicillium

Penicillium develops during storage and will show up on the bulb scales as brown rotten spots covered with a white fungal weft that later turns blue-green and is accompanied by masses of spores. Once established, the rot slowly spreads throughout the storage period, even under low temperatures (-2°C). After a fairly lengthy period of time, the fungus can penetrate the base plate, then penetrate other scales and from there penetrate other scales. These scales will then detach from the base plate and no longer contribute to the growth of the plant. This will have a major adverse impact on the growth of the plant. Although slightly infected bulbs look bad, the growth of the plant during cultivation shows few ill effects as long as the base plate remains healthy and unaffected. The disease is not transferred to the stem and is not transferred by the soil.



Penicillium

Cause
The infestation usually comes from *Penicillium* fungi commonly found in the environment and starts during storage when the spores enter wounds in the bulb tissue. An excessively high temperature and an excessively low RH during storage promote the problem. Damage to the bulbs increases the risk of a *Penicillium* infestation!

Control
- If *Penicillium* is found upon receipt of the bulbs, report this to your supplier.
- Keep the bulbs from drying out during storage and processing, and store the bulbs at the lowest possible temperature.
- Do not plant bulbs with infested base plates. Plant infested lots as quickly as possible, preferably from December through March (when they can have a slow start).
- Keep the soil at the proper moisture level before and after planting.

9.4.4 Phytophthora

If infested with *Phytophthora*, the plants will not develop at a normal pace or can suddenly wilt and start turning yellow from underneath. The base of the stem will display a soft rot and be deep green to dark brown in colour, the rot sometimes being purplish-brown and streaking upward to the aerial parts of the plant causing it to bend or fall over. If the plants are infested late in cultivation, they will not fall over but the diseased stem tissue will become desiccated. This results in a hollow interior within which fungal wefts may develop.
Finding this kind of soft rot in the aerial part of the stem is not unusual either; here it is found just beneath the top of the plants that are not completely developed. In this case, the top of the plant turns black. This leads to localised leaf yellowing and/or a bent stem.


Phytophthora

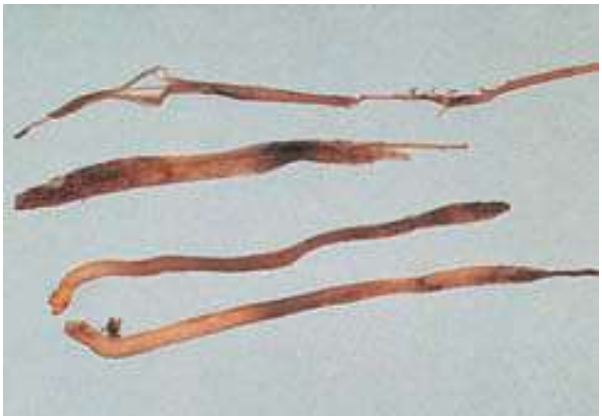
Cause
This disease, also known as foot rot or stem rot, is usually caused by *Phytophthora nicotianae*, a fungus that thrives in moist conditions. But it can also be caused by *Pythophthora cryptogea*. In the Netherlands, *Pythophthora* is unknown in bulb cultivation but can damage many other crops and is thus commonly found in cultivated soils. It is particularly found in soils previously cultivated in tomatoes and Gerbera and can survive several years in moist soil. Excessively wet soil or a combination of a wet crop and high temperatures (exceeding 20°C) encourage the development of

this disease. The fungus spreads by means of zoospores that are distributed by means of soil particles and splashing water.

Control
- Conduct soil disinfestation by means of a general soil treatment (see "General soil treatment").
- Also effective for the control of foot rot is a supplementary chemical soil treatment (if available) for the treatment described to control Pythium.
- Make sure that the soil is well drained.
- Keep the crop from remaining wet for a long time after watering.
- Make sure that the irrigation system is operating properly and that irrigation is uniform.
- Ensure good soil structure and soil drainage.
- Do not provide too much water during a single application (max. 10 ltr/m2)
- Keep the soil temperature as low as possible during the summer.
- Carefully remove diseased plants and apply proper greenhouse hygiene.

9.4.5 Pythium

When plants are infested by Pythium, they are found scattered through the crop of in patches. They develop poorly, remain shorter and their bottom leaves turn yellow. The upper leaves are narrower, drabber in colour, and droop somewhat, particularly during periods of heavy transpiration. Infested plants display more bud desiccation and, in the winter, more bud drop. The flowers often remain smaller, frequently fail to open entirely, or fail to colour properly. When removed from the soil, the bulb and stem roots display glassy, light brown and rotting spots or are entirely soft and rotted all the way through. The only thing left is an empty membrane-like shell that can easily be detached from the core.



By Phytium infected roots

Cause
This form of root rot is caused by one of the *Pythium* fungi, most commonly *Pythium ultimum*. In general, these fungi thrive under moist conditions and grow best at 20 - 30°C. The fungus will remain in the soil, as well as on - and in - the bulb roots. The development of *Pythium* fungi is promoted by less than optimum cultivation conditions, e.g. poor soil structure, soil with an excessively high EC, or soil that is too wet.

Control
- Have the EC level of the soil determined in plenty of time before planting, and leach the soil with good water if needed.
- Provide the soil with proper drainage and ensure good soil structure.

- If the soil is infested or through to be infested, conduct soil disinfestation by means of a general soil treatment (see “General soil treatment”).
- Always conduct a supplementary soil treatment immediately before planting (see “Additional soil treatment”).
- Maintain a low soil temperature at the start of cultivation and use the right cultivation procedures throughout cultivation.
- Once the plants reach a height of approx. 10 cm (and also if *Pythium* damage is to be expected), it is possible to add a water-soluble Pythium control agent to the sprinkling water. The best time for application is the evening. Three minutes of sprinkling before and after the application of this fungicide will dramatically increase its effectiveness, and the post-sprinkling will rinse off the crop.
- If infestation is observed, it would be advisable to limit the transpiration of the plants by keeping the greenhouse climate as cool as possible by applying such measures as ventilating and shading. The soil should also be kept constantly moist.
- Growing in containers filled with potting soil to which peat is added suppresses the development of *Pythium*. So does working potting soil into the greenhouse soil.

9.4.6 Rhizoctonia

If only slightly infested, damage due to *Rhizoctonia* will be limited to the leaves in the soil and the lowest green leaves of the young shoot. The leaves will display light brown spots that look as if they have been eaten away by a pest. Often hanging from the affected leaves are hyphae with soil particles clinging to them. In general, the plant’s development will be somewhat slower but it will continue to grow.

If severely infested, the plants will suffer delayed emergence and both the white underground leaves and the lowest above-ground leaves will have rotted or wilted and fallen off leaving a brown scar on the stem. The younger leaves and the growth point are usually damaged. The underground stem parts can display brown stripes and spots that are usually elongated. The emergence of stem roots is suppressed, development is delayed, and flowering is poor or non-existent because the flower buds have dried out at an early stage.

Leave infection caused by Rhizoctania solani

Cause
This disease is caused by a fungus: *Rhizoctonia solani*. It is transferred to the plants from the soil and develops most rapidly under moist conditions and at temperatures above 15°C. These conditions also frequently contribute to slowed shoot growth. This fungus is also found in many other crops such as tulips, irises, chrysanthemums and tomatoes. For this reason, many previously cultivated soils can contain this fungus.
After emergence, infestation no longer occurs, or even stops. Slightly infested plants largely recover over the growing period. Stems that have been infested are susceptible to breakage.

Control
- If soil is infested or thought to be infested, conduct soil disinfestation by means of a general soil treatment (see "General soil treatment"). After soil treatment, frequent checking should be done to make sure that the pathogen does not return. This should be done even more frequently during the summer months or when the soil temperature is high. Hygiene is particularly important. The grower may also consider a supplementary soil treatment (see the following point).
- If it is impossible to conduct a general soil treatment and an infestation of *Rhizoctonia* can be expected as based on experience with previous cultivation periods, the soil can be treated by using the appropriate fungicide (e.g. 5-10 gr./m² Rizolex, 50% tolclophos-methyl) and thoroughly tilling it into the soil (to a depth of 10 cm.). For summer cultivation or when soil temperatures exceed 16°C, a soil treatment is always desirable.
- Ensure the smooth and rapid emergence of shoots by:
    - keeping the soil sufficiently moist
    - planting bulbs with healthy bulb roots
    - pre-rooting bulbs at a low temperature
    - using tray cultivation including the use of a rooting room
- Keep the soil temperature as low as possible during the summer

9.4.7 Sclerotium
If the soil is heavily infested with this fungus, the shoots in some areas of the greenhouse will barely emerge or will emerge very slowly. Leaves that have come into contact with the soil will wilt and start to rot. Brown spots appear on the foot of the stem, which then rots all the way through and collapses. Very characteristic of this fungus is the presence of white strands of hyphae, and later the formation of round sclerotia on the diseased tissue and surrounding soil. These sclerotia are first white and then bright brown to golden brown. Often found on the soil surface around the foot of the stem are many sclerotia that sometimes grow together to form a crust. The bulbs are also infested and will rot away.

If the soil is slightly infested, the shoots will emerge normally at first. Later, however, their rate of development will decrease as the result of infestation on the stem. The leaves will turn purple and the plant will finally die back completely.

Sclerotium

Cause
This disease, also known as crown rot, is cause by *Sclerotium rolfsii var. Delphinii*, a fungus that can develop quickly, especially at higher (18˚C or warmer) soil temperatures.

The degree of infestation is determined by the degree to which the soil is infested and by the soil temperature. The soil may have become infested by a previous crop susceptible to this fungus (these plants being known as "host plants"). Various perennials including Iris, Nerine, Ornithogalum and Hippeastrum can act as host plants. Bulbs produced under Dutch conditions are not infested during bulb cultivation because the soil temperatures are too low for this. Bulbs produced in warmer climates, however, could be infested.

Control
- -Conduct soil disinfestation on soil that is infested or thought to be infested by applying a general soil treatment (see "General soil treatment").
- - Do not plant infested lots, especially not for flower production under warm conditions (soil temperatures of 18 °C or higher).
- - Carefully remove, dispose of and destroy infested plants along with the surrounding soil.

9.5 Damage caused by pests

9.5.1 Leaf nematodes
Plants produced from infested bulbs are slow to develop. They will usually not produce flowers and will have malformed leaves. It is particularly the leaves on top of the plant that can become malformed, round (among Oriental hybrids), thickened and arranged irregularly and densely on the stem. The infested plants are at first isolated specimens but, as the infestation spreads to neighbouring plants, patches of infested plants are formed. Under moist conditions, leaves from healthy plants can become infested from the pests on plants nearby. The symptoms often develop in the middle of the stem: at first, in the leaf axils, or on the leaf tips/surfaces of downward hanging leaves. On lilies with finely-veined leaves, uniform bronzy-green to brown discolorations develop on the leaf. The leaf will then wither prematurely and fall off. On lilies with thickly-veined leaves, the symptoms are different: yellow and later brown sections develop in the leaf or the leaf becomes discoloured on one side first and then on both sides. Another symptom that sometimes occurs is the appearance of white speckles on curled leaves.

Infected top leaves

Symptoms in the middle of the stem

Cause

These symptoms are caused by *Aphelenchoides fragariae* (the strawberry leaf nematode) and *Aphelenchoides ritzemabosi* (the chrysanthemum leaf nematode). Leaf nematodes depend on temperature and moisture for their development. In uncultivated soil that is also fairly free of weeds, nematodes can survive for only 4-6 weeks. Their transference to the crop grown in the following cultivation period occurs by means of infested bulbs, weeds and/or crop residues from a preceding crop. These leaf nematodes have more than 600 host plants that include many weeds, perennials and other agricultural and horticultural crops.

Under moist conditions, leaf nematodes emerge through the stomata from plants grown from infested bulbs and can then easily be spread by splashing water or wind. If a crop remains wet for a prolonged period, the infestation can spread at an explosive rate. Practically no spreading takes place in dry conditions, either in the greenhouse or outside.

Control

- Since many weeds are also host plants, use effective weed control at and around the planting location both before and during cultivation.
- Treat the soil with a nematicide according to current recommendations.
- During cultivation, carefully and promptly remove any plants showing symptoms of nematodes.
- After establishing the presence of nematodes, keep the crop as dry as possible.
- Thoroughly clear away leaf and bulb residues after each cultivation period. In addition to taking this measure, also leave the soil fallow for six to eight weeks or conduct steam sterilisation.

9.5.2 Aphids

On infested plants, the lowest leaves emerge and develop normally. The upper leaves curl whilst still young and become malformed. Aphids live only on young leaves and are more often found on the undersides of these leaves. Young flower buds can also become damaged: green spots occur on them and the flowers (particularly among the white cultivars) can become malformed and remain partially green.

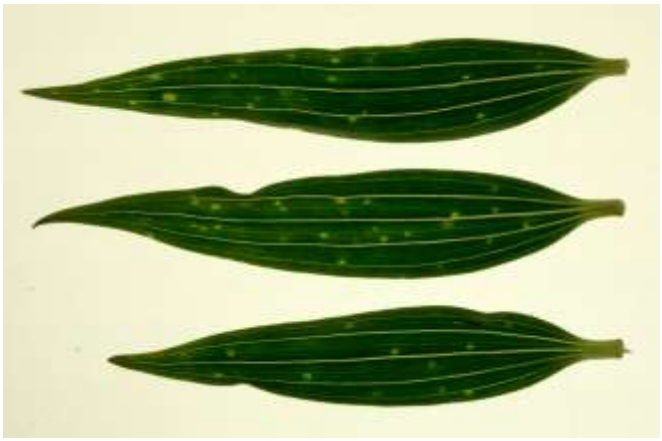
Leaves and flower buds infected by aphids

Cause
Various aphid species are encountered on lilies. In the greenhouse, one of them is *Aulacortum circumflexum*. One of the species that attack them outside is the cotton aphid, *Aphis gossypii*. The damage they cause is usually localised. It is caused by the aphid piercing the cells of the plants and then sucking the sap from the plant. Flying aphids can also cause damage by transferring viruses from plant to plant.

Control
- Apply weed control measures before and during cultivation. Aphids are often found on weeds serving as host plants.
- Have the supplier include imidacloprid (Admire) in the bulb treatment.
- After establishing the presence of aphids, spray the crop weekly with alternating insecticides and stop conducting these applications as soon as the flower buds become visible.
- If needed, a smoke treatment including an appropriate insecticide can be conducted shortly before harvest to prevent residues on the plants.

9.5.3 Thrips

Thrips use the lily for depositing their eggs. After the eggs have been deposited, the plant exhibits a kind of oversensitive reaction: watery intermingling necrotic spots. These spots are round and just a few millimetres in diameter. The symptoms can also appear on the flower buds. Lilies are not host plants for thrips so feeding damage on lily stems has never been observed.



Leaves damaged by thrips

Cause
The eggs are deposited only by the Western Flower Thrip (Frankliniella occidentalis) that can enter the greenhouse after the mowing of grass or the clearing out of crops infested with thrips in nearby greenhouses.

Control
Once the symptoms appear on the leaves, effective control is actually no longer possible. For this reason, take precautionary measures to identify the possible presence of thrips in and around the greenhouse. Hang up sticky traps. Start control measures according to current recommendations as soon as the first thrips are observed on the sticky traps.

9.5.4 Lily beetles

The Lily beetle (Lilioceris lilii) often devours a leaf right down to the stem. Flower buds can be damaged as well. The Lily beetle feeds on the leaves starting at the leaf margins. Adult beetles are 8 mm in length and conspicuous due to their bright red colour. The damaged leaves look ugly because they are covered with a thick, dark brown layer of slimy deposits.

Lily Beetle on leaf

Cause
The eggs deposited on the underside of the leaves are oblong in shape and turn reddish brown. The larvae that emerge from the eggs are a dirty yellow and about 5 mm in length. They immediately feed on the leaves and grow to become pink larvae around 15 mm long. They look dirty because they are often covered with a thick, dark brown layer of slimy deposits (their excrement). The larvae feed on the leaves from the underside and work their way through to the upper epidermis. They then pupate in the soil.

Control
In case of damage, spray with an insecticide according to the current recommendations.

9.6 Physiological disorders

9.6.1 Leaf scorch (upper leaf Necroses)
Leaf scorch occurs just before the flower buds become visible, usually on the upper leaves or petals. The young leaves first curl inward slightly; a few days later, these leaves display yellow-green to whitish spots. On Oriental hybrids, leaf scorch occurs primarily on the edges of the leaves in the form of brown spots.

In a light case of leaf scorch, the plant will continue to grow normally and the damage will appear only on leaves located at a certain height on the stem. If the leaf scorch is more severe, the white spots can turn brown in places, and the leaf will curl at the damaged location. Young flower buds will be destroyed so that the plants will not continue to develop. In very severe cases all leaves plus the tender young buds will be lost Plants will then fail to develop further. This is known as 'top scorching'. In addition to the leaves, the stipules of the inflorescence can be scorched. (Sometimes, this happens only to the stipules). When this occurs, the top of the plant grows very crookedly or turns blackish brown. This can also happen to the mesophyll on the top of the petals so that the flower bud grows irregularly and displays openings on the top.


Leaf sorch in Asiatic hybrids


Leaf sorch in Oriental hybrids

Cause
Leaf scorch is caused by a disruption of the balance between the quantity of water being absorbed by the roots and the amount of water leaving it through the aerial parts of the plant. This occurs when the plant lacks ways to absorb and emit water by means of transpiration. The result is a deficiency of calcium in the cells of the leaves. These cells then collapse and die. Leaf scorch involves many factors that impact the growth rate, water intake and transpiration of plants. Yet the one factor that has the greatest impact on this process is an abrupt change in the RH in the greenhouse. Also seen as

contributing factors are a poor root system, an excessively high EC level as measured in the soil, and plants that grow too fast for the volume of their root system. Susceptibility to leaf scorch varies widely depending on the cultivar and bulb size. Large bulbs are more susceptible than small ones. Susceptible cultivars within the Asiatic hybrids are: 'Navona' and 'Brunello'. Susceptible Oriental hybrids include: 'Star Gazer', 'Expression', and 'Acapulco'.

The planting location and planting period will also have an impact on the risk of leaf scorch. Newly harvested bulbs that are planted early in the season are less susceptible than when planted in the summer. Plants growing outside will suffer less leaf scorch than they will in an average greenhouse climate.

Control

Leaf scorch can occur from the time of crop emergence to when the buds become visible (25 to 50 days after planting). Taking these measures will minimise leaf scorch as much as possible.

- Limit high salt concentrations in the soil and leach he soil if the EC becomes too high (> 1.3 mS/cm).
- When possible, use unsusceptible cultivars and small bulb sizes: 12-14 cm and 14-16 cm.
- Plant bulbs having good bulb roots.
- Moisten the soil previous to planting.
- An effective control of diseases and pests that can damage roots.
- Plant the bulbs deeply enough (i.e. 6-8 cm of soil on top of the bulbs).
- Limit growth rate during the period in which the risk of leaf scorch is high (25-50 days after planting: from leaf unfurling to when buds are visible).
- Maintain a low RH in the greenhouse. During a period that will increase the risk of leaf scorch, take measures to prevent abrupt changes in greenhouse temperature and RH that can occur at sunrise and sunset. Try to maintain an RH of around 75%.
- Also take measures to prevent rapid growth: for susceptible Asiatic and LA hybrids, maintain a temperature of 10 - 12°C for the first 4 weeks; for susceptible Oriental hybrids, maintain a temperature of around 15°C for the first 6 weeks. Cultivation in boxes and using a rooting room would also be advisable.
- Make sure that the crop continues to transpire but prevent excessive transpiration by shading and, during sunny weather, sprinkling lightly a few times a day.
- Keep the leaves as dry as possible. If possible, do not water when the leaves are rolled up into a tube. Once the leaves have unfurled, the risk of leaf scorch (due to the water remaining in the tube) decreases. If irrigation is necessary, however, use a leaf blower to blow the water out of the tubes.
- Applying negative DIF will reduce the occurrence of leaf scorch.
- Provide a vertical flow of air (fans/Nivolator).
- Use assimilation lighting.

9.6.2 Brown leaf tips

There are several causes for brown leaf tips in lilies. An excess intake of boron or a magnesium deficiency can result in brown leaf tips during the last phase of growth. It can also be caused by excessive transpiration resulting from too much incoming sunlight and a high temperature. Brown leaf tips always start along the margins of the leaf where transpiration is strongest. Lilies that receive insufficient moisture during cultivation will be susceptible to brown leaf tips. Certain cultivars are also more susceptible to brown leaf tips.

9.6.3 Flower bud abortion and flower bud desiccation

Flower bud abortion (also known as flower bud abscission) can occur from the time that the flower buds have reached a length of 1 to 2 cm. Previous to abscission, the buds turn light green. At the

same time, the flower stem becomes constricted at the base of the bud. The bud then falls off. During the spring, the lowest buds are the first to drop; in the autumn, the higher buds will drop first.

Flower bud desiccation can occur during any stage of development. If it occurs early, the plants will remain short and the leaves will be dull green, short and narrow and arranged closely next to the stem but will display no symptoms of leaf scorch. Some or all the flower buds will desiccate during an early stage of growth and will later appear in the axils of the top leaves as small white specks. If flower bud abortion occurs later in the plant's development, the plants usually develop normally with a normal root system and with flower buds that are already clearly visible. Later, however, the buds will turn light green and shrivel. Flower buds that have already begun to display their flower colour will turn paler and dry up completely but will usually not fall off. The upper buds in the inflorescence will be the first to desiccate.

Bud abortion in an Asiatic hybrid

Cause

Flower bud abortion can occur from the time that the flower buds have reached a length of 1 to 2 cm. and when the crop receives insufficient light and/or when the flower buds are exposed to a high concentration of ethylene, a possible source being combustion gases. Under conditions of low light, the stamens inside the buds produce ethylene, and this causes the buds to abscise. High greenhouse temperatures encourage bud drop. Bud abortion can also occur among susceptible cultivars during the summer when much of the excess incoming sunlight is being filtered!

Early flower bud desiccation is encouraged by insufficient water intake through the bulb roots and stem roots as a result of shallow planting, poor bulb roots, soil that is too dry or contains excessive levels of salts, root damage, excessively high soil temperature, and a poor soil structure. Late flower bud desiccation occurs due to a shortage of available nutrients as a result of a shortage of light. Factors in this are the degree of cultivar susceptibility and the use of large bulb sizes. The greenhouse temperature has scarcely any effect on flower bud desiccation.

Control

- Do not allow cultivars susceptible to flower bud abortion and late flower bud desiccation to come into flower during a period of low light intensities.
- Carefully consider the light requirements of the cultivar and how long it takes to produce it, and ensure optimum lighting conditions in and around the greenhouse.
- Provide groups and/or cultivars susceptible to these problems with supplementary lighting during periods of low light intensities (see "Lighting equipment" in Chapter 2).
- During periods of low light intensities, do not plant overly large bulbs. At the same time, maintain a lower planting density.
- Ensure a lower soil temperature previous to planting by means of ample ventilation and shading. In the event of high soil temperatures, postpone planting for a few days.
- Plant bulbs that have reasonably healthy existing bulb roots and do not let them dry out during planting.
- Plant the bulbs deeply enough in soil that is not too dry, that has a low enough EC, and that is free of pathogens. On heavy, lumpy soils, use a mulch consisting of upgraded black peat, rice hulls, etc.
- Take measures to ensure proper rooting and optimum cultivation conditions.

9.6.4 Papery leaves

Once in the distribution chain, or after purchase by consumers, the leaves on lily stems can display spots. At first, these spots are very dry, very thin, crackly, and papery looking. Later, the flower, leaves and stem become limp. This disorder is more common among the Oriental hybrids but can also affect Longiflorum hybrids.

Papery leaf

Cause
The occurrence of papery leaves is related to weather conditions outside previous to harvest, and the RH (during the last phase of cultivation) in the greenhouse. Under bright sunlight, lily plants being produced under a high RH (exceeding 80%) will transpire slowly and accumulate excessive moisture. After harvest, the stomata on the leaves of these lilies will no longer be able to close. Areas of the leaves will then desiccate and take on a papery appearance. A high RH combined with low light conditions will also increase the risk of papery leaves.

Control
- Keep the RH in the greenhouse below 80% by watering beneath the crop, ventilating on time, and possibly heating with the windows slightly open.
- Use horizontally blowing fans for extra air circulation.
- Shade during excessive sunlight.
- Provide enough light in the greenhouse.

9.7 Deficiency and excess symptoms

9.7.1 Nitrogen deficiency
In nitrogen deficiency, the entire surfaces of the leaves turn pale; this often becomes more apparent when the plants are almost in flower. The crop often displays a rather poor condition. Flower stems produced from nitrogen-deficient soil will be lighter in weight and produce fewer flower buds and smaller leaves. Once in the vase, the leaves will turn yellow much faster than normal.


Nitrogen deficiency

Cause
This disorder is caused by the plant's insufficient intake of nitrogen. It occurs more often during warm periods when considerable quantities of water are provided. Under these conditions, nitrogen is easily washed out of the soil and becomes unavailable to the plants. Nitrogen deficiency usually occurs in patches.

Control
- Always ensure sufficient nitrogen fertilising, preferably based on the results of soil sampling conducted for the purpose fertilising.

- If nitrogen deficiency is observed during cultivation, apply a fast-acting fertiliser containing nitrogen such as calcium nitrate ($Ca(NO_3)_2$), urea ($CO(NH_2)_2$), or potassium nitrate (KNO_3). These fertilisers can be applied along with the sprinkling water or scattered over the crop and then watered in. Remember to rinse the crop off thoroughly in order to prevent leaf scorch!

9.7.2 Iron deficiency

In iron deficiency, the mesophyll between the veins of young leaves (usually the ones at the top of the plant) turns yellow-green. This occurs particularly among rapidly growing plants. The greater the iron deficiency, the more yellow the plants become. The veins, however, retain their normal green colour.

Iron deficiency

Cause

This disorder occurs more often on calcareous (high pH) soils that are light and susceptible to slaking, at locations subject to flooding, and when soil temperatures are too low. A lack of iron in a form that makes it available to the plant is the cause of this deficiency disease. The greater the iron deficiency, the more yellow the mesophyll becomes. A slight yellowing during cultivation, however, usually disappears as the harvest period approaches. Lily groups and cultivars susceptible to iron deficiency can be found among the Oriental and Longiflorum hybrids.

Control
- Ensure that the soil is properly drained and that its pH is sufficiently low (see "pH" in Chapter 3). An efficiently functioning root system considerably reduces the risk of iron deficiency.
- Provide the roots and the aerial parts of the plants with optimum growing conditions.
- When the pH of the soil exceeds 6.5, chelated iron should be applied to the soil. The need for this will depend on the susceptibility of the cultivars being produced. If needed, it should be applied previous to planting. Subsequent applications will depend on the colour of the crop. (If the colour still needs to be improved, a second application can be made around two weeks later.)
- When susceptible cultivars are being produced on a soil with a pH of 5.5 to 6.5, chelated iron can be applied only after planting: this can be done once and then, depending on crop colour, twice.
- The kind of chelated iron to be used depends on the pH of the soil and the time of year at which it is applied. Fe EDDHA 6% can be used in soils with a pH as high as 12 (i.e. all soils) and can be applied up to a few weeks previous to flowering. Fe-DTPA can be used only on soils having a pH of around 7 or less and can be applied only until the flower buds are visible. The application of too much Fe-DTPA can result in black spots appearing on the leaves. Applying chelated iron too late in the cultivation process can leave reddish-brown spots on the flowers. The addition of a wetting agent will help to prevent this.
- Apply 2 to 3 gram/m^2 before planting (work into soil thoroughly). After planting, an application should not exceed 2 grams. A second post-planting application should not exceed 1 to 1.5 gram/m^2.
- If no application was made before planting and a slight yellowing occurs, apply 2-3 gram/m^2. For a severe yellowing, 5 gram/m^2 can be applied in a single application.
- Chelated iron can be applied through the sprinkler circuit or mixed with dry sand and scattered beneath the leaves.
- To prevent leaf scorch, chelated iron should be applied when the crop is still wet and during cloudy weather as evening approaches. The crop will then have to be thoroughly sprinkled until the agent has been entirely rinsed from the leaves!
- When applying chelated iron to new cultivars, test it on a few plants first!
- When applying chelated iron by means of the sprinkler circuit, the container in which the chelated iron is mixed must be kept covered to keep it from decomposing in the presence of sunlight.

9.7.3 Other deficiency problems

One or more other deficiency problems can occur during lily cultivation. Only some of these can be identified by a discoloration of the leaves. By applying the required element in time, the symptoms can be prevented or eliminated.
In addition to the previous two deficiency diseases described, here are a few more that may occur.

Calcium (Ca)
The following symptoms will appear in the event of calcium deficiency:
- Leaves at the base of the buds become scorched when the buds become visible.
- Plants remain small and the colour of the leaves is light to pale green.
- Leaf tips bend downward and sometimes turn brown at the very end.
- The leaves are sometimes very pale green with white spots.
- Root development is poor.

calcium deficiency

Control
- A calcium deficiency can be prevented by liming the soil before planting with calcium carbonate ($CaCO_3$).
- Other fertilisers can also contribute to eliminating a calcium deficiency. These include magnesium carbonate ($MgCO_3$), magnesium oxide (MgO) and magnesium hydroxide ($Mg(OH)_2$)

Phosphate (P)
A phosphate deficiency will result in these symptoms:
- Plants remain somewhat smaller
- Colour is dull pale green
- The more mature leaves develop brownish-red leaf tips

Control
- A deficiency of phosphate can be difficult to solve during cultivation since the phosphate level should be sufficient previous to cultivation.
- Increasing the phosphate level can be done by fertilising with dicalcium phosphate ($CaHPO_4$). This fertiliser does not contain any fluoride.
- Scatter phosphate previous to tilling the soil.

Potassium (K)
A potassium deficiency can be recognised by the following symptoms:
- Plants remain small and are somewhat stocky
- Poor growth rate

- Younger leaves are dull yellow-green with a brown discoloration except for the leaf tips
- Small white necrotic spots over the entire surface of the leaves
- Ultimately, the leaf tips wither

Control
- Potassium deficiency can be eliminated by fertilising with such fertilisers as nitrate of potash (K_2O). This fertiliser can be added to the sprinkling water.

Magnesium (Mg)
Necrotic spots appear on the leaves when temperatures fluctuate sharply. A magnesium deficiency appears suddenly and displays the following symptoms:
- Plants remain small
- Leaves are light green and bent downward
- Brownish-white spots sometimes occur along the length of the leaves
- The most mature leaves show the worst symptoms


magnesium deficiency

Control
- A magnesium deficiency can be eliminated by applying magnesium sulphate with a sprinkler circuit or scattering it among the plants.

Manganese (Mn)
A manganese deficiency is not very obvious and will not have a major impact on the growth of the plants. It can be recognised by the following symptoms:
- The youngest leaves in the top of the plant are somewhat lighter in colour
- The leaf tips sometimes turn yellowish / light brown.

Control

- A manganese deficiency can be eliminated by applying chelated manganese or manganese sulphate ($MnSO_4$).

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9.7.4 Nutrient excess symptoms

The leaves will not reveal an excess of potassium, magnesium, iron, copper and molybdenum.
An excess of manganese can be recognised by a purple discoloration on the veins of the plant. This starts as small purple-red dots on the tops of the older leaves. It can occur following steam sterilisation. It is exacerbated in soils with a low pH.
An excess of boron produces white and sometimes brown areas on the leaf tips of all the leaves, but this symptom is most obvious on the leaves at the top of the plant.
Excessively high calcium levels can hinder the intake of iron, phosphate and magnesium.

Control

- An excess of magnesium can be eliminated by liming the soil at least one week previous to planting so that the pH exceeds 6.5. It can also be accomplished by lightly tilling the soil at least three weeks before planting.
- Have soil sampling conducted in order to determine any nutrient excesses so that they can be eliminated.
- If the soil sampling results show that the soil contains enough boron, remove boron from the fertilisers to be applied.

9.8 Viruses

Much time and attention is devoted to the control of viruses in the cultivation of lily bulbs. Bulb growers spray crop protection agents every week to counteract the transmission of viruses. The crop is also checked in the field at various times throughout cultivation at which time any infected bulbs are removed. Even these efforts, however, cannot always prevent the occurrence of a virus in the crop. There are multiple causes for this. The lot of bulbs could be infected, but it is also possible that the lot of bulbs became infected at the production facility during flower production. Cultivation conditions could also have affected the expression of symptoms. Here is a summary of the most commonly occurring viruses in the flower production of lilies and what can be done about them.

9.8.1 Lily Symptomless Virus (LSV)

Although its name suggests otherwise, an LSV infection actually does produce symptoms. The leaves of these lilies display light green stripes between the veins, a light green veining, or light brown spots on the undersides. The symptoms are most conspicuous under low light conditions. Not all of the affected plants exhibit symptoms. Poor growing conditions (dripping irrigation pipes) amplify the expression of symptoms among plants growing close to these conditions. The virus is transmitted by aphids within a limited area (this is known as non-persistent transmission). This virus affects a limited number of host plants; in addition to the lily, the only others known are the alstroemeria and tulip.

LSV

Control

- Start with lots having low percentages of LSV infection.
- Pursue optimum growth.

9.8.2 Lily Mosaic Virus (LMoV)

A mottled pattern consisting of vaguely contoured light and dark green spots and streaks occurs on the leaves. The leaves of some cultivars become curled or contorted. Brown necrotic streaks can appear on the stem. The growth of diseased plants is extremely retarded and they die back prematurely beginning with the lowest leaves that turn yellow and brown. If the bulbs were infected, the leaf symptoms can be observed immediately after emergence. What can also occur during a massive spreading of the virus is a rapid yellowing of the leaves in the middle and top of the plant during the initial weeks following emergence. This yellowing is often followed by a purple or brown discolouration and then leaf abscission. Brown streaks can often be observed on the stem. Cutting the stem lengthwise reveals brown vascular bundles and often hollow stems. Among Oriental cultivars, these symptoms are preceded by crimped leaves, a light green spottiness on the top leaves, and crooked growth of the stem at the location of the infection. The virus is transmitted by aphids within a limited area (this is known as non-persistent transmission). This virus has a wide range of host plants including anemones, dahlias, gladioli, tulips, hippeastrum and various weeds.

LMoV

Control

- To minimise the spread of this virus, start with lots having a low percentage of lily mosaic virus.
- Conduct aphid control according to current recommendations until the flower buds become visible.
- Cultivate a closely spaced weed-free crop.

9.8.3 Cucumber Mosaic Virus (CMV)

Its symptoms are similar to those of the Lily Mosaic Virus and consist of sharply defined, light green spots and streaks, often accompanied by curling leaves. The streaks occur over the entire leaf but can also be defined by the vein. The initial symptoms develop in the top of the plant and spread to the underlying leaves. If the entire plant displays symptoms from top to bottom, they can also occur on the buds. The disease is exacerbated by the simultaneous presence of Lily Symptomless Virus (LSV). A plant infected with this virus does not necessarily exhibit symptoms and can frequently occur without any sign of symptoms.

CMV is transmitted by aphids by means of non-persistent transmission. This virus is only rarely encountered in the production of lily bulbs in the Netherlands but is seen increasingly in the bulbs produced in France and the Southern Hemisphere. Damage occurring during the growing season is usually limited to symptoms on the top of the plant. Infections originating in the bulb result in symptoms affecting the leaves starting from the bottom of the plant to the top.

CMV

Control

- Conduct aphid control according to current recommendations until the flower buds become visible.
- Remove plants showing symptoms of CMV in the earliest stage possible.
- Cultivate a closely spaced weed-free crop.

9.8.4 Plantago Asiatica Mosaic Virus (PlAMV)

The Plantago Asiatica Mosaic Virus (PlAMV) can produce severe symptoms in lilies. An infected plant has undulating leaves with irregularly shaped veins that cause leaves dissimilar in shape. Grey and brown spots appear on the leaves later. Even in a healthy-looking crop, the leaves can exhibit severe brown discolouration a few weeks before harvest. The undersides of leaves display watery intermingling brown spots. Brown streaks can occur on the stem. Not all plants infected with PlAMV display symptoms during the forcing process. The expression of symptoms depends heavily on the cultivar and the growing conditions. PlAMV can have a major impact on the Oriental and OT hybrids in particular. Longiflorum lilies can be infected with PlAMV but never exhibit the symptoms during the forcing process. The LA hybrids can also be infected with this virus and, except for only a few

cultivars, not exhibit symptoms during flower production. Symptoms often show up under strong temperature fluctuations or under poor cultivation conditions. If the bulb is infected not only with PlAMV but also another virus, it will be more prone to showing symptoms.

PlAMV

PlAMV

Control

- Whenever possible, buy lots that have been tested and found to be virus-free.
- Avoid major temperature fluctuations by providing enough heat during periods of low outside temperatures.
- Do not cultivate lilies when temperatures are lower than 12°C.
- Provide sufficient light during dark days.
- Provide sufficient fertiliser (but not too much)
- Keep track of the RH because the symptoms increase as the RH rises.
- There are definite differences in damage and kinds of symptoms among the various cultivars. For more information, consult your supplier.

Chapter 10 – Selection of cultivars

10.1 Introduction

New lily cultivars in the various groups are introduced for commercial cultivation every year. In itself, this is a good thing since it increases the uses for lilies. But it also makes it difficult for flower producers to choose from the many new and existing cultivars. Yet making a responsible choice is very important for the grower because it will have a major impact on how much he earns from his efforts. Having information about the characteristics of many cultivars and their cultivation figures can be helpful for growers when making their choice. The supplier will be glad to assist in this. When making a choice for the purpose of achieving certain goals, certain aspects should be considered. These aspects can be related to the lily group or cultivar.

10.2 Group selection

The following aspects could play a role in choosing among lily groups.

- **Financing.** The purchase costs for some cultivars in the Oriental and OT hybrid group are higher than for lilies in the Asiatic and LA hybrid group.
- **Climate conditions.** Asiatic and LA hybrids are more sensitive to low light conditions than cultivars from the other groups. Oriental, OT, LO, OA and Longiflorum require somewhat higher minimum temperatures than do the Asiatic and LA hybrids.
- **Supply options.** Depending on the cultivar, not all bulbs from the various groups can be stored for the same length of time. This is why not all cultivars will be available for delivery in the autumn.
- **Duration of cultivation.** On average, Asiatic and LA hybrids require substantially less time to produce than the cultivars in the other groups.
- **Sales potential.** Oriental, OT, LO and OA hybrids take up more space than Asiatic hybrids and often have a strong fragrance. Longiflorum hybrids are still often seen as flowers for gravesites, and they can also have a strong fragrance.
- **Familiarity with the crop.** Unfamiliarity with a group means that the grower will be accepting a certain risk when it comes to applying the right cultivation procedures. Gathering information about this from suppliers and experts or conducting trial runs with a limited number of bulbs during various seasons would be a good idea.

10.3 Cultivar selection

- **Market demand.** Become acquainted with the type, colour, length and price class demanded by the market in your sales region.
- **Colour.** The Asiatic and LA hybrids are available in a wide variety of colours. The other groups are more limited in colour range.
- **Length.** The length of the stem often determines the price. Cultivars that produce long stems are often more sensitive to low light conditions and will take longer to produce. These factors make them less suitable for a winter cultivation period. In addition, these cultivars can also become too tall during the winter, thus making them limp and difficult to harvest.
- Short cultivars, however, will not grow tall enough during the summer. These are the only kind of lilies used for producing pot lilies.
- **Growing period.** Knowing about how long it will take to cultivate a cultivar is extremely important for proper planning. The figures given in the tables were based on a spring cultivation period at a greenhouse temperature of approximately 14°C. Cultivation will take considerably less time during the summer. As the autumn progresses, however, time needed for cultivation will increase again. The length of time needed to produce a certain cultivar during the winter and

during the summer can vary by 4 weeks. During an early spring cultivation period, use is sometimes made of "old harvest" bulbs instead of "new harvest" bulbs because bulbs lifted previously will produce flowers faster and more uniformly.

- **Number of buds and presentation.** In terms of buds, a good cultivar from the Asiatic and LA group should produce at least five buds per stem. For the other groups that produce larger buds, 3-4 buds would be acceptable. Presentation is also important. Cultivars that produce smooth buds showing good colour even when not yet open are preferable. Cultivars that produce many leaves within the flower cluster are less desirable since these leaves will tend to hide the buds.
- **Sturdiness.** Cultivars display great variation in the sturdiness of their stems. The cultivation season also plays a role in this. During autumn and winter cultivation seasons, the less sturdy cultivars will produce stems that are too limp.
- **Susceptibilities.** Cultivars (including 'Dreamland', 'Navona', 'Acapulco', 'Star Gazer') can be susceptible to leaf scorch. Using smaller bulb sizes reduces this susceptibility. Cultivars in the Oriental and Longiflorum hybrid groups are susceptible to iron deficiency.
- **Light susceptibility.** Cultivars susceptible to flower bud drop must not be produced during a time when bud elongation coincides with the darker months of the year, and especially not if the greenhouse receives a lot of shade or if it's plastic is old and dirty.
- **Keeping quality.** Keeping quality is a very important aspect when selecting a cultivar. Although it is not forbidden to grow cultivars with poor keeping quality, choosing cultivars with a good keeping quality is still worth recommending, especially in regard to having satisfied consumers. Leaf yellowing and a poor opening of buds are common causes for the reduction of ornamental value.
- **The position of the flower.** Most Asiatic and LA hybrids produce flower buds angling upward. Some cultivars in the other groups produce flower buds angling horizontally or downward from the stem. In terms of the labour required, the latter have disadvantages associated with harvesting, grading, bunching and transport. The demand for cultivars with buds angled horizontally or downward is also smaller.
- **Bulb size.** No matter what cultivar is chosen, the bulb size will have to be chosen as well. Larger bulb sizes usually produce a longer and heavier stem with more flower buds. But the use of large bulbs will also require a lower planting density to achieve optimum cultivation results.