# Lilium: A High-value Cut flower Production guide for lucrative return


## ABSTRACT

*Lilium sp.* is cultivated worldwide and is one of the most important generators cut flower and pot plant. It is a genus of great economic significance for production and commercialization of its cut flower in the international cut flower market. Species of genus lilium, originated from Asia, Europe, and North America, are mostly vegetatively propagated monocot perennials and are one of the economically most important flower bulbs. Asiatic and Oriental hybrid lilies are the most important groups and are derived from interspecific crosses of the Sinomartagon and Archelirion sections, respectively. Lilies can be propagated by seed, bulb division, bulb scales, stem bulblets, stem bulbils (in some species), and tissue culture. Propagation of Lilium is mainly through bulbs. Small bulbs are removed from parent bulbs after 6-8 weeks of flower production. The best time of planting hybrid lilies under north Indian climate is from mid-September to mid-December. For Asiatic Lily, suitable planting time in Northern Plains is Oct-Nov whereas; in hills March-April is the suitable planting time.Flowers are ready for harvesting between 90-120 days after planting. It is best to cut the flowers in the morning. As soon as the colour starts to develop in the first bud, the flower stalk should be cut 8-10 cm above from the ground.



*Keywords: Cut flower, Lilium, Bulbous flower, High value Ornamental crop*



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## Introduction

The genus Lilium in the Liliaceae family is one among the most important flowers farmed for the cut flower market. Due to its size, beauty and longevity, lilium is among the top ten cut flowers in the world (Thakur *et al*., 2005). As a cut flower, lily is the fourth most important crop in the Netherlands. Species of genus lilium, originated from Asia, Europe, and North America, are mostly vegetatively propagated monocot perennials and are one of the economically most important flower bulbs. Lilies produce big attractive flowers with a wide range of colours and shapes, therefore, they make excellent cut flowers, wonderful flowering potted plants and have a great ornamental value for landscape purposes.The long-standing popularity of Liliumasornamentalplantsisduetotheirlarge,showyflowersthatoftenhave a strongfragrance(Woodcock&Stearn,1950). It has been used for different purpose like ornamental plants throughout the world, as well as important edible plants and biological medicinal products. The petals, roots and bulbs of the plant contain many bioactive compounds; many of them could also find their place in modern medicine. (GP Panda, CR Mohanty and L DIP, 2020) Cut flowers are used in bouquet preparation/floral baskets, as corsages, in landscape gardening, flower arrangement and for decoration. High quality cut flowers, which are being exported from India, are produced in hi-tech floricultural units

generally termed as protected cultivation. Now-a-days cut flowers like lilium are gaining importance in Indian floriculture market with the liking of people towards new and exotic flowers and with the increase in living standard of people. Lilies, especially Asiatic and Oriental types are most fascinating, in international floriculture trade. A large number of species and varieties have varied uses and can be grown in border, beds, pots and are excellent cut lowers of magnificent appearance and beautiful colours. At present, the three major markets for lilium are fresh cut flowers, potted flowering plants and landscape or garden plants.

Lilium is one of six major genera of flower bulbs (geophytes) produced worldwide. There are over 100 species and over 9,400 cultivars in the genus Lilium, which is part of the Liliaceae family. These cultivars are classified into seven categories (Comber, 1949). Northern hemisphere, mainly Asia, North America and Europe, especially China, Nepal, Korea and Japan, constitute the gene centres of this genus around the world. *Lilium sp.* is cultivated worldwide and is one of the most important generators cut flower and pot plant. It is a genus of great economic significance for production and commercialization of its cut flower in the international cut flower market (Jimenez *et al*., 2012).It is currently one among the most important flowers farmed for the cut flower market. Due to its size, beauty and longevity, lilium is among the top ten cut flowers in the world (Thakur *et al*., 2005). As a cut flower, lily is the fourth most important crop in the Netherlands. Species of genus lilium, originated from Asia, Europe, and North America, are mostly vegetatively propagated monocot perennials and are one of the economically most important flower bulbs. Lilies produce big attractive flowers with a wide range of colours and shapes, therefore, they make excellent cut flowers, wonderful flowering potted plants and have a great ornamental value for landscape purpose. In the language of flowers, lily symbolizes purity and innocence. These are herbaceous flowering plants grown from bulbs, comprising of genus of about 110 species in the lily family Liliaceae. It is native from the northern temperate regions. The species in this genus are the true lilies while the other plants with lily in the common name are related to the other groups of plants. Lilies are usually erect leafy stemmed herbs. The majority of species form tunic less scaly underground bulbs from which they give flowers. The large flowers have three petals along with three petals like sepals. In the late 1990s, the first interspecific hybrids (LA) were developed through crossing between Longiflorum (L) and Asiatic (A). These LA hybrids had all colour ranges of the Asiatic group, with fragrant, and elegant flower form of the Longiflorum. The recent introduction of new interspecific hybrids obtained from crosses between Longiflorum and Asiatic hybrids (LA), between Longiflorum and Oriental hybrids (LO), between Oriental hybrids and Trumpet species (OT) have increased the availability of cut and pot cultivars.

LA hybrids, the first interspecific hybrids introduced in the late 1990s, are a colourful group, and are produced from crosses between Longiflorum (L) and Asiatics(A). These cultivars combined the full colour range of the Asiatics, with the elegance of flower form and fragrance of the Longiflorum. They are brightly-coloured trumpet type lilies and the LA gets a trumpet shape, a great strength and a long vase life from the Longiflorum, while from the Asiatic they derive warmer colours and an upright calyx. (Fiorenzo Gimelli, 2011)

**Asiatic Lily**: These are premium Cut flower grown under partial shade and needs expertise and are a bit expensive to cultivate. Also, its storage and multiplication is a challenge. Some of its important varieties are Elite, Polyana, Snow star,San Francisco, Gold Stripe,Golden Melody,Parisienne, Delta,Corina, Beatrix, London, Paroto, Alaska and Gran Paradiso,Los Angeles etc.

**Oriental Lily:** Oriental lilies are larger than Asiatic and are fragrant but late bloomer. These lilies bloom after Asiatic lilies. Many Oriental lilies may grow 3 to 6 feet (1-2 m.) in height, much taller than Asiatic lilies. Some of the important varieties are Star Gazer, Star Gazer Pink (They are Scented).

Plate 1 :Photomicrographs of oriental lily

UNDER PEER REVIEW

. 'Polyanna'

'San Francisco'

'Golden Melody'

. 'Snowstar'

'Gold Stripe'

'Parisienne'

'Delta'

'Corina'

'Los Angeles'

**Source: University of Florida Institute of Food and Agricultural Sciences (UF/IFAS)**

Asiatic and Oriental hybrid lilies are the most important groups and are derived from interspecific crosses of the Sinomartagon and Archelirion sections, respectively (Leslie, 1982). Flower colour is an important characteristic that determines the commercial value of floricultural crops. Much interest has been placed on cultivars that bear flowers with novel colours, intensities, hues, and patterning. A typical feature of Asiatic hybrid lilies is large colour variation, including yellows, oranges, pinks, reds, and white. Various pigments are involved in flower colour; pink and chocolate brown result from anthocyanins, yellow and orange are caused by carotenoids, and red is produced by the combined presence of anthocyanins and orange carotenoids. Pink and red-purple colours predominate in Oriental hybrid lilies and are a result of anthocyanin accumulation (Yamagishi, 2013). Crosses between L. longiflorum and 'Asiatic' lilies lead to development of 'LA' hybrids while crosses between L. longiflorum and 'Oriental' produced the 'LO' hybrids, specially the difficult hybridisation between Asiatic hybrids and Oriental hybrids ('OA' hybrids), a combination of the two most commercially important lily clusters, are a break-through in lily breeding and hybridisation (Van Tuyl *et al*., 1991). Lily is the common English name for flowering plants of the Asiatic lily genus and they are extensively being grown in polyhouse as cut flower in global flower trade because there is a greater variety of growth seasons, a vast range of colours, and enduring quality.

## 1. CULTIVARS

The plant height, days to flowering, number of flowers/plants, spike length and other qualitative as well as quantitative parameters depend on the cultivars/varieties of Lilium. Therefore, proper varietal selection for the location specific use is necessary. Some of the commercial cultivars are as follows

• **Asiatic Lilies**: Elite, Polyana, Nepal, Beatrix, London, Prato, Alaska and Gran Paradiso, Apeldoorn, Brunello, Grand Cru, Connecticut King, Harmony, Romneo, Toscana, Brindisi, Litouwen, Pavia, Sulpice, Tresor, Eyeliner, Prato, Solemio, Indian Diamond, Yellow Diamond and Indian summerset

• **Oriental lilies**: Siberia, Lombardia, Tiber, Sorbonni, Star Gazer, Marco Polo and Casablanca

## 2. SOIL

Soil with good texture and proper drainage is preferred. The soil should be light and porous but rich in organic matter. Lilies are sensitive to high concentration of salt which adversely affects the plant growth. The soil used for cultivation of lilies, has to be in good structure particularly the top layers and should also be kept well drained during the entire growing period. Maintaining the correct pH of the soil plays a major role in the root development and uptake of nutrients. It is advisable to maintain a pH of 6 to 7 for the Asiatic and longiflorum hybrid groups and a pH of 5.5 to 6.5 for the oriental hybrids.As for the soil suitable for growing lily, it must be sterile, deep, well-ventilated, light or medium textured, rich in organic matter and its acidity number (pH) from 6-6.5 in a semi-shady place (Khattab and Wasfi, 1988) .Lilies could be forced in various kinds of soils, however growing medium should be well aerated, with good water holding capacity, good drainage and good physical structure. In heavy soils without enough drainage, the development of root system is suppressed and plants are more susceptible to soil borne diseases (Beattie and White, 1992).

### 2.1. Different Growing Media:

Due to high requirements of nutrient for the growth of lilium, growers very often use pots instead of planting bulbs directly into the soil on greenhouse beds. Therefore it is important that the growing media selected for planting of lilium bulbs should provide all the necessary attributes for its proper growth and development.Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. They are often dry, nutrient deficient and fast-draining. They have little or no ability to transport water from deeper layers through capillary transport. Thus it helps in proper drainage and there are no chances of water logging conditions. Coco peat, also known as coir dust or coconut mesocarp, has been considered as a renewable sphagnum peat substitute for the use in horticulture (Yau and Murphy, 2000 Pickering, 1997).Due to low levels of nutrients in its composition, coco peat is usually not the sole component in the medium used to grow plants. It has a good physical properties, high total pore space, high water content, low shrinkage, low bulk density, high water holding capacity and has around 1000 times more air than soil. It is considered as a good growing media component with acceptable pH, electrical conductivity and other chemical attributes. Vermicomposts are produced through interactions between earthworms and microorganisms in the breakdown of organic wastes (Edwards et al., 2010).

## 3. ENVIRONMENTAL PARAMETERS

Controlled environment is essential for commercial cultivation in the non-traditional areas; hence the emphasis is on protected cultivation of Lilium. It should not be grown in direct sunlight. Light is a very important factor for lily cultivation. It should be grown in a shady place, otherwise the plants remain small. Use of shade net of 50 to 75% for shade is beneficial. 2000 to 3000 candle feet light is required for best flower production. High light intensity in summer reduces the stem length and therefore 50% shade nets are

UNDER PEER REVIEW

recommended to cover the crop (Van Tuyl JM.*et al*., 1985). Low light intensity in winter leads to flower abortion and abscission whereas additional/ Supplementary lighting during winter increases yield, stem sturdiness and quality of flowers (Stamps R, 2009) . When there is more light, the length of the flower stalks does not increase relatively, which adversely affects the quality of flowers. Initial temperature of 12 to13°C (until stem roots have developed). Asiatic hybrids grow well at 21 to 220 C (day temperature of) and 14 to 150 C (night temperature). However, it can also grow at day temperature up to 250 C and night temperature up to 8 to 100 C. In oriental hybrids, the optimum temperature during day is 20 to 220 C and during night is 15 to 170 C. It can tolerate a temperature of up to 250 C.

## 4. PROPAGATION METHOD

Lilies can be propagated by seed, bulb division, bulb scales, stem bulblets, stem bulbils (in some species), and tissue culture (Austin-McRae, 1998; Kumar et al., 2006; Marinangeli et al., 2003; Simmonds and Cumming, 1976). Propagation of Lilium is mainly through bulbs. Small bulbs are removed from parent bulbs after 6-8 weeks of flower production. Then to remove their dormancy, they are stored in a cold house at 2-5 0 C for 6-10 weeks depending upon the cultivar six-week cold storage period at 20 C to 50 C needed to break dormancy has also been reported by other workers who also reported that bulbs can be stored at -20 C up to one year. After this, small bulbs are planted in pots or beds. It takes 2-3 years from small bulbs to form proper sized flower bulbs. The bulbs are produced at the joints of leaves and stems. When these bulbs are fully mature, they are collected from the plants and planted in pots or beds. The bigger the bulbs, the better the chances of flower production. Normally 12-14 cm or larger bulbs are used for Asiatic lilies and large bulbs (20 to 22 cm or more) should be used for Oriental hybrid lilies. For cut flower production, the smaller bulb sizes (usually 12-14 cm for Asiatic and 16-18 cm for Orientals) are often recommended for forcing purposes

One of the best and most prolific vegetative propagation methods for lilies is in vitro scale culture (Bahr and Compton, 2004) This study reports a successful and reliable protocol for mass multiplication of Lilium under in vitro conditions. The experiment was conducted during 2008-09. Fresh bulbs of Lilium were collected from polyhouse of Central Institute of Temperate Horticulture, Srinagar India. The middle scales of bulbs were separated and washed thoroughly under running tap water. The explants were surface sterilized with 70% ethanol for 30 seconds followed by 5% sodium hypochlorite for 10 Min. and washed 5-6 times with sterilized distilled water before culturing.Improved vegetative traits could be attributed due togood water holding capacity and proper drainage of media containing, cocopeat and vermiculite either with soil or perlite which provide better condition for root development and producing long root system,These findings are in close conformity with Treder (2008) in Oriental lily, Wazir et al. (2009) in alstroemeria and Seyedi et al. (2012) in lily.

Lilium is also propagated by scale. In this method healthy, disease free large size dormancy free bulbs from are selected. The structure of the Lilium bulb is similar to that of a garlic bulb, with numerous scales attached to the base plate. The outer and middle scales are separated from the bulb with a small portion of the base plaque. The effects of different growing media for the propagation of bulb scales of *Lilium*, cultivar Chianti, were investigated. Bulb scales were planted in pots containing sawdust, soil + sawdust (1:1), moss grass [sic], perlite, vermiculite, sawdust + moss grass (1:1) and sand.(Manish Kapoor ; Grewal, H. S. ; Arora, J. S. , 2000)

### 4.1. Vegetative propagation

**4.1.1.Division:** The bulbs under the soil starts enlarging because of transfer of food gathered during growing stage to the developing bulb. During this process, some bulbs divide into two parts having common basal plate. These divisions are called as offsets. The

UNDER PEER REVIEW

offsets have its own growing point. They grow together as long as not separated from each other. If these bulbs are left longer to split and divide, they will eventually lose vigour. The offsets can gently be taken apart using hands or by sharp sterilized knife. The rate of division varies with the genotypes. In general Asiatic lilies divide faster than oriental ones.

### 4.1.2.Stem Bulbils

Bulbils are aerial bulblets produced in the axils of leaves. They are usually dark purple to brown and 1-2 cm long. The capacity to produce bulbils varies with the species. Lilium tigrinum, L. bulbiferum, L sulphureum and L. sargentae are easy to form bulbils. The production of bulbil can be encouraged by disbudding. The bulbils are harvested after flowering is over. They may have dormancy and planted in late summer.

**Fig . 1 showing stem detached bulbils (left) and bulbils attached with flowering axis (right)**

### 4.1.3.Stem Bulblets

The stem bulblets are formed on the stem above the bulb and beneath the soil. The number and size of bulblets depends upon species, variety and health and vigour of the plant. These bulblets are usually larger than scale propagated bulblets. The stem bulb production can be encouraged by deep planting of bulbs, removing leaves at basal end and earthing up and applying plant growth regulators.

### 4.1.4. Bulb Scales

Propagation through bulb scales is the commercial method of propagation of lilies. The bulbs of lily are composed of many scales attached to the reduced stem (basal plate). When the scales are detached from the bulb and planted in suitable medium they produce bulblets. Planting of bulblets outdoor for two to three seasons produce commercial size bulbs.

### Removal of bulb scales

The clean, healthy, disease free bulbs are selected from the mother stock for removal of scales. The scales are detached very carefully in such a way that they retain tissues from the basal plate. The scales broken halfway fail to produce bulblets. The scales may be removed at any time of the year, however, just before planting or after flowering is the best time. The detached scales should washed in running water and soaked in fungicide (Bavistin 1.5 g/l) for 30 minutes. The scales are air dried in a shady place to get away with adhered water.

fig . 2 (**Showing role of Etherel in promoting branching bulbing of *Lilium longiflorum*)**

Source: A Technoguide for Propagation of Lilium, National Research Centre for Orchids ICAR-Darjeeling Campus, A.J.C. Bose Road Darjeeling-734101, West Bengal

## 5. POTTING MEDIA

Several potting media has been suggested for planting of bulb scales. These include vermiculite, peat, sawdust, cocopeat, combination of peat and perlite etc. We have found that sawdust of Cryptomeria japonica is the best medium for planting of scales. It holds optimum moisture (50-60%) and provides sufficient porosity to develop the bulblets. The potting compost should be s planting of the scales. sterilised before planting of the scales.Superior flowering traits might be due to better growing conditions and good physico-chemical properties of media containing, cocopeat and vermiculite either with soil or perlite. These finding are in agreement with the result obtained by Grassotti*et al*. (2003) in Lilium, Awang *et al*. (2009) in Celosia cristata, Kale *et al*. (2009) in gerbera, Tehranifar*et al*. (2011) in Lilium and Khalaj *et al*. (2011) in gerbera.

In order to increase the size of the bulblet during scale propagation of Lilium the potting mixture was enriched with N:P:K (10:10:10) and N:P:K (10:25/25) @ 10, 20 g/l. The outer bulb scales of four cultivars namely Siberia, Voltage, Farfala and Cocordia were planted and incubated for 13 weeks. The enrichment of poting mixture with fertilizer had no significant effect on bulblet number, bulblet weight and biomass/scale. It appears that bulblet weight, number and biomass are determined by the reserved food in the scales and roots formed on the bulblets play no role in absorption of nutrient from the medium.

## 6. PLANTING TIME AND METHOD

The best time of planting hybrid lilies under north Indian climate is from mid-September to mid-December. For Asiatic Lily, suitable planting time in Northern Plains is Oct-Nov whereas; in hills March-April is the suitable planting time. However, October November month will be suitable for planting lilium in regions like Bundelkhand, MP and Chhattisgarh. Before planting the bulbs, it should be checked that they are not dormant. In protected cultivation, raised beds of one meter wide should be made, in the middle of which 40 cm wide path should be given. The soil of the bed should be dug at least 40 to 45 cm deep and mixed with well decomposed cow dung at the rate of 5-10 kg per square meter. The beds should be made about 25-30 cm high. The bulbs should be planted at a distance of 15 cm and line to line at a distance of 30 cm and at a depth of 10 to 15 cm. It is essential that the soil be sterilized before planting the bulbs. To sterilize the soil, it may be treated with formalin solution (one litre of formalin with 7 litres of water) and cover it with a polythene sheet, which is removed after a week and left open for 15 days so that the gas escapes from the soil.

### 6.1. Planting depth

The optimum sized lilium bulbs should be planted at a depth of 10 - 12 cm . Planting depth varies according to the size of the bulb. Generally, bulb should be planted to the depth of three times more than the diameter of the bulb. Sufficient soil on top of the bulb is necessary in which the stem roots can develop. When planted at a shallow depth, stem root development is not proper and therefore will affect the flower yield and quality. (Thangam M., *et al*. 2016)

### 6.2. Planting density

Planting density depends on the cultivar, bulb size and time of the year, with a range of 25-60 bulbs/$m^2$. Some of the commonly used planting distance with bulb size and density taken commercially are as below

Table 1 :planting distance with bulb size and density

| Bulb Size (cm) | Planting distance (cm) | Number of Bulbs/m2 |
|---|---|---|
| 8-10 | 15*15 | 49 |
| 10-12 | 16*15 | 42 |
| 12-14 | 16*18 | 36 |
| 14-16 | 16*18 | 36 |

Optimum bulb size and planting density in lilium. (Thangam M.*et al*., 2016)

## 7. FERTIGATION

Since lilium is a bulbous crop, most of its nutrients are already present in the bulb itself. Lilium is a very salt sensitive crop and therefore one should take care while applying fertilizers. It is advisable to apply 12:61:00@ 2kg/100m2 at least one week before plantation.
Table 2 :Fertigation doses

Later on during the first three weeks when the stem rooting takes place, no additional fertilizers are required. Good root development is important at this stage.
Three weeks after plantation: - Calcium Nitrate @ 1 kg/100m2
Six weeks after plantation: - Potassium nitrate @ 1 kg/100m2
If plants show symptoms of weakness during growing period due to Nitrogen deficiency, then a top dressing of Ammonium Nitrate@ 1 kg/100 m2 can be applied up to three weeks before harvesting.
Balode and Latvia (2018) pointed out the importance of using organic fertilizers with specific concentrations in plant growth *Lilium longiflorum*: Which is used with a particular concentration, leads to an increase in plant height and root length. Also, expanding their use above a specific limit negatively affects growth. Seyedeh*et al*. (2015) emphasized that mineral and organic nutrition, especially in the growing period, is the most important and effective component of increasing the bulb size Easter lily. Chandra et al. (2004) have shown

| Fertigation doses | Quantity (g/m2/week) | |
|---|---|---|
| | Asiatic | Oriental |
| Calcium Nitrate | 2.5 | 2.5 |
| 19:19:19 | 0.5 | 0.5 |
| Potassium Nitrate | 2.2 | 2.3 |
| Micronutrient mixture | 1.2 | 1.2 |

that poultry glaucoma improves the soil's chemical properties compared to inorganic sources of nitrogen such as ammonium nitrate, and the use of such fertilizers is an integral part of sustainable agriculture.
(Anonymous, 2008).

## 8. WATER MANAGEMENT

Irrigation should be done on the basis of season and temperature. Before planting bulbs in the beds, irrigation should be done and after that light irrigation should be done. Since the stem roots of the lilium develop in the upper part of the soil, moisture should be maintained in the top 30 cm layer of the soil. It should be noted that the water should not stagnate but the moisture should remain. There should be proper drainage system. Drip irrigation system is installed for providing irrigation. The lateral has the dripper 20 cm apart and placed away from the plant to avoid rotting. As the stem roots develop in the top layer, it must be kept constantly moist. Water requirement in summer is about 6 to 8 lit/m2 /day whereas, water requirement in other season is about 4 to 5 lit/m2 /day (Sheikh MQ.*et al*., 2015).

## 9. STAKING

Lilium plants need support because their roots are not strong and the flower stems will remain straight. The need is further increased when the heads of large flowers become heavy and the branches are unable to support their weight. Bamboo sticks and twine are used for support. Apart from this, nylon or plastic nets are also used. As the plants grow, the height of the nets is also increased. A net of 4 to 6 inches width of nylon is used.

## 10. Harvesting and postharvest handling

Lilies are distinguished by having large and attractive flowers. They are among the six most economically important major geniuses of bulbous plants (Dole and Wilkins,

1996, 1999).The right stage and time of plucking flowers is very important for the flower grower. Flowers are ready for harvesting between 90-120 days after planting. It is best to cut flowers in the morning. As soon as the colour starts to develop in the first bud, the flower stalk should be cut 8-10 cm above from the ground (Sheikh MQ., et al., 2015) The top should be cut with a sharp knife or scissors. After cutting the flower stems, immediately put them in clean cold water so that they remain fresh for a long time. Unnecessary leaves in the stalk should also be removed before sending them for sale in the market, so that the process of transpiration can be kept fresh for a long time by minimizing the process of transpiration. Lilies are among export flower crops which maintaining the freshness and extending the vase life of cut plants are very important to the success of their exports quality.Growing plants of large bulbs give a thick flower market and flowers that are better in number and quality, and have more leaves and therefore a larger leaf flat than the growing plants of small bulbs (Lang and Heins, 1990). During post harvesting period maintaining physiological functions of cut flowers vary actively even after harvest and the beginning of their senescence very often found depends on ethylene. (Asghari, R. ; Ahmadi, A. 2014) Asiatic hybrids take 8-10 weeks, while Orientals 14-16 weeks from planting to harvesting. During bunching, remove 10 cm of foliage from the end of the stems and subsequently sleeve the flowers. Immediately after bunching, the cut flowers should be placed in cold water in cold storage room at 2ºC to 3ºC.It is suggested to add 2% sucrose and 100ppm GA3 as a preservative agent to water to improve vase life of flower. When dispatching lily flowers use only perforated boxes to maintain a proper temperature during transport. They are pulsed with 0.2 mM STS + 10% sucrose for 24 hr.Based on the growth observation of lily bulbs (*Lilium* Oriental hybrids, 'Acapulco', 'Marco Polo', 'Siberia', 'Sobonne' and 'Tiber'), we found the mountainous condition was suitable for the bulb development. Total 288,020 bulbs (12-14 cm, 14-16 cm and 16-18 cm in circumference) of Oriental lily were harvested from 401,500 imported bulblets (6/9 cm), which were grown in the mountainous region (Jinyun, Zhejiang Province) having an elevation of 880 m. The average ratio for harvested flowering bulbs (>12 cm) and big bulbs (16-18 cm) was 71.7% and 15.4%, respectively.

11. **Grading:** After Harvesting, the lilies are usually sorted by number of flower buds per stem and length of the stem. The leaves from the bottom 10-15 cm of the stem should be removed to improve the keeping quality of the flowers
12. **Digging and storage of bulbs**

After the flowers bloom, the leaves turn yellow, and then the bulbs are removed. Irrigation is stopped about 2 weeks before the bulbs are harvested. Leaves are removed and bulbs cleaned. Bruised and small bulbs should be sorted, otherwise there is a possibility of rotting in the go down. To prevent rot, keep them immersed for half an hour in a solution of 0.2% Bavistin or 0.2% Captan. After drying it in the shade, the bulbs are stored by making layers on cocopeat or wood sawdust in a light wooden or paper box. The layer should have the right amount of moisture so that the bulbs do not rot or dry out. They should be stored in cool places (2-3 0C). Lilium bulbs are dormant when they are harvested, due to which they do not germinate in spite of the right environment. The dormancy of Asiatic hybrid lilies can be removed by storing bulbs at 2 to 4 °C for 5 to 6 weeks and Oriental bulbs at 1 to 2 °C for 6 to 8 weeks.

### 12.1. Optimum Conditions for Breaking Bulb Dormancy

In their native habitats, Lilium plants are exposed to a wide range of adverse climatic conditions, including seasonal fluctuations in temperature, humidity, daily irradiation, and photoperiod (Anderson et al., 2010).Lilium bulbs have developed mechanisms to survive in low or high temperature and/or drought of areas with adverse climatic changes. Cold dormancy is one mechanism wherein the bulbs such as lily and tulip develop a rest period in which they do not show any visible external growth and developmrnt (De Hertogh and Le Nard, 1993). The temperature

UNDER PEER REVIEW

has been shown to be a major factor affecting bulb growth, resulting in increases or delays in development (Mojtahedi et al., 2013). Lilium species have an underdeveloped embryo at the time of maturity that grows within the bulb before radicle emergence (Dhyani *et al*., 2013).

**Low Tempreture Treatment and Hot Water Soaking:-**

Bulbs were exposed to 1°C, 4°C, or 7°C for 35, 50, or 65 days. Each treatment was replicated three times and there were three bulbs per replicate. The bulbs were then packed in a polyethylene zip-lock plastic bag filled with moist peat moss. For the hot water soaking treatments, the bulbs were first soaked in hot water at 45°C for 1 hour and then stored at 4ºC for 35, 50, or 65 days. In addition, the bulbs were planted directly without any treatment as the control. After satisfying the required temperature and duration treatments, the bulbs were planted in plastic pots filled with sterilized commercial soil mixture and vermiculite with a planting depth of about 5-10 cm. The plants were maintained and managed inside the greenhouse at 20-25/16-20°C (day/night) from the emergence, vegetative growth, and reproductive development.

## 13. Crop Duration

Asiatic Hybrids: 8-10 weeks
Oriental Hybrids: 14-16 weeks

**14. Yield:** The average yield is 30 - 40 flower stems/$m^2$

(TNAU 2021)

## 15. DISEASES AND THEIR CONTROL

The important diseases, their symptoms and control measures have been presented as below.

Table 3 :important diseases and their symptoms and control measures

| Diseases | Symptoms | Control Measure |
|---|---|---|
| Penicillium | Occurs during during bulb storage. The rotting spots are white and later on with fluffy bluish green fungus on the scales. These bulbs will produce plants with retarded growth. | Storing bulbs at the recommended temp. Removing the infected scales as early as possible. |
| Bulbs and Scale rot | Brown spots are observed on the bulb top and sides. The bulbs will start rotting. The plants will have pale foliage and retarded growth. | Soil drenching with Carbendazim @ 1g/L or Difenoconazole @ 0.5ml/L |
| Fusarium | Yellowing of the lower leaves which later on turn brown and then to orange to dark brown spots on the stems. | Soil disinfection with fungicides. Maintaining the recommended greenhouse temp and humidity |
| Phytophthora | The leaves will start turning yellow. Wilting of foliage will take place. Stem base will become dark brown and this will continue upwards. | Soil disinfection. Soil should have optimum moisture with proper drainage. Maintaining the soil temp. |

UNDER PEER REVIEW

| | | |
|---|---|---|
| | Plants will have retarded growth. | |
| Botrytis | Dark brown spots occur on foliage. Bud starts rotting and deformed. Flowers have grey, watery and round spots. | Irrigation in the morning hours should be done. Spraying with fungicides vizcaptaf @ 2g +Bavistin @ 2g/Lor Bavistin @2g+ Dithane M45 @ 2g/L. |

Source: adapted from CCARI, 2010

## 16. Biology of important pests:

**16.1. Virus:** Viruses are obligate parasites of the cell machinery (nucleic acid and protein synthesis). There are RNA and DNA viruses (Glits and Folk 2001).There are about 21 viruses infecting lilies (de Best *et al*., 2000; Chastagner*et al*., 2018; Sastry *et al*., 2019).It is very hard to identify viruses based solely on symptoms .Depending on the time of infection, symptoms may only occur in the next growing season (which is very common in flower bulbs).It is also common that a plant is infected with multiple viruses (complex infection).Trumpets, Aurelians and some Asiatics have a good general resistance, TA hybrids are promising.Tetraploids have an improved resistance because of the thicker epidermis.A systemically infected plant cannot be cured, it is infected for life.

- Viral load of plant organs differ:
  - Very low in meristems and in seeds → decontamination might be possible.
  - Low in roots and storage organs.
  - Usually high in symptomatic leaves and flowers
- Viruses can Transmission:
  - Mechanically: Physical contact of plant parts (roots, leaves), Plant-sap (dead-heading, cutting stems, knives, scissors)
  - Vegetatively:Grafting, Cuttings, Storage organs (scales, bulbs, bulbils, rhizomes,stolons, etc.)
  - Generatively:Seeds, Pollen

Vectors:Fungi**,** Parasitic plants (e.g.: Cuscuta- dodder)**,** Animals- Nematodes – 6% &Arthropods – 94 %

**Most important viruses infecting lilies**:

- **Arabis mosaic virus** (ArMV) – mosaic and necrotic stripes and spots, can be symptomless. Spreads mechanically, by nematodes and seed (incl. weeds).
- **Cucumber mosaic virus** (CMV) – slight green mosaic, oak leaf pattern and then necrotization, leaf brittleness and bud/flower malformation. Spreads mechanically, via aphids, Rhizoctonia (Andika et al. 2017) and weed seeds.
- **Lily mottle virus** (LMoV) – vein clearing, mosaic, mottle, yellow streaking, leaf curling, and flower breaking. L. formosanum is hypersensitive. Spreads mechanically and by aphids.
- **Lily symptomless virus** (LSV) – may or may not show symptoms, mild vein clearing and mottle, earlier dormancy. Spreads mechanically and by aphids.
- **Lily virus X** (LVX) – symptomless. Besides lilies it can infect Trycirtis. Spreads mechanically and by aphids.
- **Plantago asiataica mosaic virus** (PlAMV) – In the beginning it caused severe necrosis and plant death, nowadays brown necrotic spots on the leaves, later vein necrosis, leaves become brittle, can be symptomless. Spreads mechanically, by plant contact, water (washing), soil and by aphids.

UNDER PEER REVIEW

- **Strawberry latent ringspot virus** (SLRSV)-symptomless. Spreads mechanically, by nematodes and seeds.
- **Tobacco rattle virus** (TRV) – Chlorotic spots, veinal chlorosis, these can necrotize, twisted leaves and growth. Spreads mechanically, by nematodes and by weed seeds.
- **Tulip virus X** (TVX) – light green or yellow spots, flower breaking (thin). Spreads mechanically, by plant contact, by water (washing), by soil and mites. (de Best et al. 2000; OEPP/EPPO 2002; Chastagner et al. 2018)
- These viruses are all quarantine in nuclear stocks (OEPP/EPPO 2002)

16.1.1. **Cucumber mosaic virus**:

**Hosts:**>1000 species! Mostly Cucurbitaceae (gourd family) and Solanaceae (nightshades), but also common on monocots and weeds. Stellaria media (chickweed) is an asymptomatic reservoir.
**Transmission:** aphids, plant sap, mechanically, seeds (mainly weed hosts), Rhizoctonia solani (Andika *et al*. 2017)
**Symptoms:** Light green to yellow stripes, vaguely defined light green spots, angular light and dark green spots, typical oak leaf pattern, but after the flowering period the light green spots and stripes in Longiflorums more often turn into gray necrotic spots, and in Asiatics into brown necrotic spots. The leaf margins are sometimes wavy; in several cultivars the leaves are curled. Flower breaking is more accompanied by flower malformation. The clinical picture is often more severe in the simultaneous presence of the lily symptomless virus, in this case the stripes and spots necrotize. During the growing season in which the infestation occurs, symptoms are usually confined to the top of the plant. Late infections do not become apparent until the following season, usually showing symptoms throughout the plant. A mosaic of veins consisting of sharply defined, light green to yellow veins usually accompanied by a strong curling of the leaves and bud/flower deformity is a typical picture. In maritime and cooler climates the virus is relatively rare in lilies. This is in contrast to warm countries, where it can be a clear problem in susceptible cultivars, such as 'Casa Blanca'. The virus does not pass with the seed in lilies (de Best *et al*. 2000).

Plate 2 :Cucumber mosaic virus (CMV)

UNDER PEER REVIEW


Cucumber mosaic virus – CMV

**Source:János ÁGOSTON1 , Dr. (PhD) 1 ELKH-SZE PhatoPlant-Lab, Széchenyi Isván University, Mosonmagyaróvár, H-9200, Hungary**

### 16.1.2. **Lily mottle virus**:

**Hosts:** Alstroemeria, Lilium, Tulipa
**Transmission:** aphids, plant sap, mechanically
**Symptoms:** The mosaic on the leaves can consist of light and sometimes dark green spots, light green to yellow stripes, vaguely defined light green spots, angular light and dark green. Later in the season, usually after flowering, brown necrotic spots may appear. In some cultivars the leaves are also curled or pinched. Brown necrotic streaks sometimes occur on the stem. Color breaking consisting of dark and/or light spots, flecks or mottle. Diseased plants have stunted growth and die off earlier, starting with a yellowing and browning of the lower leaves (Derks 1995; de Best et al. 2000). Brown (concentric) circles or spots occur on the bulbous scales of various Asiatic cultivars. Whitish rings may be visible on the pink, orange or brown scales of Orientals and OT hybrids. With Longiflorums, no clear symptoms are visible on the bulbs. The leaf symptoms are usually best observed immediately after emergence and around flowering. Sometimes the leaves show no symptoms, while the flowers show a clear breaking. In general, the symptoms in the simultaneous presence of lily mottle and lily symptomless virus are often less streaky, but more mosaic-like. After flowering leaf symptoms are more noticeable. In flower cultivation under glass, the symptoms, especially with Longiflorums, are most apparent in the winter period at temperatures of 15 °C and lower. A number of strains can be distinguished within the lily mottle virus, which differ in the range of lilies that they can infect. The virus spread is largely limited to the cultivar groups, for example to the Asiatics. In the absence of control measures the virus quickly becomes epidemic. The virus does not pass with the seed (de Best et al. 2000).
**Control:** culling infected plants; keeping the beds weed free; avoid scaling of batches grown in warm countries or have such batches of susceptible cultivars tested beforehand; spray against vectors according to current advice.


Lily mottle virus – LMoV


Lily mottle virus – LMoV


Plate 3 : culling infected plants
**Source: Pest and disease management of lilies (Lilium) North American Lily Society Virtual Judging School - Fifth Session Hybridizing, Propagation & Cultivation tips March 18, 2023**

### 16.1.3. Lily symptomless virus –LSV:Lily streak, lily rosette

ORDER PREVIEW

**Hosts:** Alstroemeria, Hymenocallis, Lilium, Tulipa
**Transmission:** aphids, plant sap, mechanically
**Symptoms:** Many Asiatic lily cultivars show yellow, purple or brown stripes at the end of the growing season, while Orientals show brown spots or sometimes a light green vein pattern. In sunny summers, these symptoms may already be visible around flowering. In greenhouse cultivation lilies can show light green stripes between the veins (much like iron deficiency), a light green vein pattern or light brown spots on the underside of the leaves, white stripes on pink flowers and buds of Orientals or a paler flower color. In some lily cultivars, for example 'Annabelle' and 'Casa Rosa', the leaves yellow from below and look a bit baggy. The symptoms are most apparent in the winter period (de Best et al. 2000), and under cool conditions < 15°C (Derks 1995). It is striking that both in outdoor cultivation and in the greenhouse only a part of the diseased plants show symptoms. Plants with and without symptoms are usually next to each other. Locally poor growing conditions, enhance the symptom expression in the plants growing there. Scouting for the disease is virtually impossible, because the symptoms are inconspicuous or appear late in the season. A reduction of 20% in bulb yield is possible. When harvesting the cut lilies, the stem weight is remarkably lower, the stem is shorter and less sturdy and the flower buds are fewer in number and smaller, vase life is shorter. The virus does not pass with the seed (de Best et al. 2000).
**Control:** use virus-free tissue culture batches or certified batches with a very low disease, spray against vectors according to current advice.

Lily symptomless virus – LSV

Lily symptomless virus

Plate 4 :Lily mottle virus
**Source: Pest and disease management of lilies (Lilium) North American Lily Society Virtual Judging School - Fifth Session Hybridizing, Propagation & Cultivation tips March 18, 2023**

## 16.2. Fungi

- Fungi are a diverse group of pathogens. The vast majority of them have whitish threads/filaments (hypha, plural hyphae) which makes up the body of the organism called mycelium (plural mycelia).
- They propagate via spores.
- Transmission:
  - Seed: surface, under the seed coat, in the endosperm, in the cotyledons and in the embryo, through style infection, through the hilum (eye of a bean seed).
  - Vegetatively: bulbs, tubers, rhizomes, stolon, grafting.
  - Water: splashing water.
  - Wind: most of the spore bearing fungi.
  - Soil: sticking soil, containerized plants, plugs, liners, used pots.
- Fungi can survive on dead plant material or in soil for a couple of years (Glits and Folk 2001)

UNDER PEER REVIEW

### *16.2.1.* ***Botrytis elliptica:*** Fire, grey mold of lily, Botrytis blight (syn. *Botrytis liliorum*)

**Hosts:***Lilium* sp.
**Transmission:** wind (airborne spores), sclerotia forming on plant debris.
**Symptoms:** The first symptoms are recognizable as small grey-brown to dark brown pots on the leaf. Later irregular, concentric rings can be observed in the spots. Heavy disease attack leads to accelerated death of the leaf tissue. On the dead, affected tissue the fungus can form large amounts of light brown to gray-brown spores that disperse easily. The plants can die off prematurely. The bulb is not affected. Fire frequently occurs during a period of rainy weather or dew. The fungus forms 2 to 3 mm large, black, round or oval sclerotia on dead tissues at the end of the season. The sclerotia can survive 1 to 2 years in the soil (de Best *et al*., 2000). Orientals, Trumpets and Aurelians are less susceptible than Asiatics. L. lankongense and its hybrids are very tolerant, while L. davidii and its hybrids are very susceptible (Reddy 2016). Plants in a juvenile stage (basal leaves in a rosette) are also very susceptible. Tetraploids appear to be more tolerant, because of their thicker epidermis. Cultivars with good tolerance of the disease are: L. regale (and hybrids), L. lankongense (and hybrids), 'Mozart', 'Casa Blanca', 'Cobra', 'Le Rêve' (Joy), 'Sorbonne', 'Tiara', 'Time Out', 'Conca d'Or', 'African Queen'. Highly sensitive cultivars: L. candidum, L. davidii (and hybrids), L. lancifolium (and hybrids), 'Chianti', 'Connecticut King', 'Côte d'Azur', 'Gironde', 'Sweet-kiss', 'Yellow Star', 'White Heaven', 'Red Alert', 'Royal Fantasy' (Reddy 2016; Chastagner*et al*., 2018).
**Control:** do not plant too close, apply good weed control, clean up plant debris and burn them or cover them with at least 30 cm (~ 1 foot) soil to facilitate natural decomposition; spray with Bordeaux mixture or use of a copper and mancozeb based chemical. Switch, Signum, Chorus, Teldor, Folicur, Luna Experience, Amistar Top, Flint Max = Flint Extra, Prosaro are also good.


**Plate 5 :**Botrytis elliptica

**Source: Pest and disease management of lilies (Lilium) North American Lily Society Virtual Judging School - Fifth Session Hybridizing, Propagation & Cultivation tips March 18, 2023**

### 16.2.2. *Fusarium oxysporum***f.sp. lilii**

**Black root rot of lily, cortical root rot, basal rot, bulb rot**
**Hosts:** the species itself has a wide host range, this specialized form only attacks Lilium.
**Transmission:** propagating material, soil, wind (airborne spores)
**Symptoms:** Fusarium occurs on all soil types and once infected soil remains infected for years. Fusarium infects the roots just behind the root cap or directly infect the scales through stomata, and it can survive up to a decade in the soil with their spores (Glits and Folk 2001; Chastagner et al. 2018). The fungi mainly attack the underground parts of the plants in places where injuries have occurred. The plants can be affected from the soil, but the fungi can also transfer with the bulbs (de Best et al. 2000). Before the destruction of the main bulb, infected bulbs tend to produce a lot of stem bulbs and scale bulblets, which are

UNDER PEER REVIEW

frequently infected, then the stem withers (Chastagner et al. 2018). It has been noted in grains and maize that Fusarium spores can infect the seeds through the stigma, or mycelia can grow up through the stem into the seeds while the host is asymptomatic.
**Control:** In bulb cultivation remove affected bulbs from the batch; give the planting material a warm water treatment. In scale propagation only use healthy bulbs for scales. In home gardens if the bulb base is healthy or partly rotten you can plant them, just cut out the rotten part and plant it from a distance from healthy stock. If tor stops next year you can move the plant to the collection. Mancozeb is good, Folicur (tebuconazole), Prosaro, Luna Experience, Amistar Top, Flint Max are very effective.

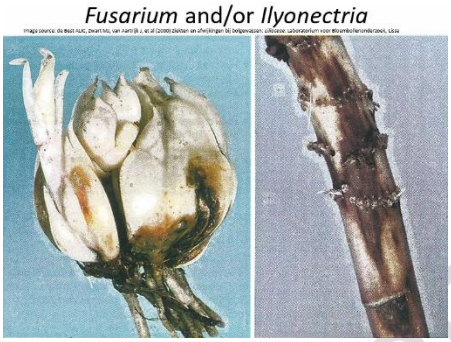


Plate 6 : Fusarium oxysporum
**Source: Pest and disease management of lilies (Lilium) North American Lily Society Virtual Judging School - Fifth Session Hybridizing, Propagation & Cultivation tips March 18, 2023**

### 16.2.3. *Penicillium* sp.

**Hosts:** many hosts, mainly occurs in the warehouse
**Transmission:** propagating material, wind (airborne spores)
**Symptoms:** During storage, brown, dry, rotten spots develop on the scales, spread further. Gradually blue-green spores are formed. The attack can penetrate into the bulb base and from there into other scales, which then detach from the base. Bulbs that have a few rotten spots when planted can grow out a healthy stem, and grow a new healthy bulb. Heavily affected bulbs and bulbs with damage to the basal plate may rot in the soil or grow weak. Storage rot develops during storage under dry conditions, especially on moist bulbs packed/stored in wood shavings, wood dust or dry peat. The fungus can only enter the scales through wounds that occurred during or after digging up. Immature harvested bulbs are more susceptible to Penicillium attack. Bulbs that are kept cool and at high humidity as soon as possible after harvesting are not or hardly affected. The high humidity counteracts drying out and accelerates wound healing. A low temperature slows down the growth of the fungus (de Best et al. 2000).
**Control:** In home garden discard symptomatic scales and plant the bulb if the base is healthy. In case of rotten base discard the bulb. Drenching in mancozeb is good, Folicur (tebuconazole), Prosaro, Luna Experience, Amistar Top, Flint Max are very effective.

### *16.2.4. Rhizoctonia solani*

**Damping off, Rhizoctonia disease**
**Hosts:**> 1000 hosts, common in seedlings and pepper
**Transmission:** propagating material, soil, soil covered tools, splashing (and washing) water, airborne spores (only the sexual stage)
**Symptoms:** Laves start drooping, they have a darker or grayish coloration. Brown, elongated spots and stripes can also develop on the underground part of the stem. As a result of the attack, the plants grow 'pinched' and they remain shorter than healthy plants. Such plants often flower poorly or not at all, some or all of the flower buds blast

UNDER PEER REVIEW

at an early stage. The bulb scales themselves may also be affected, producing light brown, superficial spots of various sizes with blurred edges. It can severely attack seedlings and young plants from tissue culture or from scale propagation, causing damping off before or after emergence of the leaves (Chastagner et al. 2018). The pathogen is present in all natural soils (Reddy 2016). In bulb cultivation in the open ground, Rhizoctonia disease mainly occurs in scale cultivation and small planting stock. The plants die prematurely. In addition to bulbous plants, the fungus also affects many other crops (de Best et al. 2000), but it preferably infects young plants, pepper can be infected at adult stage (Glits and Folk 2001). The sexual stage sporulates usually in early summer after rain, under warm and moist conditions.
**Control:** In propagation use fresh or steamed media/soil and new trays and pots; use a free draining mix; do not oversaturate substrate with water; scales can be dipped in a systemic fungicide before or after scaling. Mancozeb with copper are good, Previcur, Folicur, Amistar Top, Luna Experience, Prosaro are also good. Be aware of the dosage when drenching!

## 16.3. Animal pests:

### 16.3.1. **Slugs and snails**: **Gastropoda**

**Hosts:** many hosts
**Transmission:** propagating material, plant residues, soil (pots, trays) Reproduction, overwintering: 1-4 gen./year, eggs or adults.
**Symptoms:** Plant parts are eaten, typical dried slime on the surface. Slugs and snails prefer a damp/moist environment, they usually feed once or twice a week usually night time. Eggs are pearl like, transparent or opalescent, rubbery, sticky. They are laid in groups in the moist soil or substrate, sometimes under rocks or in crevices.
**Control:** animals can be collected by hand or by traps (beer, hollowed potatoes) and then killed. Metaldehyde (blue granules) dehydrates the animals but rain or overhear irrigation can rehydrate the animals and they survive. Parasitic nematodes can be used under moist conditions. Copper strips can be used as physical barriers. Iron-phosphate (Sluggo) is also a good choice.

### 16.3.2. Halyomorphahalys: Brown marmorated stink bug

**Hosts:** many hosts
**Transmission:** airborne animal, originated in Asia.
**Reproduction, overwintering:** 1 gen./year (USA, EU), in Asia 5-6 gen./year, adults
**Symptoms:** Plant show small (~3 mm), roundish or star-like yellowing, juicy plant parts can become sunken after the feeding of the animal, then tissues necrotize, collapse or become spongy. Leaves, herbaceous stems, buds/flowers and fruits can be damaged, adults prefer fruit. In the case of heavy infestation plant parts may become severely disfigured.
**Control:** use a thick woven net to cover crop. Spraying with neonicotinoids (tiametoxam, acetamiprid, imidacloprid, Sivanto Prime), carbamates (pirimicarb) or organophosphates where allowed.

### 16.3.3. Aphids:Aphididae

**Hosts:** many hosts, some species alternate between herbaceous and woody hosts
**Transmission:** airborne animal Reproduction, overwintering: many gen./year, eggs (in most cases)
**Symptoms:** The lower foliage leaves of affected plants have grown normally. The upper leaves curl in a young stage and become deformed. The aphids only live on young leaves and mainly on the underside of them. Usually the young buds are also damaged, so that

UNDER PEER REVIEW

green spots appear on them and the flowers later are sometimes deformed and (particularly with white cultivars) remain partly green. The damage occurs locally. Aphid colonies can cause serious damage to lily plants. Hidden in the inner youngest part of the sprouts, they remain unnoticed for a long time. Flying aphids can cause damage by transmitting viruses. Various aphid species are found on lilies. In the field they occur in spots on the underside of the leaves, as a result of which the plant can die completely (de Best et al. 2000).
**Control:** to combat direct crop damage, spray crops with insecticides after April in accordance with current advice. Pyrethroids (Decis, Karate=Lamdex, Fastac CS, Baythroid XL and Warrior II), neonicotinoids (tiametoxam, imidacloprid, acetamiprid), carbamates, organophophates are all good, but please always follow the instructions on the label.

### 16.3.4. June beetle, chafer grubs, white grubs: Melolonthidae

**Hosts:** many hosts
**Transmission:** adults fly Reproduction, overwintering: 1-5 years / 1 gen, larvae (in most cases)
**Symptoms:** Plants show symptoms of drought, sometimes they flop over at soil level. The larvae eat all plant organs in the soil. The grubs are very voracious, smaller ones usually start eating the stem roots, then basal roots, scales/bulbs and then the stem. The grubs search out plant roots by going in the direction of carbon dioxide. They can spread around a meter per week. They easily find the rows and go unnoticed under the soil, one can only see plants dyeing in a succession. They prefer light sandy soils, but can appear in every soil type. Depending on the species one generation can take from 1 to 5 years. Species can be identified by adults or by the anal hairs of the grubs. Adults usually fly just before sunset and they can feed on every above ground parts of many plants. In some places more than 1 species may co-occur.
**Control:** do not plant any crop if there are 2 or more grubs/m2 30 cm deep in summer; keep plots weed free. depth of 30 square meter of soil; fumigate soil where allowed; sow a catch crop and till so birds can pick out grubs. Under moist conditions entomopathogenic nematodes (Steinernema feltiae) or entomopathogenic fungi (Beauveria bassiana, Metarhizium anisopliae) can be applied with success.

### 16.3.5. ***Liliocerislilii:*** **Lily beetle (syn. *Criocerislilii*, *Liliocerisliliorum*)**

**Hosts:** Convallaria majalis (rarely), Fritillaria sp., Lilium sp., Polygonatum sp. (rarely) Transmission: adults fly
**Reproduction, overwintering:** 1 – 4 gen./year, adults in soil
**Symptoms:** Often the leaf is eaten away down to the stem. The flower buds can also be damaged. Adults have a bright red color. Eggs are deposited in groups on the underside of the leaves. The larvae emerge in 5-10 days from the eggs. They quickly grow to approx. 15 mm by eating directly from the leaves. The larvae have a frosty appearance, as they are often covered in a thick dark brown layer of slimy dirt (their excrement). The larvae first graze the leaf from the underside to the top epidermis, the larger ones eat the leaf as is. They then pupate in the soil. Depending on the weather conditions, several generations can develop per year. The beetles can be found early in spring (April) on lilies and Fritillaria. The first eggs are not laid until May. It usually takes 45 – 50 days for a generation to emerge. Adults may stay in a diapause in the soil till next year, so the spring population is always bigger then the rest. The lily beetles are rarely if ever encountered in the cultivation of bulbs, as the crop is sprayed regularly against aphids; they are common where lilies are planted in parks, home gardens (Sáringer 1990a; de Best et al. 2000; Reddy 2016). A very similar animal is the onion beetle (Liliocerismerdigera) which can also feed on lilies.
**Control:** regularly catch and destroy beetles and larvae in gardens; in case of damage, spray with an insecticide according to current advice. Good choices are: Coragen, Benevia,

*Lilioceris lilii*

*Lilioceris lilii*

*Lilioceris lilii*

UNDER PEER REVIEW

Exirel, Altacor, Vantacor, Verimark, dimethoate or malathion. Decis, Karate, Fastac CS, Baythroid XL and Warrior II can also be good for young larvae.
Plate 7 :Liliocerislilii

**Source: Pest and disease management of lilies (Lilium) North American Lily Society Virtual Judging School - Fifth Session Hybridizing, Propagation & Cultivation tips March 18, 2023**

16.3.6. **Thrips:** This is also a sucking type of insect. A severe attack will adversely affect the plants growth and flowering. Those flowers will not be accepted in the market. Regular spraying with Monocrotophos @ 2 ml/litre of water will protect the plants from the attack of thrips.

16.3.7. **Mites:** Spraying Wettable sulphur @ 1.5 g/L or Abamectin @ 0.4 ml/L or Propargite @ 2 ml/L

## 17. NUTRIENT DEFICIENCIES

17.1. **Iron deficiency:** The mesophyll between the veins of young leaves is yellow-green (especially in fast-growing plants). The symptom occurs when the buds grow out. The cause is iron deficiency and the symptom is clearer the greater the deficiency. The deficiency mainly occurs on calcareous and on light, loamy soils and in places where there is flooding. There are clear differences in sensitivity within the range (de Best *et al*., 2000). Control: Apply iron chelate, 5 g/m2 when symptoms show, rinse plants with a lot of water to avoid chemical burn; apply other iron based supplements according to current advice. FeEDTA, FeEDDHA and FeEDDHSA chelates are good (LibrelHiFe, Ultraferro). Avoid inorganic iron, like iron-chloride or iron sulfate.

17.2. **Nitrogen deficiency:** Plants show a general yellowing starting from the bottom of the foliage working upwards, new leaves are yellow, veins are also the same color as the interveinal region. Control: use nitrogen based fertilizers according to current advice, avoid overdosing as tissues become spongy which invites pathogens, and plants may flop over. Agroleaf Power 31-11-11, Peters Professional/Plantafol 30-10 10 are good choices.

17.3. **Potash deficiency:** Leaf edges and leaf apices show a thin browning with a yellow halo. Control: apply potash fertilizers according to current advice.

17.4. **Sulphur deficiency:** Plant shoot tops become almost white, common on sandy soils. Control: use Sulphur containing fertilizers, like ammonium-sulfate or magnesium sulfate (Epsom salt), potassium-sulfate according to current advice.

17.5. **Calcium deficiency:** Leaf apices and shoot tops become grayish or whitish and soon turn brown and die. Control: use calcium containing fertilizers: calcium-chloride, calcium-acetate, calcium-nitrate according to current advice.

Generally deficiency symptoms show a marked improvement 3-4 weeks after the first or second application.

UNDER PEER REVIEW

## 18. Disorder

### 18.1. Leaf scorch:-

- Leaf scorch occurs when there is disturbance in balance between absorption and evaporation of water.
- Due to deficiency of Mn/Al at overdose of nitrate level
- It causes calcium deficiency in the cell of the youngest leaves.
- A sudden change in the Rh inside the greenhouse affects the physiological imbalance that leads to poor root system.
- Larger bulbs are more susceptible than smaller one.

Control: -

- Soil should be moist before planting.
- Plant the bulb with good root system & plant adequate depth of soil.
- Avoid susceptible varieties.

18.2. **Bud blast:** It is due to storage of water at top of plant, competition for nutrients, fluctuating carbohydrate level, low light intensity and high nitrate level.

18.3. **Puffy foliage:** It is due to frost injury and stunting of plants.

## 19. CONCLUSION

The results of the present study indicated that Lilies (genus Lilium L.) have retained their position as one of the most important ornamental plant groups both as garden plants as well as pot cultured and cut flowers. Lilium occupies prominent place in the global flower market and is counted among the first ten major cut flowers in the international floriculture industry. At the commercial level, Asiatic, Oriental and L.A. are common in India. With the increase in liking and demand of lilium cut flowers, its commercial cultivation is on the rise. For higher and quality yield and also for production in non-traditional regions it is being cultivated under protected cultivation. The yield depends on various factors such as varieties, planting time, space, water, nutrient and insect pest disease management as well as post-harvest handling. They originate from underground bulbs and produce large, showy blossoms and as a thumb rule, the bigger the bulbs, more is the stem length and the number of flower per stem. The best time of planting hybrid lilies under north Indian climate is from mid-September to mid-December whereas, the lilium bulbs should be planted at a depth of 10 - 12 cm. Water requirement in summer is about 6 to 8 lit/m2/day whereas, water requirement in other season is about 4 to 5 lit m2/day. Lilium plants need support because their roots are not strong and the flower stems will remain straight. The knowledge of the right stage and time of plucking flowers is very important for the flower grower. Flowers are ready for harvesting between 90-120 days after planting. Based on the recommended package and practices, the lilum cultivation can be taken up in new areas after proper validation of these technologies.

UNDER PEER REVIEW

## REFERENCES


1. Ahmed Z., et al. (2018) “Response of flowering in lily to light and temperature: Advances”. Rastriya Rishi 13.1.
2. Anderson, J.V., R.W. Gesch, Y. Jia, W.S. Chao, and D.P. Horvath. 2005. Seasonal shifts in dormancy status, carbohydrate metabolism, and related gene expression in crown buds of leafy spurge. Plant Cell Environ. 28:1567-1578.
3. Anderson, N.O., A. Younis, and Y. Sun. 2010. Intersimple sequence repeats distinguish genetic differences in Easter lily ‘Nellie White’ clonal ramets within and among bulb growers over years. J. Amer. Soc. Hort.Sci. 135:445-455
4. Andika IB, Wei S, Cao C, et al (2017) Phytopathogenic fungus hosts a plant virus: A naturally occurring cross-kingdom viral infection. Proc Natl Acad Sci USA 114:12267–12272.
5. Austin-McRae, E. 1998. Lilies: A guide for growers and collectors. Timber Press, Portland, OR. Blythe, E.K., J.L. Sibley, J.M. Ruter, and K.M. Tilt. 2004. Cutting propagation of foliage crops using a foliar application of auxin. Scientia Hort. 103(1):31–37.
6. Awang Y, Shaharom A S, Mohamad R B and Selamat A. 2009. Chemical and physical characteristics of cocopeat-based media mixtures and their effects on the growth and development of Celosia cristata. American Journal of Agricultural and Biological Sciences 4: 63–71.
7. Bahr L R and Compton M E. 2004. Competence for in vitro bulblet regeneration among eight Lilium genotypes. Horticulture Science 39: 127–9.
8. Balode, A and Latvia, U(2018). Influence of vermicompost substrates on the growth of Lilium longiflorum. Sciences and Technologies, Jelgava (Latvia). Faculty of Agriculture Language :Volume .2018 Page : 34–37 ISBN : 978-9984-48-284-2.
9. Beattie D.J. and White J.W. 1992. Lilium hybrids and species. In: De Hertogh A.A. and Le Nard M. (Eds.) the Physiology of Flower Bulbs. Elsevier, Amsterdam.
10. CCARI, 2010.
11. Chandra K. Reddy, E. Z. Nyakatawa, and D. W. Reeves. (2004). Tillage and Poultry Litter Application Effects on Cotton Growth and Yield,” published in Agronomy Journal, Vol. 96, November-December.
12. Chastagner GA, van Tuyl JM, Verbeek M, et al (2018) Diseases of Lily. In: McGovern RJ, Elmer WH (eds) Handbook of Florists’ Crops Diseases. Springer International Publishing, Cham, pp 1229–1288.
13. Comber, H.F. (1947) A new classification of the Lilium. Lily Yearbook, Royal Horti Soc, London 15, 86? 105.
14. de Best ALIC, Zwart MJ, van Aartrijk J, et al (2000) Ziekten en afwijkingen bij bolgewassen: Liliaceae. LaboratoriumvoorBloembollenonderzoek, Lisse.
15. De Hertogh, A. and M. Le Nard. 1993. The physiology of flower bulbs. Elsevier Science Publishers, The Netherlands.
16. Derks AFLM (1995) Lily. In: Loebenstein G, Lawson RH, Brunt AA (eds) Virus and virus like diseases of bulb and flower crops. Wiley, Chichester, pp 313–321.


UNDER PEER REVIEW

17. Dhyani, A., S.S. Phartyal, B.P. Nautiyal, and M.C. Nautiyal. 2013. Epicotyl morpho-physiological dormancy in seeds of Lilium polyphyllum (Liliaceae). J. Bio. Sci. 38:13-19.
18. Ding, M., D. Yusong, and F. Yanyana. 2013. The effects of different altitudes on the physiological changes of oriental lily bulbs during dormancy releasing. Acta Hort. 1002:179-186.
19. Dole, J., and Wilkins, H. (1996). Direction of *Lilium* research. *Acta Hortic.* 414, 295–300.
20. Dole, J., and Wilkins, H. (1999). *Lilium, Asiatic and Oriental, Floriculture Principles and Species*. Upper Saddle River, NJ: Prentice Hall, 408–416.
21. Dr. Ram Pal, Dr. M. Dayamma, Dr. A.M. Khan, Dr. D.R. Singh. A Technoguide for Propagation of Lilium. 1st ed. Darjeeling; 2016.
22. Edwards, C.A., Arancon, N.Q., VaskoBennett, M., Askar, A., Keene, G. 2010. Effect of aqueous extracts from vermicomposts on attacks by cucumber beetles (Acalymnavittatum) (Fabr.) On cucumbers and tobacco hornworm (Manduca sexta) (L.) on tomatoes. Pedobiologia, 53(2): 141- 148.
23. Glits M, Folk Gy (2001) Kertészetinövénykórtan. MezőgazdaKiadó, Budapest.
24. Grassotti A, Nesi B, Maletta M and Magnani G. 2003. Effects of growing media and planting time on lily hybrids in soilless culture. Acta Horticulturae 609: 395–9.
25. Grassotti A and Gimelli F. (2011) "Bulb and cut flower production in the genus Lilium current status and the future". Acta Horticulturae900 : 21-36.
26. Hu, W.Y, Duan, JA, Qian, D.W., Wang, DW, 2007, Stulis on chemical constituents in fresh flesky scale lest of Lalam lancifolium, China J. Chu. Mater. Med. 32 (16), 1656-1659
27. Jimenez, S., Plaza, B.M., Segura, M.L., Contreras, J.I. and Lao, T.M. (2012). Peat substrate reuse in Lilium "Haveltia" crop. Commun. Soil Sci. & Plant Analysis, 43 :243-250.
28. Journal of Pharmacognosy and Phytochemistry 2020; 9(4): 185-187.
29. Kale R D, Jagtap K B and Badgujar C D. 2009. Effect of different containers and growing media on yield and quality parameters of gerbera (Gerbera jamesonii Bolus ex. Hooker F.) under protected cultivation. Journal of Ornamental Horticulture 12(4): 261–4.
30. Khalaj M A, Amiri M and Sindhu S S. 2011. Study on the effect of different growing media on the growth and yield of gerbera (Gerbera jamesonii L.) Journal of Ornamental and Horticultural Plants 1(3): 185–9.
31. Khattab, Mahmoud and Wasfi, Imad Al-Din. (1988): Ornamental bulbs, diseases, pests, and methods of resistance, Maarif facility in Alexandria, 370 pages.
32. Lang, N. and Heins, R. (1990).The lowdown on bulb size influence lily development . Grower Talks, 53: 52-54.
33. Mojtahedi, N., J.I. Masuda, M. Hiramatsu, N.T.L. Hai, and H. Okubo. 2013. Role of temperature in dormancy induction and release in one-year-old seedlings of Lilium longiflorum populations. J. Japan. Soc. Hort. Sci. 82:63-68.
34. M. Yamagishi, Y. Yoshida, M. Nakayama, The transcription factor LhMYB12 determines anthocyanin pigmentation in the tepals of Asiatic hybrid lilies (Lilium spp.) and regulates pigment quantity, Molecular Breeding, http://dx.doi.org/10.1007/s11032-011-9675-6, in press.
35. OEPP/EPPO (2002) PM 4/4(2) Certification scheme for lily. EPPO Bulletin 32:79–89.
36. Reddy PP (2016) Lilies. In: Sustainable Crop Protection under Protected Cultivation. Springer Singapore, Singapore, pp 381–391.

UNDER PEER REVIEW

37. Sáringer Gy (1990a) Család: Levélbogarak- Chrysomelidae. In: Jermy T, Balázs K (eds) A Növényvédelmiállattankézikönyve 3/A. AkadémiaiKiadó, Budapest, pp 234–339.
38. Sastry KS, Mandal B, Hammond J, et al (2019) Encyclopedia of plant viruses and viroids. Springer India, New Delhi.
39. Seyedeh Mahboubeh M M, Zahra O A, MostafaM. (2013) . The Effects of different organic fertilizers on the growth of Lilies(Lilium Longiflorum): Science Explorer Publications. ISSN2251-828x/,4(1) :181-186.
40. Seyedi N, Mohammadi Torkashvand A and Allahyari M S. 2012. The impact of perlite and coco peat as the growth media on Lilium. Asian Journal of Experimental Biological Sciences 3(3): 502–5.
41. Sheikh MQ., et al. "Lilium. ICAR-Directorate of floricultural research Bulletin (2015): 18
42. Stamps R. "Use of Coloured Shade Netting in Horticulture". HortScience 44 (2009): 239-241.
43. Tehranifar A, Selahvarzi Y and Alizadeh B. 2011. Effect of different growing media on growth and development of two Lilium (Oriental and Asiatic hybrids) types in soilless conditions. Proceedings of IInd International Symposium on the Genus Lilium, pp 139–42, 30 August 2010, Pescia.
44. Thakur, R., Sood, A., Nagar, P. K., Pandey, S., Sobti, R.C. and Ahuja, P.S. (2005). Regulation of growth of Lilium plantlets in liquid medium by application of paclobutrazol or ancymidol for its amenability in a bioreactor system: growth parameters. Plant Cell Rep., 25 : 382-391.
45. Thangam M., et al. (2016) "Lilium cut flower production under naturally ventilated polyhouse". Extension Folder No. 74, ICARCENTRAL COASTAL AGRICULTURAL RESEARCH INSTITUTE, Goa.
46. Treder J. 2008. The effect of cocopeat and fertilization on the growth and flowering of Oriental Lily 'Star Gazer'. Journal of Fruit and Ornamental Plant Research 16: 361–70.
47. Van Tuyl JM., et al. "Low light intensity and flower bud abortion in Asiatic hybrid lilies. I. Genetic variation among cultivars and progenies of a diallel cross". Euphytica 34 (1985): 83-92.
48. Wale S, Platt HW, Cattlin N (2011) Diseases, pests and disorders of potatoes: a colour handbook. Manson, London.
49. Wazir J S, Sharma Y D and Dhiman S R. 2009. Performance of potted alstroemeria (Alstroemeria hybrida L.) in different growing media under wet temperate conditions. Journal of Ornamental Horticulture 12(3): 167–74.
50. Woodcock H.B.D. & Stearn W.T.1950. LiliesoftheWorld: TheirCultivation and Classification. Country Life, London.
51. Xia Y.P., et al. "Studies on the bulb development and its physiological mechanisms in lilium oriental hybrids". (May 2005). Acta Horticulture.673(673): 91-98.
52. Yau, P.Y., Murphy, R.J. 2000. Biodegraded cocopeat as a horticultural substrate. Acta Horticulture, 517: 275-278.

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