PLANT SCIENCE TODAY
ISSN 2348-1900 (online)
Vol 11(4): 548-556
https://doi.org/10.14719/pst.4821

HORIZON
e-Publishing Group
HePG

REVIEW ARTICLE

Bulbs to blooms: advancements in sustainable *lilium* farming

D. Sarvessh[1], C. Ravindran[2*], J. Rajangam[3], K. R. Rajadurai[1], K. Venkatesan[1], K. Kalpana[3], T. L. Preethi[4], S. Kumar[2] & R. Manivannan[2]

[1]Department of Floriculture and Landscape Architecture, Horticultural College and Research Institute, TNAU, Periyakulam, Tamil Nadu - 625 604, India

[2*]Horticultural and Forestry Research station, Kodaikanal, Dindigul, Tamil Nadu Agricultural University, Tamil Nadu - 624 103, India

[3]Horticultural College and Research Institute, Periyakulam, Theni, Tamil Nadu Agricultural University, Tamil Nadu - 625 604, India

[4]Krishi Vigyan Kendra, Tirur, Tiruvallur, Tamil Nadu - 602 025, India

*Email: ravindran.c@tnau.ac.in

OPEN ACCESS

ARTICLE HISTORY

Received: 26 August 2024
Accepted: 20 September 2024

Available online
Version 1.0 : 14 October 2024
Version 2.0 : 17 October 2024

Check for updates

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc
See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

CITE THIS ARTICLE

Sarvessh D, Ravindran C, Rajangam J, Rajadurai KR, Venkatesan K, Kalpana K, Preethi TL, Kumar S, Manivannan R. Bulbs to blooms: advancements in sustainable lilium farming. Plant Science Today. 2024; 11(4): 548-556. https://doi.org/10.14719/pst.4821

Abstract

The commercial cultivation and marketing of cut flowers presents significant opportunities. The market for exotic cut flowers is expanding day to day. *Lilium* holds a significant position in cut flower industry and is recognized as one of the top ten major varieties in the global floriculture sector. Its cultivation in non-traditional areas needs to be explored to meet the increasing demand. Hence, different research work has been undertaken in different places in order to standardize the cultivation of *Lilium* in open conditions. However, its cultivation is now being done under protected structures for better quality and yield. Furthermore, the practice of protected cultivation makes it possible to grow *Lilium* in non-traditional areas. An effort has been made to compile the production techniques developed for the commercial production of *Lilium*, such as higher yielding cultivars, suitable propagation techniques, intercultural operations, insect-pest disease management and post-harvest technology. These techniques will be replicated in non-traditional areas after proper validation.

Keywords

Bulbs; *Lilium* cultivation; propagation; varietial wealth; vaselife

Introduction

One of the most important genera of landscape plants for pot or bed planting as well as for cut flowers is *Lilium*, which belongs to the Liliaceae family. It is also among the most exquisite and well liked decorative bulbous plants. The blooms are breathtaking and incredibly alluring in their appearance, attractiveness and color. The *Lilium* is a symbol of innocence and purity in the language of flowers. It is appropriate to refer to *Lilium* as the nobleman of the plant kingdom. Because of their variety in color, scent and adaptability to a broad range of climates, the cultivated genotypes of the genus *Lilium* are preferred in the floriculture industry (1). These hybrids, especially the Asiatic and oriental varieties are becoming more popular in both landscape and the cut flower business (2). About 50-60 species have been reported in Asia, 24 in North America and 12 in Europe. It has been discovered that lilies grow in a range of soil types, including acidic and alkaline soils, from sea level to elevations of up to 2000 m, but the production of high-quality cut flowers requires the use of a good growing medium. Because of their tender, non-tunicated bulbs, lilies need a growing

medium that is porous, airy, well-drained and rich in organic matter or humus. The properties of various substrates have an impact on crop productivity and plant growth both directly and indirectly (3).

IMPORTANCE OF *LILIUM* UNDER PROTECTED CULTIVATION

- Climate change has become an increasingly critical global issue that can no longer be overlooked.
- The primary human-induced contributors are overpopulation and rapid urbanization, driven by the unsustainable use of fossil fuels and deforestation for industrial purposes.
- In controlled environments, crops are protected from cold, wind, storms, rain and frost. These conditions lead to higher germination rates, stronger plant growth and earlier flowering (4) .
- Yields and quality improve, with longer shelf life, while water usage is optimized, reducing consumption by 40 -50 %.
- Inputs are used more efficiently and the incidence of pests and diseases in *Lilium* is reduced.
- *Lilium* can be cultivated year-round, even in unfavorable weather conditions, making it suitable for high-value export crops, boosting revenue and reducing labour requirements.
- This creates more self-employment opportunities, particularly for educated youth. Additionally, manipulating the microclimate and using insect-proof nets aid in plant breeding to develop new varieties and produce seeds (5).

SCOPE OF *LILIUM* PRODUCTION UNDER PROTECTED CONDITION

Cultivation in a variety of agro climatic zones: Globally, deserts, arid lands and barren, uncultivated fallow lands account for the majority of uncultivated land. For the indigenous population, even a small portion of this area put under greenhouse cultivation might result in significant profits. Greenhouses in cities: vegetables and ornamentals are in high demand year-round as well as during the off-seasons in cities. Promoting the greenhouse cultivation of horticulture crops will help to meet this demand. The majority of lily growers employed greenhouses and 89 % of survey respondents grew cut lilies in greenhouses using soil cultures (6). Export of agricultural products: encouraging the production of *Lilium* flowers under protection or in greenhouses will help satisfy demand abroad. Greenhouses (GH) for plant propagation: greenhouse technology is being currently thought of as an appropriate approach for raising seedlings and cuttings. Greenhouse technology for biotechnology: Material generated through tissue culture or for plants to grow in controlled environments, nutrient film technique is required (7). Greenhouse for rare and healthful plant cultivation: India is known for its large-scale cultivation of rare plants, such as orchids and a diverse range of herbs. The right environmental conditions for the intensive cultivation of those plants might be provided by the greenhouse (8).

LILIUM DIVISIONS AND VARIETAL WEALTH

It is estimated that lilies have been cultivated for 3000 years and that they first appeared more than 5 million years ago. There are over 80 species which can be discovered in gardens across different regions, exhibiting a range of shapes, sizes and colors in their blooms (9). Divisions of *Lilium* (Table 1), Interspecfic hybrids (Fig. 1) and Groups of *Lilium* (Table 2). Oriental lilies are originated from temperate regions and have large bulbs and larger size, more fragrant flowers with a predominant pink or white hue. They also have fewer, larger leaves. Asiatic lilies have a greater quantity of smaller leaves that are erect and arranged in a spiral pattern atop the stems. The flowers come in variety of colors and shades and are odorless. All cultivated lilies nowadays are hybrids of hybrids. Cultivars of *Lilium longiflorum* have longer, clustered flowers with more buds. Prominent cultivars of Asiatic hybrid *Lilium* include Vivaldi, Tierango, Alaska (Pink), Cannes (Salmon), Pavia, Nashville, Nov Cento (Yellow), Monte Negro (Red), Tresor, Brunello, Lyon, Orange Matrix (Orange) and Merente, Navona and New Wave (White). Siberia (white), Sorbonne (pink), Star Gazer (dark pink), Tropical (dark red), Legend (yellow) and Casa Blanca are some of the more well-known cultivars of hybrid Oriental lilies. Fangio (purple), a well-liked LA hybrid, is doing well in the Eastern regions (Table 1 and 2, Fig. 1) (10).

ENVIRONMENTAL PARAMETERS

Commercial cultivation of lilies especially in non-traditional areas requires a controlled environment and so protected cultivation of lilies are the focus of attention. For the cultivation of lilies, light is a critical component. If it is not grown in a shaded area, the plants will continue to be small. It is advantageous to use a shade net that provides 50-75 % shade (11). The ideal flower production requires 2000-3000 candle feet of light. High light levels as seen during hot summers, shorten stems, so It is suggested that cover the crop with 50 % shade nets (12). The winter season low light levels cause flower abortion and abscission, but additional or supplemental lighting improves flower quality, yield and stem strength (13). The length of the flower stalks does not increase proportionately with increased light, which degrades the quality of flowers. Asiatic hybrids thrive in temperatures between 21 and 22 ºC during the day and 14 to 15 °C at night. It can, however, also grow in temperatures as high as 25 ºC during the day and as low as 8 to 10 °C at night. The ideal temperature range for oriental hybrids is 20 to 22

Table 1. Division and interspecific hybrids of *Lilium*.

DIVISIONS OF *LILIUM*	Asiatic hybrids (Division I), Turks' Cap hybrids (Division II), *Lilium candidum* hybrids (Division III) North American *Lilium* (Division IV) *Lilium longiflorum* (Division V), Trumpet *Lilium* (Division VI), Oriental *Lilium* (Division VII)

Table 2. Most prominent groups of *Lilium*.

	ASIATIC HYBRIDS	ORIENTAL HYBRIDS	TROPICAL HYBRIDS	LONGIFLORUM *LILIUM*
BLOOM TIME	Early summer	Mid summer	Early summer	Spring
FRAGRANT	no	Yes	Yes	Yes
MATURE HT	2-3 ft	3-4 ft	4-6 ft	3-4 ft
BLOOM COLOUR	Red, yellow, orange, pink, dark purple, white, bicolour	Varying shades of pink, white, salmon, lemon yellow	White, yellow, orange, pink, red, purple	Pink, red, white
PLANTING SEASON	Spring and fall	Spring and fall	Early summer	Spring and fall
FLOWER FACE	Up	Out	Up	Out

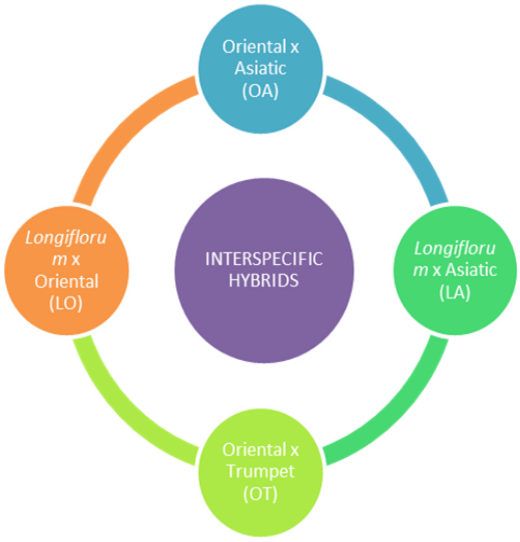

Fig. 1. Interspecific hybrids of *Lilium*.

ºC during the day and 15 to 17 ºC at night. It can withstand temperatures as high as 25 ºC. However, if the temperature drops below 15 ºC, the foliage will turn yellow and the buds will drop. The ideal daytime temperature for *Lilium longiflorum* hybrids is 24 °C, while the ideal night time temperature is up to 14 °C (14). An approximate humidity of 60 to 75 % is necessary to produce high-quality flowers. Additionally, there must be more carbon dioxide inside the protected area than outside of roughly 800-1000 parts per million roughly 2000 parts per million for hybrids of *Lilium longiflorum* (15).

LILY PROPAGATION METHODS

Division techniques

The commercial method of vegetative propagation of *Lilium* is through bulb propagation. This method of propagation produces true to type plants but growth is very slow and crop is more susceptible to viral infections (16). Simple bulb division or splitting, bulb scaling, bulbils (small bulbs carried in the leaf axils or small bulbs carried on the subterranean section of the stem) are examples of vegetative propagation. Several *Lilium* species can be multiplied successfully by scaling, and during this process, bulb let formation is stimulated by leaf emergence from the scales (17).

Seeds

It takes longer to grow a mature bulb from seed than it does through vegetative propagation. It is a technique for producing a lot of bulblets from a single pod and is applied in the creation of new varieties (14). Most species and cultivars that grow from seed require 3 years to flower, but flowering plants can be generated in the second year (in case of *Lilium longiflorum*) or third year (in case of Asiatic) or the fourth year (in case of Orientals) (18).

Micro Propagation

For the purpose of producing of true-to-type, high-quality planting material in *Lilium*, micropropagation is crucial. For a few years, a huge number of plantlets or bulbs produced *in vitro* can be planted *in vivo* in order to produce more larger-sized bulbs. It was found that *in vitro*, the *Lilium* LA hybrid cultivar Fangio significantly increased the amount of greenish calli mass when Murashige and Skoog Medium incorporated with 1.0 mg/L BAP and 2.0 mg/L 2,4-D was used. In Murashige and Skoog medium incorporated with BA 2.0 mg/L + NAA 0.5 mg/L, the heaviest bulblets with average initial weight (365 mg), most number of shoots, most shoot length (12 cm) and highest bulblet regeneration (94 %) were obtained (19). For the cultivation of high-quality *Lilium* plants *in vitro*, Red (R) light was found to enhance stem elongation and increase the number of leaves in *Lilium* cultured *in vitro*, while Blue (B) light was associated with elevated levels of sugars and soluble protein contents. Notably, the treatment with a Red to Blue light ratio of 7:3 proved to be optimal for photosynthesis.

Bulbs

The primary means of propagating lilies is through bulbs. Six to eight weeks after the parent bulbs begin to produce flowers, the small bulbs are removed. Then, depending on the cultivar, they are kept in a cold house for 6-10 weeks at 2-5 ˚C to break their dormancy (20). Other workers have also reported that bulbs able to store at -2 ˚C for up to a year, and that a 6 weeks cold storage period at 2˚to 5 ˚C is required to break dormancy (14). Bulbs are formed at the joints where the leaves and stems meet. These bulbs are harvested from the plants once they reached maturity and placed in pots or beds. Increased bulb size positively correlates with increased flowering time. Large bulbs (20 to 22 cm or more) should be used for Oriental hybrid lilies and bulbs measuring 12 to 14 cm or more are typically used for Asiatic lilies. The smaller bulb sizes of 12-14 cm for asiatics and 16-18 cm for orientals are frequently advised for flower forcing when producing cut flowers (21). Scale is another way that *Lilium* spreads. Using this method, large, disease-free and healthy bulbs are chosen for dormancy. Similar in structure to a garlic bulb, the *Lilium* bulb has multiple scales affixed to its base plate. A tiny piece of the

base plaque divides the outer and middle scales from the bulb. Before planting, they are treated for 30 min with a fungicide such as Bavistin or Carbendazim (1 g) and Dithane M-45 (2 g) per L of water. Then they are shade dried for 12 h in a cool area. The scales are then planted in disease-free mixtures like cocopeat, wood sawdust or vermiculite after being treated with NAA (500 ppm) and allowed to dry. Sand or friable clay can also be used. After applying a fungicide solution to the mixture, it is put into pots, trays or other flat containers. These scales produce tiny bulbs in a matter of months, which develop into flowering bulbs in 3-4 years. Ensuring that the atmosphere remains moist throughout the process is crucial (22) .

PLANTING LILY BULBS

The best month for planting of Asiatic *Lilium* was November (5). As the roots are responsible for absorbing water and nutrients for first 3 weeks after planting, it is crucial that the bulbs are sound and have well-formed, healthy roots before planting. As the shoot breaks off, the stem immediately above the bulb begins to sprout and are known as stem roots (23). Water and nutrients will be supplied to the plant by these stem roots rather than bulb roots. So, proper growth of the stem roots is essential for producing high-quality flowers. For winter planting, the recommended depth is between 10 and 12 cm (12). Deep planting at 25 cm significantly improved total stem and root systems, stem diameter, leaf area and flower quality, specifically, vase life from deep planting were higher when bulbs were planted 25 cm deep when compared to planting at 5 cm and 15 cm (4). October through November is a good time to plant the Asiatic lilies in the Northern Plains, while March through April is a good time to plant in the hills. However, in areas like Chhattisgarh, MP and Bundelkhand, October and November are good months to plant *Lilium* provided the bulbs are not be dormant while planting. Digging the soil to a minimum depth of 40 to 45 cm and adding well-decomposed cow dung at a rate of 5 to 10 kg/m^2 is recommended. The height of the beds should be between 25 and 30 cm. Planting the bulbs requires a 15 cm spacing between each bulb, 30 cm between lines and a 10 to 15 cm depth. Sterilizing the soil is a must before planting the bulbs. The soil can be sterilized by applying a formalin solution, covering it with a polythene sheet and then removing the sheet after a week and leaving it in place for 15 days to allow the gas to escape (22). It was optimized 10-12 cm is the standard planting depth for *Lilium* bulbs, planting depth varies according to the size of the bulb. Generally, bulbs should be planted to the depth of 3 times more than the diameter of the bulb.

Planting density

Planting densities range from 25 to 60 bulbs/m^2, depending on the cultivar, size and season (15). Some of the commonly used planting distance according to the bulb size and density are given below in Table 3 (12).

SOIL FERTILIZATION AND NUTRIENT MANAGEMENT

Soil mixture

Cocopeat can be used as growing medium for cultivation in polyhouses. For successful flower production, soil preparation should be done in such a way that the network of roots can easily establish and make the plants strong. If necessary, it can also hold food and water. But there's a chance that bulbs in the ground will rot (24).

Table 3. Optimum bulb size and planting density in *Lilium*.

Bulb Size (cm)	Planting distance (cm)	Number of Bulbs/m^2
8 -10	15 x 15	49
10 - 12	16 x 15	42
12 - 14	16 x 18	36
14 - 16	16 x 18	36

Light and well-drained soil is good. Soil pH between 6.0-7.0 for Asiatic and *Longiflorum* hybrids and 5.5 to 6.5 for oriental hybrids are thought to be the best. Proper drainage arrangements in the growing mixture are also crucial for crop growth, as they prevent plant roots from rotting. Mixing soil with sand, peat or perlite will result in a good mixture. It is also possible to prepare and use a 2:1:1 mixture of soil, cow dung and sand (22). In cocopeat, the ideal bulb diameter and stem length were attained. Recommended media mixture should be combined with 90 g urea, 250 g SSP and 65 g MOP/m^2 prior to the bulbs being planted (8). Throughout the crop growth period, 0.2 % of water-soluble fertilizer poly feed (NPK 19:19:19) should be applied weekly. In contrast, the largest number of flowers (7 in Siberia; 5.67 in Vespucci), highest stem weight (266.13 g in Vespucci; 353.91 g in Siberia) were recorded in cocopeat. The earliest flowering time (154.78 d) and the longest plant height (120.82 cm in the 'Siberia' variety) were found in peat and pumice (25).

Fertilization schedule

Plants need to be fed in liquid form or with fertilizers that are released gradually. Being a bulbous crop, *Lilium* already contains the majority of its nutrients in the bulb. Specially, At the first three weeks when rooting occurs, no extra fertilizer is needed (26). At this point, good root development is crucial. Applying 12:61:00 at 2 kg/100 m^2 is recommended at least 1 week prior to planting. Since this crop is extremely sensitive to salt, caution should be used when applying fertilizers. If fertigation is not used, the following fertilizer doses are applied: 1 kg/100 m^2 of calcium nitrate after 3 weeks of planting and 1 kg/100 m^2 of potassium nitrate after 6 weeks of planting. Up to 3 weeks prior to harvesting, a top dressing of ammonium nitrate at a rate of 1 kg/100 m^2 can be applied if plants are not robust enough during the growing season (27) (Table 4 (28).

According to a study, after 15 days of planting, foliar application of Murashige and Skoog macronutrients at 100 mL L^{-1}, Murashige and Skoog micronutrients at 10 mL L^{-1} and Murashige and Skoog vitamins at 1 mL L^{-1} improves the size and quality of cut flowers in *Lilium* hybrid. Alternatively, application of calcium nitrate (Ca- 18.8 %, N-15.5 %) at 1 kg/100 m^2 3 weeks after planting, potassium nitrate (13:00:45) at 1 kg/100 m^2 6 weeks after planting and mono ammonium phosphate (12:61:0) at 2 kg/100 m^2 at

Table 4. Fertigation dose of *Lilium*.

FERTIGATION DOSES	QUANTITY (Mg/M²/WEEK)	
	Asiatic	Oriental
19:19:19	500	500
Micronutrient mixture	1200	1200
Calcium Nitrate	2500	2500
Potassium Nitrate	2200	2300

least 1 week prior to planting increases yield and flower quality.

Growth Retardants

The application of growth retardants, specifically paclobutrazol and cycocel, yielded noteworthy impacts on the growth, flowering and bulb characteristics of Asiatic *Lilium*. Notably, the treatment combination of paclobutrazol at 60 ppm and cycocel at 200 ppm demonstrated compelling results. This combination resulted in the minimum days required for bulb sprouting (17.66 days), producing the shortest plants (45.18 cm) with a reduced number of leaves (35.00). Additionally, it exhibited a shorter duration to color break (48.00 days), anthesis (52 days) and the maximum number of bulbs per plant (3.91), along with a smaller bulb diameter (6.33 cm) yet boasting the highest propagation coefficient (3.91). Contrastingly, the treatment with cycocel at 200 ppm stood out in terms of maximum flower diameter (15.27 cm), bulb weight (98.10 g) and scale size (2.03) (29).

Organic and synthetic fertilizer

Application of vermicompost resulted that, better growth and development as plants had a greater number of leaves, leaf dry mass, fresh stem and dry weight, stem height and diameter, root number and length and also an increased level of gibberellic acid in root tissues. Vermicompost treatments at suitable levels of 20 % and 30 % had stimulating effects on the number of flowers and their diameters and caused earliness in flowering. The result of the present study showed that the use of vermicompost, particularly, with a 30 % content had favourable results on growth and development of the Asiatic *Lilium* hybrid var. Navona (30). An experiment was conducted to study the effect of organic manure and inorganic fertilizer, results indicated that 50 % RDF + FYM 14 t/ ha recorded minimum days to first bud initiation, days to first floral bud emergence and days to first flower opening. The same treatment recorded highest number of bud per plant, number of spike per plant, number of spike per ha, weight of single bulb, diameter of single bulb, number of bulb per plants and bulb yield/ha (17). The flowers with the longest vase life (9 days) were observed when grown in a substrate comprising 20 % compost derived from water hyacinth (31).

IRRIGATION

One of the most crucial elements in lily cultivation that encourages growth is irrigation. Prior to bulb planting, the soil is moistened. The bulbs are generously watered after planting to ensure that the soil properly clings to the roots and bulbs. It is crucial to maintain a constant moisture level in the top (30 cm) soil since the stem roots grow there. However, water stagnation should be avoided. The amount of water used per day during the dry spell could reach up to 10 L/m²/day (12). When irrigated with the ultra-filtration water type as opposed to the effluent filtration and mixed water treatment, lily cultivars produced the highest flower yields (kg m^{-2}) (32). When UF irrigation was used instead of other types of water, crops grew noticeably more flowers per stalk, heavier flowers, longer and thicker stalks and more buds overall (21). To ensure optimal flowering, 6-8 L of water/m² should be applied in the summer and 4-5 L in the winter (33).

Water management

Irrigation should be done first, followed by light irrigation, before bulb planting in the beds. Moisture should be kept in the top 30 cm of the soil because the *Lilium*'s stem roots grow in the upper soil. It should be remembered that moisture should persist and the water should not stagnate. To provide irrigation, a drip irrigation system is installed (34). To prevent rotting, the dripper on the lateral is positioned 20 cm apart from the plant. It needs to be kept consistently moist as the top layer grows stem roots. The amount of water needed in the summer is roughly 6 to 8 L/m²/day, while the amount needed in other seasons is roughly 4 to 5 L/m²/day. Irrigation is done using rose can during the first 2 weeks. From the third week onward, drip irrigation is advised. In addition, the irrigation water's EC should be less than 0.5 m²/cm and its chlorine content should be around 200 ppm (15).

LILIUM PLANT CARE AND MAINTENANCE

Staking and supporting tall varieties

Because of their weak roots and straight flower stalks, *Lilium* plants require support. When big flower heads get heavy and the branches can no longer hold their weight, the need is intensified (35). Twine and bamboo sticks are utilized as supports. In addition, nets made of nylon or plastic are employed. The nets' height rises in tandem with the plants' growth. A nylon net with a width of 4 to 6 inches is utilized (2).

Disease and pest management

The important diseases, pest and disorder their symptoms and control measures have been presented as below: (Table 5-7) (22, 36).

HARVESTING LILY FLOWERS

Timing for optimal flower harvest

It is critical for flower growers to understand when and at what stage to pluck flowers. It takes 90-120 days after planting for flowers to be ready for harvest (37). The ideal time to harvest flowers is early morning. The flower stalk is cut 8-10 cm above the ground as soon as the first bud begins to exhibit colour (15).

Table 5. Diseases of *Lilium.*

Diseases	Symptoms	Control Measure	
Blue mold rot, *Penicillium* spp.	Occurs when bulbs are being stored. Initially, the decaying areas are white and as time goes on, the scales develop fluffy, bluish green fungus. Plants borne from these bulbs will grow more slowly.	Keeping bulbs at the suggested temperature and removing the contaminated scales as soon as feasible.	
Bulbs and Scale rot	The sides and top of the bulb have brown spots. The bulbs will begin to decompose. The plants will grow more slowly and have pale foliage.	Soil drenching with carbendazim at 1 g / L or difenoconazole at 0.5 mL / L	 On the left side: scale rot; on the right side: bulb rot
Fusarium	Lower leaf yellowing that eventually turns brown, then orange and finally dark brown patches on the stems.	Fungicide-based soil disinfection is necessary. Preserving the humidity and temperature in the green house as advised	
Phytophthora	The leaves will begin to turn yellow. There will be foliage wilting. The base of the stem will turn a dark brown color, continuing upward. Plant growth will be slowed down.	Disinfection of soil. The ideal moisture content for soil requires adequate drainage. keeping the soil's temperature constant.	
Botrytis elliptica	There are dark brown patches on the foliage. Bud begins to rot and become malformed. Flowers have round, grey and wet spots.	It is best to water in the early morning. Applying fungicides such as vizcaptaf (2 g) + Bavistin (2 g/L) or Dithane M45 (2 g/L)	

Table 6. Pest of *Lilium.*

Common pests	Control measures
Aphids	Use Dimethoate (30 EC at 2 mL/L) or imidacloprid (17.8 % SL @ 1 mL/L)
Mites	Apply 1.5 g/L of wettable sulfur, 0.4 mL/L of abamectin or 2 mL/L of propargite via spraying.
Thrips	Applying 25 EC methyl demeton or 30 EC methyl ester at a rate of 2 mL/L via spraying

Table 7. Disorder of *Lilium.*

Common disorder	Causes
Leaf scorch	Caused by an excess of nitrate level and a deficiency of Mn/Al
Bud blast	This is caused by water storage at the top of the plant, nutrient competition, varying carbohydrate levels, low light intensity and elevated nitrate levels.
Puffy foliage	This results from plant stunting caused by frost damage

Proper harvesting techniques

To ensure that the flower stems stay fresh for as long as possible, they should be immediately placed in clean, cold water after cutting. In order to minimize transpiration and prolong the freshness of the process, any unnecessary leaves on the stalk should be removed before putting them up for sale in the market. Oriental hybrids require 14-16 weeks from planting to harvest, whereas Asian hybrids require 8-10 weeks (38). When bunching, 10 cm of foliage is cut off from the tips of the stems and the flowers are covered with sleeves. The cut flowers must be kept in cold water in a cold storage room between 2 and 3 °C as soon as they are bunching. To extend the vase life of flowers, it is advised to add 2 % sucrose and 100 ppm GA_3 as preservatives to water. Perforated boxes should be used for packing to ensure that lily flowers are transported at the right temperature. For 24 h, they are pulsed with 0.2 mm STS and 10 % sucrose (12). The flower vase life is greatly increased when a 5 % sucrose solution containing 200 ppm HQS (Hydroxyquinoline Sulfate) is added (39). The application of SiO_2 NPs through the foliar method induced a greater flower shelf life of up to 21.62 % (40).

YIELD AND GRADING

The flower yield ranges between 30 and 40 flower stems/ m^2 (41). Grading is done based on the length of the stem and the quantity of buds per stem. High-quality flower stems free of defects or insect disease outbreaks fetch highest prices (42).

ECONOMICS

It is possible to plant 27000 *Lilium* bulbs in a 1000 m^2 poly shade net structure. The total cost for 5 years of 2 season cultivation, including structure, inputs and wages will be Rs. 7015250. The gross income for this period will be Rs. 13750000, with a net profit of Rs. 6734750. As a result, *Lilium* cultivation is very profitable right now. It respectably draws the attention of the highly educated masses and undoubtedly will boost prosperity and pride for both the people and the country (43). The cultivation of *Lilium*, yields a substantial benefit-cost ratio of 2.54:1, establishing it as a highly profitable venture for farmers in hilly regions (44).

CONSTRAINTS IN PRODUCTION AND MARKETING OF *LILIUM* FLOWERS

For most flowers, finding high-quality planting material is a major challenge; this is especially true for *Lilium*s, since the bulbs must be imported from the Netherlands. Other significant obstacles include the fact that *Lilium* cultivation is capital-intensive, the lack of technical understanding in this area and issues with pests and diseases like *botrytis.* Because cut flowers are traded on credit, there are irregular payments and payment defaults as a result. Flowers are in higher demand and they were only recently supplied in small quantities to markets that were far away. Air freight may decline as production and volume increase. For example, air freight to Kolkata costs Rs. 28/kg if the shipment weighs more than 500 kg, but because of small consignments, the traders always have to pay Rs. 40-42/kg. Lack of specialized, adequate transportation facilities (cool chains) frequently forces growers to use overnight buses to get to Bangalore and Coimbatore, which provides the least amount of protection for the quality of their flowers. Between 5 and 10 % of flowers are wasted during the season and up to 35 % during the off-season as a result of challenges faced during transportation (45).

Conclusion

Lilium cultivation is highly recommended for protected cultivation with controlled environmental parameters like optimum temperature, humidty, slight and percised fertigation and cultural practices etc. The market's preference for a particular color, such as white, should be taken into consideration when expanding the area under *Lilium* flowers and consequently, the supply of high-quality planting materials through the establishment of public or private plant material multiplication centers. It would also be advantageous to train growers in standardized production, marketing and value addition. Finally, considering the possibility of opening an auction center in many cultivating areas would help growers avoid being completely dependent on a small number of traders. It is necessary to promote wholesalers to open a model "Flower boutique" at strategic locations like airports and commercial districts. An excellent model for advancing this industry would be to establish Floriculture Infrastructure Parks (FIP) in various growing regions. In addition to providing the necessities like water, refrigeration units and packing houses, this kind of business also handles the identification of possible markets, including global markets. Additionally, by establishing a network of flower distribution outlets to meet the needs of people across regions and by widely publicizing the idea of "say it with flowers," e-commerce in the cut flower trade may become more popular.

Future Prospects

The growing demand for ornamental flowers worldwide and the adaptability of *Lilium* in a variety of applications make *Lilium* cultivation appear promising. *Lilium* are still in high demand in the floral industry due to their distinctive petal patterns and wide variety of vivid colors, which helps to fuel a thriving market. Additionally, the growing popularity of flower gifts and the use of *Lilium* in a variety of settings, including festivals and weddings, increase their economic potential. Because some lily species are prized for their therapeutic and skincare qualities, *Lilium* cultivation is also becoming more popular in the pharmaceutical and cosmetic sectors. The market appeal of *Lilium* is expected to increase as a result of research and development into breeding techniques to improve traits like fragrance, longevity and disease resistance. additionally, the shift towards sustainable and eco-friendly practices in agriculture aligns well with *Lilium* cultivation, which can be adapted to environmentally friendly methods. The ease of cultivating *Lilium*s, their adaptability to different climates and the potential for

year-round production further contribute to the positive outlook for *Lilium* cultivation. Overall, the future seems bright for the *Lilium* industry, driven by its aesthetic appeal, diverse applications and adaptability to evolving market trends.

Acknowledgements

The support and guidance of all the peer-reviewed manuscript by reviewers are very much appreciated.

Authors' contributions

DCTL: Writing of original draft and conceptualization. CJKRKKS: Revision of draft, inclusion of tables and figures, proof reading. SRTLKK: Revision, formatting and Supervision. All the authors read and approved the final version of the manuscript.

Compliance with ethical standards

Competing interests:

Authors do not have any conflict of interests to declare.

Ethical issues:

There are no any ethical issues.

Declaration of generative AI and AI-assisted technologies in the writing process

For paraphrasing few sentences, I have used only the Chatgpt AI tool.

For data running and analysis, I have used AGRES software.

Funding:

No funding was received.

References

1. Bahr LR, Compton ME. Competence for *in vitro* bulblet regeneration among eight Lilium genotypes. HortScience. 2004;39(1):127-9. https://doi.org/10.21273/HORTSCI.39.1.127
2. Yang Y, Zong J, Huang P, Yang F, Liang Y. Time of pruning influences the growth and bulb yield of edible lily (*Lilium davidii* var. *unicolor*) plants. 2013;88(6):721-6. https://doi.org/10.1080/14620316.2013.11513030
3. Rajera S, Sharma P, Letters. Effect of different growing media on bulb production of hybrid lily. 2017;6(23):1382-7. https://doi.org/10.20546/ijcmas.2017.608.247
4. Mukherjee A, Rakshit S, Nag A, Ray M, Kharbikar H, Shubha K, et al. Climate change risk perception, adaptation and mitigation strategy: An extension outlook in mountain Himalaya. 2016:257-92. https://doi.org/10.1007/978-981-10-2558-7_10
5. Chandrashekar S, Naik BH, Chouhan ML, Mastiholi A. Influence of date of planting on the morphological parameters of asiatic lily cv. Pavia.
6. Kang Y-I, Joung HY, Goo DH, Choi YJ, Choi MP, An HR, et al. A survey on cut flower cultivar trends and horticultural status of lilies (Lilium hybrids) in South Korea. 2013;23(5):629-34. https://doi.org/10.21273/HORTTECH.23.5.629
7. Streck NA. A generalized vernalization response function for lily.
8. Giri TK, Beura S, Behera S, Acharjee S. Response of asiatic lilium hybrid cv. Tresor to foliar application of different group of nutrients. 2017;6(9):3280-6. https://doi.org/10.20546/ijcmas.2017.609.404
9. Sarvade S, Ranpise S, Thorat A. Evaluation of different varieties of lilium (Lilium sp.) for flowering and flower quality under shade net conditions". 2015;33(2 (Part I)):499-501
10. Ahmed Z, Ganai N, Nazir N, Kaur PJRK. Response of flowering in lily to light and temperature: Advances. 2018;76-8
11. Masoodi NH, Nayeem S, Toa J. Evaluation of different lilium hybrids under climatic conditions of Kashmir valley. 2018;17 (1):556008. https://doi.org/10.19080/ARTOAJ.2018.17.556008
12. Du Y, Wei C, Wang Z, Li S, He H, Jia G. Lilium spp. pollen in China (Liliaceae): taxonomic and phylogenetic implications and pollen evolution related to environmental conditions. 2014;9 (1):e87841. https://doi.org/10.1371/journal.pone.0087841
13. Thangam M, Safeena S, Devi SP, Singh NP. Lilium cut flower production under naturally ventilated polyhouse. 2016
14. Stamps RHJH. Use of colored shade netting in horticulture. 2009;44(2):239-41. https://doi.org/10.21273/HORTSCI.44.2.239
15. Arya R, Arya S, Arya R, Kumar J. Fundamentals of Agriculture (ICAR-NET, JRF, SRF, CSIR-NET, UPSC & IFS): Scientific Publishers; 2015.
16. Deswiniyanti NW, Lestari NKDJKLS. In vitro propagation of *Lilium longiflorum* Bulbs using NAA and BAP plant growth regulator treatment. 2020. https://doi.org/10.18502/kls.v5i2.6437
17. Lokeshwar Prasad SS, Lall D, Singh V. Effect of organic manure and inorganic fertilizer on plant growth and flower yield of Asiatic lily (*Lilium longiflorum*) sp. Zephyranthes. 2017;35 (2A):929-32
18. Bakhshaie M, Khosravi S, Azadi P, Bagheri H, Van T. Biotechnological advances in Lilium. 2016;35:1799-826. https://doi.org/10.1007/s00299-016-2017-8
19. Gochhayat AA, Beura S, Subudhi E. Effect of surface sterilization time and plant bioregulators for callus formation in hybrid Lilium Cv. Tresor. 2017;14(2):709-13. https://doi.org/10.13005/bbra/2498
20. Mir J, Ahmed N, Itoo H, Sheikh M, Rashid R, Wani S. In vitro propagation of Lilium (*Lilium longiflorum*). 2012;82(5):455. https://doi.org/10.56093/ijas.v82i5.17812
21. Bonnier F. Long term storage of clonal material of lily (Lilium L.). 1997
22. Safi M, Bulad A, Blawenah A, Bashabsheh I. Water use efficiency, flower yield and quality of '*Lilium aziatische*'irrigated with different water types. 2007;9(2):264-6
23. Sharma G. Protected Cultivation of Lilium cut flower in the non-traditional regions. Acta Scientific Agriculture 2022;6(6):6-12.https://doi.org/10.31080/ASAG.2022.06.1140
24. Hani MB, Othman YA, Al-Ajlouni MG. Deep planting improved stem root growth, flower yield and quality of Lilium cultivars. 2022;40:143-50. https://doi.org/10.1590/s0102-0536-20220203
25. Thangam M, Singh D. Lilium cut flower prduction under naturally ventilated polyhouse. In: coastal, institute. ICAR-Central Coastal Agricultural Research Institute Ela.
26. Heidari S, Mortazavi SN, Reezi S, Nikbakht A, Research P. Composted palm waste as an alternative of coco peat in growing media: effects on growth and nutritional status of Lily cut flower (Lilium spp.). 2021;4(Special Issue-Plant Nutrition in Horticulture):49-66
27. Karagüzel O. Effects of different growing media on the cut flower performances of oriental two Lilium varieties. 2020;13 (5):85-92. https://doi.org/10.25165/j.ijabe.20201305.5173

28. Alsaleh T, Awadh A. The Effect of the size of the bulbs and the type of fertilizer In the number and length of leaves and flower production in *Lilium longiflorum*. 2020;15(2):92-102

29. Singh AK, Sisodia A, Kaur S, Shakywal R, Rathour S. Flower production with drip irrigation: Increasing yield and quality of flowers.

30. Ahmed Z, Nazir A, Nazki I. Growth and flower production of lilium as influenced by precise application of mineral nutrients. 2023;25(1):96-100. https://doi.org/10.5958/2349-297X.2023.00011.9

31. Malik K, Wani A, Nazki I. Effect of growth retardants on growth, flowering and bulb yield of Asiatic Lilium. 2021;11:448-52. https://doi.org/10.29322/IJSRP.11.04.2021.p11260

32. Moghadam A, Ardebill Z, Saidi F. Vermicompost induced changes in growth and development of Lilium Asiatic hybrid var. Navona. 2012;7(17):2609-21. https://doi.org/10.5897/AJAR11.1806

33. Norian N, Rohollahi I, Technology. Evaluation of organic fertilizer from Water Hyacinth (*Eichhornia crassipes*) as substrate for Lilium sp. 2018;19(3):267-76

34. Biabi H, Mehdizadeh SA, Salmi M, Agriculture Ei. Design and implementation of a smart system for water management of lilium flower using image processing. 2019;160:131-43. https://doi.org/10.1016/j.compag.2019.03.019

35. Othman YA, Asaf TS, Al-Ajlouni MG, Hani MB, Hilaire R. Holding solution pH and composition consistently improve vase life of rose, lily and gerbera. 2023;15:57-62. https://doi.org/10.25081/jp.2023.v15.7742

36. Omidian M, Roein Z, Shiri M. Effect of foliar application of 24-epibrassinolide on water sse efficiency and morpho-physiological characteristics of Lilium hybrid under deficit irrigation. 2022;41(4):1547-60. https://doi.org/10.1007/s00344-021-10400-8

37. Kumari S, Dhiman S, Sharma P, Dhiman M. Performance of Lilium hybrids under mid-hill conditions of Himachal Pradesh. 2018;9(4):404-7

38. Conijn C.Developments in the control of lily diseases. International Symposium on the Genus Lilium 1027; 2014. https://doi.org/10.17660/ActaHortic.2014.1027.23

39. Singh AK, Hembrom R, Singh J, Sisodia A, Pal A. Effect of iron and zinc on growth and postharvest life in Lilium cv. Tresor. 2015;33(2):625-8

40. Kumar D, Bhanwala V, Kumar S, Kumar P, Saran M. Lilium: A guide to protected cultivation in Haryana. 2023:7

41. Juan Francisco SN, Yolanda GG, Adalberto BM. Silicon nanoparticles improve the shelf life and antioxidant status of Lilium. 2021.https://doi.org/10.3390/plants10112338

42. Mahesh M, Prasad V, Kumar N. Evaluation of different Lilium hybrids (*Longiflorum asiaticum*) for better flowering, quality of flowers and economics under shadenet in prayagraj agro climatic conditions. 2023. https://doi.org/10.5958/2231-6736.2023.00044.3]

43. Agritech potral. Lilium 2021 [Available from: https://agritech.tnau.ac.in/horticulture/horti_flower%20crops_lilium.html

44. Neelam S, Singh A, Singh S. Cultivation and market economics of lilium flowers grown in Kumaun hills of Uttarakhand. 2019;15(1):163-6

45. Gajanana T, Sudha M, Murthy DS, Dakshinamoorthy V. Economics of production and marketing of bulbous ornamentals-a case study of lilium. 2008;22(2):170-83