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Production Technology of Lilium Under Protected Condition

Narendra Kumar[1*], V. M. Prasad[2] and Vijay Bahadur[3]

[1 2 & 3]Department of Horticulture, SHUATS, Prayagraj

Corresponding Author : Gangwar077@gmail.com

Introduction

Flower bulbs, also called ornamental geophytes, exhibit great diversity in their morphology, growth and developmental biology and physiological responses to environmental factors. Horticulturally, they contribute significantly to the global ornamental industry and are utilized for commercial bulb and flower production, including outdoor and forced fresh-cut flower and potted plants and for landscaping, including private gardening, Although ornamental geophytes belong to more than 800 different genera, the industry is dominated by 7 genera: *Tulipa, Lilium, Narcissus, Gladio-lus, Hyacinthus, Crocus,* and *Iris*. Most of the traditional flower bulbs are cultivated in temperate-climate regions of the world.

The genus *Lilium* belongs to the Liliaceae family which comprises of about 80 species and thousands of cultivars. The lily species are taxonomically classified into seven different sections based on various morphological and physiological characteristics. The diversity of flower colour, shape, fragrance and other phenotypic and physiological characteristics are found in the wild species which are dispersed in the Nortern Hemisphere (10^0 to 60^0), mainly in Asia, North America and Europe. Especially, China, Nepal, Korea and Japan are the gene centers of this genus around the world. All over the world the lily occupies a prominent place in horticulture as cut flower, pot and garden plant. As a cut flower, lily is ranked as the fourth most important crop in the Netherlands. At present, commercial cultivation of lilium in India is centered in and around Himachal Pradesh, Uttrakhand, Jammu and Kashmir and Haryana. From where flowers are being sent to local and inter-national market.

Botanical Desceiption

Lilium belong to family liliaceae. The bulb is made up of over-lapping scales and bulb tunic. The stem is unbranched and leafy with the leaves scattered up the stem or arranged in whorls. Leaves are narrow to broadly oval. Flower stalks are long and sturdy. Size of flowers varies from 10-20 cm across and stem length ranges from 50-120 cm depending on the variety. The lily inflorescence may be a raceme, an umbel or a single terminal flower. The forms of the flower vary between species and cultivars, some being pendulous, other erect or horizontal and there is variation in the extend of recurving of the perianth segments. Flower colour include white, yellow, pink. Orange and red. Many lilies have flowers with secondary colours or speckled blooms. The fruit is a capsule containing numerous flat seeds. Lilies produce different kinds of root like contractile, feeder and stem roots. Some lilies produce root along the stem from the top of the bulb, slightly above the soil surface. These roots help in supporting the plant and absorbing water and nutrients. Lily bulb have a solid basal plate that produces roots from its bottom and a concentric of tight-to-loose, fleshy, over-lapping scales of varying width from its top. Mature bulbs are 4-9 inches in circumferences.

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Classification and Varieties

Lilies are classified into Asiatic, oriental and longiflorum hybrids each with their specific characteristics. Most of the cultivars, however, are interspecific hybrids within the sections (especially Leucolirion, Archelirion and Sinomartagon) and represent the most important cultivated groups which are:

a. The Longiflorum hybrids which originate from intra- or interspecific hybridization in the Leucolirion section, have trumpet-shaped, pure white flowers, a distinctive fragrance, year- round forcing ability and mostly outward-facing flowers. Important cultivars are: Ace, Nellie White, Snow Queen, Casa Rosa, Deliana etc.

AceNellie,WhiteSnow,Quee, Casa Rosa,Deliona

b. The Asiatics hybrids are derived from interspecific crosses among at least 12 species of the Sinomartagon section. Cultivars of Asiatic hybrid lilies have a wide colour variation in their flower tepals (orange, white, yellow, pink, red, purple and salmon) and early to late flowering. Some species in the section show resistance to *Fusarium* and viruses. Important cultivars are: Brunello, Elite, Navona, Pollyanna, Pavia, Tresser, Dreamland, Prato, Vivaldi, Torento, Grand Paradiso, Shiraj, London, Detroit etc.

Brunello Elite Navona Pollyanna Dreamland

Prato Torento Grand Paradiso Shiraj Detroit

c. The Oriental hybrids are nowadays the most important lily hybrid group. They result from hybridization among five species of the Archelirion section. Generally, Oriental hybrids are late-flowering, with big and showy flowers with a pleasant fragrance. Commercially important cultivars are Stargazer, Siberia, Tiber, Casendra, Barnini, Lombardia, Casa Blanca, Le Reve etc.

d. Rcentiy, the demand of LA (Longiflorum x Asiatic) hybrids and LO (Longiflorum x Oriental) hybrids have gained momentum and replaced the Asiatic Hybrids. LA hybrids are more floriferous than the Asiatic ones. Important LA-hybrids are: Pavia, Brindisi, Ceb- Diabolo, Fangio, Samur, Ercolano, Cilesta, Bestseller, Honesty, Indian Summerset, Mastermind, White Heaven etc.

BarniniLombardiaCasa Blanca Le Reve

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Fangio Ercolano Cilesta Brindisi

Varieties recommended for cultivation				
Varietiy	**Growing period (day)**	**Plant height (cm)**	**Number of buds**	**Colour**
Brunello	90-100	90-100	6-7	Orange
Barition	80-90	120-130	7	Orange
Gironde	90-100	110-120	7	Yellow
Navona	90-100	80-90	6	White
Nello	110-120	120-130	6	Orange/red
Tresser	100-110	100-110	6-7	Orange
Oriental hybrid				
Acapulco	90-100	120-130	4	Dark pink
Barnini	100-110	120-130	5	White
Laguna	100-110	100-110	5	Pink/red
Mero star	90-100	120-130	6	White
Mother choice	100-110	120-130	6	White
Rialto	110-120	120-130	5-6	White
Siberia	110-120	100-110	5	Pink. White
Sorbonne	110-120	100-120	5	Pinkish White
Tiara	90-100	110-120	5	Reddish White
Tiber	100-110	100-120	6	Pink
LA-hybrid				
Bright Diamond	90-100	130-135	5	White
Ceb Dazzle	90-100	100-110	6-8	Yellow
Cilesta	80-90	120-130	6	Orange
Courier	80-90	100-110	6	White
Ercolano	90-100	90-100	5	White
Eyeliner	90-100	120-130	5	Yellow
Golden tycoon	100-110	120-130	6	Yellow
Litowen	80-90	120-130	6	White
Menorca	90-100	130-135	5	Salmon
Serrada	90-100	110-120	6	Yellow
Pavia	90-100	100-110	6	Yellow
OT-hybrid				
Avocado	110-120	130-140	6	Salmon/yellow
Yelloween	100-110	130-140	5	Yellow
Torriana	100-110	110-120	4	Pink
Rexona	80-90	110-120	4	White
Belladonna	100-110	100-110	4	Yellow
Addison	100-120	120-130	7	White

Propagation

Lilium is propagation by bulblets, axillary bulbils, separation of scales, division of bulbs, leaf cutting and through micro-propagation. Vegetative propagation allows plants to grow into true-to-type. Propagation through scales is a rapid means of multiplication.

A. Scale

Vegetative propagation by scaling is the most cost-efficient and rapid method to increase a clone. Most lilies can be propagation readily from bulb scales. Only

clean, large, disease-free bulbs from stock are used for scale propagation. Break the scales off cleanly at the basal plate to permit good bulblet formation. Dip the scales in suitable fungicide (Carbendazin 2g/l for 20 minute); thiabendazole, (TBZ) or in 200 ppm NAA or IBA or BA (100 ppm) for 30 minute. Pack the scales thinly in layers in a moist medium in trays or boxes. The sphagnum peat and vermiculite are excellent media for scaling. Incubate the scales in a well-ventilated room at 24^0C until the bulblets and roots are fully formed. The duration of incubation depends on the variety. Asiatic hybrid lilies require 10-12 weeks, trumpet species and hybrids 12 to 14 weeks and Oriental hybrid lilies 16 to 18 weeks.

Bulblets Formation from Scales

B. Stem Bulblet

Bulblets may be formed on the underground or above ground part of the stem. The number and size depends on the species or cultivar and the strength of the individual bilb. Stem of a vigorous one can generate up to a dozen or more bulblets. Perfectly formed small bulbs with scales and roots behave independently once the stem dies back. The number of these bulblets to be harvested from the buried part of the stem is positively correlated to the amount and vigor of the stem rooting. To increase the harvest by number and, even more significantly, by weight and volume, stem rooting needs to be encouraged. This can be done initially by providing an open, gritty, humus-rich soil and planting the bulb with at least 10-15 cm deep above their noses, kept moist but not over-wet. Stem rooting activity can be dramatically increased by humus mulches from late spring on words.

C. Axillary Bulbils

Samll, dark bulbils appear in the leaf axils; they swell to become purple-black mini-bulbs, something to produce leaves and root before they are fully ripe and fall to the ground. Bulbils formation can be enhanced by removal of flower buds. If bulbils are harvested and potted

up before late season, a good proportion of reasonable sized plants can be obtained to bear one or more flowers in the very next season.

D. Tissue Culture

Tissue culture is a method of propagation plants in the laboratory. Tiny amounts of plant tissue are placed in sterile nutrient medium. Plant growth hormones are added to the medium to induce these cells to multiply and differentiate until they form tiny bulblets. This technique has revolutionized the horticultural industry by permitting the production of vast number of springs from an individual plant. It is possible to select a seedling and within two years produce several thousand bulblets, which can be marketed in another two years. The material used to initiate a lily tissue culture usually comes from bulb scales, but stem segments with an internode, or flower bids, can also be used. To avoid sacrificing a precious plant, bulbs may be carefully dug, leaving the stem intact in the ground, where it usually produces stem bulblets. The material to be cultured should be kept fresh packed dry to prevent fungal growth.

E. Production Technology

Growing Environment: Most of the lilies are commercially grown under protection in greenhouse or polyhouse, and under shading nets. These require sufficient light proper ventilation.

Location: Lilies prefer location having cool temperature, free from water logging and strong winds. Asiatic lilies are relatively easier tp grow and can be grown in elevated location, even in the plains during the cooler months. Oriental hybrid lily can be successfully grown in cool hilly regions.

Climate

Temperature: Asiatic lilies require a night temperature (in greenhouse) of 13-17°C and higher than 21°C day temperature; while oriental lilies require 17-18°C night temperature (in greenhouse) and day temperature should be ideally around 29°C. In general, Asiatic lilies took 30-35 day to flower and oriental took 50-55 day. When seasonally warm temperatures occur, keeping the soil and air temperatures below 20°C is recommended. Temperature below 15°C can result in bud drop and yellowing of foliage in oriental hybrids.

Light: Light influences flowering both, photoperiodically and photosynthetically. Long photoperiods enhance floral initiation, making lilies a quantitative long day plant. Long photoperiods can substitute for cold on weekly basis. Lilies require a medium to high light intensity (>2500 foot candles) in greenhouse cultivation, especially during the short days of the winter. In locationwhere the day length is shirter than 12 hours, lilies respond to assimilation lighting during the winter. This aids in reducing flower abortion and flower abscission with sensitive varieties. Extremely high light intensities and the accompanying high temperatures can cause flower abortion, leaf scorch and/or leaf sun burning. For quality flower production in lilium, 2000-3000 foot candles of light is essential.

Humidity: Humidity is the amount of moisture present in the air. If the temperature is higher, air can contain more humidity as compared low temperature. Plants require humidity of 75 to 85% when grown in polyhouse/greenhouse/tunnels. If the humidity reaches 100%, the plants can become wet and it generally occurs when the temperature drops too much during the night.

CO_2: CO_2 has a positive effect on the growth and flowering of lilies. An optimum concentration of 800 to 1,000 ppm is recommended for commercial cultivation. The use of 1,000 ppm CO_2 in conjunction with supplemental lighting improve quality, reduced flower bud abortion and reduce the number of days to flower. A higher concentration (2,000ppm)is needed for the Longiflorum

hybrids, as this group neened high levels of CO_2 .

Ventilation: It has been observed that, a lot of heat build-up underneath polyfilm inside a polyhouse. Sometimes, temperature can rise to record high if no provision is made for proper ventilation. To have proper ventilation inside the greenhouse, it is advisable to build a structure with a top ventilation gap of minimum 3 feet. Depending on design and size of the greenhouse, one can have a provision for side ventilation as well, If the distance from side to center of the greenhouse is less than 30 feet, side ventilation in combination with top ventilation is recommended. The side should completely, as to keep the natural airstreams flowing.

Protected Cultivation of Lilium

Bedding Media and Cultivation

Soil: Lilies can be forced into flower in almost any type of soil. The soil used for cultivation of lilies should have good structure, particularly the top layers and should also be kept well drained during the entire growing period. Heavy soils is also essential for good healthy root system and thus for plant development. Maintaining the optimum pH of soil plays a major role in 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 pH of 5.0 to 6.5 for the oriental, OA, LO and OT hybrids. The Electrical Conductivity (EC) less than 1.0 is best suited for growing the lilium crop. The Chlorine in the soil should not exceed 1.5 ml/ lit.

Planting Depth: Lilium bulbs should initially be planted at a depth of 15 cm. After planting and irrigation, the soil will settle down about an 3-4 cm leaving 10 cm of soil on top of the bulb. This is sufficient for the stem roots to develop properly. Shallow planting will result in poor stem-root development and hence compromise on the quality of the flower. Planting depth varies according to the size of the bulb. Bulbs planted at 5cm deep delays the flowering time, while bulbs planted by kept nose at soil line and ½ bulb exposed resulted earlier flowering. Generally bulb should be planted to the depth of three times more than the diameter of the bulb.

Planting Density: Due to the differences in plant growth produced by the various groups, cultivars and bulb sizes, the planting density should vary accordingly. Planting density will also depend on the planting period and the type of soil used. For flowering during months with high temperature and high light intensities, the planting density can be higher. In darker periods (winter) or under conditions of low light, the planting density should be lower. On heavy soil such as peat soil, the plants will exhibit densities per square meter area according to the bulb sizes.

Table 2. Indication of planting density according to bulb size per net square meter

Bulb size (cm)	Bulb /m^2	Planting distance (cm)
8-10	49	15x15
10-12	42	16x15
12-14	36	16x18
14-16	36	16x18

Mulching: One way of conserving moisture in between watering is by mulching. Mulching is advantageous for lilies. It keeps the soil cool, loose, discourages weeds, control soil borne pathogehs and control black body radiation. It provides fluffy, nutritious medium

for the stem-roots to revel in, and it keeps the soil from baking and packing and catches and holds every little shower. The mulch can consist of rice hulls, rice straw, pine needles, upgraded black peat, etc. A certain amount of care should be taken when mulching, due to the possible presence of the fungus *Rhizoctonia solani*in some mulching materials.

Stalking: A plant support system may be necessary depending on the cultivation period and cultivars taller than 80-100 cm will usually need support. The usual way of providing this support is the use of wire grids similar to those used in chrysanthemum cultivation. These grids then raised as the crop grows taller. Such grid can also be used during planting as a way to determine planting density.

Irrigation: The amount of irrigation water depends on type of soil, greenhouse climate and the variety Too much or too little watering will result in uneven, delayed emergence and growth; reduction in stem length; *pythium* (by excessive watering) and even flower bud desiccation among certain susceptible cultivars. Water requirement in summer is 6 to 8 l/m2/day and in other season are 4 to 5 l/m2 / day. First two weeks, irrigation only by using water can or shower is advised. Third week onwards, it is recommended to use drip for irrigation. Lilies are sensitive to salt content will also reduce the roots capacity to absorb water, and this will lead to a reduction in the height of the crop. The maximum acceptable chlorine level of irrigation water used for greenhouse irrigation is 200 ppm.

Fertilization: For satisfactory growth and flowering, regular supply of nutrients is essential. 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. Especially in the first three weeks when the rooting takes place, no external fertilizers application are required. Good root development is important at this stage. It is however advisable to apply 15:15:15, NPK@ 2kg/100m^2 at least one week before plantation. Three weeks after plantation: Calcium Nitrate @ 1 kg/100m^2. Six week after plantation : Potassium nitrate @ 1kg/100m^2. If plants are not strong enough during growing period due to Nitrogen deficiency, a top dressing of Ammonium Nitrate @ 1kg/100m^2 can be applied up to three weeks before harvesting.

Harvesting

Postharvest Treatment of Lilium Flower

- Lilium should be harvested at the cutting stage, i.e., 8 to 10 cm above the ground when lower first bud shows the colour of flower.
- Stems drying should be avoided during and after harvesting.
- After harvesting, stems are graded according to number of flower buds per stem, length sturdiness of stem, and any disorders affecting leayes and flower bud.
- During bunching, timming of 10 cm of foliage from end of the stems and the stems cut to equal lengths and subsequently sleeve the flowers.
- Immediately after bunching, the cut flower should be placed in cold water in cold storage room at 2^0 C to 3^0 C. Addition of sucrose (2%) and GA_3 (100 ppm) as a preservative agent improve the vase life of flower.
- During transportation, only perforated boxes should be used to maintain a proper temperature.

Procedure for Postharvest Treatment of Bulbs

- Maintenance of soil moisture level in such a way that bulb scales should not dry out. Excessive moisture may lead to rotting of bulbs.

- The bulbs should remain in the beds for 4 to 5 weeks (above ground stem portion should dry out and can be pulled out from bulb easily).
- After 5 weeks, remove the bulbs from soil along with dried stem.
- Dried stem should be carefully without damaging the bulb.
- Washing of bulbs with clean water and treat them with Carbendazim (2%) solution for 10 minute.
- The bulbs should be air dry in shade. Too much drying may loosen root-skin. Such bulbs after planting may develop root rot.
- Immediately after drying, pack the bulbs in plastic crates with moist coco peat wrapped with perforated plastic sleeves.
- Coco peat used for packing must be sterilized.
- Keep the crates in cold storage at 2^0 C for 6-8 week or 2 week and then at -1^0 C for 6 week for longer storage.
- Keep crates open for one day in cold storage and then close with plastic sleeves.

Lilium Bulb Production

Nutrient Deficiency

a) Iron (Fe)

Symptom: The leaf tissue between the veins of young leaves become yellowish-green, particularly in plants with rapid growth. The greater the iron deficiency the more yellow plant will become.

Control

- Well drained soil with low pH level.
- Application of Chelated-Fe (2-3 g/m^2) before planting and after planting (maximum 2 g/m^2).

b) Nitrogen (N)

Symptoms: The whole leaf become lighter in colour and this is often more noticeable when plants are about to bloom. The plant often seems rather slight yellow in appearance. Soil with a low nitrogen lavel produce a crop with stems which are lighter in weight and have less flower buds. The foliage in the vase will turn yellow more quickly.

Control

- Application of sufficient quantities of nitrogen, preferably based on the results of soil sample.
- Application of additional nitrogen, if the nitrogen deficiency is diagnosed during cultivation.

c) Phosphorus (P)

Symptoms: Deficiency initially appeared as very stunted plants with normal green leaf pigmentation. Later symptoms developed in the lowest leaves as uniform chlorosis of the entire leaf. This was followed slowly in then lower by tan-brown necrosis. Chlorosis and necrosis progressed up the plant. These latter two symptoms were similar to the symptoms of N deficiency in appearance, location, sequence, and progression.

Control

- Application of di-calcium phosphate.
- Apply phosphate previous to tilling the soil.

d) Potassium (K)

Symptoms: Deficiency symptoms occurred initially on leaves of the upper half of the plant, either as dark brown spots or

streaks. This brown pigmentation developed in a zone covering the mid 40-60 % of these leaves between their tip and base. Position of the initial symptom within this zone varied from leaf to leaf appearing either on the margins of the leaf, along the mid-vein, or across the entire leaf width. The pigmented tissue became necrotic and appeared to desiccate. Tissues at the terminal end of these leaves turned light green. The symptoms of dark pigmentation and necrosis spread toward both ends of the affected leaves and to leaves lower on the plant.

Control

- Fertilizing the crop with nitrate of potash through sprinkling.

8. Physiological Disorder

a) Leaf Scorch

Cause: Leaf scorch occurs when there is a disturbance in the balance between absorption and evaporation of water. This is the result of inadequate absorption or evaporation which causes a calcium deficiency in the cells of the youngest leaves. Cells are destroyed and die. A sudden change in the relative humidity inside the greenhouse can affect this process related to poor root system and high salt level in the soil. Large bulbs are more susceptible then smaller one. Oriental hybrids are more susceptible than Asiatic and LA hybrids.

Control

- Disease and pest which could damage the roots should be controlled effectively.
- Soil should be moistened before planting.
- Avoid using susceptible varieties or avoid using larger bulbs, as these are extra sensitive.
- Plant bulbs with a good root system.
- Proper depth of planting. Allow 6 to 10 cm of soil on top of the bulb.
- Prevent large difference in greenhouse temperature and humidity. Maintain RH level of 75% is advisable.
- Rapid growth of the crop must be prevented.
- Maintain even transpiration rate and avoid excess transpiration by shading.

b) Bud Drop and Bud Desiccation

Cause: Bud drop occurs when plants receive insufficient light. In light deficient condition the stamens in the bud produce ethylene causing the bud to abort. There is an increased risk of bud desiccation if rooting conditions are poor e.g., too dry soil.

Control

- Avoid using varieties susceptible to bud drop to grow in poor light conditions.
- To prevent bud desiccation, bulb should be allowed to dry out during planting. The bulbs should root.
- Well and grown in favourable condition, particularly light and transpiration are concerned.

Conclusion

Protected cultivation is an upcoming and alternative production system involving high techniques and intensive practices mainly for urban and export demands of horticultural crops for food. Nutritional and economic security. Reduction in the uses of synthetic pesticides by the growers would not only mean less expenditure on healthy and nutritious production.

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