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Review Article

Protected Cultivation of Lilium Cut Flower in the Non-Traditional Regions

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Abstract

Cut flowers have a lot of potential for commercial cultivation and marketing. The demand for exotic cut flowers is growing day by day. Among cut flowers, Lilium occupies an important place and is counted among the ten major cut flowers in the international floriculture industry. with the increase in demand, there is a need to diversify its cultivation in the non-traditional area also. Though, various works have been carried out depending upon the region to standardise the package and practices in traditional areas. However, for better yield and quality, its cultivation has now been carried under protected structures. Moreover, protected cultivation enables the possibility to grow lilium in non-traditional area as well. This article is compilation of the production techniques viz., improved cultivars, propagation methods, intercultural operations, insect-pest disease management and post-harvest technology developed for commercial production of Lilium which can be replicated in traditionally non-growing areas after its proper validation.

Keywords: Bulbs; Lilium; Post-Harvest Management; Protected Cultivation

Introduction

Floriculture in India is an upcoming business opportunity which comprises of flower trade, production of nursery plants and potted plants, seed and bulb production, dry flowers, landscaping, micro propagation and extraction of essential oils. The loose flowers are grown in open field conditions whereas majority of cut flowers are grown under protected cultivation. Area under protected cultivation has expanded in recent years. The major flower growing states are Tamil Nadu, Karnataka, West Bengal and Maharashtra. Production of loose flower is more in states like Tamil Nadu, Karnataka and Madhya Pradesh. Whereas, the production of cut flowers is taken in states viz., West Bengal, Karnataka, Odisha and Uttar Pradesh [1]. In recent years, there has been an increase in the demand for high-yielding flowers such as orchids, anthuriums and liliums. Out of these, the demand of Lilium is being accomplished by importing it from different states of country due to lack of cultivation in the many potential states and regions viz., UP, MP, Chhattisgarh etc. Lilium is a tuberous flower that is grown for cut flowers. It is a member of the family 'Liliaceae'. Lilium occupies an important place in the global flower market and is counted among the first ten major cut flowers in the international floriculture industry. It occupies a prominent place among the commercially grown tuber flowers in India. Lilium flowers are found in many colors, due to which it looks beautiful and attractive, as well as its flower stalk is long and strong. Apart from cut flowers, these flowers are used for making bouquets, flower decorations and site beauty in pots. At the commercial level, Asiatic, Oriental and L.A. are common in India. Hybrid lilium are also being grown. Areas with a temperate climate are favorable for the cultivation of lilium. In India, it is cultivated mainly in Himachal Pradesh, Uttarakhand, Bangalore and some parts of Punjab. Good quality bulbs are being imported from other countries for the cultivation of Lilium in India. However, the

cultivation of cut flower crops in the protected structures enables production not only in the off-season but also in the yet not so explored non-traditional areas having market potential. This is very much true in case of lilies which are now being cultivated under protected cultivation in sub-tropical areas. Possibilities of protected cultivation of Asiatic lilium in these regions can be explored to earn more income. In a study conducted at Indira Gandhi Agricultural University by the author in non-traditional growing area of Raipur in Chhattisgarh and data presented in the table 1, the average plant height in protected cultivation of Asiatic lily was found to be about 87.20 cm and the number of leaves was found to be about 81.8. The average length of the leaves was 13.74 cm whereas; the width of the leaves was recorded 4.44 cm while the average length of flowers was noted to be about 9.04 cm and width17.08 cm. On an average 4-5 flowers were obtained from each plant. The buds start coming in about 15 to 20 days after planting and the flowers bloom after about 35 days of bud formation. On the other hand, lilies grown in pots in shady places got flowers almost 10-15 days late as compared to protected cultivation.

Plant Length (cm)	Number of leaves	Length of leaves (cm)	Width of leaves (cm)	Length of flower (cm)	Width of flower (cm)
87.20	81.80	13.74	4.44	9.04	17.08

Table 1: Botanical and floral evaluation of lilium under protected cultivation.

This paper compiles the production technology of lilium cultivation under protected condition from the various literatures available for expansion in the non-traditional areas.

Lilium: An important cut flower

Cut flowers are used in bouquet preparation/floral baskets, as corsages, in landscape gardening, flower arrangement and for decoration [2]. Important cut-flowers are gerbera, orchid, rose, carnation, chrysanthemum, anthurium and gladiolus. 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 colors. At present, the three major markets for lilium are fresh cut flowers, potted flowering plants and landscape or garden plants. Its cultivation was restricted to temperate zone but with the efforts of protected cultivation, it is now being grown successfully in plains also.

Lilium is one of six major genera of flower bulbs (geophytes) produced worldwide. These are herbaceous flowering plants grown from bulbs, comprising of genus of about 110 species in the lily family Liliaceae [3]. 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 gives 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 color ranges of the Asiatic group, with fragrant, and elegant flower form of the *Longiflorum* [4]. 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 (4). The hybridization within sections of lilies has led to development of prime lily cultivar groups as given below (Table 2).

Group	Interspecific hybridization among
Oriental	*L. auratum, L. speciosum, L. japonicum. L. rubellum, L. alexandrae* and *L. nobilissimum*
Asiatic	*L. dauricum, L. lacifolium and L. maculatum* and so on
LA	*L. longiflorum* × Asiatic hybrids
LO	*L. longiflorum* × Oriental hybrids

Table 2: Prime lily interspecific groups.

Source: TNAU Agritech Portal, 2021; [15]

- ***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, Nepal, Beatrix, London, Paroto, Alaska and Gran Paradiso.

- ***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).

Cultivars

The plant height, days to flowering, number of flowers/plant, 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
- ***LA hybrids:*** Brindisii, Lateya, Litouwen, Menorca, Pavia
- Easter lily (*Liliumlongiflorium*) var. Osant (white) is also grown under poly-houses.

Propagation method

Propagation in Lilium can be done through bulbs, bulbils and scales. It may also be planted by seed, but flowers with good qualities are not obtained from it. Nevertheless, plant breeders use seeds to produce new varieties of plants. 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 [5]A six-week cold storage period at 2^{0}C to 5^{0}C needed to break dormancy has also been reported by other workers who also reported that bulbs can be stored at -2^{0}C up to one year [6]. After this, small bulbs are planted in pots or beds. It takes 2-3 years from small bulbs to form proper sized flower bulbs [7]. 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 asiatics and 16-18 cm for orientals) are often recommended for forcing purposes [8]. 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. They are treated with fungicide like Bavistin or Carbendazim at 1 g and Dithane M-45 at 2 g per litre of water for half an hour before planting and then dried for 12 hours in a cool shady place. After drying, the scales are treated with NAA (500 ppm) and planted in disease free mixtures like cocopeat, wood sawdust or vermiculite. If these are not available then friable clay or sand can also be used. The mixture is then treated with a fungicide solution and filled in flat containers, plastic trays or pots. After a few months, small bulbs are formed in these scales, which take 3 to 4 years to become flowering bulbs. It is very important to maintain moisture in the atmosphere throughout the process.

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.

Planting depth

The optimum sized lilium bulbs should be planted at a depth of 10 - 12 cm [9] 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.

Planting density

Planting density depends on the cultivar, bulb size and time of the year, with a range of 25-60 bulbs/m^2 [10]. Some of the commonly used planting distance with bulb size and density taken commercially are as below (Table 3).

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

Table 3: Optimum bulb size and planting density in lilium [9].

Soil mixture

Light and well-drained soil is good. The values of soil pH between 6.0-7.0 (Asiatic and Longiflorum hybrids) and 5.5 to 6.5 for the oriental hybrids are considered to be the best**.** 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. It can also hold water as per the requirement and also has the ability to hold moisture and food items. But there is a fear of rotting of bulbs in the soil. Cocopeat can also be used as growing medium for cultivation in polyhouses. In the growing mixture used to grow the crop, proper drainage arrangement is also very important; otherwise the roots of the plants may rot. A good mix can be made by mixing sand, peat or perlite with soil. A mixture of soil, cow dung and sand (2:1:1) can also be prepared and used.

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 recommended to cover the crop [11]. 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 [12]. 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 22^{0}C (day temperature of) and 14 to 15^{0}C (night temperature). However, it can also grow at day temperature upto 25^{0}C and night temperature upto 8 to 10^0 C. In oriental hybrids, the optimum temperature during day is 20 to 22^{0}C and during night is 15 to 17^{0}C. It can tolerate a temperature of upto 25^0 C. However, the bud drop and yellowing of foliage occur if temperature lowers down below 15^0 C. In Longiflorum hybrids, the acceptable day temperature is 24^{0}C whereas night temperature is upto 14^{0}C [13]. About 60 to 75% humidity is required to get good quality flowers. It is also necessary that the amount of carbon dioxide is higher in the protected area than outside. It is necessary to maintain favorable temperature and light and adequate moisture for successful flower production. Other important parameters required for quality cut flower production under protected cultivation are Co_2 concentration of about 800-1000 ppm (about 2000ppm for Longiflorum hybrids) [14].

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/m^2/day whereas, water requirement in other season is about 4 to 5 lit/m^2/day [14]. For the first two weeks irrigation is done only by using water can or shower. Third week onwards it is recommended to use drip for

irrigation. Furthermore, the EC of irrigation water should be < 0.5 mS/cm and about 200 ppm Chlorine level of irrigation water [14].

Nutrient management

Plants require liquid feeding or use of controlled released fertilizers. Since lilium is a bulbous crop, most of its nutrients are already present in the bulb itself. Especially in the first three weeks when the rooting takes place, no additional fertilizers are required. Good root development is important at this stage. It is advisable to apply 12:61:00@ 2kg/100m^2 at least one week before plantation. It is a very salt sensitive crop and therefore care should be taken with applying fertilizers. If nutrient is not applied as fertigation, the fertilizer dose applied after three weeks of plantation is Calcium Nitrate @ 1 kg/100m^2 and after six weeks of plantation Potassium nitrate @ 1 kg/100m^2 is applied [6,9] If plants are not strong enough during growing period due to Nitrogen deficiency then a top dressing of Ammonium Nitrate@ 1 kg/100 m^2 can be applied up to three weeks before harvesting. Different fertigation doses for Asiatic and oriental lilies has been given in table 4.

Fertigation doses	Quantity (g/m^2/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

Table 4: Fertigation doses in lilium.

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.

Diseases and their control

The important diseases, their symptoms and control measures (Table 5) have been presented as below:

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 green house 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. Plants will have retarded growth.	Soil disinfection. Soil should have optimum moisture with proper drainage. Maintaining the soil temp.
Botrytis	Dark brown spots occur on foliage. Bud starts rotting and deformed. Flowers have grey, watery andround spots.	Irrigation in the morning hours should be done. Spraying with fungicides vizcaptaf @ 2g +Bavistin @ 2g/Lor Bavistin @2g+ Dithane M45 @ 2g/L.

Table 5: Disease management in lilium.

Source: adapted from CCARI, 2010; [16].

Pests and their control

Some of the common pests and their control are as follows

- ***Aphids:*** Applying Imidacloprid 17.8 % SL @ 1 ml/L or Dimethoate 30 EC @ 2 ml/L.
- ***Mites:*** Spraying Wettable sulphur @ 1.5 g/L or Abamectin @ 0.4 ml/L or Propargite @ 2 ml/L.
- ***Thrips:*** Spraying Methyl demeton 25EC @ 2 ml/ or Dimethoate 30EC @ 2ml/L.

Disorders

The most common disorders in Lililum are as follows

- ***Leaf scorch:*** Due to deficiency of Mn/Al at overdose of nitrate level
- ***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.
- ***Puffy foliage:*** It is due to frost injury and stunting of plants.

Harvesting and postharvest handling

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 [9]. It is best to cut flowers in the morning. As soon as the color starts to develop in the first bud, the flower stalk should be cut 8-10 cm above from the ground [14]. 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. 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 [14]. 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.

Yield and grading

The average yield varies from 30 - 40 flower stems/m^2 [15]. They are graded on the basis of length of stem and number of buds per stem. Good quality flower stems which do not have any marks or outbreak of insect disease are sold in the market at a good price.

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 ^{0}C). 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.

Conclusion

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. Proper varietal selection for the location specific use for Asiatic Lilies, Oriental lilies, LA hybrid and Easter lily grown under polyhouses is important. Propagation in Lilium can be done through bulbs, bulbils and scales. 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. Planting density depends on the cultivar, bulb size and time of the year, with a range of 25-60 bulbs/m^2. Water requirement in summer is about 6 to 8 lit/m^2/day whereas, water requirement in other season is about 4 to 5 lit m^2/day. Lilium plants need support because their roots are not strong and the flower stems will remain straight. 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.

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