

**Specific Objectives:**

To accustom students with production technology of economically important flowers.

**Theory:**

Introduction, Environmental simulation, Climate and soils, propagation, crop management practices, harvesting, post harvest handling and marketing of important floral crops such as carnation, chrysanthemum, roses, snapdragon, marigold, jasmine (motia), nemesia, statice, stock, geranium, zinnia, dahlia, , freezia, gladiolus, crocus, iris, liliun, daffodil (narcissus), tulip, tuberose.

**Practical:**

Identification, nursery raising, planting and cultural operations, harvesting and packing of important flowers for commercial production and marketing, Visit of commercial production areas and floral markets.

**Books Recommended:**

1. Armitage, A.M. and J.M. Laushman. 2003. Specialty Cut Flowers (2<sup>nd</sup> Ed.). Timber Press, Windsor, Australia.
2. Bose, T.K., L.P. Yadav, P. Pal, V.A. Parthasarathy and P. Das. 2003. Commercial Flowers (2nd Ed.). Naya Udyog, Calcutta, India.
3. Banerjee, U. 2001. Commercial Flower Production. Mangal Deep Publications, Jaipur, India.
4. Larson, R.A. 1980. Introduction to Floriculture. Academic Press, New York, USA.
5. Prasad, S. and U. Kumar. 2005. Commercial Floriculture. Agrobios (India), Jodhpur, India.
6. Rees, A.R. 1992. Ornamental Bulbs, Corms and Tubers. Crop Production Science in Horticulture 1. CAB International, Wallingford, U.K.
7. Dole, J.M. and H.F. Wilkins. 1999. Floriculture: Principles and Species. Ball Publishing, USA.
8. Yadav, I.S. and M.L. Choudhry. 1997. Progressive Floriculture– Production Technologies of Important Commercial Flower Crops. The House of Sarpan, Bangalore.
9. Laurie, A. 2004. Floriculture: Fundamentals and Practices. McGraw Hill Book Company, New York.

## **Commercial flower production**

### 1. ROSE

The Queen of Flowers

#### INTRODUCTION

- **Roses are symbol of beauty, love, affection, romance etc.**
- **Besides their aesthetic value, they are important for their economic uses, such as**
  - **cut flowers**
  - **essential oils & Essences for cosmetics**
  - **rose petals**
  - **rose dry buds**
  - **rose water**
  - **rose hips**
  - **rose achenes**
  - **rose nursery stock**

Roses as cut flowers

- **Value of fresh cut flower trade amounts to 50% followed by live ornamental plants (43%) and cut foliage (7%) of floriculture trade.**
- **Out of all cut flowers, roses account for 50 % of total exports in world trade.**

#### ROSE GROWING AREAS OF PAKISTAN

- **Qasur (Pattoki)**
- **Lahore**
- **Sheikhupura**
- **Rawalpindi**
- **Faisalabad**
- **Hyderabad**

Characteristics of a Cut Rose Production Farm

**Any farm site selected for cut rose flower growing should have:**

- **adequate quality water;**
- **well-drained soil, with a pH from 6.0–7.0;**
- **good access for machinery;**
- **power for irrigation pumps, the cool room, and the packing shed.**

#### CRITERIA FOR SELECTION OF ROSE VARIETIES FOR EXPORT

- **Distinguishing characters of the variety**

- Comparison with existing varieties regarding Production level and price
- Agro-climatic requirements
- Physical analysis of the variety (Bud size, no. of leaves, stalk length etc.)
- Market response of the variety (local and international markets)
- Economic feasibility
- Insect/ pest and disease resistance

## CHARACTERISTICS OF EXPORT QUALITY CUT ROSE FLOWERS

- Low cost of production
- Long harvesting period
- Long stalk length (40-60 cms.)
- High level of production
- Long vase life
- Colour persistence for long period
- Bud diameter

## Advantages of Greenhouse Technology

- Controlled temperature and humidity that prevent pests and diseases
- Standards are followed with more consistency
- Varieties achieve their maximum potential in terms of bud size, color and other physical attributes
- Sizes vary from short to very long stems (reaching up to a meter in length) and production may be programmed depending on buyers' demand
- ☉ Less thorns that makes handling easier
- ☉ Clean petals and leaves, again for easier handling
- ☉ Good vase life so consumers can enjoy the flowers longer
- ☉ Year round reliable supply of flowers

## Greenhouse rose cultivation

- Greenhouse Location
- Greenhouse Orientation
- Air circulation and ventilation
- Layout and Fertigation
- Climatic Requirements
- Cultural Requirements

## Greenhouse Location

- The area should however have sufficient wind breaks on all sides to minimize the wind damage.
- The soil should be well drained.

- There should be sufficient scope for future expansion in terms of area, availability of water etc.
- The labor availability around the year is to be ensured.

#### Greenhouse Orientation

- **Light levels in the greenhouse should be adequate and uniform for ensuring good crop growth.**
- **Prevailing winds should not adversely affect either the structure or the operation of the facility.**
- **In a north-east to south-west oriented greenhouse it helps in reducing winter heating costs in cold climates and provides max. light.**

#### Air circulation and ventilation

- This is important for three reasons.
  - It helps control humidity;
  - It moderates temperature, especially on sunny days;
  - It pulls out the excess oxygen produced by the plants and brings in additional carbon dioxide the plants need

#### Layout and Fertigation

- If roses are to be grown in greenhouse, trenches should be dug 4' wide and 2' deep which should be filled with sweet sand after lining with polythene sheet.
- Plantation should be done at 1' distance in 1' apart rows with total plantation of 15,000 plants per acre.
- Nutrition and irrigation is provided through drip irrigation system daily during summer and at alternate day during winter.

#### Fertilization

- Application of nutrients should be based on analysis of soil and plant.
- General recommendation is application of 2 bags of N: P: K (17:17:17) per acre per month.
- 10: 20: 20 N: P: K application per acre on monthly basis.
- If soil is poor, then micronutrients and growth promoters should also be used occasionally.
- If fertilizer is applied through fertigation, then split these monthly doses into ten splits each of which should be applied at 3 days interval.
  - Ammonium Sulphate (2 Kg),
  - Calcium phosphate (2 kg)
  - Potassium Sulphate (1 Kg).
- These chemical fertilizers should be mixed and of the mixture
- 75 g should be applied per plant/month.

- Compost or leaf mould needs to be added regularly.

### Climatic Requirements

- Plenty of light, humid and moderate temperatures ranging from 15 °C to 25 °C may be considered as ideal conditions for roses.
- At temperature below 15 °C roses can be grown, but the interval between flushes becomes longer.
- At higher temperatures, above 30 °C, roses can be grown provided high humidity is maintained and evaporation is slowed down.
- The desired humidity level is 65-75%.

### Temperature

Affects quality and quantity of plant and flowers

Most of roses Night temperature 60°F (15.5°C)

Optimum growing temperature 17-25°C Not below 15°C ,above 27°C

Under high temperature Flowers are small having few petals

Cool temperature Bullheads are produced

### Humidity

#### Roses required high humidity

- By damping the paths
- By Misting

#### Humidity helps in two ways

- Reducing transpiration
- Reduce incidence of red spider mite

#### Excessive Humidity

- Foliage decrease
- Downy mildew
- black spots

### Plants Management Practices.

- Pruning is an important step in regenerating the growth and flowering of roses.
- Correct pruning is an essential factor for success in rose growing and therefore, should be done with precision and care.
- There is a marked difference in growth habit of roses and each type has its own particular method and season of pruning. the practice of rose pruning consists of two operations.
  - ☉ Thinning out : Comprises removal of old, weak, dry, diseased stems.
  - ☉ Heading back/shortening of stems. **Cutting down of last years**

## **growth to desirable height**

### **Objectives of pruning roses plants.**

- To remove the unproductive growth
- To ensure production of large number of strong and healthy shoots, which will bear flowers and improve quality of blooms.
- Keep the rose bush in proper shape and size.
- To allow high and air to reach in centre of plant.
- Annual removal of wood on which flowers were produced will encourage growth of new healthy shoots which bear more flowers than old branches.
- Produced longer stems
- To facilitate various cultural operations, like weeds, hoeing etc.
- To rejuvenate the old plants
- To obtain a flush of flowers for a specific date e.g. valentine day 14 Feb.

### **Pruning Time.**

- ☉ The purpose of pruning will not serve, if it is done at wrong time
- ☉ Sufficient time must be allowed for the new shoots to mature and flower
- ☉ Diseased, dry wood, grown irregularly should be removed without waiting for proper seasons
- ☉ Best time is period when the activity of rose plants is least and plant is at near dormant stage.
- ☉ In Indo Pakistan sub continent October to December depending on climatic condition of the region. Temperate climate normally Autumn.

### **How to prune:**

Every rose stem has (eye) buds alternating on opposite sides, usually out ward and in ward.

- The basic rule in pruning is always to cut at about half a centimeter above a vigorous bud that points in the direction and desires the new shoot to grow.
- A bush rose is to kept open in the center, the cut is made at an out ward growing bud.
- Whichever bud is selected the cut should be slightly slanting. A horizontal cut retains moisture and therefore is liable to cause fungus growth.
- ☉ While making cut care should be taken not to make it too high above the eye as there may be chance of die back of the shoot. If cut is on the other hand, very near the eye, the bud may die for the want of sap flow.
- ☉ It is absolutely necessary to cut sharp and clean.
- Broken tissues, bruises or hanging shreds of bark are an invitation to pests and diseases.
- All wounds are painted with the fungicides and benlate.

## **Pakistan's Competitive Advantages In rose production**

- Favourable agro climatic conditions
- Easy availability of land
- Cheap Labour
- Proximity to markets in Japan, Pacific rim, South- east Asia and Middle East countries which have a large growing demand.
- In west, the biting cold of winter months curtails rose production during Christmas and New Year, when the demand for roses increases four fold. As this period is the prime cultivation time in Pakistan, the potential in enormous.
- Cut rose flowers fetch maximum price during first and last quarter of the year, whereas, during 2nd and 3rd quarter, price is less.
- The Pakistani flowering season is during the period from November to April, hence the produce will be available in first and last quarters, thus commanding highest prices in the international markets.

## **Export potential**

- The main criterion for cut rose flower export is Stalk length, bud diameter, quality and freshness.
- The export potential of a country depends mainly on the availability of a strong and well developed domestic market for that particular commodity. Therefore, development of the domestic market is a necessary prerequisite to increase the export potential.
- For the sound growth of the domestic market, it is essential to make available good quality planting material, technical knowhow and credit facilities, training of farmers in modern methods of cultivation and post-harvest handling, provision of capital assistance and creation of infrastructural facilities

## **Causes of short post harvest life**

Fresh roses deteriorate for one or more reasons.

Five of the most common reasons for early senescence are:

1. Inability of stems to absorb water due to blockage
2. Excessive water loss from the cut roseflower
3. A short supply of carbohydrate to support respiration
4. Diseases
5. Ethylene gas

## **HARVESTING**

- It is done normally by hand using a sharp shear or knife.

- Harvested flowers shouldn't be placed on soil to avoid contamination of the foliage and flowers with disease organisms.
- Too early harvesting can result to bent necks.
- Harvest at calyx-flex stage for distant markets or storage.
- For local markets, harvest at loose-bud stage.
- Harvest early in the morning or late in the afternoon.

## STAGE OF HARVEST

### ADVANTAGES OF BUD STAGE HARVESTING

- **Reduces growing time**
- **Increases floral product packing density**
- **Simplifies temperature management**
- **Reduces mechanical damage**
- **Reduces desiccation**
- **Lowers the shipping cost**

## PROTECTION OF ROSE CUT FLOWERS

- Shade them
- No ground contact
- Use good quality water
- Protect flowers during transport from field to shed
- Protect flowers in packing shed or cooler
- Badly wilted flowers need to be rehydrated and cooled

## GRADING

- **Uniformly developed flowers**
- **Uniform petal coloring and free from defects and injuries**
- **Relative uniform stem diameter**

## PULSING

- Placing freshly harvested flowers for relatively short time in a specially formulated solution to extend their vase life.
- Sugar 2-10%
- STS 500-1000 ppm
- Silver nitrate 1000 ppm



## FLORAL PRESERVATIVES

- **Very effective to increase longevity**
- **Provide sugar (carbohydrate)**
- **Serve as antimicrobial**
- **Prevent stem blockage**
- **Acidify the solution**
- **Doubles vase life**

## Packaging

- Depends on flower size, desired appearance or buyer specifications
- Flowers are bunched with 10,25 or more blooms per bunch
- Packed in bulk or by count depending on box size and customer order
- Moisture resistant paper, polythene sleeves, fiberboards, aluminum foil and corrugated plastic boxes are commonly used

## Cold Storage

- Temperature of refrigerated storage should be 0-3°C
- Maintain good air circulation inside cooler to ensure uniform temperature
- Be careful of desiccation
- Control ethylene gas build-up
- Discard old flowers
- Wash cooler
- Replace preservative solution every 2-7 days
- Wash buckets with disinfectant

## TRANSPORTATION

- Decide whether to transport the material in or out of water
- Use modified refrigerated transportation units such as refrigerated semi-tractor trailers or ice cream trucks
- Maintain temperature between 35° and 40°F during transit
- Flowers must never be transported along fruits or vegetables

## POST HARVEST PROBLEMS

- Air embolisms
- Physiological plugging
- Bacterial plugging
- Ethylene
- Mechanical Damage

–Diseases (Grey mould fungus)

### **Major constraints in the development of rose industry in Pakistan**

- Non-availability of planting material of elite varieties of cut roses.
- Non availability of standardized greenhouse technology for export quality cut flower production.
- Inadequate credit facilities to take up the cultivation of roses on commercial scale.
- Lack of current database in respect of area and production of roses.
- Non- existence of scientific marketing system.
- Lack of human resource development program in floriculture.
- Inadequate post-harvest management facilities.
- Ignorance of world trends in floriculture trade.
- Absence of Flower export organizations.
- Aphids are the most common insect pests on roses.

### **Rose aphids**

#### **Damage**

- Aphids favor rapidly growing tissue such as buds and shoots.
- Low to moderate levels of aphids do little damage to plants
- Moderate to high populations can secrete honeydew, resulting in the growth of sooty mold, which blackens leaves.
- Very high numbers may kill buds or reduce flower size.

#### **Control**

- Aphids have many natural enemies including lady beetles, soldier beetles, and syrphid flies that may rapidly reduce increasing populations.
- Knocking aphids off with a forceful spray of water.
- Neem oil can also be used to increase mortality of aphids
- Aphids are easy to control with insecticides such as the foliar systemic acephate (Orthene) or malathion.

#### **• Black spot,**

caused by the fungus *Diplocarpon rosae*,

- Black spots with feathery or fibrous margins on the upper surfaces of leaves and stems.
- Small black fruiting bodies are often present in spots on the upper sides of leaves.
- There is no fungal growth on the undersides of leaves.
- The fungus requires free water to reproduce and grow, so leaves should not be allowed to remain wet for more than 7 hours.

Dark blotches and yellowing on a rose leaflet infected with black spot

#### Control

- Provide good air circulation around bushes.
- Remove fallen leaves and other infested material
- Prune out infected stems during the dormant season.
- Miniature roses are more susceptible than other types, although a few varieties are reliably resistant to all strains of black spot.
- Fungicides (such as chlorothalonil or triforine) can be applied preventively.
- A combination of sodium bicarbonate or potassium bicarbonate or neem oil has also been shown to be effective in reducing black spot.

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#### Downy mildew

caused by the fungus

*Peronospora sparsa*, requires moist, humid conditions.

- Interveinal, angular purple, red, or brown spots appear on leaves,
- Leaf yellowing
- Abscission.
- Fruiting bodies of the fungus occasionally may be observed on the undersides of leaves.

Downy mildew on rose leaf (right of center).

Powdery mildew on leaves and flower bud

#### Control

- Downy mildew can be reduced by increasing air circulation through pruning
- Avoiding frequent overhead irrigation.
- Control with fungicides is very difficult
- Environmental management is much more likely to be effective.

Rose with chlorotic, underdeveloped blossom and puckered needlelike shoots caused by glyphosate (Roundup) herbicide

**Rust**, caused by the fungus *Phragmidium disciflorum*, is favored by cool, moist weather.

- Infected plants have small orange pustules on leaf undersides
- Upper sides of leaves may discolor and leaves may drop.

Pustules of rose rust appear as reddish brown spots on the lower leaf surface (left and bottom) and as yellow patches on the upper leaf surface (right).

#### Control

- Avoid overhead watering and prune back severely affected canes.
- During the winter collect and dispose of leaves remaining on the plants as well as those that have fallen off.
- Preventive applications of fungicides can be used.

## 2. Bougainvillea.

(*Bougainvillea* species and hybrids; Family Nyctaginaceae). The bougainvillea is a versatile ornamental plant for planting in both small and large gardens. It is highly prized for its beauty and utility. It is named after Louis Antoine de Bougainvillea, a French navigator. Being a native of tropical and subtropical South America, it is well adapted to our climatic conditions.

**SPECIES AND HYBRIDS.** The cultivars commonly grown in gardens belong to four botanical species and their interspecific hybrids, viz. *Bougainvillea glabra*, *B. spectabilis*, *B. peruviana* and *B. buttiana*. The species differ from one another in some characters such as growth, habit, leaf shape and size, colour of bracts and habit of flowering. Many cultivars have arisen as a result of natural crossing between two species, such as *spectoglabra* or *glabra-peruviana* hybrids, or as selections from seedling progenies. The variegated foliage types have evolved in nature as bud sports.

**VARIETIES.** There are hundreds of varieties of *Bougainvillea* in various attractive colours grown in gardens. The flowers of *Bougainvillea* are usually referred to the three coloured bracts, and real flowers are small and tubular, with a star-shaped apex that is often inconspicuous and attached to the centre of each bract. The bracts are white, light mauve, magenta, pink, terracotta, deep mauve, red, yellow, orange or lilac. The bracts may be small or large. Some of the outstanding varieties are 'Snow Queen' (white), 'Shubhra' (white), 'Sanderiana' (deep mauve), 'Trinidad' (pale mauve), 'Mrs. H.C. Buck' (deep rose), 'Mary Palmer' (bicoloured deep rose and white flowers on the same plant), 'Louis Wathen' (orange), 'Enid Lancaster' (yellow with shades of rose), 'Ladt Marry Baring' (Yellow), 'Mrs. Butt' (deep crimson), 'dr. R.R. Pal' (brick red), 'Sonnet' (light rosy purple), 'Spring Festival' (medium magenta purple), 'Summer Time' (bright red), 'Partha' (young bracts orange changing to pink purple), 'Tomato Red' (terracotta), 'Sensation' (deep magenta), 'Blondie' (orange turning light rose), 'Isabel Greensmith' (coppery changing to rose), 'Bois due Rose' (biscuit colour), 'Begum Sikander' (white with rose edges) and 'Wajid Ali Shah' (rose). There are also multi-bracted cultivars like 'Mahara' (red), 'Roseville's Delight' (orange), 'Cherry Blossom' (white), 'Los Banos Beauty' (rose). A few important varieties having variegated leaves are 'Rao' (white and green bracts red), 'Thimma' (yellow and green, bracts bicoloured like 'Mary Palmer'), 'Louis Wathen' (variegated white and green, bracts orange) and 'Glabra' (variegated white magenta green). The variegated 'Mahara' - white and green and 'Archana' (variegated 'Roseville's Delight' yellow and green).

**USES.** The bougainvillea can be used both as a shrub and as a climber. The shrub forms an attractive lawn specimen. It is also grown as a standard. A hedge of bougainvillea is quite common and colourful. It can also be trained on a tall tree, on the trunk of a dead tree or on a trellis, arch, pergola or screen. It is ideally suited for growing in large earthen pots, wooden tubs or cement pots.

**PROPAGATION.** The bougainvillea is propagated from cutting, layering or budding. For budding, the commonest rootstock is the cultivar, 'Dr. R.R. Pal'. The best time for propagation from cutting and layering is during the rainy season (June-July). Seeds are used only for evolving

new varieties. However, many varieties fail to set seeds but seed-setting is better in Bangalore, Mysore and Hyderabad than in Delhi and the Punjab.

**PLANTING.** The best time to plant bougainvillea is from July to September. The plant may be grown about 1.5-2.5 metres apart but in a hedge, a closer distance may be adopted. At the time of planting, about 8-10 kg of well-rotted cow dung manure may be added to the soil in each pit which is about 75 cm in diameter and 60 cm deep. The plants do not require much manuring. They should be pruned in June after they have finished their flowering to obtain better blooms in the next season, i.e. in winter (October-January) and in summer (March- June). After pruning, about 8-10 kg of cowdung manure may be applied to each plant, followed by copious watering. The plant must receive full sunshine for good growth and abundance of flowering. The soil should be well drained.

During peak flowering, watering should be restricted; otherwise the flowers will fall off quickly under heavy watering. The plants usually need more frequent watering during summer than in winter. The plants are very hardy and, once established they grow successfully and flower profusely without much manuring or watering.

The plants are almost free from disease and insect pests.

### **3. Daffodils**

Daffodils are hardy and easy perennials to grow in most regions of North America, except Southern Florida. Plant the bulbs in the fall and they will bloom in late winter or early spring.

Their attractive flowers usually bear showy yellow or white flowers with six petals and a trumpet-shape central corona. Leafless stems bear between 1 and 20 flowers; sometimes the flowers need to be staked so that they don't weigh down the stems.

Daffodils are suitable for planting between shrubs or in a border, or for forcing blooms indoors. They also look wonderful in a woodland garden and in large groves. You'll find that many gardeners plant the bulbs not just by the dozens but by the hundreds! Daffodil flowers are also excellent for cutting.

#### **PLANTING**

- Select a site that offers full sun or part shade.
- Most daffodils tolerate a range of soils but grow best in moderately fertile, well-drained soil that is kept moist during the growing season.
- Many of the popular species prefer neutral to acidic soils, but some prefer slightly alkaline soils, so consult your local nursery to see which is best for your daffodil variety.
- Select high-quality daffodil bulbs that have not dried out. The larger the bulb, the better.

- **Plant daffodil bulbs in the fall**—about 2 to 4 weeks before the ground freezes. See [local frost dates](#) and get more tips on [planting fall bulbs](#).
- Plant bulbs 1-½ to 5 times their own depth. Where winters are severe, make sure there is at least 3 inches of soil covering the bulb.
- Daffodils will tolerate some crowding but prefer to be spaced 3 to 6 inches apart.
- It may help to sprinkle a little bulb fertilizer in the hole during planting. [Learn more about preparing soil for planting](#).
- Resist the temptation to uncover spring-flowering plants such as daffodils and [tulips](#). You can loosen [mulch](#), but the shoots will still benefit from protection against cold, drying winds.

## CARE

- Apply a low-nitrogen, high-potash (potassium) fertilizer after flowering if bulbs are not performing as desired. [Learn more about soil amendments](#).
- Water late-flowering daffodils in dry spring weather (flowers may abort in dry conditions).
- Deadhead plants as flowers fade (for neater garden appearance) and allow leaves to remain for at least 6 weeks.
- Lift and divide the clumps when flowering becomes sparse or the clumps congested.
- After daffodils bloom in the spring, allow the plants to grow until they die off. They need time after blooming to store energy in the bulbs for next year's bloom.
- To remove the dead plants, either snip them off at the base, or twist the leaves while pulling lightly.
- Once daffodils and tulips have gone by, add bonemeal to the soil for next year's blooms.

## PESTS/DISEASES

Daffodils are both [deer-resistant](#) and [rodent-proof](#), as these animals do not like the taste of the bulbs in the Narcissus family.

Daffodils are also [poisonous to pets](#), so make sure your animals don't munch on them.

The most common problems include large narcissus bulb fly, bulb scale mite, narcissus nematode, [slugs](#), narcissus basal rot and other fungal infections, and viruses.

## HARVEST/STORAGE

- When cut, daffodils should be kept alone in a vase, as their stems secrete a fluid that promotes the wilting of other flowers. If you must combine them, soak them by themselves for as long as possible, then rinse them and add them to the arrangement last.
- Note that contact with the sap of daffodils may irritate skin or aggravate skin allergies.

#### RECOMMENDED VARIETIES

- ‘Golden Ducat’ is a double daffodil with pure yellow petals. It blooms in mid- to late season and grows 12 to 16 inches tall.
- ‘Petit Four’ is a good choice for a partially shady site. The flower has white petals with a double cup of apricot pink and grows 16 inches tall.
- ‘Rip van Winkle’ is miniature double daffodil that grows 6 to 8 inches tall and looks great in a grove with many others of its kind.

## 4. *Lilium*

*Lilium* L. hybrids, Asiatic or Oriental lilies are members of family Liliaceae and are highly popular cut flowers around the world. Other important lilies include the Easter lily (*Lilium longiflorum* Thunb.) and many garden species and hybrid lilies. The lily family is very large and contains many commercially important floriculture crops including *Allium*, *Alstroemeria*, *Brodiaea*, *Convallaria*, *Eremurus*, *Hyacinthus*, *Lachenalia*, *Muscari*, *Ornithogalum*, and *Tulipa*. The genus *Lilium* includes almost 100 species, most of which are distributed between 10° and 60° north latitude. Asia has 50 to 60 species, North America has 24 species, and Europe has 12 species.

Numerous hybrids and cultivars exist and are grown as garden perennials for summer colour, as field- and greenhouse-grown cut flowers, and as potted flowering plants. Cut flowers and potted plants are grown either for specific holidays or for regular year-round production.

Although collectively referred to as “hybrid lilies”, lilies are often referred to by the hybrid group to which they belong such as “Asiatic,” “Oriental,” or “LA” (Beattie and White 1993). Asiatic hybrids include such flower colours as orange, red, yellow, tan, and white and flowers are usually orientated upward with little or no fragrance. Oriental hybrids have various shades of red, pink, and white with strongly fragrant flowers oriented horizontally. The leaves of commercial hybrids and most species are evenly spaced along the stem, but the leaves of some species are in distinct whorls.

### Propagation

The storage organ is an imbricated bulb that consists of numerous fleshy scales, which are modified leaves attached to a compacted stem (basal plate) (Bailey and Bailey 1976).

Commercially, scale propagation or *in vitro* propagation are most common (Park et al. 2002). Plants can also be propagated by seed, aerial axillary stem bulbils, underground stem bulblets or bulb divisions. Larger bulbs generally produce more flowers/stem than smaller bulbs. Never allow bulbs to dry out during shipping, storage, programming, and planting.

### **Flowering physiology and dormancy**

The primary responses of lily to temperature (cold) are rapid stem elongation, flower initiation, and flower development. The respiration rate of several Asiatic cultivars during cold treatment increases and then declines; the decrease in respiration could be used by commercial growers to determine when floral initiation is complete. Light influences flowering both photoperiodically and photosynthetically. Plant quality is increased and height is usually reduced with natural high light levels or with supplemental high-intensity lighting. Long photoperiods enhance floral initiation, making lilies a facultative long days' plant (Grueber and Wilkins 1984; Roh 1989). Increasing light intensity increases photosynthesis, which increases the rate of flower development and the number of flowers formed, reduces bud abortion, and enhances the total flower potential.

### **Climatic requirements**

Asiatic hybrids are cooled at 2 to 5°C for 6 to 10 weeks, cultivar dependent, prior to greenhouse forcing (De Hertogh 1996). Oriental and LA hybrids are cooled at 2 to 4°C for at least 8, preferably 9 to 10, weeks prior to greenhouse forcing (Beattie and White 1993; De Hertogh 1996; Fig. 10.19). Moving bulbs from cold storage too early will extend the forcing period. Bulbs can be held in moist peat for many months if temperatures are lowered from -1 or -2 to -4°C (Beattie and White 1993; De Hertogh 1996). Asiatic and LA bulbs are typically stored at -2°C and Orientals and LO bulbs are stored at -1.5°C. Consequently, year round forcing is possible. However, prolonged storage lowers the number of flower buds. Prior to freezing, bulbs are first cooled for 9 to 12 weeks and then frozen. During freezing, high humidity must be maintained to prevent sprouting. For maximum stem strength and minimum bud abortion, avoid warm temperatures. During hot weather, try to keep the soil and air below 20°C and use soil mulch, if possible (De Hertogh 1996). Once flower initiation occurs in Asiatic hybrids, light intensity and duration have little influence on rate of flower development, which is temperature dependent. Up to 40 to 50% shade can be used on Oriental lilies to increase stem length of cut lilies; remove when buds are well developed.

### **Soil requirements**

Lily bulbs are grown in a wide range of soil and media types both in the field and under protection in ground beds, bulb crates, or pots. De Hertogh (1996) recommended a well-drained, fluoride-free, sterilized planting medium. A 1:1:1 soil mix of "composted soil, peat, and perlite, "ordinary" garden soil, coco coir or peat and sand can be used for successful cut lily production. The pH of the growing medium is extremely important, with pH 6.0 optimum.



## **Cultural requirements**

### ***Nutrition***

With cut lilies, excessively high nutrient levels can reduce plant height. Because the bulb has nutrient reserves, it is suggested that fertilization is not needed during forcing (McKenzie 1989), that fertilization should commence only after shoot emergence (Aimone 1986), or that fertilization should start at the visible bud stage of development if the medium has nutrient reserves. However, experience has shown that a nutrition program should commence at shoot emergence, using calcium nitrate and potassium nitrate at a 2:1 ratio on a weekly basis, assuming that the medium has been amended with phosphorus. Slow-release fertilizers can also be used.

### ***Irrigation***

The growing medium should be kept moist but not saturated, because root rot problems can be intensified by poor aeration. Water stress and wilting can cause bud abortion or abscission.

### ***Spacing***

Bulb size and type of hybrid determine spacing for cut flower production. Due to the smaller plant circumference of Asiatic hybrids, more bulbs per square meter can be planted compared with Oriental hybrids. Generally, 54 to 86 bulbs can be planted/m<sup>2</sup> with the Asiatics and 32 to 43/m<sup>2</sup> with the Orientals when using 15 to 17.5 cm bulbs.

The bulbs should be planted at least 5 cm below the surface of the medium to encourage stem roots. Bulbs for cut flower production are commonly grown in plastic crates, which are placed crate to-crate on the ground. Crates allow easy handling of large numbers of bulbs. No pinching or disbudding required.

### ***Staking***

Some cut flower cultivars require one or two layers of netting for support. It is wise to place the net on the beds at planting and then slowly raise it as the shoots elongate (De Hertogh 1996).

### ***Scheduling***

Bulbs can be forced any week of the year from frozen bulbs or from bulbs produced in the other hemisphere. Precise timing is complicated because the forcing time varies greatly with each cultivar. The leaf numbers at any particular forcing date and flower development rate also depend on the cultivar. Days to shoot emergence vary from 2 to 3 weeks in midwinter to 3 to 4 days for bulbs planted in April or later. Generally, Asiatics require 60 to 85 days of total greenhouse forcing time with 30 to 35 days to flower from visible bud, and Orientals require 85 to 120 days of greenhouse forcing time with 50 to 55 days to flower from visible bud (Fig. 10.20; De Hertogh 1996).

## **Physiological disorders**

Flower bud abortion at an early stage of development or abscission at a later stage is a low light and ethylene-mediated phenomenon. High temperatures or depletion of the carbohydrate supply may accentuate bud abortion and abscission. Mechanical stress (shaking plants twice daily), which tends to cause the release of ethylene, reduces bud abortion. Leaf or leaf tip burn, also known as upper leaf necrosis, is a common problem, which occurs when the palisade parenchyma cells under the epidermis collapse. These areas turn a white-gray approximately 2 cm back from the tip, while the tip remains green. The typical developmental sequence of the symptoms from bottom to top of the plant is normal leaves, injured leaves, and then normal leaves and flowers. These symptoms occur shortly before or at visible bud.

Leaf burn is thought to be due to insufficient translocation of calcium (Chang and Miller 2003). Culturally, high relative humidity and little or no stem root development are considered responsible for leaf burn. The problem can be reduced experimentally by removing the lower leaves or commercially by routinely spraying calcium chloride or calcium nitrate (68 to 136 mM). Another foliar problem, leaf scorch, appears as a burned-looking, crescent-shaped area on the margins of the leaves, or as an actual tip burn. The cause is fluoride, which is a natural contaminant of phosphate or is injected into municipal water sources (De Hertogh 1996).

### **Harvest and handling**

Cut stems are generally harvested when buds are well coloured but not yet open. Each cultivar, however, has an optimal stage of development (number of flowers showing colour) for harvest. Various types of postharvest preservatives can be used to allow all buds of cut Asiatic hybrid flowers to open and to prevent leaf yellowing. Many lilies are considered sensitive to ethylene, and silver thiosulfate should be used to protect the flowers against ethylene. Postharvest life is also improved even when bulbs were soaked in STS. The soaking treatment protected flowers from exogenous ethylene, resulting in a similar improvement to vase life as placing the stems in STS solutions. 1-MCP is also effective at preventing bud and flower abscission and vase life decline due to exogenous ethylene.

Cut stems can be stored for 4 weeks at 1°C if stems are first treated for 24 hr in silver nitrate at 50 ppm. After cold storage, recut the stems and place in 30 ppm sucrose and 200 ppm 8-hydroxyquinolin citrate (8-HQC). Antimicrobial agents other than 8-HQC are also effective. Cold storage decreases longevity by increasing leaf yellowing and bud blasting and reduce vase life.

Leaf yellowing can also be prevented by spraying [1:1 benzyladenine: gibberellic acid (BA:GA)] at 25:25 ppm on the cut stems prior to or immediately after cold storage. The chemical cannot reverse leaf yellowing so it must be applied when the leaves are still green. Leaf yellowing can also be prevented by spraying BA:GA at 100:100 to 250:250 ppm BA:GA on the entire plant.

**Freesia**

Botanical name: *Freesia ×hybrida*

Common name: Freesia

Family: Iridaceae. There are 19 species in the genus Freesia.

Origin: South Africa.

**Propagation**

Freesias annually form a new corm and numerous cormlets, which normally require an additional year of growth to flower. Plants can be grown from seed with ease and will flower in approximately 9 months. Tissue culture is also used to obtain disease free stock.

**Planting**

The medium must be free of fluoride and no superphosphate added. Beds, ridges or benches should be at least 25 cm deep and contain pasteurized, well drained media with a pH of 6.5 to 7.0.

**Climatic requirements**

High-quality freesias grow best at 13 to 16°C. Temperatures above 16°C should be avoided after corms have been planted. Freesias may be a difficult species to grow if proper temperatures are not maintained. Floral initiation normally occurs 6 to 9 weeks after planting. Floral initiation is enhanced by short days, even though freesia is a day-neutral plant. Vegetative growth is favored by long days and high light levels. Plant and flower quality are best when the light level is greater than 2500 fc (Dole and Wilkins 2005).

**Cultural requirements**

Application of 200 ppm N from a balanced N–P–K fertilizer every two weeks is adequate. Ammonium-based nitrogen should be avoided because freesias are a “cold” crop. No superphosphate must be used, because it may contain a natural fluoride contaminant, which will cause leaf tip burn. The medium should be kept moist, but not wet. Freesias have contractile roots and the corm is systematically “pulled” deeper into the medium profile where moisture is more abundant.

Consequently, corms are easy to overwater and thus rot. The best irrigation system for cut flower production is drip irrigation laid between the rows of planted corms. Corms are spaced an average of 4 cm apart; 2.5 cm during bright weather and 5.0 cm during dark periods. Corms are planted 5 cm deep as measured from the base of the corm. No pinching or disbudding is required. After harvesting the first stem, two to four lateral shoots may develop if temperatures remain cool. Lateral stems will be shorter than the first stems harvested. Up to three layers of mesh are required for cut flowers to produce straight stems. When corms are planted for cut flowers, a harvest can be expected in 16 to 17 weeks at 10 to 13°C and can last 4 weeks.

### ***Harvest and handling***

Cut flowers should be harvested when the first floret is puffy and beginning to open and at least two other buds are well coloured. Cut stems can be stored at 0 to 2°C. Cut flowers can be held dry for brief periods, but should be stored in water with preservative for longer periods. Treating flowers with 0.5 mM STS or 740 ppb 1- MCP can prevent the decline in vase life due to dry storage. Sucrose and other components found in a floral preservative extend the vase life. Freesias are very sensitive to ethylene. Fluoride in water can reduce cut flower life.