Cultivation of Some overlooked Bulbous Ornamentals-A review on its commercial viability

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Abstract: Bulbous plants are often used as ornamental plants. The subterranean organs of these plants store moisture, nutrients and other essential for plant survival. Adaptation to tough environments makes bulbous plants invaluable in a garden setting. They can be planted under shrubs or between perennials in the flower border or can be naturalized informally in lawns and orchards, or formally in seasonal bedding display. For splashes of color all around the garden, bulbous plants can also be planted in pots. Bulbous plants ring the seasonal changes throughout the year with glorious flower display. Though the bulbous crops have potential for cultivation but only a few bulbous crops like *Tuberose, Heliconia, Alstromeria* and *Gladiolus* are commercially exploited. Other bulbous crops like *Tulips*, *Aamaryllis* and *Narcissus* are also popularly known as cut flowers worldwide. In India these crops along with other bulbous crops still remain minor crops in terms of commercial value. There are many other bulbous crops like *Achimenes, Canna, Cooperia, Crinum, Croccus, Dahlia, Eucharis, Gloriosa, Hemerocallis, Hippeastrum, Hymenocallis, Nelumbo, Zephyranthus* and these are popular only as garden or landscape components in India. This review deals with some overlooked bulbous crops which can be exploited commercially.
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1. Introduction

Ornamentals are an important economical factor worldwide. Often under estimated, ornamental plant production even exceeds vegetable and fruit production in many countries of the world. However, scientific research on genetics and molecular biology has only been conducted on a few species. There are several reasons for this situation. The group of ornamental plants is very large, comprising hundreds of different species from various taxonomic groups. Among them few potential minor bulbous ornamental viz.. Canna, Mirabilis, Liliums, Narcissus, Iris, Crocus, Tulip, Freesia, Hyacinth and Zephyranthes are discussed. Furthermore, many ornamental species are polyploids with characters that hamper genetic characterization, for example, high heterozygosity, low seed set, and crossing barriers. As a consequence, the application of biotechnological strategies is mainly use full for analyzing their genetic diversity and commercial scale of cultivation. The ancient man obtained his food from wild plants. Cultivation of useful food crops was perhaps first started on the lower slopes of Zagros Mountains and the fertile crescent of the Tigris and Euphrates valleys in northern Iraq and in the Tehuacan valley of Mexico, as these regions had a large number of ancient settlements. The available evidences indicate that domestication of plants dates back to 7,000 B.C. (Alam and Sharma, 2012; Singh and Srivastava, 2009). The prehistoric man discovered the virtue of certain wild plants and profoundly altered them into useful cultivated plants. Many cultivated species have changed so much during their long years of domestication that today their wild ancestors cannot be traced with certainty. But with the progression of civilization, the man started cultivation of plants to meet the requirements other than his food and they discovered and identified those plants which can be used for decoration of his surrounding as ornaments. Earlier Greek and Roman naturalists like Theophrastus, Dioscorides, Pliny the Elder and Galen laid down the scientific foundation of domestication of wild plants which also includes ornamental plants, subsequently they became useful. In ancient times it was believed that useful cultivated plants were a gift of God. Alexander von Humboldt (1807) also considered the origin of useful plants as an impenetrable secret. Later, Darwin's evolutionary theory (1868) suggested that origin of useful cultivated plants has occurred through natural selection and hybridization (Sharma, 2011). In the present scenario, these ornamental plants are not only the beautiful plants but also they become the status symbol of society. The use of these plants is also multifaceted they are now essential part society in almost every type of their celebration or otherwise gathering. This makes them economically as well as commercially important. Although there are numerous ornamental plants are known today, but, the bulbous ornamental have their unique

recognition. A bulb is an underground upright shoot that has modified leaves (or thickened leaf bases) that are used as food storage organs by the plant. A bulb's leaf bases generally do not support leaves, but contain food reserves to enable the plant to survive unfavorable conditions. The leaf bases may resemble scales, or they may overlap and surround the center of the bulb as with the onion. A modified stem forms the base of the bulb, and plant growth occurs from this basal plate. Roots come out from the underside of the base, and new stems and leaves from the upper side. Most true bulbs have their scales closely packed together (*Hyacinthus*) but some types, such as the Lily *(Lilium*), they are loose and swollen. Most popular bulbs have a papery skin, the tunic, whose function is to protect the tissues within. Some true bulbs such as the Lily do not have a tunic and are therefore easily damaged by rough handling. Vegetative reproduction in true bulbs is by means of offsets called bulblets. Flower bulbs, also called ornamental geophytes (Raunkiaer 1934; Rees 1989), 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 flowers 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, Gladiolus, Hyacinthus, Crocus*, and *Iris.* Most of the traditional flower bulbs are cultivated in temperate-climate regions of the world. However, as the global demand for all ornamental geophytes continues to increase, it is obvious that innovative production and marketing efforts are needed. This is true not only for the leading genera but also for the extensive diversity that exists among the several hundred other taxa (Bryan 1989, 2002). Thus, in a new production area with a warm climate, research needs to be focused primarily on the development of new commercial products and precision production methods. At the same time, special techniques must be developed for the successful production of the traditional taxa. Therefore, this chapter has three primary objectives: (1) to focus on the global status of the flower bulb industry; (2) to outline the salient scientific research that has lead to the success of the industry and, especially, the studies that have been conducted in the past 100 years; and (3) to summarize the impact and roles of the commercial, hobbyist, and government organizational infrastructures that have and it is hoped will continue to support the flower bulb industry (Chandrasekran et al. 2010).

There should be no confusion among bulb, corm and rhizome because unlike bulb, a corm is a short, vertical, swollen underground plant stem consisting of one or more internodes with at least one growing point, with protective leaves modified into skins or tunics. The thin tunic leaves are dry papery, dead petiole sheaths, formed from the leaves produced the year before, which act as a covering that protects the corm from insects and water loss. Internally a corm is mostly made of starch-containing parenchyma cells above a circular basal node that grows roots. Corms are sometimes confused with true bulbs; they are often similar in appearance to bulbs externally, but corms are internally structured with solid tissues, which distinguish them from bulbs, which are mostly made up of layered fleshy scales that are modified leaves. As a result, when a corm is cut in half it is solid, but when a true bulb is cut in half it is made up of layers. Sometimes people are confused in between bulb and rhizome also, but, a rhizome is a horizontal stem that growth underground, often sending out roots and shoots from its nodes. Some plants have rhizomes that grow above ground or that lie at the soil surface, including some *Iris* species. Usually, rhizomes have short internodes; they send out roots from the bottom of the nodes and new upward-growing shoots from the top of the nodes (Benschop et al. 2010). For many plants, the rhizome is used by farmers and gardeners to propagate the plants by a process known as vegetative reproduction. Examples of plants that are propagated this way include irises, Lily of the Valley, Cannas. Another structure known as tuber also have some superficial resemblance but a stem tuber forms from thickened rhizomes or stolons. The tops or sides of the tuber produce shoots that grow into typical stems and leaves and the under sides produce roots. They tend to form at the sides of the parent plant and are most often located near the soil surface. The below-ground stem tuber is normally a short-lived storage and regenerative organ developing from a shoot that branch off a mature plant. The offspring or new tubers, are attached to a parent tuber or form at the end of a hypogeogenous rhizome. In the fall the plant dies except for the new offspring stem tubers which have one dominant bud, which in spring regrows a new shoot producing stems and leaves, in summer the tubers decay and new tubers begin to grow. Some plants also form smaller tubers and/or tubercules which act like seeds, producing small plants that resemble (in morphology and size) seedlings. Some stem tubers are long lived such as those of tuberous begonia but many tuberous plants have tubers that survive only until the plants have fully leafed out, at which point the tuber is reduced to a shriveled up husk.

Adaptation to tough environments makes bulbous plants invaluable in a garden setting. Many are suitable for the kind of thin, dry and nutrient deficient soil found at the foot of a hot and sunny wall. Others can cope with dry shade and are therefore ideal for planting under deciduous or evergreen trees, where nutrients and soil moisture are deficient. Spring-flowering, summer-flowering and autumn-flowering bulbs provide the opportunity to add extra color to any garden. They can be planted under shrubs or between perennials in the flower border or can be naturalized informally in lawns and orchards, or formally in seasonal bedding display. For splashes of color all around the garden, bulbous plants can also be planted in pots. Bulbous plants ring the seasonal changes throughout the year with glorious flower display. Some possess handsome foliage, others are valued for their flagrance, but above all, their blooms are the most essential. They offer a wide variety of color and form, from bright, primary shades to delicate, pastel hues (Watson and Dallwitz, 1994).

Traditionally, bulbous plants are cultivated in parterres and herbaceous borders. The choice of the species depends on a number of factors, among them, the site in the garden (shady or sunny) and the type of soil, the color and the effect that is pursued in the garden and the part of the year when the flowering is wanted. Some examples of bulbous plant genera and their flowering season are given below. Spring flowering species belong to the genera *Allium, Arum, Asphodelus, Camassia, Convallaria, Crocus, Cyclamen, Eranthis, Freesia, Fritillaria, Galanthus, Hyacinthus, Hippeastrum, Iris, Ixia, Leucojum, Muscari, Narcissus, Ornithogalum, Ranunculus, Scilla, Trillium, Tulipa* and *Zephyranthes*. Summer flowering species are included in the genera *Achimenes, Agapanthus, Allium, Alstroemeria, Amaryllis, Anemone, Begonia, Calochortus, Canna, Crinum, Crocosmia, Dahlia, Dierama, Eucomis, Galtonia, Gladiolus, Gloriosa, Haemanthus, Hymenocallis, Lilium, Oxalis, Pancratium, Paradisea, Polianthes, Sprekelia, Tritonia, Watsonia, Zantedeschia.* Genera like *Crocus, Colchicum, Cyclamen, Lycoris, Nerine, Sternbergia* usually flower in the fall and winter flowering genera of bulbous plants are *Galanthus, Crocus, Cyclamen* and *Eranthis.*

On the basis of location and environment they are classified as:

Shade loving bulbous plants: Many species of bulbous plants have woodland or shady places as their natural habitats. In the garden they are especially valuable, ornamenting places which may otherwise be difficult to plant. Some species for shade are *Allium ursinum, Anemone blanda, Anemone nemorosa, Arum italicum, Convallaria majalis, Corydalis flexuosa, Cyclamen purpurascens, Disporum flavescens, Erythronium, Fritillaria pallidiflora, Galanthus, Hyacinthoides non-scripta, Iris douglasiana, Leucojum vernum, Lilium martagon, Ranunculus ficaria, Sanguinaria canadensis, Smilacina racemosa, Trillium* and *Uvularia grandiflora.*

Sun loving bulbous plants:

A rock garden, also known as a rockery or an alpine garden, is a type of garden that features extensive use of rocks or stones, along with plants native to rocky or alpine environments. It is possible to cultivate a great number of species in it. The only limitation is the size of the plants, they must be small. Some of the genera of bulbous plants with species well suited for the rock garden are: *Allium*, *Anemone*, *Anthericum*, *Bulbocodium*, *Chionodoxa*, *Cyclamen*, *Eranthis*, *Erythronium*, *Galanthus*, *Ipheion*, *Muscari*, *Ornithogalum*, *Oxalis*, *Romulea*, *Rhodohypoxis* and *Scilla*.

Export potential and marketing opportunities for bulbous ornamental Government of India has identified floriculture as a sunrise industry and accorded it 100% export oriented status. Owing to steady increase in demand of flower floriculture has become one of the important Commercial trades in Agriculture. Hence commercial floriculture has emerged as hi-tech activity-taking place under controlled climatic conditions inside greenhouse. Floriculture in India, is being viewed as a high growth Industry. Commercial floriculture is becoming important from the export angle. The liberalization of industrial and trade policies paved the way for development of export-oriented production of cut flowers. The new seed policy had already made it feasible to import planting material of international varieties. It has been found that commercial floriculture has higher potential per unit area than most of the field crops and is therefore a lucrative business. Indian floriculture industry has been shifting from traditional flowers to cut flowers for export purposes. The liberalized economy has given an impetus to the Indian entrepreneurs for establishing export oriented floriculture units under controlled climatic conditions.

Agricultural and Processed Food Products Export Development Authority (APEDA), is responsible for export promotion and development of floriculture in India. Floriculture products mainly consist of cut flowers, pot plants, cut foilage, seeds bulbs, tubers, rooted cuttings and dried flowers or leaves. The important floricultural crops in the international cut flower trade are Rose, Carnation,

Chrysanthemum, Gerbera, Gladiolus, Gypsophila, Liastris, Nerine, Orchids, Archilea, Anthuriu, Tulip, and Lilies. Floriculture crops like gerberas, carnation, etc. are grown in green houses. The open field crops are chrysanthemum, roses, gaillardia, lily Marygold, aster, tuberose etc.

Areas of Cultivation: Maharashtra, Karnataka, Andhra Pradesh, Haryana, Tamil Nadu, Rajasthan, West Bengal have emerged as major floriculture centers. At present in India about 160.7 thousand ha area is under Cultivation in floriculture. Production of flowers is estimated to be 870.4 Mt of loose flowers and 43417.5 million (numbers) of cut flowers. India's export of Floriculture has been increased from Rs. 340.14 Crores in 2007-08 to Rs. 368.81 Crores. The major exporters include USA, Netherland, UK, Germany, Japan.

Minor bulbous ornamentals:

The minor bulbous ornamentals like Tulips, *Aamaryllis* and *Narcissus* are also popularly known as cut flowers worldwide. In India these crops along with other bulbous crops still remain minor crops in terms of commercial value. There are many other bulbous crops like *Achimenes*, *Canna, Cooperia, Crinum, Croccus, Dahlia, Eucharis, Gloriosa, Hemerocallis, Hippeastrum, Hymenocallis, Nelumbo, Zephyranthus* and these are popular only as garden or landscape components in India. This chapter discusses some of the important bulbous plants in detail. Narcissus The genus consists of about 63 species, plus many subspecies and natural hybrids, and they primarily originate in the Iberian Peninsula and Europe (Wylie 1952; Hanks 1993). They were popular as early as the 16th century in the United Kingdom and in the Netherlands but did not become an important bulbous crop until the 19th century (Barr 1884; Doorenbos 1954; Hanks 1993). The breeding of Narcissi started between 1835 and 1855 in the United Kingdom and at the end of the 19th century in the Netherlands (Wylie 1952; Doorenbos 1954). The number of cultivars increased rapidly and characteristics such as plant vigor and the size, shape, and colors of the flowers were markedly improved (Kington 1989). These improvements were possible due to the high degree of variability in the genus, the ease of inter- and intraspecific crossings, and the development of polyploidy, mainly through the existence of unreduced gametes that are present in all groups of garden Narcissi (Wylie 1952; Doorenbos 1954).

Since 1955, the Royal Horticultural Society (UK) has published the registrations of all Narcissi cultivars. The Society is the International Registration Authority for Narcissi. The 1989 edition (Kington 1989) listed 23,000 names, which represented an estimated 18,000 cultivars (Hanks 1993). However, the number of commercially grown cultivars is considerably lower. In the season 2006–2007 (PT/BKD 2007), 1,734 ha were devoted to Narcissi bulb production in the Netherlands. About 480 cultivars were grown, but only a few were produced on significant acreages.

In the first decades of the 20th century, one of the main objectives of Dutch breeders was breeding of yellow trumpet daffodils (Dix 1974b). The well-known 'Golden Harvest' (1927) is a cross between 'Golden Spur' and 'King Alfred'; however, this cultivar is susceptible to basal rot.

In 1911, a mutant with a split corona was found. It was called 'Orchid daffodil', but later the name was changed to 'Buttonhole'. Split-corona daffodils were initially described by De Mol (1923). In 1928, the breeder J. Gerritsen also discovered a split corona in his seedlings and called it a collar daffodil. In 1969, the group of the "split corona" daffodils became a new division in the classified list of daffodils (Kington 1989).

The breeding of N. tazetta ("Paperwhites") in Israel initially resulted in release of a few cultivars, including well-known 'Ziva'. Recently, new cultivars 'Ariel', 'Nir', and 'Inbal', have been released for use in gardens and forced potted plant production. Currently, N. tazetta is the leading flower bulb under production in Israel. In 2005, about 25 million bulbs were exported for dry sales, home forcing, and potted plant production and cut-flower forcing (Kamenetsky 2005).

Propagation systems, including twin scaling and micropropagation, have been developed and assist in accelerating the release of new cultivars (Hanks 1993). Somatic embryogenesis and genetic transformation have been achieved in N. pseudonarcissus cultivars (Sage and Hammatt 2002).

In India *Narcissus pseudonarcissus* (Wild Daffodil) is a perennial herb arising out of bulb. It has pale yellow flowers with a darker central trumpet. Flowers are fragrant, 5-7 cm wide. Flower-tube is 1.5-2 cm, tapering abruptly to base; distinct portions of tepals are erect to spreading, yellow, often twisted, 2.5-3.5 × 1-1.5 cm, tip pointed. Corona, the central trumpet, is yellow, tubular, 3-3.5 × 1.5-2.5 cm, the opening flared and ruffled. Stamens protrude to only midlength of the corona. Style extends 2-5 mm beyond anthers. Flower- stalks are 0.5-1 cm. The strap-like, upright, grey-green leaves of the wild daffodil are also distinctive. The species is native to Western Europe from Spain and Portugal east to Germany and north to England and Wales. It is commonly grown in gardens and populations have become established in many other parts of Europe. Wild plants grow in woods, grassland and on rocky

ground. Wild Daffodil is also cultivated in India, apart from the more common daffodil which is called Nargis in India.

Propagation of Narcissus: Narcissi grow adequately in many soil types. A well drained, deep, fertile soil containing abundant organic matter, however, results in the best performance. If natural drainage is poor, break the subsoil with a pickax. If the site is low, create a raised bed several inches above the surrounding soil level. Incorporate large amounts of coarse organic matter (2 inches or more) to loosen very heavy clay soil. Good sources of organic matter are well-rotted manure, undecomposed peat moss, or compost. Narcissi, like most bulbous plants, thrive in slightly acid soils (pH 6.0 - 6.5). Do not add any limestone unless you have your soil tested. The soil should be of average fertility. High fertility, particularly in nitrogen, promotes excessive leaf growth at the expense of high-quality flower production, as well as the excessive splitting of bulbs. Color and size of foliage are good indicators of fertility level. Large and bluishgreen leaves indicate an abundance of nitrogen, whereas small and light green leaves indicate a shortage. Commonly available “bulb food” or “bulb booster” fertilizers are useful when preparing soil for narcissus planting. These products are relatively low in nitrogen, but contain enough to support healthy plant growth. Apply 2 – 4 pounds of fertilizer per 100 square feet of bed.

Bone meal is a traditional fertilizer for bulbous plants that releases phosphorus slowly, but it is usually too low in nitrogen to be used alone. An additional source of nitrogen must be used together with bone meal. Wood ash is an alternative way to supply potassium. For average situations, apply 3 to 4 pounds of bonemeal and 5 to 6 pounds of wood ash to each 100 square feet of soil. Mix the fertilizers thoroughly with the soil before planting. The nutrients need to be located in the soil in the vicinity of and just below the bulb for best uptake by the plant. Generally, a yearly application of fertilizer should be made immediately after flowering. Bulbs planted in sandy soils benefit from fertilization in the spring when new growth is developing and also after flowering. Do not allow the fertilizer to remain on the leaves. Wash it off quickly. If narcissi are naturalized in open lawn areas which are regularly fertilized, the lawn fertilizer is adequate for the bulbs, too.

Cultivation

October is usually best for bulb planting for this plant. This enables the bulbs to develop strong roots in the fall, which supports flowering in the spring. The proper depth to plant narcissus bulbs is governed by the size of the bulbs and the soil type. As a general rule, plant bulbs twice as deep as their greatest diameter in medium to heavy soils and about three times their depth in sandy soils. Spacing of bulbs will depend upon the size and type of bulb, and on how soon you want a dense planting. Minimum spacing will vary from 3 inches for small bulbs to 5 to 7 inches for large bulbs. Planting too close results in poor development of foliage and flowers. The closer the bulbs are planted together, the more massive the color display, but it will be necessary to dig the bulbs and divide them sooner to keep up flowering. Narcissi do multiply in time, so wider spacing will eventually result in a dense stand of plants.

Plant the bulbs with the flattened base down. Small bulbs can be planted with a dibble, trowel, or bulb planter. If you use a dibble, put a handful of screened soil or sand in the bottom of the pointed hole to avoid an air space underneath the bulb. This insures good contact between the bulb base and soil. A trowel or spade is better to use for large bulbs, owing to the size of the hole needed. There is little need for cultivating other than to control weeds. In fact, deep cultivation can be harmful. A 2-inch winter mulch of straw, peat moss, leaves, or similar materials is beneficial the first year after planting. It is particularly useful for bulbs planted late in the season or for bulbs planted in southern exposures, where the soil warms early and the growing tips may be damaged. The mulch provides insulation as well as prevents heaving during periods of freezing and thawing.

In the spring, after the danger of severe frost is over, gradually remove all but 1 inch of the mulch. The remaining layer then acts as a summer mulch to control weeds, to promote aeration, to add organic matter, and to preserve moisture.

Narcissi, like other bulbous plants, may be increased by two methods: division and seed. Bulbs multiply underground naturally by division. Division occurs as the “mother” bulb matures, thus creating a number of new “daughters.” Bulbs resulting from division always produce flowers identical to those of the “mother” plant. Increase of narcissi by seed requires that pollinated and fertilized flowers be left on the plant so the seed capsules can ripen. Collected seed can be sown in the fall in a prepared seedbed for spring germination. Seedlings require several years to reach flowering size. Seedlings usually produce flowers which differ in character from those of the parent plants.

Remove flowers as soon as they begin to fade. This not only makes the plants look better, but it also prevents undesirable seed development. Seed development results in smaller bulbs the next year. Do not remove the green leaves of the plants until

they begin to turn yellowish green. The length of time it takes the foliage to mature differs, depending on the type of plant and the overall cultural conditions. During this time, the bulbs gain most of their size and become mature. This is also when the flowers form for the next blooming season. This natural process of maturity and bulb development occurs only when leaves are allowed to manufacture plant food. At a minimum, leave foliage on for one month after flowering is ended. Gathering and tying together of foliage is not necessary, but if performed, you should only do it after the 1- month minimum period.

The best flowers are generally produced the second, third, or fourth year. When the flowers gradually become smaller and fewer in number, usually due to crowding, it is a good idea to lift and replant the bulbs. Dig the bulbs as soon as the tops begin to die back. Digging before the tops have fully disappeared helps locate clumps and makes digging easier. The bulbs will either remain temporarily dormant, or they will start to grow new roots. Be sure to follow proper planting techniques as described above.

If anyone intend to store the bulbs, remove all yellow foliage as soon as you have dug the bulbs. Then place them in an airy location in the shade for several days. Store in a cool, shady, airy, and dry location. Keep them out of direct sunlight. The mother and daughter bulbs need not be kept together in storage; they may be divided.

Tulip

The center of origin of the genus is located in Central Asia, extending from the region of Tien-Shan and Pamir-Alai to the north and northeast (Siberia, Mongolia, and China), south to Cashmere and India, and west to Afghanistan, Iran, the Caucasus, and Turkey (Hoog 1973). A classification of the genus by Hall (1940) was based on morphological and cytological characteristics. Subsequently, Botschantzeva (1982) published a comprehensive treatise on tulips. Recently, a revision of the genus Tulipa based on morphological and cytogenetical characteristics, crossing data, and data on the geographical distribution has been proposed by Van Raamsdonk et al. (1997). According to their analyses, the genus Tulipa includes about 55 species distributed in two subgenera. *T. gesneriana*, which is related to garden tulips, is the most cultivated species.

Scientific research on tulip genetics and breeding started in Europe about 1960, almost 400 years after their introduction to Europe. In Germany, the research was focused on the heritability of traits such as bulb production (i.e., the number and weight of bulbs) and flower color (Weber and Horn 1978).

Subsequently, studies on tulip genetics and breeding were carried out primarily in the Netherlands, where numerous traits were investigated. The initial studies determined the chromosome number of a very large number of commercial cultivars and the possibility of the production of tetraploid plants (Zeilinga and Schouten 1968a,b). Eikelboom et al. (2001) have summarized the various techniques to produce tetraploids.

Also, the production of 2n pollen has been reported in Japan by Okazaki (2005). Extensive programs also were developed to investigate the feasibility of breeding and selecting cultivars with characteristics of importance for bulb growers and flower producers. Special efforts were placed on disease resistance, mainly Fusarium and the tulip breaking virus (TBV). The research also addressed other aspects, including the transmission of the traits, the development of screening tests for the selection of resistant genotypes, and the evaluation of the characteristics of commercial cultivars (Eikelboom et al. 1992). The studies showed that some resistance, especially for TBV, occurred in T. fosteriana (Eikelboom et al. 1992; Eikelboom and Straathof 1999).

The length of the juvenile phase, which is 5 to 6 years, is a major impediment to tulip breeding. By accelerating the yearly growth cycles, Fortanier (1971) was able to shorten the duration of the juvenile period.

Research programs on use of the interspecific crosses in breeding for disease resistance and new aesthetic and physiological traits in garden tulips were developed in the Netherlands. They indicated that the possibilities of using interspecific crosses are limited (Van Raamsdonk et al. 1995). Either inhibition or poor pollen tube growth is often observed (Kho and Baer 1971). To avoid this problem, various techniques, including in vitro techniques such as in vitro pollination, ovule culture, ovary-slice culture (Okazaki 2005), embryo culture and embryo rescue (Custers et al. 1992, 1995; Okazaki 2005), and hormone treatments were investigated. Studies on in vitro propagation with the goal of accelerating the propagation of new cultivars and to provide the breeders with additional tools has been carried out mainly in Japan, Great Britain, France, and the Netherlands. Although some positive results were obtained, they were genotype dependent. As a result, it was suggested that in vitro bulb production was often very low. Later, studies in the Netherlands combined stem segment in vitro culture with subsequent adventitious bud subculture, and propagation rates up to 6,000 bulblets after 2 years

could be obtained (De Klerk et al. 2005).

Currently, none of these techniques is used routinely in tulip breeding programs. Embryos excised from mature seeds have expressed a high degree of reactivity in vitro (Aubert et al. 1986). The problem is that the genotype propagated in vitro is unknown. Thus, the technique is not valuable if a true to type propagation is the goal. However, embryo culture and especially the culture of immature embryos can be of interest for the interspecific hybridizations (Custers et al. 1992, 1995; Okazaki 2005).

The ability to regenerate tulips in vitro is necessary for breeders to take advantage of all the techniques that can be used in the major agricultural plants. For example, the production of haploid plants has not been perfected, even though some positive results have been published. The same situation exists for genetic transformation. Thus, improved systems must be developed for in vitro plant regeneration.

Due to the large size of the genome of tulips, the use of molecular markers is limited. However, the use of isozyme techniques permits the identification of tulip cultivars. The vase life of the tulip is a trait that must be considered in a breeding program, and this characteristic is highly variable in the genus. A 4-year study using more than 300 cultivars and species demonstrated that lowers grown in the field and transferred to 20^0C after harvest had a vase life from 4 to over 10 days.

Cultivation

Tulip is first plant among bulbous ornamentals due to its pleasingly coloured and beautiful flowers. A number of fascinating and bewitching cultivars grown to excellence in a large variety of delicate and brilliant shades have developed tulips cultivation into a great bulb growing industry. In India, its cultivation so far is limited to a few recreational gardeners of the hilly areas in Kashmir and Himachal Pradesh. Tulips are suitable for pot culture, in beds, borders, formal and informal location. They are also suitable for growing in basins in apple, orchards, lawns, rockeries and wild gardens. It belongs to the family Liliaceae.

The flower is shaped like a cup or egg with six petals. The flowers are self coloured or a combination of two or more colours and some are striped and marked with contrasting colours. The colours of flowers range from white to black including several like red, scarlet, crimson, terracotta, orange, pink, purple, violet, chocolate, brown, cherry, magenta, salmon, carmine, rose, cream, yellow, apricot, lilac, mauve, blue and various other hues.

Tulip is planted in hills where night and day temperatures range between 5-10 and $20\text{-}25^0$C respectively during growing season. Direct sun during morning and evening is beneficial for improving its flower quality, whereas partial shade is required during mid-day. Frost is harmful mainly during bulb emergence. Kangra, Kullu, Mandi, Solan, Shimla, and Sirmour are most suitable areas for tulip cultivation. A well drained, light sandy loam soil is most suitable. In heavy soils, well-decomposed manure should be thoroughly mixed.

There are various classes of garden tulips that are in cultivation. These are early flowering tulips like Duc van Tol, Single Early, Double Early, the mid season such as Mendal and Triumph, the late flowering tulips like Darwin, Darwin hybrids, Breeders, Lily flowered, Cottage, Rembrandt, Bijbloemen, Parrots, Double Late and Species tulips and their hybrids. A few species like *Tulipa stellata* and *T. aitchisonii*, are natives of Himalayas. *T. stellata* is commonly known as Star Tulip.

Tulips are propagated by bulblets and bulbs. Seed is also used to propagate but it produces different shades of flowers.

At higher altitudes (ca 1,000-1,800m above msll) October-December is perfect time of planting, whereas in high hills (above ca 1,800m above msl) November-December and February. The staggered planting at 15 days intervals ensures regular cut flower supply. Bulbs should be planted 5-8cm deep at 15cmx10cm spacing in beds. In a 15cm pot, 3-5 bulbs should be planted. Watering in glass house/polyhouse every alternate day is beneficial, whereas in open areas irrigation should be at weekly interval. Partial shading during mid-day is beneficial for improving scape length and flower longevity. Interculture is necessary to keep the field weeds free and make soil porous.

No additional manures are required if soil is sufficiently rich. However, well-rotten farmyard manure @ 3-5 kg/m^2 should be mixed thoroughly. Spraying of micronutrient rich solution Multiplex @ 50 ppm (once or twice) before colour-breaking is beneficial.

In midhills, tulips flower during February-April and in high hills during April-June. The scapes along with 2 leaves are cut when 25-50% colour develops on petals. The flowers are packed in bundles of 10 or 20 each. They are sent to markets after covering with newspaper to avoid brushing injury.

Bulbs are harvested when leaves start turning yellow or 40-45 days after flowering. Old bulb scales and roots should be removed. They should be air-dried in partial shade. Putting them in wooden trays in single or double layers they are marketed. However, for quality flower production by

succeeding crop, bulbs should be stored at 7-9^{0}C for 6-8 weeks during September-October for proper development of flower primodia, since tulips are very sensitive to fluctuating temperature which otherwise leads to flower abortion.

Tulip flowers are attacked by thrips. Spraying of Rogor (0.05%) controls them effectively. Bulb rot is controlled by treating them with Bavistin (0.1%) or Dithane M-45 (0.2%).

Canna

The name Canna originates from the Celtic word for a cane or reed. *Canna* is a genus of nineteen species of flowering plants. *Canna* is the only genus in the family Cannaceae. The species have large, attractive foliage and horticulturists have turned it into a large-flowered and bright garden plant. In addition, it is one of the world's richest starch sources, and is an agricultural plant. Although a plant of the tropics, most cultivars have been developed in temperate climates and are easy to grow in most countries of the world as long as they can enjoy at least 6–8 hours average sunlight during the summer. The plants are large tropical and subtropical perennial herbs with a rhizomatous rootstock. The broad, flat, alternate leaves, that are such a feature of this plant, grow out of a stem in a long narrow roll and then unfurl. The leaves are typically solid green but some cultivars have glaucose, brownish, maroon, or even variegated leaves (Baardse, 1977).

The flowers are composed of three sepals and three petals that are seldom noticed by people, they are small and hidden under extravagant stamens. What appear to be petals are the highly modified stamens or staminodes. The staminodes number (1–) 3 (–4) (with at least one staminodal member called the labellum, always being present. A specialized staminode, the stamen, bears pollen from a half-anther. A somewhat narrower, 'petal' is the pistil which is connected down to a three-chambered ovary. The flowers are typically red, orange, or yellow or any combination of those colours, and are aggregated in inflorescences that are spikes or panicles (thyrses). Although gardeners enjoy these odd flowers, nature really intended them to attract pollinators collecting nectar and pollen, such as bees, hummingbirds and bats (Baily, 1976). The pollination mechanism is conspicuously specialized. Pollen is shed on the style while still in the bud, and in the species and early hybrids some is also found on the stigma because of the high position of the anther, which means that they are self-pollinating. Later cultivars have a lower anther, and rely on pollinators alighting on the labellum and touching first the terminal stigma, and then the pollen. The wild species often grow to at least 2–3 m (6.6–9.8 ft) in height but there is a wide variation in size among cultivated plants; numerous cultivars have been selected for smaller stature. *Canna* grows from swollen underground stems, which store starch, and this is the main attraction of the plant to agriculture, having the largest starch particles of all plant life. *Canna* is the only member of the Liliopsida Class (monocot group) in which hibernation of seed is known to occur, due to its hard, impenetrable seed covering (Baker, 1982).

The genus is native to tropical and subtropical regions of the New World, from the southern United States (southern South Carolina west to southern Texas) and south to northern Argentina. Although all cannas are native to the New World, they have followed mankind's journeys of discovery and some species are cultivated and naturalized in most tropical and sub-tropical regions. Canna cultivars are grown in most countries, even those with territory above the Arctic Circle, which have short summers but long days, and the rapid growth rate of Cannas makes them a feasible gardening plant, as long as they receive 6–8 hours of sunlight each day during the growing season and are protected from the cold of winter.

The first Cannas introduced to Europe were *C. indica* L., which was imported from the East Indies, though the species originated from the Americas. Charles de L'Ecluse, who first described and sketched *C. indica* indicates this origin, and states that it was given the name of *indica*, not because the plant is from India, in Asia, but because this species was originally transported from America: "Quia ex America primum delata sit"; and at that time, one described the tropical areas of that part of the globe as the Western Indies. Much later, in 1658, Pison made reference to another species which he documented under the vulgar or common name of 'Albara' and 'Pacivira', which resided, he said, in the *shaded and damp places, between the tropics*; this species is *Canna angustifolia* L., (later reclassified as *C. glauca* L. by taxonomists). Without exception, all Canna species that have been introduced into Europe can be traced back to the Americas, and it can be asserted with confidence that Canna is solely an American genus. If Asia and Africa provided some of the early introductions, they were only varieties resulting from *C. indica* and *C. glauca* cultivars that have been grown for a long time in India and Africa, with both species imported from Central and South America. Canna is an American genus, as pointed out by Lamarck (Barnhoorn, 1995) where he argues that "Cannas were unknown to the ancients, and that it is only after the discovery of the New World, that they made their appearance in Europe; Since Canna have very hard and durable seed coverings, it is likely that seed remains would have survived in the right

conditions and found by archaeologists in the Old World. If the soils of India or Africa had produced some of them, they would have been imported before the 1860s into European gardens.

Commercially, some species and many cultivars are widely grown in the garden in temperate and sub-tropical regions. Sometimes, they are also grown as potted plants. A large number of ornamental cultivars have been developed. They can be used in herbaceous borders, tropical plantings, and as a patio or decking plant. Internationally, cannas are one of the most popular garden plants and a large horticultural industry depends on the plant.

The canna rhizome is rich in starch, and it has many uses in agriculture. All of the plant has commercial value, rhizomes for starch (consumption by humans and livestock), stems and foliage for animal fodder, young shoots as a vegetable and young seeds as an addition to tortillas. The seeds are used as beads in jewelry. The seeds are used as the mobile elements of the kayamb, a musical instrument from Réunion, as well as the hosho, a gourd rattle from Zimbabwe, where the seeds are known as *"hota"* seeds. In more remote regions of India, cannas are fermented to produce alcohol. The plant yields a fibre—from the stem—it is used as a jute substitute. A fibre obtained from the leaves is used for making paper. The leaves are harvested in late summer after the plant has flowered, they are scraped to remove the outer skin and are then soaked in water for 2 hours prior to cooking. The fibres are cooked for 24 hours with lye and then beaten in a blender. They make a light tan brown paper. A purple dye is obtained from the seed. Smoke from the burning leaves is said to be insecticidal. Cannas are used to extract many undesirable pollutants in a wetland environment as they have a high tolerance to contaminants. In Thailand, Cannas are a traditional gift for Father's Day. In Vietnam, canna is called *dong riềng* and its starch is used to make cellophane noodles known as *miến dong*.

Although most Cannas these days are cultivars, there are approximately 20 known species of the wild form, and in the last three decades of the 20th century, Canna species have been categorized by two different taxonomists, Paul Maas, from the Netherlands and Nobuyuki Tanaka from Japan. Both reduced the number of species from the 50-100 accepted previously assigning most as synonyms. This reduction in species is also confirmed by work done by Kress and Prince at the Smithsonian Institution, however, this only covers a subset of the species range.

In recent years many new cultivars have been created, but the genus suffers severely from having many synonyms for many popular ones. Most of the synonyms were created by old varieties re-surfacing without viable names, with the increase in popularity from the 1960s onwards. Research has accumulated over 2,800 Canna cultivar names; however, many of these are simply synonyms.

Agricultural varieties:

The Canna Agriculture Group contains all of the varieties of Canna grown in agriculture. Canna achira is a generic term used in South America to describe the cannas that have been selectively bred for agricultural purposes, normally derived from *C. discolor*. It is grown especially for its edible rootstock from which starch is obtained, but the leaves and young seed are also edible, and achira was once a staple foodcrop in Peru and Ecuador. Trials in Ecuador using a wide range of varieties have shown that achira can yield on average 56 tons of rhizomes and 7.8 of extractable starch per hectare. However the crop needs 9-12 months to mature to full productivity.

Many more traditional varieties exist worldwide, they have all involved human selection and so are classified as agricultural cultivars. Traditionally, *Canna 'edulis'* has been reputed to be the variety grown for food in South America, but there is no scientific evidence to substantiate the name. It is probable that *edulis* is simply a synonym of *C. discolor*, which is also grown for agricultural purposes throughout Asia.

Cultivation

Cannas grow most excellent in full sun with reasonable water in well-drained rich or sandy soil. Cannas grow from perennial rhizomes but are frequently grown as annuals in temperate zones for an exotic or tropical look in the garden. In arid regions, cannas are often grown in the water garden, with the lower inch of pot submerged. In all areas, high winds tear the leaves so shelter is advised.

The rhizomes are frost tender and will rot if left unprotected in freezing conditions. In areas which go below about −10 °C in the winter, the rhizomes can be dug up before freezing and stored in a protected area (above 7 °C) for replanting in the spring. Or else, it is optional that Cannas are protected by a thick layer of mulch overwinter.

Cannas are largely free of pests but in the sometimes plants may become victim to the Canna Leaf Roller and the resultant leaf damage, while not fatal to the plant, can be most distressing to a keen gardener.

Canna is extraordinarily free of disease, compared to many genera. However, they may fall victim to canna rust, a fungus resulting in orange spots on the plant's leaves, caused by over moist soil.

Cannas are also susceptible to certain plant viruses, some of which are Canna specific viruses, which may result in spotted or streaked leaves, in a mild form, but can finally result in stunted growth and twisted and distorted blooms and foliage. The flowers are sometimes affected by a grey, fuzzy mold called Botrytis. Under humid conditions it is often found growing on the older flowers. Treatment is to simply remove the old flowers, so the mold does not spread to the new flowers.

Seeds are produced from sexual reproduction, involving the transfer of pollen from the stamen of the pollen parent onto the stigma of the seed parent. In the case of Canna, the same plant can usually play the roles of both pollen and seed parents, technically referred to as a hermaphrodite. However, the cultivars of the Italian Group and triploids are almost always seed sterile, and their pollen has a low fertility level. Mutations are almost always totally sterile.

Canna seeds have a very hard seed coat, which contributes to their dormancy. Germination is facilitated by scarification of the seed coat, which can be accomplished by several techniques.

The species are capable of self-pollination, but most cultivars require an outside pollinator. All cannas produce nectar and therefore attract nectar consuming insects, bats and hummingbirds that act as the transfer agent, spreading pollen between stamens and stigmas, on the same or different inflorescence.

Micropropagation, or tissue culture as it is also known, is the practice of rapidly multiplying stock plant material to produce a large number of progeny plants. Micropropagation using in vitro methods that produce plants by taking small sections of plants and moving them into a sterile environment, where they first produce proliferations that are then separated from each other and then rooted or allowed to grow new stem tissue. The process of plant growth is regulated by different ratios of plant growth regulators or PGRs, that promote cell growth. Many commercial organizations have attempted to produce Canna this way, and specifically the “Island Series” of Cannas was introduced by means of mass produced plants using this technique. However, Cannas have a reputation of being difficult micropropagation specimens.

Micropropagation techniques can be employed on specimens infected with Canna virus and used to disinfest plants of the virus, it is possible to use a growing shoot tip as the explant, the growing tip is induced into rapid growth, which results in rapid cell division that has not had time to be infected with the virus. The rapidly growing region of meristem cells producing the shoot tip is cut off and placed in vitro, with a very high probability of being uncontaminated by virus, since it has not yet had contact with the sap of the plant which moves the virus within the plant. In this way, healthy stock can be reclaimed from virus contaminated plants.

Canna indica: It is commonly called "Indian shot" (*Canna indica*) and it belongs to the mostly tropical, monocotyledonous *Canna* Family (Cannaceae). Indian shot is a robust perennial herb up to three feet (1 m) tall that grows from a thick, branching, underground rhizome. The large green leaves taper into slender petioles that form a sheath around the main stem. Unlike the numerous cultivated varieties of domesticated cannas (*Canna generalis*), with showy yellow, orange, pink or red blossoms, the flowers of *C. indica* are much smaller and typically only come in red. Cannas are popular cultivated flowers in tropical and temperate gardens because they produce some of the world's most beautiful and exotic blossoms. The unique flower has three small greenish sepals (appearing like bracts), three green or colored petals, and five (or fewer) very showy petaloid false-stamens called staminodia. The large, colorful staminodia form the main showy part of the blossom that people associate with petals. Very hard, BB-like seeds are produced in bumpy, papery capsules after the blossoms have withered away. Because of their dense, woody seed coat, the seeds need to be scarified and soaked in water prior to germination. According to The Wealth of India (1973), the seeds are bored for necklaces before ripening.

Four o'clock (*Mirabilis*)

Mirabilis is a genus of plants in the family Nyctaginaceae known as the four o'clocks. The best known species may be *Mirabilis jalapa*, the plant most commonly called four o'clock. There are several dozen species in the genus, of herbaceous plants, mostly found in the Americas. Sometimes they have tuberous roots which enables them to perennate through dry and cool seasons. They have small, deep-throated flowers, often fragrant. Although best known as ornamental plants, at least one species, *Mirabilis expansa*, *mauka*, is grown for food. The other species are *Mirabilis alipes, Mirabilis coccinea, Mirabilis expansa, Mirabilis greenei, Mirabilis jalapa, Mirabilis laevis, Mirabilis longiflora, Mirabilis macfarlanei, Mirabilis multiflora, Mirabilis nyctaginea, Mirabilis oblongifolia, Mirabilis pumila, Mirabilis tenuiloba* (Bogers and Bergman, 1986).

A curious aspect of this plant is that flowers of different colors can be found simultaneously on the same plant. Additionally, an individual flower can be splashed with different colors. Another interesting point is a color-changing phenomenon. For example, in the yellow variety, as the plant matures, it can display flowers that gradually change to a dark pink

color. Similarly white flowers can change to light violet.

The flowers usually open from late afternoon onwards, then producing a strong, sweet-smelling fragrance, hence the first of its common names. In Southern India, it is called as "Anthi Mandhaarai". In Andhra Pradesh it is called as "Chandrakantha. In Kerala it is called as 'Naalu mani poovu'. In Maharashtra, it is called "Gulabakshi". In Assamese it is called 'Godhuli Gopal', 'godhuli' meaning evening.In Bengali it is called "sandhyamaloti". In China, it is called the "shower flower" or "rice boiling flower" because it is in bloom at the time of these activities. In Hong Kong, it is known as "purple jasmine". Despite their appearance, the flowers are not formed from petals – rather they are a pigmented modification of the calyx. The flowers are pollinated by long-tongued moths of the Sphingidae family, such as the sphinx moths or hawk moths and other nocturnal pollinators attracted by the fragrance.

Cultivation

M. jalapa is a native of tropical South America, but has become common all through tropical and warm temperate regions. In cooler temperate regions, it will die back with the first frosts, re-growing in the following spring from the tuberous roots. The plant does best in full sun. It grows to approximately 0.9 m in height. The single-seeded fruits are spherical, wrinkled and black upon maturity, having started out greenish-yellow. The plant will self-seed, often spreading rapidly if left unchecked in a garden. Some gardeners recommend that the seeds should be soaked before planting, but this is not totally necessary.

The flowers are used in food colouring. The leaves may be eaten cooked as well, but only as an emergency food. An edible crimson dye is obtained from the flowers to colour cakes and jellies. In herbal medicine, parts of the plant may be used as a diuretic, purgative, and for vulnerary (wound healing) purposes. The root is believed an aphrodisiac as well as diuretic and purgative. It is used in the treatment of dropsy. The leaves are used to reduce inflammation. A decoction of them (mashing and boiling) is used to treat abscesses. Leaf juice may be used to treat wounds. Powdered, the seed of some varieties is used as a cosmetic and a dye. The seeds are considered poisonous.

Lilium

Lilium is a genus of herbaceous flowering plants growing from bulbs, all with large prominent flowers. They comprise a genus of about 110 species in the lily family Liliaceae. Most species are native to the temperate northern hemisphere, though the range extends into the northern subtropics. The botanic name *Lilium* is the Latin form and is a Linnaean name. The Latin name is derived from the Greek generally assumed to refer to true, white lilies as exemplified by the Madonna lily.

Lilies form an important group of flowering garden plants, and are important culturally and in literature in much of the world. Some species are sometimes grown or harvested for the edible bulbs. The species in this genus are the true lilies. Many other plants exist with "lily" in the common English name, some of which are quite unrelated to the true lilies.

The genus includes about 100 species that are native to North America, Europe, and Asia (Beattie and White 1993). There is a large diversity in plant architecture, flower shapes, colors, sizes and fragrance, and bulb morphology within these species. The cultivars that are currently popular are derived primarily from species originating from Japan and China. *L._elegans* is considered to be a natural hybrid of *L. maculatum* and *L. dauricum*, and about 150 cultivars of *L._elegans* were developed and cultured by hobbyists in Japan in the mid-17th century during the Yedo period (1600–1867). Although they were not commercially used at the time, *L. longiflorum*, which is native to Ryukyu Archipelago, Japan, was described in 1784 by C. P. Thunberg using a dried specimen. Initially, live bulbs were introduced to the Royal Horticultural Society in the United Kingdom in 1819 via China and, subsequently, in 1830 to the Netherlands from Japan by P. F. von Siebold.

Later this species, known today as Easter lily, replaced the Madonna lily in European countries where the majority of the population is Christian due to its vigor and the ability to control flowering by temperature (Miller 1993). Many other *Lilium* species were also introduced from Japan in late 1800s, and they contributed to the establishment of lily breeding programs in European countries.

Lily breeding was initiated in Europe in the middle of the 19th century and increased dramatically after the beginning of the 20th century (Baardse et al., 2001). Interspecific crosses played a fundamental role in the diversification of the cultivars. The major breeding research took place in Europe and the United States A milestone for lily bulb and flower production was the breeding program that was initiated about 1940 by Jan de Graaff and his collaborators at the Oregon Bulb Farms (USA) with the assistance of some Universities (Baardse et al., 2001). The first hybrid group released from this program was the Mid-Century Hybrids (now called Asiatic Hybrids). These hybrids have a complicated parentage that included *L. bulbiferum, L. dauricum, L. concolor,* and *L. tigrinum*, which are native to

middle and far Asia. When introduced into the Netherlands about 1960, they were rapidly accepted. They adapted readily to the Dutch climatic conditions and, in addition, could be used for cut-flower production in greenhouses (Baardse et al., 2001). Thus, lily usage changed from the garden to greenhouse forcing. The U.S. cultivars provided material for additional breeding programs that became established in the Netherlands. Even though their overall importance has decreased, bulb production of the Asiatic Hybrids still occupied 649 ha in the Netherlands in 2007 (PT/BKD 2007). The second significant step was the production of the "Oriental Hybrid" lily group. It is composed of a very large group of hybrids using *L. auratum, L. speciosum, L. japonicum,* and *L. rubellum,* all of which are native to Japan (Rockwell et al. 1961). Initially, the breeding was carried out in the United States at the Oregon Bulb Farms; the USDA Laboratory in Beltsville, MD; and Boyce Thompson Institute in Yonkers, NY (currently at Ithaca, NY); and in Australia. The success of the "Oriental Hybrids" was due not only to their aesthetic value but also to the fact that they could be used for cut-flower production. After their introduction in the Netherlands in the 1970s, their production rapidly increased, and new cultivars were bred and released. In 2007, 1,685 ha were devoted to bulb production of the Oriental Hybrids, which currently are the most cultivated group (PT/BKD 2007). Besides cultivars adapted to cut-flower production, some short-stemmed types that are adapted to potted plant production were also bred. This breeding program was initiated using a mutant selected in New Zealand (Baardse et al., 2001). Asiatic and Oriental hybrids have revolutionized lily bulb production and utilization and constitute the major part of the current lily bulb and flower production in the world. The exception is the Easter lily in the United States, which uses cultivars of *L. longiflorum* (native to Japan), but only for pot plant production for Easter. This production remains economically important in North America. In the Netherlands, Israel, Japan, Korea, and China, bulbs of *L. longiflorum* are also produced in significant quantities, but the grown cultivars are used primarily for cut-flower production.

The introduction of the Asiatic and Oriental hybrids resulted in tremendous changes in lilies production. The Netherlands rapidly became the world leader in lily bulb and flower production, and active breeding programs were initiated after the 1970s. One major research effort was devoted to interspecific hybridization in order to improve the cultivars for characteristics such as virus, Fusarium, and Botrytis resistance; tolerance to low temperatures and low-light conditions; year-round forcing capabilities; and vigorous growth (Van Tuyl et al. 2003).

A major problem in lily breeding has been the failure to produce either intra- or interspecific crosses. Self-incompatibility studies were conducted with *L. longiflorum*. Some of the successful procedures to overcome self-incompatibility include: the use of plant growth regulators, style heat treatments, and the use of irradiated "mentor" pollen (Van Tuyl et al. 1982).

Another solution was the breeding of *L. longiflorum* at the tetraploid level. A recent survey of natural populations of *L. longiflorum* in Ryukyu Archipelago of Japan and Taiwan has revealed that in the both north and south perimeter populations, self-compatible individuals are dominant (Sakazono et al. 2006).

Interspecific hybridizations have sexual barriers than can be classified into two groups: (1) prefertilization barriers and (2) postfertilization barriers. Research on these problems has been carried out in the Netherlands and Japan. In order to overcome incongruity (a pre-fertilization barrier), two major techniques have been developed. The first technique is named cut style or amputed style (VanTuyl et al. 1982), and the second is grafted style (Van Tuyl et al. 1995). Even though these two techniques can produce positive results, they are generally combined with various in vitro techniques in order to overcome the postfertilization barriers. Initially, embryo culture was used. Later other techniques such as embryo rescue, ovary slice, ovary, and ovule culture were used successfully (Okazaki et al. 1995).

The range of lilies in the Old World extends across much of Europe, across most of Asia to Japan, south to the Nilgiri mountains in India, and south to the Philippines. In the New World they extend from southern Canada through much of the United States. They are commonly adapted to either woodland habitats, often montane, or sometimes to grassland habitats. A few can survive in marshland and epiphytes are known in southeast Asia (including *L. arboricola*). In general they prefer moderately acidic or lime-free soils. *Lilium longiflorum* flower have Stigma, Style, Stamens, Filament, Tepal.

Cultivation

Lilies are leafy stemmed herbs. They form naked or tunic-less scaly underground bulbs which are their overwintering organs. In some North American species the base of the bulb develops into rhizomes, on which numerous small bulbs are found. Some species develop stolons. Most bulbs are deeply buried, but a few species form bulbs near the soil

surface. Many species form stem-roots. With these, the bulb grows naturally at some depth in the soil, and each year the new stem puts out adventitious roots above the bulb as it emerges from the soil. These roots are in addition to the basal roots that develop at the base of the bulb. Most cool temperate species are dormant in winter. Most species are deciduous, but a few species (*Lilium candidum*, *Lilium catesbaei*) bear a basal rosette of leaves during dormancy.

The large flowers have six tepals. They are often fragrant, and come in a range of colours ranging through whites, yellows, oranges, pinks, reds and purples. Markings include spots and brush strokes. The plants are late spring or summer flowering. Seeds ripen in late summer. They exhibit varying and sometimes complex germination patterns, many adapted to cool temperate climates.

Lilies can be propagated in several ways: by division of the bulbs; by growing-on bulbils which are adventitious bulbs formed on the stem; by scaling, for which whole scales are detached from the bulb and planted to form a new bulb; by seed; there are many seed germination patterns, which can be complex; by micropropagation techniques; commercial quantities of lilies are often propagated in vitro and then planted out to grow into salable sized plants. Many varieties of lily are extremely toxic to cats, causing acute renal failure even in small amounts. This is particularly true in the case of Easter lily plants, though other *Lilium* and the related *Hemerocallis* can also cause the same symptoms

Iris

Iris is a genus of 260 -300 species of flowering plants with showy flowers. It takes its name from the Greek word for a rainbow, referring to the wide variety of flower colors found among the many species. As well as being the scientific name, *iris* is also very widely used as a common name for all *Iris* species, though some plants called thus belong to other closely related genera. The genus *Iris* is diverse and includes many rhizomatous and bulbous irises (De Munk and Schipper 1993). Economically, the bulbous Irises are the most important, and they are divided into three major groups: "Reticulata," "Juno," and "Xiphium" (De Munk and Schipper 1993). The latter group is the most important for flower bulb industry. Most of the commercial cultivars belong to the Dutch Iris (*Iris_hollandica*) group, which was derived from crosses between *Xiphium* species and specific cultivars. Two *Xiphium* species were important in the development of the commercial cultivars: *X. vulgare*, native to the Iberian *peninsula*, and *X. tingitanum*, which is native to Morocco. These species differ in chromosome numbers and vigor. The *X. vulgare* types have a wide range of flower colors (white, blue, yellow, bronze); the *X. tingitanum* types have only blue and white flower colors.

The *X. vulgare* types are small bulbous cultivars and can flower with a bulb that is 5 cm to 6cm in circumference; the *X. tingitanum* are large bulbous types and flower only with bulbs greater than 8 cm in circumference.

However, the *X. tingitanum* types have more potential for early and retarded (year-round) flowering. Currently, the large-bulbing cultivars represent about 90% of the total acreage devoted to Iris bulb production in the Netherlands (PT/BKD 2007).

Iris breeding started at the beginning of the 20th century in the Netherlands (Dix 1974b), and initially the "Spanish" irises (*X. vulgare* group) and numerous cultivars were released. There were, however, two very important breakthroughs: the successful interspecific crosses between small-bulbing cultivars of the *X. vulgare* group and the crosses between the two different types of the *X. tingitanum* species. Subsequently, these crosses produced large-bulbing cultivars—for example, 'Wedgwood', 'Prof. Blaauw', and 'Blue Magic'—and they are adapted to year-round flower production (Dix 1974b). 'BlueMagic' is still the most widely grown cultivar in the Netherlands. In the season 2006–2007, 109 ha out of the 379 ha devoted to bulbous Iris were planted with 'Blue Magic' (PT/BKD 2007).

Initially, breeding with these interspecific hybrids was limited since they were sterile. However, a fertile spontaneous tetraploid of 'Wedgwood' was observed about 1952. Thus, it was possible to make crosses with cultivars of the X. vulgare types, and several triploid cultivars were produced. Among them was 'Telstar'. Currently, this is the second most important cultivar in the Netherlands and was grown on 52 ha in the 2006–2007 season (PT/BKD 2007). Under the very different growing conditions in western France (Brittany), a few fertile plants were found in 'Prof. Blaauw' in 1974 (Le Nard, unpublished data). The seeds were collected, and they produced fertile plants that appeared to be tetraploids. These plants were intercrossed and also crossed with diploid cultivars. The resulting selections were released to the growers in the 1990s.

Scientific research devoted to Iris breeding has been limited, and most of the plant breeding has been carried out by Iris growers. One program was developed in the Netherlands with the goal of using interspecific hybridization in order to obtain cultivars in various colors that could be flowered year-round (Eikelboom and Van Eijk 1990). The research

provided some data on the transmission of flower colors, but the production of fertile tetraploid plants through the application of colchicine to scales was not successful. Perhaps the combination of mitotic substances and in vitro culture can be used for the bulbous Iris (Kim and De Hertogh 1997).

At present, the breeding and development of cultivars of Iris is carried out only by bulb companies. This situation probably is related to the fact that during the last two decades of the 20th century, interest in bulbous Iris has decreased in the Netherlands. For example, while 924 ha were devoted to Irisbulb productioninthe 1987–1988 season(PVS/BKD1988), only 360 ha were grown in 2007–2008 season (PT/BKD 2008).

The genera *Belamcanda* (blackberry lily), *Hermodactylus* (snake's head iris), *Neomarica* (walking iris) and *Pardanthopsis* are sometimes included in *Iris*.

Uses: Irises are extensively grown as ornamental plants in home and botanical gardens. Presby Memorial Iris Gardens in New Jersey, for example, is a living iris museum with over 10,000 plants, while in Europe the most famous iris garden is arguably the Giardino dell'Iris in Florence (Italy) which every year hosts one of the most famous iris breeders' competitions in the world.

Bearded rhizomatous : The most commonly found garden iris is the bearded German Iris (*I. germanica*), a hybridogenic species, and its numerous cultivars. Various wild forms and naturally occurring hybrids of the Sweet Iris (*I. pallida*) and the Hungarian Iris (*I. variegata*) form the basis of most all modern hybrid bearded irises. Median forms of bearded iris (intermediate bearded, or IB; miniature tall bearded, or MTB; etc.) are derived from crosses between tall and dwarf varieties.

Cultivation

The bearded irises are easy to cultivate and propagate, and have become very popular in gardens. They grow in any good free garden soil, the smaller and more delicate species needing only the aid of turf ingredients, either peat or loam, to keep it light and open in texture. The earliest to bloom are species like *I. junonia* and *I. reichenbachii*, which flower as early as February and March, followed by the dwarf forms of *I. pumila* which blossom during March, April and May. During the latter month and the following one, most of the larger-growing "tall bearded" irises bloom, such as the German Iris and its variety florentina, Sweet Iris, Hungarian Iris, Lemon-yellow Iris (*I. flavescens*), *Iris sambucina, I. amoena*, and their natural and horticultural hybrids such as those described under names like *I. neglecta* or *I. squalens* and best united under *I. lurida.*

Beardless rhizomatous iris types commonly found in the garden are the Siberian Iris (*I. sibirica*) and its hybrids, and the Japanese Iris (*I. ensata*) and its hybrids. "Japanese Iris" is also a catch-all term for the Japanese Iris proper (hanashōbu), the Blood Iris (*I. sanguinea, ayame*) and the Rabbitear Iris (*I. laevigata, kakitsubata*). *I. unguicularis* is a late-winter-flowering species from Algeria, with sky-blue flowers blotched with yellow, produced (in the Northern Hemisphere) from November to March or April. Yet another beardless rhizomatous iris popular in gardening is *I. ruthenica*, which has much the same requirements and characteristics as the "tall bearded" irises.

"Reticulate" irises with their characteristic bulbs, including the yellow *I. danfordiae*, and the various blue-purple *I. histrioides, I. reticulata*, as well as the smooth-bulbed *I. filifolia*, flower as early as February and March. These reticulate-bulbed irises are miniatures and popular spring bulbs, being one of the first to bloom in the garden. Many of the smaller species of bulbous iris, being liable to perish from excess of moisture, should have a well-drained bed of good but porous soil made up for them, in some sunny spot, and in winter should be protected by a covering of half-decayed leaves or fresh cocos-fibre refuse.

Bombay Sapphire gin contains flavoring derived from particular bearded iris species. Rhizomes of the German Iris (*I. germanica*) and Sweet Iris (*I. pallida*) are traded as orris root and are used in perfume and medicine, though more common in ancient times than today. Iris essential oil (absolute) from flowers is sometimes used in aromatherapy as sedative medicines. The dried rhizomes are also given whole to babies to help in teething. Gin brands such as Bombay Sapphire and Magellan Gin use orris root and sometimes iris flowers for flavor and color.

Iris rhizomes also contain notable amounts of terpenes, and organic acids such as ascorbic acid, myristic acid, tridecylenic acid and undecylenic acid. Iris rhizomes can be toxic. Larger Blue Flag (*I. versicolor*) and other species often grown in gardens and widely hybridized contain elevated amounts of the toxic glycoside iridin. These rhizomes can cause nausea, vomiting, diarrhea, and/or skin irritation, but poisonings are not normally fatal. Irises should only be used medicinally under professional guidance.

Iris pallasii var. *chinensis* is the source of the anti-cancer principle "Irisquinone" effective against U14 and Lymph sarcoma and some other cancers. In water purification, Yellow Iris (*I. pseudacorus*) is used. The roots are usually planted in a substrate (e.g. lava-stone) in a reedbed-setup. The roots then improve water quality by consuming nutrient

pollutants, such as from agricultural runoff. An iris – species unspecified – is one of the state flowers of Tennessee. Tradition holds that the particular iris symbolizing Tennessee is a purple cultivar, to go alongside the wild-growing Purple Passion Flower (Passiflora incarnata) which is the state's other floral emblem. Greeneville, Tennessee is home to the annual Iris Festival celebrating the Iris, local customs, and culture.

Crocus

Saffron is a spice derived from the flower of *Crocus sativus*, commonly known as the saffron crocus. *Crocus* is a genus in the family Iridaceae. Each saffron crocus grows to 20–30 cm (8–12 in) and bears up to four flowers, each with three vivid crimson stigmas, which are each the distal end of a carpel. Together with the styles, or stalks that connect the stigmas to their host plant, the dried stigmas are used mainly in various cuisines as a seasoning and colouring agent. Saffron, long among the world's most costly spices by weight, is native to Southwest Asia and was first cultivated in Greece. As a genetically monomorphic clone, it was slowly propagated throughout much of Eurasia and was later brought to parts of North Africa, North America, and Oceania.

The genus *Crocus* is well known for its exquisitely beautiful flowers that are used in specialized gardening. Its cultivated species *Crocus sativus* is of prime economic importance since times immemorial. Saffron is known to society for its medicinal & aromatic value. Saffron is produced from dried stigmas of *Crocus sativus* L. member of large family Iridaceae. The sterile *C. sativus* is considered to be originated from the fertile *C. cartwrightianus*.It is extensively cultivated in Spain, India, the Mediterranean, Russia and China. It originated in Mid and southern Europe, N. Africa, Middle East and Central Asia. There are some 80 species of small cormous perennial herbs from which have come many wild & garden varieties including the so called Dutch crocuses. Leaves of crocus are long, linear with silver white central stripe. They emerge from bracts or cataphylls either at flowering time or once the flowers have withered. Flowers are tubed, flaring to funnel shaped. Self coloured or striped, solitary flowers are sometimes surprisingly fragrant. Crocus spp. are available in a range of deep intense & glossy colours, often with colour contrast between inner & outer surface of petals or flowers variously feathered with light & dark shades.

Uses: Historical records detailing the use of saffron date to ancient Egypt and Rome, where it was used as a dye in perfume and as a spice and colorant for culinary purpose. From ancient times saffron has been also used as a drug to treat various human health conditions. Medicinally, saffron is used as a part of traditional healing; and in modern medicine it has been discovered that it can also be used as anti-carcinogenic (cancer-suppressing), anti-mutagenic (mutation-preventing), immune-modulating, and antioxidant-like properties. The principal colouring agent of saffron is the glycoside crocin; the bitter substance is the glucoside picrocrocin. *C. vernus* or Dutch crocus gives a great effect in the garden, indoor decoration or in pots.

The domesticated saffron crocus, *Crocus sativus*, is an autumn-flowering perennial plant unknown in the wild. It is a sterile triploid form, possibly of the eastern Mediterranean autumn-flowering *Crocus cartwrightianus*, which is also known as "wild saffron" and originated in Central Asia. "Triploid" means that three homologous sets of chromosomes compose each specimen's genetic complement; *C. sativus* bears eight chromosomal bodies per set, making for 24 in total. The saffron crocus likely resulted when *C. cartwrightianus* was subjected to extensive artificial selection by growers seeking longer stigmas. *C. thomasii* and *C. pallasii* are other possible sources. Being sterile, the purple flowers of *Crocus sativus* fail to produce viable seeds; reproduction hinges on human assistance: corms, underground bulb-like starch-storing organs, must be dug up, broken apart, and replanted. A corm survives for one season, producing via this vegetative division up to ten "cormlets" that can grow into new plants in the next season. The compact corms are small brown globules that can measure as large as 5 centimetres (2.0 in) in diameter, have a flat base, and are shrouded in a dense mat of parallel fibers; this coat is referred to as the "corm tunic". Corms also bear vertical fibers, thin and net-like, that grow up to 5 cm above the plant's neck (Krelage, 1946)

C. sativus plant grows to a height of 20–30 cm (8–12 in), and sprouts 5–11 white and non-photosynthetic leafs known as cataphylls. They are membrane-like structures that cover and protect the crocus's 5–11 true leaves as they bud and develop. The latter are thin, straight, and blade-like green foliage leaves, which are 1–3 mm in diameter, either expand after the flowers have opened ("hysteranthous") or do so simultaneously with their blooming ("synanthous"). *C. sativus* cataphylls are suspected by some to manifest prior to blooming when the plant is irrigation relatively early in the growing season. Its floral axes, or flower-bearing structures, bear bracteoles, or specialized leaves that sprout from the flower stems; the latter are known as pedicels. After aestivating in spring, the plant sends up its true leaves, each up to 40 cm (16 in) in length. In autumn, purple buds appear. Only in October, after

most other flowering plants have released their seeds, do its brilliantly hued flowers develop; they range from a light pastel shade of lilac to a darker and more striated mauve. Upon flowering, plants average less than 30 cm (12 in) in height. A three-pronged style emerges from each flower. Each prong terminates with a vivid crimson stigma 25–30 mm (0.98–1.2 in) in length.

Cultivation

Crocus prefers cool winters with some rain in autumn, winter and spring. They require warm summers with very little rainfall. They are very cold hardy plants. The optimum summer temperature ranges between 20-30 ^{o} C with winter temperature 2-7 ^{o} C. An excellent flower quality can be obtained between temperature range from 13 ^{o} C to 19 ^{o} C and at 60-65% Relative Humidity. Heavy snowfall can damage the plants & flowers. Similarly hot and humid climate favours rot & decay of corms.

Crocus spp. are in active growth from autumn to late spring and several species survive summer drought below ground by means of a compact corm. They begin their growth at the onset of autumn rain and initiate flowering. The leaves may emerge at the same time or after the flower senesce depending on the species.

Crocus prefers deep well drained, light clay fertile soil for easy root development. The optimum pH range of soil is 6.0-7.0. Soil having low Phosphates and Nitrogen with optimum potassium level is most suitable for crocus cultivation. Soil having poor drainage may lead to corm decay. Never use fresh manure in the soil.

Crocus sativus thrives in the Mediterranean regions, an ecotype apparently similar to the North American chaparral, and similar climates where hot and dry summer breezes sweep semi-arid lands. It can nonetheless survive cold winters, tolerating frosts as low as −10 °C and short periods of snow cover. Irrigation is required if grown outside of moist environments such as Kashmir, where annual rainfall averages 1,000–1,500 mm; saffron-growing regions in Greece (500 mm or 20 in annually) and Spain (400 mm or 16 in) are far drier than the main cultivating Iranian regions. Rain immediately preceding flowering boosts saffron yields; rainy or cold weather during flowering promotes disease and reduces yields. Persistently damp and hot conditions harm the crops, and rabbits, rats, and birds cause damage by digging up corms. Nematodes, leaf rusts, and corm rot pose other threats. Yet *Bacillus subtilis* inoculation may provide some benefit to growers by speeding corm growth and increasing stigma biomass yield.

The plants grow poorly in shady conditions; they grow best in full sunlight. Fields that slope towards the sunlight are optimal. Planting is mostly done in June in the Northern Hemisphere, where corms are lodged 7–15 cm deep; its roots, stems, and leaves can develop between October and February. Planting depth and corm spacing, in concert with climate, are critical factors in determining yields. Mother corms planted deeper yield higher-quality saffron, though form fewer flower buds and daughter corms. Italian growers optimize thread yield by planting 15 cm deep and in rows 2–3 cm apart; depths of 8–10 cm optimizes flower and corm production.

When saffron is dried after its harvest, the heat, combined with enzymatic action, splits picrocrocin to yield D–glucose and a free safranal molecule. Safranal, a volatile oil, gives saffron much of its distinctive aroma. Safranal is less bitter than picrocrocin and may comprise up to 70% of dry saffron's volatile fraction in some samples. A second element underlying saffron's aroma is 2-hydroxy-4,4,6-trimethyl-2,5-cyclohexadien-1-one, the scent of which has been described as "saffron, dried hay like". Chemists found this to be the most powerful contributor to saffron's fragrance despite its being present in a lesser quantity than safranal. Dry saffron is highly sensitive to fluctuating pH levels, and rapidly breaks down chemically in the presence of light and oxidizing agents. It must therefore be stored away in air-tight containers in order to minimise contact with atmospheric oxygen. Saffron is somewhat more resistant to heat.

C. sativus prefers friable, loose, low-density, well-watered, and well-drained clay-calcareous soils with high organic content. Traditional raised beds promote good drainage. Soil organic content was historically boosted via application of some 20–30 tonnes of manure per hectare. Afterwards, and with no further manure application, corms were planted. After a period of dormancy through the summer, the corms send up their narrow leaves and begin to bud in early autumn. Only in mid-autumn do they flower. Harvests are by necessity a speedy affair: after blossoming at dawn, flowers quickly wilt as the day passes. All plants bloom within a window of one or two weeks. Roughly 150 flowers together yield but 1 g (0.035 oz) of dry saffron threads; to produce 12 g (0.42 oz) of dried saffron (or 72 g (2.5 oz) moist and freshly harvested), 1 kg (2.2 lb) of flowers are needed; 1 lb (0.45 kg) yields 0.2 oz (5.7 g) of dried saffron. One freshly picked flower yields an average 30 mg (0.0011 oz) of fresh saffron or 7 mg (0.00025 oz) dried. Saffron contains more than 150 volatile and aroma-yielding compounds. It also has many nonvolatile active components, many of which are carotenoids, including zeaxanthin,

lycopene, and various α- and β-carotenes. However, saffron's golden yellow-orange colour is primarily the result of α-crocin.

The various saffron crocus cultivars give rise to thread types that are often regionally distributed and characteristically distinct. Varieties from Spain, including the tradenames "Spanish Superior" and "Creme", are generally mellower in colour, flavour, and aroma; they are graded by government-imposed standards. Italian varieties are slightly more potent than Spanish; the most intense varieties tend to be Iranian. Various "boutique" crops are available from New Zealand, France, Switzerland, England, the United States, and other countries, some of them organically grown. In the U.S., Pennsylvania Dutch saffron—known for its "earthy" notes—is marketed in small quantities.

Consumers may regard certain cultivars as "premium" quality. The "Aquila" saffron, or *zafferano dell'Aquila*, is defined by high safranal and crocin content, distinctive thread shape, unusually pungent aroma, and intense colour; it is grown exclusively on eight hectares in the Navelli Valley of Italy's Abruzzo region, near L'Aquila. It was first introduced to Italy by a Dominican monk from Inquisition-era Spain. But the biggest saffron cultivation in Italy is in San Gavino Monreale, Sardinia, where it is grown on 40 hectares, representing 60% of Italian production; it too has unusully high crocin, picrocrocin, and safranal content. Another is the "Mongra" or "Lacha" saffron of Kashmir (*Crocus sativus* 'Cashmirianus'), which is among the most difficult for consumers to obtain. Repeated droughts, blights, and crop failures in the Indian-controlled areas of Kashmir combine with an Indian export ban to contribute to its prohibitive overseas prices. Kashmiri saffron is recognisable by its dark maroon-purple hue; it among the world's darkest, which hints at strong flavour, aroma, and colourative effect (Lambrechts et al., 1992).

Zephyranthes

Zephyranthes is a genus of 71 species in the Amaryllis family (subfamily Amaryllidoideae). There are numerous hybrids and cultivars. Common names for species in this genus include fairy lily, rain flower, zephyr lily, magic lily, Atamasco lily, and rain lily. The name is derived from *Zephyrus*, the Greek god of the west wind, and *anthos*, meaning flower, referring to the slender stalks. The genus is native to the Americas. Several species have become naturalized (sometimes unintentionally) in other places like Hawaii, Indonesia, and Thailand. The species that are native to the higher altitudes in Mexico (e.g. *Z. lindleyana*, Central America (Costa Rica, e.g. *Z. carinata*) and parts of North America (e.g. *Z. longifolia*) or Argentina (e.g. *Z. candida*) represent the species having the greatest potential for cold hardiness.

These perennial bulbs (geophytes) tolerate many ecological niches (periodically wet soil to desert conditions), and have many ornamental characteristics. Care should be taken with the plants since many of the parts, leaves, bulbs etc. are currently considered toxic. The genus has been evaluated for possible medicinal properties, and the biochemically toxic compounds are classed as alkaloids.

Species in the genus which are listed in this article vary in morphology. Along with floral morphology, characteristics such as bulb size, bulb tunic color, and leaf morphology help identify individual species.

Foliage in the wild is often ephemeral, but under cultivation becomes more persistent. Leaf color ranges from the bright grassy green of *Z. candida* (shown in the photo) to rather broad glaucous colored foliage such as found in *Z. drummondii*. A few of the species have distinct bronze tints in the foliage when grown in bright light. Size of leaves in these species, ranges from dark green and tiny grassy leaves in species like *Z. jonesi* or *Z. longifolia*, to broader, glaucous leaves in species like *Z. drummondii*. Perhaps largest leaves of all is found on *Z. lindleyana* from Mexico, usually distributed as a cultivar called 'Horsetail Falls,' this species has handsome broad leaves almost like a *Hippeastrum*.

Flower color in the species ranges from white to yellow (various tints of this color from lemon to sulfur) and pink. *Zephyranthes* have erect flower stalks which support a flower that may be upward facing or slightly nodding. The funnel-shaped, flowers with six petals can be crocus shaped, but may also open flat such as in *Z. jonesii* or even reflex slightly.

The flowers of some species have a sweet, pleasant fragrance. Fragrance appears to be recessive in crosses, but there are a few species or hybrids, *Z. drummondii* (white), *Z. morrisclintae* (pink) and *Z. jonesii* (light yellow), that all carry the trait. At least two of these open their flowers at night and are attractive to nocturnal insects. The flowers typically last only for a day or two; but new flowers may appear in a succession of blooms, especially during humid or rainy weather.

Various members of the genus may bloom spring only or repeat and continue into autumn, often a few days after rainstorms thus one of the common names, rain lilies. Periods of synchronous bloom, which breeders have dubbed "blitzes", are part of their ornamental value, but also times breeders exploit for the purpose of producing new hybrids.

Most species under cultivation will bloom without the naturally imposed drought and wet that occurs in nature. Greenhouse grown plants bloom very freely but cycle through periods of bloom. One of the longest blooming of all the species is *Z. primulina* which blooms from April until October. Although it is apomictic, it is a choice parent for crosses because of its rapid repeat flowering trait and long bloom season. Some other species such as *Z. morrisclintae* appear to bloom only in the spring season. Most of these species are easily propagated vegetatively via offsets or twin scaling. A few of them such a *Z. clintae* are slow to produce increase.

Unusual phenotypes can be preserved vegetatively. Sexual reproduction is via seed. The apomictic species freely set seed and faithfully reproduce the maternal phenotype. Sterility in hybrids can be problematic; reasons for this are mentioned below. Seed usually is best sown quickly after harvest, although short term storage can be successful. Maiden seedling can be brought into bloom for some of the hybrid in 8–12 months after sowing in ideal conditions. This makes it easy to carry out checks for apomixis.

Cultivation

Usually rain lilies are sold in nurseries already potted up. This is of advantage since the growth cycle is not interrupted. Rarely the dried bulbs are marketed. Such dried bulbs usually become established after one to two growing seasons and will regain flowering strength.

While *Zephyranthes* can stand dry periods, but if the elegant green leaves require remaining showing all year, it is essential to add some water in drier periods or more arid climates. This can be a good thing if they are dry a week or so between watering. The cycle of drying then watering encourages them to send forth bewitching flowers.

The flowering time for *Zephyranthes* is from summer to autumn where they send up a succession of crocus-like flowers after heavy rain or watering. Zephyranthes can be planted all year round from a full sun position to partial shade. They have attractive dark green foliage from spring to late autumn, but are dormant over the winter period. These bulbs perform best uninterrupted and will quickly form dense clumps.

Zephyranthes prefer well drained soil, enriched with well rotted compost and a small amount of complete fertilizer. Plant in to moist soil 5 to 7.5cm deep and up to 10cm in sandy soils. Leave 7 to 10cm between each bulb when planting out. Top dress each spring with a complete fertilizer.

These plants are usually propagated by dividing clumps of bulbs, but can also be grown from seeds. They are widely cultivated as ornamental plants. They are relatively low-maintenance, becoming dormant during extended periods of drought. They are less tolerant of colder temperatures than other species of *Zephyranthes*. In India, they are also used in folk medicine, along with *Zephyranthes flava*. The bulbs of *Z. rosea*, like other members of *Zephyranthes* and *Habranthus*, contain various toxic alkaloids including lycorine and haemanthamine. They can cause vomiting, convulsions, and death to humans, livestock, and poultry. Pests of *Z. rosea* include chewing insects. They are also vulnerable to the necrotrophic fungus *Botrytis cinerea*.

Hyacinth

Hyacinths differ from most economically important flower bulbs because all the commercial cultivars belong to one species, Hyacinthus orientalis. The species is indigenous to Asia Minor and was first described in 1562 by de L'Obel (Dix 1974b). In 1581, he also described another flowering type called "Roman Hyacinths": H. orientalis var. albulus (Dix 1974b). At that time, blue-, white-, and purpleflowering cultivars had been identified. Double-flowering types were described in 1612, and they remained popular until the middle of the 19th century (Doorenbos 1954).

Breeding was started in the Netherlands at the beginning of the 18th century and was conducted primarily by wealthy amateur breeders. Pink- and reddish flowering types were obtained about 1709 and yellow flowering types in 1760 (Doorenbos 1954). Subsequently, breeders produced numerous cultivars. At their peak of production, over 2,000 cultivars were grown. Some are in Hortus Bulborum (see Section IV.B.3).

Even though the number of cultivars decreased after the second half of the 19th century, breeding continued in the Netherlands. Some cultivars—for example, 'L'Innocence' (1863), 'City of Haarlem' (1893), and 'Pink Pearl' (1922)—are still produced commercially in the Netherlands (PT/BKD 2007).

After 1910, when Nicolaas Dames demonstrated that Dutch-grown bulbs could be forced in December, the breeding objectives and uses of hyacinths changed significantly. The focus became forcing. In spite of the fact that only one species is available for breeding, new types are still being bred and released. This can be due to the fact that cytological studies revealed some peculiarities of hyacinths, and a number of them are heteroploids (Doorenbos 1954). By using the "Roman Hyacinth Types," cultivars producing several flowering stems per bulb have been obtained (Dix 1974b).

Hyacinth breeding has, and currently is,

carried out largely by private companies. The exceptions are cytological studies (De Mol 1935; Hosokawa 1999) and resistance to yellow disease (Xanthomonas hyacinthi) (Van Tuyl and Toxopeus 1980; Van Tuyl 1982). Flower color, especially yellow, is an important goal of hyacinth breeding. Yellow cultivars tend to have a low vigor and are susceptible to diseases but do have a reasonable bulb production (Krelage 1883).

The physiological disorder called floral stalk topple is well known in hyacinths, but until recently it has had a low priority in the breeding programs. At the HOBAHO Testcentrum in Hillegom, the Netherlands, breeding has focused on having a strong floral stalk combined with an inflorescence with many florets. In 2007, three cultivars (Baltic Sea, Deep Sea, and Woodbells) were registered by the Testcentrum at the KAVB.

Hyacinthus is a small genus of bulbous flowering plants in the family Asparagaceae, subfamily Scilloideae. Plants are commonly called hyacinths. The genus was formerly the type genus of the separate family Hyacinthaceae; prior to that it was placed in the lily family Liliaceae. *Hyacinthus* is native to the eastern Mediterranean (from south Turkey to northern Israel), north-east Iran, and Turkmenistan.

Three species are within the genus *Hyacinthus*: *Hyacinthus litwinowii, Hyacinthus orientalis* - Common, Dutch or Garden Hyacinth, *Hyacinthus transcaspicus,* Some authorities place *H. litwonowii* and *H. transcaspicus* in the related genus *Hyacinthella*, which would make *Hyacinthus* a monotypic genus.

The Dutch, or Common Hyacinth of house and garden culture (*H. orientalis*, native to southwest Asia) was so popular in the 18th century that over 2,000 cultivars were cultivated in the Netherlands, its chief commercial producer. This hyacinth has a single dense spike of fragrant flowers in shades of red, blue, white, orange, pink, violet, or yellow. A form of the common hyacinth is the less hardy and smaller blue- or white-petalled Roman hyacinth of florists. These flowers should have indirect sunlight and are to be moderately watered.

Several types of brodiea, deathcamas, squill, and other plants that were formerly classified in the lily family and have flower clusters borne along the stalk also have common names with hyacinth in them. Hyacinths should also not be confused with the genus *Muscari*, which are commonly known as grape hyacinths.

Hyacinths are sometimes associated with rebirth. The Hyacinth flower is used in the Haftseen table setting for the Persian New Year celebration Norouz held during the Spring Equinox.

Hyacinth bulbs are poisonous; they contain oxalic acid. Handling hyacinth bulbs can cause mild irritation to people with sensitive skin. Protective gloves may be worn to avoid irritation.

Myth associated with Hyacinth

Hyacinth was a beautiful youth loved by both the god Apollo and the West Wind, Zephyr. Apollo and Hyacinth took turns at throwing the discus. Hyacinth ran to catch it to impress Apollo, but he was struck by the discus as it fell to the ground, and died. A twist in the tale makes the wind god Zephyrus responsible for the death of Hyacinth. The youth's beauty caused a feud between Zephyrus and Apollo. Jealous that Hyacinth preferred the radiant archery god Apollo, Zephyrus blew Apollo's discus off course, so as to injure and kill Hyacinth. Apollo did not allow Hades to claim Hyacinth. Instead, Apollo made a flower, the hyacinth, from Hyacinth's spilled blood.

Varieties of *Hyacinths*: Single *Hyacinths*: The full heads on these classic hyacinths look good in the garden or when forced in pots. The Blue Giant is one of the largest singles which has sky blue flowers with dark blue veins. Double *Hyacinths*: Fluffy whorls of colorful flowers are arranged on 10-12 inch stems. Hollyhock is an outstanding variety that features dark pink blooms. Multiflora *Hyacinths*: Each bulb produces a number of flower stalks with loose arrangements of flowers. These are less formal than singles and doubles.

Cultivation:

Planting of hyacinth bulbs should be done in fall, i.e. 6 to 8 weeks earlier than a hard frost is expected and when soils are below 60^0 F. Prepare the garden bed by using a garden divergence or tiller to loosen the soil to a depth of 12 to 15 inches, then mix in a 2 to 4-inch layer of compost. Dig a hole 6 to 8 inches deep. Set the bulb in the hole, pointy end up, then cover with soil and press firmly. Space bulbs 4 to 6 inches apart. Water thoroughly after planting.

After they bloom in spring, allow the plants to grow until the leaves die off. They need time after blooming to store energy in the bulbs for next year. To remove the dead plant, either snip them off at the base, or twist the leaves while pulling lightly.

Keep Hyacinths watered during dry spells in fall. After the plants have finished flowering in spring, cut back flower stalks but allow the leaves to die back naturally, hiding the unsightly foliage with annual or perennial plantings. An annual application of compost should provide adequate nutrients. Flower size may decline in subsequent years, so some gardeners treat Hyacinths as annuals and plant fresh bulbs each fall. Summer Hyacinths bear fragrant,

bell-shaped flowers for a month in mid-summer. If planted in March, you can expect blossoms in July. The Hyacinth bulb may be propagated vegetatively by removing the bulblets that have developed by the end of the growing season

Other Genera of Ornamental importance

Besides genera that comprise most of the worldwide bulb production, there are other ornamental geophytes that are of economic importance in the cut-flower and pot plant industries. Cut-flower statistics from the Netherlands showed that *Freesia, Alstroemeria*, *Hippeastrum*, *Gladiolus* and *Zantedeschia* were, respectively, the 8th, 10th, 11th, and 13th most important cut flowers at the flower auctions (www. vbn.nl 2006). Anemone and Ranunculus are two other important genera for cut-flower production, especially under Mediterranean climatic conditions (Umiel and Hagiladi 2004). Some of these genera also are used for potted plant production (De Hertogh 1996). The commercial development of these genera has been supported by plant breeding programs, but most are relatively new ones.

Freesia

Freesia, which is native to South Africa, was introduced into England about 1816, but interspecific hybridization started only in the beginning of the 20th century (Bryan 1989, 2002). Breeding programs were established in England, France, and the Netherlands, and they produced types with a wide range of flower colors and double flowers. A milestone was the production of tetraploid plants with large flowers (Sparnaay 1966). The possibilities of propagation be seed of these new cultivars was also studied by Sparnaay (1966), but vegetative multiplication generally is used. Currently, Freesia breeding is being conducted by private companies and mainly in the Netherlands.

Freesia flowers are “zygomorphic” which just means that they grow along one side of the stem, in a single plane. When you look at a flower stalk however, you'll see that the blooms are facing upwards. How does this work? Freesias stems have the unusual habit of turning at right angles just below the bottom flower. This causes the upper portion of the stem to grow almost parallel with the ground. The flowers bloom along the top side of the stalk, facing upwards. This makes them lovely to look down into in a garden setting and ideal for arrangements. Its native place is South Africa. It is usually up to 18 in (45 cm). Flower stems often need to be staked to hold them upright.

Cultivation

For cultivation of this plant a concentrated light, some cool, direct morning sunlight is fine. Keep the soil lightly moist. Overwatering should be avoided because it will cause the corms to rot. Average to moderate humidity is favourable for proper growth. Whilst freesia plant is growing and flowering Warm temperatures of about 28°C until corms start emergent, it should followed by cool temperature of 16-18°C. Feed every 2 weeks, beginning with the first show of flower buds till the end of flowering. Use a high-potassium liquid fertilizer diluted by half.

A second time indoors corms will not bloom. They make offsets that can be planted. After flowering, allow the foliage to die back naturally, then cut off the stems, subsequently remove and store the offsets in a dry place.

Planting of freesia corms should be done in early spring because they require cool nights to set their blooms. By allowing the narrow, bladelike leaves to dry up naturally at the end of the season, one should have a plumper corm to store for next year's flowers. Potted freesia plants displayed on a courtyard or sunny portico will share their fragrance up close for your enjoyment.

Alstroemeria

Alstroemeria species originate in Chile, Peru, and Brazil (Bridgen 1993; De Jeu et al. 1992). Commercial breeding for greenhouse cut-flower production was initiated in England about 1948. Later, breeding was started in the Netherlands, and numerous interspecific hybrids combining important characteristics, such as year-round flowering, plant habits for cut flower or potted plant forcing, long flowering periods, a range of flower colors and shapes, and the ability to be increased by in vitro propagation, have been obtained (De Jeu et al. 1992; Bridgen et al. 2002). Alstroemeria breeding was enhanced by the production of tetraploid plants and by various in vitro techniques (De Jeu et al. 1992; De Jeu 2000; Bridgen et al. 2002).

Cultivation

About 190 cultivars and many hybrids have been developed, with diverse markings and colors, ranging from pink, red, purple, white, golden yellow and orange to apricot and lavender. The most popular and showy hybrids commonly grown is a result from crosses between winter-growing species from Chile with summer-growing species from Brazil. This tactic has overcome the problem of recurring dormancy and resulted in plants that are evergreen, or nearly so, and flower for most of the year. Most cultivars available for the home garden usually

blossom in the late spring and early summer. The roots are resilient to a temperature of 23 °F. The plant requires at slightest six hours of morning sunlight, regular water, and well-drained soil

Hippeastrum

Hippeastrum consists of about 60 species that are concentrated in two areas of diversification: eastern Brazil and the central southern Andes of Peru, Bolivia, and Argentina (Meerow et al. 1992a). Interspecific hybridizations, using a very limited number of species, have produced large-flowered, tetraploid hybrids. In order to enlarge the genetic diversity of the commercial material,

Breeding at the diploid level has been achieved (Meerow et al. 1992a). In general, the breeding programs have been conducted primarily by private companies in the United States, the Netherlands, and South Africa. This programs have produced a large number of cultivars expressing a great diversity in the types of flower (colors and shapes) and stem length. A new program on Hippeastrum hybridization, using wild relatives and embryo rescue in vitro techniques, currently is being developed in Israel (Sandler-Ziv et al. 2004).

Cultivation

A stylized flower of a *Hippeastrum* cultivar (under its common name of amaryllis) is used internationally as a symbol for organizations associated with Huntington's disease, a genetic degenerative disease of the nervous system. The widely-used logo represents a double image of a head and shoulders as the flower of a growing and vibrant plant. The reduced size of the inner head and shoulders image symbolizes the diminution in a person caused by Huntington's disease. The leaves represent the protection, purpose, growth and development of the Huntington's community worldwide in its search for a cure and treatment.

Zantedeschia

Zantedeschia consists of a few species native to Africa (Singh 1996; Singh et al. 1996). The species are distributed into two groups that differ by their type of growth. One species, Z. aethiopica, is an evergreen plant producing white flowers in winter and spring. he second group includes about 8 species and subspecies that are deciduous and summer flowering, and produce colored flowers ranging from pink and dark maroon to yellow (Funnell 1993). Active breeding programs concerning the species of the second group, and including interspecific hybridizations, started in the 1980s in New Zealand and resulted in a large number of commercial cultivars. The major objectives were a large number of flowers per tuber and diversity in flower colors. In vitro techniques, including embryo culture and tissue culture for rapid propagation, were developed (Funnell 1993). Breeding by Dutch companies started in the 1990s. Breeding for soft-rot [*Pectobacterium* (*Erwinia*) *carotovorum*] resistance is a major goal, but no definitive results have been obtained (Snijder et al. 2004).

Anemone and Ranunculus are native to Middle East and were introduced into Europe during the Crusades. Generally, they are seed propagated, and the tubers and tuberous roots are marketed for use in gardens or for a cut-flower or potted plant production (De Hertogh 1996). The genus Anemone consists of only a few species and subspecies. Two are produced on a commercial scale: *A. blanda* is produced in the Netherlands for use as garden plant or potted plant.

Zantedeschia grows naturally in marshy areas and is only deciduous when water becomes limited. It grows incessantly when watered and fed frequently and can survive periods of minor frosts. *Z. aethiopica* is a very strong and strong plant, being able to grow in many soils and habitats, multiplying by rhizome-offsets *Z. odorata* is a rare species, resembling *Z. aethiopica*, but deciduous and smelling like freesia, endemic to a few localities in South Africa. *Z. albomaculata* is a widespread and variable species, growing from South Africa north to Kenya, varying in shades of white to cream and pink to orange-shades. *Z. elliotiana* is known from horticultural sources only and is probably of hybrid origin. *Z. jucunda* and *Z. pentlandii* are rare species with beautiful large yellow showy flowers. *Z. rehmannii* is a pink-flowered species with sword shaped leaves.

Cultivation

Zantedeschias bring into being large, showy flowers spathes and are often grown both as ornamental plants and for cut flowers. *Zantedeschia* are resilient plants, but some are more winter-tolerant than others. The white *Zantedeschia aethiopica* and some of its relatives can survive at minimum winter temperatures below -23 °C, and many others can be grown in even warmer areas where all the ground does not freeze. Several species are less resilient and can only survive winter temperatures to -12 °C. This plant has to be grown as gentle bulbs or houseplants in cooler areas. Species and hybrids between *Z. elliotiana*, *Z. jucunda*, *Z. pentlandii* and *Z. rehmannii* appear to have an most favorable temperature for growth near 25°C, with growth being suppressed once daily average temperatures persist at 28 °C.

Widespread profitable production of Zantedeschia for cut flowers and/or planting material occurs in different parts of world. In the South-West

of Western Australia, *Z. aethiopica* was introduced for horticulture. It has become a widespread and conspicuous weed of watercourses, heath, and wetter pastures. The supposed white calla is derived from *Z. aethiopica*. All varieties with flowers with shades of yellow, orange, red, purple are mainly derived from *Z. albomaculata*, *Z. pentlandii*, *Z. elliottiana* and *Z. rehmanni*.

In distinction, the production of *A. coronaria* is intense in Israel, the Mediterranean, and cool oceanic regions of western Europe and the United States where they are used mainly as cut flowers. Active breeding work for cut-flower usage has been conducted in the United States, the Netherlands, and more recently in France and Israel.

Gladiolus

The genus includes more than 150 species that are mainly native to eastern, southern, and western regions of Africa, but about 12 species originate in the Mediterranean region (Cohat 1993). The first species were introduced to Europe prior to 1740 (Beal 1927). The modern cultivars were developed by interspecific crosses that started as early as 1807 and continued during the 19th century in Great Britain, France, Germany, the Netherlands, Belgium, and the United States (Ohri and Khoshoo 1985). Only 8 species, all of them originating from Africa, were used in these interspecific crosses. They led to the creation of two types of hybrids: spring flowering and summer flowering. The spring-flowering types were the results of intercrosses between diploid species, and they were widely cultivated in Europe by the middle of the 19th century. After 1839, their popularity waned because of the successful hybridization between a diploid and a hexaploid species that produced tetraploid plants. These summer flowering hybrids had vigorous growth characteristics, long and strong floral spikes, and were adapted to the European climatic conditions.

These hybrids were a significant turning point in the evolution of the garden gladioli. They provided the genotypes for the summer-flowering cultivars that currently are used worldwide not only in gardens but also for commercial cut-flower production. Repeated intercrossing between the tetraploid summer-flowering hybrids, plus interspecific crosses with three additional polyploidy species, produced the diversified group of large-flower-size cultivars (Ohri and Khoshoo 1985). Most of these cultivars were bred and released by professionals and amateurs in various parts of the world, such as the United States, Canada, Europe, Australia, and New Zealand. In each country, the selection criteria varied. For example, ruffled or laciniated flowers were mainly selected in the United States and Canada. In Europe, and especially in the Netherlands in the last few decades, special attention was given to the breeding of cultivars adaptable to cut-flower production.

Cultivation

The corms of most species and hybrids should be taken in autumn and stored over winter in a frost-free place, then replanted in spring. Plants are propagated moreover from small cormlets produced as offsets by the parent corms, otherwise from seed; in both cases, they take several years to get to flowering size. Clumps should be dug up and divided every few years to keep them dynamic.

Due to their complex interspecific origin, the modern large-flowered cultivars are tetraploid and heterozygous, which makes genetic studies very difficult. Cohat (1988) showed that the heritability of quantitative characteristics was medium to high. The evaluation of numerous cultivars and species by the U.S. Department of Agriculture (USDA), and in the Netherlands (Straathof et al. 1998) indicated the existence of sources of resistance in some species and in the large-flowered group. The breeding program in Florida (Wilfret and Magie 1979) has produced some positive results.

However, the existence of physiological races of *Fusarium* could make it difficult to obtain total resistance. To accelerate the selection process for resistance to *Fusarium*, Straafhof et al. (1997) studied a technique using seedling populations. Also, the possibility of an in vitro selection for *Fusarium* resistance, using cell suspension cultures and challenged by fusaric acid, was studied by Remotti et al. (1997), but no practical applications have been reported. Dry rot (*Stromatinia gladioli*) is another serious disease during corm production, especially in the Netherlands. A testing method for selecting resistant material was evaluated. Research on *in vitro* propagation techniques has produced many positive results (Bajaj et al. 1983; Ziv 1989; Kasumi et al. 1998). Successful genetic transformations for Gladioli has been reported by Kamo (1997) and Leoffler and Van Harmelen (1998), but no commercial use of these results has been reported. The possibility of in vitro production of polyploid plants by using colchicine has been reported by Meyers (1996).

Ranunculus

Ranunculus asiaticus is the only species cultivated for its ornamental characteristics. It was widely grown in the Mediterranean areas and in the cool oceanic areas of Western Europe (Flanders, England) in the 18th and 19th centuries (Meynet 1993b). The species can be used not only as garden plants but also as cut flowers, because it is winter

flowering and has long stems and attractive and long lasting flowers. Pot plant production is also possible because genetically short-stemmed types exist, and plant growth retardants (PGRs) can be applied (De Hertogh 1996). Since *R. asiaticus* has some auto-incompatibility and is susceptible to inbreeding, commercial cultivars are mostly hybrids (Meynet 1993a; b). By using the sib mating technique, genetic, homogeneous material can be obtained, and cultivars exhibiting homogeneous colors are available. The production of true F1 hybrids should be possible through the use of double haploids issued from anther in vitro culture (Meynet and Duclos 1990a). However, since the double haploid plants have a low vigor, seed production is still a major problem. Anther *in vitro* culture has also produced a large somaclonal variation through somatic embryos, and the new characteristics, especially colors, appeared stable and were transmitted as nuclear mutations (Meynet and Duclos 1990b).

Ranunculus, or Persian buttercup, grows from unusual spider-like bulbs that remain viable for as long as a year when stored in a cool, dry location. The foliage is fuzzy and bright green and the flowers are borne on 12- to 18-inch hollow stems in spring. The flowers are daisy-like or multi-petaled and almost any color, depending on variety, with some bi-color varieties available. The flower petals are tissue-paper thin and translucent. They can be used for long-lasting fresh flower arrangements

Recently, flower types with green centers have been obtained. This occurred because with some genetic types, the ovaries can produce leaf or bract like organs. In general, breeding programs with Ranunculus has been carried out either by small research teams or private companies in France, Italy, Japan, Israel, and the United States. These programs have released a wide range of cultivars that are propagated primarily by seed. The exceptions are the recent Italian cultivars, which have been vegetatively propagated through in vitro culture.

Cultivation

The best growth of Ranunculus (*Ranunculus asiaticus*) can be obtain growing it at places where nocturnal temperatures ranges 30 and 50 degrees Fahrenheit and daylight temperatures ranges 60 and 75 degrees Fahrenheit. The bulbs of ranunculus can be planted in the fall or winter. In cooler climates, the bulbs are started indoors and planted outside in spring.

For planting of ranunculus bulbs in the ground, organize the planting area 12 weeks before the last average frost date. The planting location must be well-drained as a result the bulbs can remain dry during their dormant period at the end of the summer. Transform the soil with a 1 to 2 inch layer of manure and include it into the top 6 inches of soil. Planting of the ranunculus bulbs should be in a manner where the "legs" pointing downward, 2 inches deep and 4 inches apart. Softly cover with soil and water thoroughly to allow the dried bulbs to begin their growth cycle.

If preparatory plants indoors, plant bulbs 2 inches deep in well-drained containers 12 weeks before the last average frost date. Keep the soil moist, but not wet and grow the plants in a brightly lit location where the temperatures are between 45 and 60 degrees. Set the plants outside in the garden one week after your last average frost date. Ranunculus can tolerate a light freeze.

Fertilize Ranunculus with a water-soluble fertilizer diluted to half strength every 10 days during the foliage production period. Avoid fertilizer once blooming begins. Too much fertilizer will support foliage at the cost of bloom production.

Water the plants carefully during the growing season, particularly if the weather is oddly warm. The root system of ranunculus is small, so the plants wilt quickly in warm weather. However, if they are growing in a container be care should be taken to not sink the plants with too much water.

Ranunculus flowers are cut in the bud stage or while half-open. They will keep on to open over several days when the stem end is placed in clean cool water. Straight away place the cut ends in a container of water. Use a sharp cutting tool to cut ranunculus flowers as low as possible to the ground without damaging the foliage. The plant needs the foliage to create energy for next year's growth.

2. Conclusion

There have been numerous efforts to search for and introduce new ornamental geophytes. Some have already gained popularity, but some have not yet appeared in the markets. There are still regions in the world where expeditions for indigenous species need to be expanded and, especially, continued. Taxonomic studies and classifications of geophytes, of either known or newly introduced species, are important. Currently, studies using classical or molecular approaches are limited (Meerow 2002; Duncan et al. 2005). Clarifying the geographic distribution of wild geophyte species and their genetic diversity is important not only for breeding studies but also for the conservation of rare and endangered species. Reevaluation of known geophytes is also necessary in their natural habitats both for conservation purposes and for obtaining information, such as the finding of self-compatible *Lilium longiflorum*.

Effective propagation systems, including *in*

vitro propagation, need to be developed for many bulb crops. In vitro propagation remains expensive, depends on countries with low labor costs, and still has not become a final solution to all problems. The cost of in vitro propagation increases with the economy development in developing countries. Without more efficient propagation systems, industry must keep searching for the low labor-cost countries.

The world floriculture industry is in state of unrest, with drastic changes in supply position. New markets as well as new suppliers are emerging and disappearing in short span of time. New exporting countries emerge only to find that other countries are pushing hard to become the next generation exporters (EXIM BANK, 2006).

The market of cut flowers consists of a range of product groups, which offer varying opportunities for countries like India, as potential suppliers. It is a highly competitive market in which importers are continually seeking new, special and different products. They tend not to change easily from one cut flower supplier to another but co-operation with a company supplying a new product is considered attractive. The market is clearly searching for novelty products. A new product also offers the prospect of making higher profits than those gained from selling conventional floriculture products. Demand of foliage verities is still increasing in Europe, particularly for small leafed foliage for use of bouquets. Furthermore, European importers do not have any reticence about using tropical foliage. The opportunities are optimal for tropical countries like India in supplying products during periods when these products are scarce in the western markets.

In order to compete, Indian exporters must be able to supply products of consistent quality and on a regular basis. With a strong preference for direct marketing and private R & D for developing proprietary products, the industry will have to develop an unique selling proposition to increase the competitiveness. Joint initiatives may be taken for creation of appropriate infrastructure for production, post harvest handling and transportation of floriculture products. The marketing and distribution channels are also to be strengthened. With all initiatives, it may be deduced that the structure and composition of Indian floriculture industry may undergo major changes in future.

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