UNIT 2 *IRIS* (BULBOUS), *LILIUM* AND *NARCISSUS*

Structure

2.0 OBJECTIVES

After going through this unit, you will be in a position to:

- explain the bulbous and cormous ornamentals and their various uses,
- distinguish the true bulbous ornamentals from other bulbous plants,
- know various commercial plants falling under true bulbous ornamentals,
- know about the classification, important species and various varieties of Iris, Lilium and Narcissus,
- describe their propagational methods, soils, planting, nutritional requirements and other cultural practices,
- know their growth habits, influence of light and temperature for inducing flowering and bulb production,
- explain how and when to harvest the flowers and bulbs and their post harvest and storage techniques, and
- know various insect-pests, diseases and physiological disorders attacking the crops and their remedial measures.

2.1 INTRODUCTION

Bulbous ornamentals are also called **ornamental bulbs, flower bulbs (flowering** and **non-flowering)** and **geophytes.** These are plant species that survive under the adversities of weather conditions not only by seeds but also by specialized underground storage organs, whether it is cold winters or hot and dry summers. Annuals perennate only through seeds which may remain viable for varying periods - a few days to many years or even centuries but **geophytes** can rely, in addition, on special underground storage organs such as **bulbs** [*Amaryllis, Fritillaria, Haemanthus, Hippeastrum, Hyacinthus, Leucojum, Lilium, Narcissus, Iris* (bulbous), *Ornithogalum, Polianthes, Sprekelia, Tigridia, Tulipa, Zephyranthes,* etc.], **corms** [*Crocus, Freesia, Gladiolus, Homoglossum, Sparaxis, Tritonia, Watsonia,* etc.], **rhizomes** [*Alstroemeria, Anemone, Anigozanthos, Caladium, Canna, Hedychium, Iris* (bearded, beardless and crested), *Oxalis, Zantedeschia,* etc.] and **tubers** [*Achimenes*, *Agapanthus, Arum, Begonia* (tuberous), *Cyclamen, Dahlia* (root tuber/tuberous roots), *Eremurus, Gloriosa, Ranunculus* (root tuber), *Sinningia*, etc.]. Horticulturally, the bulb means every plant having underground storage organs whether it is true bulb, corm, tuber or rhizomes but botanically they are separate entities.

The **bulb** (true botanical bulb) is a sort of plant in embryo, consisting of a very short stem known as disc which constitutes of tough tissues, the basal plate with a shoot protected by modified white and fleshy leaf bases (scales), altered or adapted so for storage. The scales contain stored food reserves, *viz.,* carbohydrates (starch, sugar) and certain proteins. From the basal plate thin adventitious roots sprout. They are of two types: **tunicated** where leaves are layered closely around each other and where outermost one is often dry and brown in colour and form a tunic around the bulb e.g. *Hyacinthus, Narcissus* and *Tulipa* whereas in other bulbs i.e. **non-tunicated ones** the leaves though not wrapped but overlap each other, are more succulent which do not form a tunic and such bulbs are known as scaly bulbs, e.g. *Fritillaria* and *Lilium*. Most bulbs (except *Cardiocrinum*) are

perennial and renew annually the food stored in the scales. In the centre of the bulb is an embryo shoot, often with a complete embryo flower. Most bulbs form offsets or small bulbs (**bulblets**) around themselves, and sometimes the mother bulb itself splits into 2-5 smaller bulbs. In certain genera or species e.g. *Lilium tigrinum,* very small bulbs called as **bulbils** are formed on the flowering stems, in the axils of the leaves, which when detached and planted in suitable media and situation, grow into full sized bulbs.

Under this unit three crops, *viz., Iris* (bulbous), *Lilium* and *Narcissus* are being described.

2.2.1 Iris (bulbous) (Family - Iridaceae)

(Common name **Rainbow flower**)

2.2.1.1 Classification, Species and Varieties

Irises (bulbous) make beautiful cut flowers, though vase life is short. Consist of 300 species but bulbous irises are only a few, and are grown only for cut flowers both in the greenhouse and outdoors, for pots and bowls. Their rootstock is true bulb. In iris, the perianth tube branches into an inner and outer series, each being of 3 segments, 3 outer petals being known as falls and the 3 inner ones as standards. Projecting between the falls and the standards are the 3 style arms which are strap-shaped petals. The irises grown for cut flowers are produced from tunicated bulbs which are renewed every year as in the process of formation of the new daughter bulbs, old (mother bulb which was planted) ones are fully used up, so every year it is a new bulb or annual bulb. Irises, as a whole, have 27 sections out of which three sections [section 25, subgenus **XIPHIUM** (the **Spanish** irises,), section 26, subgenus **SCORPIRIS** (the **Juno** irises), and section 27, subgenus **HERMODACTYLOIDES** (the **Reticulata** irises)] are dealt only with bulbous group, and the members (species, hybrids and varieties) falling under these three sections only have true bulbs as their underground storage organs, which are being described here under.

i) **Xiphium group** (the **Spanish irises**, the varieties of *I. xiphium*) **:** All the species under this section come from hot areas around the Mediterranean hence, they are tender. Bulb medium sized with no storage roots but fibrous and thin, tunics papery, leathery or tough and not tunicated, leaves channelled, stem simple, 1-3 flowered and 90 cm tall. This section provides good **cut flowers**. *Iris boissieri (I. diversifolia), I. filifolia, I. juncea, I. serotina, **I. tingitana*** (good for forcing), ***I. xiphioides*** (wrongly named as **English iris** and is still so-called, varieties are 'King of the Blues, Mont Blanc, Queen of the Blues, etc., all good for borders)*, **I. xiphium*** (*I. hispanica*), etc. are the example species under this group, bolder ones being the most popular. The hybrids of this section are hardier than the parent species and are referred to as **Dutch, Spanish** and **English** irises, and are collectively known as *Iris* x *hollandica Tub.* **Dutch** irises (*I. tingitana* x *I. xiphium* and its various forms x *I. filifolia x I. boissieri x* Spanish cv. Cajanus, originating in Holland, and widely used for the **cut flower** market throughout the year*)* are the first of the hybrids to flower, and colour range is white, yellow, blue and purple. The most popular var. Wedgwood (pale-blue) is the best example of Dutch iris. Other varieties are Angel Wings, Apollo, Blue Diamond/ Blue Magic, Bronze Perfection, Convent Garden, Golden

Harvest, H.C. van Vliet, Ideal, Lemon Queen, Marquette, National Velvet, Princess Irene, Professor Blaauw, Purple Sensation, Symphony, Telstar, White Excelsior, Yellow Queen, etc. **Spanish** irises are forms of *I. xiphium,* and flower about two weeks later than Dutch irises but flowers are smaller. It has range of colours including smoky shades. **English** irises have largest flowers in the group, with limited colour range i.e. white, pink, purple and blue but no yellows.

ii) **Juno group :** Though they are little known but have very attractive flowers. Leaves are lanceolate and deeply channeled. Bulbs with papery tunics, not netted, have thick storage roots when dormant and which develop feeding roots during the growing season, therefore, bulbs are to be handled carefully because if once these are damaged the bulbs take time to recover. The growth pattern is akin to a sweet corn plant. The largest section having 55 species and some of them are *I. albomarginata, I. aucheri, I. baldschuanica,* ***I. bucharica****, I. caucasica, I. cycloglossa, I. drepanophylla, I. fosteriana, I. galatica,* ***I. graeberiana****, I. hippolyti, I. hymenospatha, I. kopetdagensis, I. kuschakewiczii, I. kuschkensis, I. latifolia, I. linifolia, I. magnifica, I. microglossa, I. narbutii, I. nicolai, I. odontostyla,* ***I. orchioides****, I. palaestina, I. persica, I. planifolia, I. porphyrochrysa, I. Regis-uzziae, I. rosenbachiana, I. stenophylla, I. stocksii, I. tubergeniana, I. vicaria, I. warleyensis, I. wendelboi, I. willmottiana, etc.,* bolder ones being the most popular.

iii) **Reticulata group :** In this group the tunic of the bulb is reticulated (netted) with fibres, leaves are tubular with four or eight ribs and terminating into a pale-green sharp point. Species and garden hybrids are all hardy, bear early flowers and are suitable for planting in rockeries, borders, and in pots for greenhouse culture. Species are *I. bakeriana,* ***I. danfordiae*** where after flowering bulbs break up into bulblets of varying sizes, *I. histrio*, ***I. histrioides,*** *I. hyrcana, I. kolpakawskiana, I. pamphylica,* ***I. reticulata*** (garden hybrids are derived from *I. histrioides* and *I. reticulata* e.g. Alba, Cantab, Clairette, Edward, Gordon, Harmony, Purple Gem, Royal Blue, Spring Time, Violet Beauty, etc.).

2.2.1.2 Propagation

In iris, the main flowering bulb is renewed annually. The daughter bulbs forming near the centre of the mother bulb grow rapidly after the mother bulb has flowered, and attains full growth by lifting time. Several smaller bulbs are also attached with the full grown daughter bulb. These bulbs are graded as rounds, large flat side, small flat side and smalls (pips, 1 cm or below in diameter). First two grades flower successfully to the marketable quality while other two grades require further one year growing. The flowering size bulb in large bulbing cultivars should have not less than 8 cm circumference while small bulbing cultivars not less than 5 cm. The size of top grade bulb is 10 cm and above.

A full size **bulb** may produce only two to four new bulbs per season, depending on the number of axillary buds present in the mother bulb. A number of smaller **offsets** are produced by the mother bulb which should be separated and grown to maturity in a nursery bed, which may take one or, at the most, two years to attain flowering size. **Chipping** is so far the most advantageous method for bulking up the iris stock. For cross-cutting or chipping**,** usually large old bulbs (>10 cm circumference) are chosen. Bulbs may be chipped into half, quarter, and 1/8 and

incubated in plastic bags like to that of twin-scaling, and planted in a 50:50 grit + peat medium which provides good results. Moreover, chipping can not be done again and again through the same bulbs. To maintain a virus-free stock through asexual propagation is the most challenging task. Hence, **tissue culture** technique is being employed which apart from providing the virus-free plants, is helping in bulking up the desired number of planting material of the elite cultivars in a quickest possible time, and which together is also giving 30-50 % more yield. The sources of explants are axillary buds, scale pieces, basal plate sections, flower stem sections and the destructed apical meristem on a basal plate containing a new leaf primordium. Full or half strength MS medium supplemented with 2-4 % sucrose, 0.03-2.0 mg/l NAA or equal amount of NAA and BA or kinetin @ 0.5-1.0 mg/l, at a pH of 5-6 in the medium, at 15-25°C temperature is optimum for its micropropagation.

Small bulbing type cultivars are fertile and produce **seeds** but growing through seeds is the job of a breeder and not of the amateur grower because seeds may not come true to type so when new varieties are to be evolved, seed propagation is done. Immediately after maturity of the capsules, the seeds are collected and sown thinly in a soil based medium worked with some sand to 2 cm top of the soil where these will remain for two years with utmost care, as these require frost protection. As soon as the growth stops, these are lifted, stored in sand, and again planted in the following season like the bulbs and when fully grown to flowering size bulbs, these are harvested.

2.2.1.3 Climate Requirements

Irises are sensitive to insufficient light intensity. Too little light can result in culls due to flower blast. Irises need at least half a day of sun (six hours of sunlight per day) and well-drained soil. Without enough sun, they won't bloom. They prefer fertile, natural to slightly acidic soil of pH of 605 to 608. If the soil is very acidic, sweeten it with a bit of lime. Soil drainage is very important. Loosen the soil with a tiller or garden fork to a depth of 12 to 15 inches, then mix in a 2 to 4 inches layer of compost. September is the best time of planting.

After planting, keeping the soil at the right temperature is important. It should not be any lower than 5-8°C but not higher than 20°C. The optimum soil temperature is 15°C. Low soil temperature will increase production time. High soil temperatures will reduce the forcing time but will also produce shorter plants. In the field, the optimum air temperature is 15-17°C; in the greenhouse, 12-17°C. The minimum temperature that irises can tolerate is 0°C and maximum average daily temperature is 20°C. The crop is most comfortable at a relative humidity of 70-75 %.

Iris will thrive without feeding, but will respond to its application. A nice garden soil will grow fine iris. An application of a balanced (12-12-12) fertilizer applied as a top dressing dusted around and in between the plants in early spring is desirable.

2.2.1.4 Soils, Preparation of Land, Planting, Mulching and Weed Control

Any type of **soil** where cultivation is already being done is suitable for iris cultivation also, but the soil should be well drained with a pH of 6.0-7.0. Most

suitable soil is sandy loam. Bulbous irises, as in case of many other crops, require sunny location away from the shadows of trees, etc. Low irradiance levels may cause flower abortion which can be prevented by providing supplemental lighting. In a forcing greenhouse, the optimal light intensity requirement is more than 2500 fc. Ethylene, instead of, heat treated bulbs reduces bud abortion to a greater extent. During winter forcing, all irises require high irradiance. Shading may be required against high temperature during bright sunny days. However, the field where irises have once been grown, should be avoided for next four years as a safeguard against soil-borne pathogens.

Land preparation should start one fortnight before planting. The field is ploughed to a depth of 25 cm and at time of first ploughing, farmyard manure at the rate of 2-3 kg per square metre should be incorporated in the soil and thoroughly mixed. All sorts of perennial weeds should be hand-picked or taken out by fork. Second ploughing, followed by planking is done after 7-10 days after first ploughing so that all those annual weeds coming up are knocked down in the soil. Third ploughing is required to be done about two days before planting and at this time there should be sufficient moisture so that effectively planting is done and no watering is required until the bulbs start sprouting. Now the beds are prepared with sufficient channels for irrigation and paths for cultural operations and movement. If there is no danger of water-logging during the course of whole cropping, planting on flat beds will be alright.

Since lack of light to the plants during winter is the main cause of bud abortion hence winter crops i.e. in the plains require more spacing, especially in greenhouses. The **spacing** is also dependent on bulb sizes. Larger bulbs of more than 10 cm, 9-10 cm and 8-9 cm may require to be planted at the rate of 220, 240 and 270 per square metre, respectively, in the glasshouses. In open field, they are planted 5 cm from plant to plant in the row, rows spaced 10 cm, purring 50-60 cm space from bed to bed.

Ideal **time for planting** in India is October, especially in the plains. These may also be planted in September - October in the hills but will require frost protection, otherwise these may be planted on the hills (temperate regions) in March. The tips of each bulb should be covered by a depth of soil equal to its height.

After planting, field may be mulched either with organic **mulches** (manure, chaff, dry grasses, leaves, saw dust, etc.) or plastic to conserve the moisture and to suppress the weed growth. Pendimethalin (stomp) **herbicide** at the rate of 3 litre/ha as pre-emergence may be showered in the planted field after mixing this in water sufficient to wet the surface. This will not allow germinating the annual weeds up to 75 days provided afterwards soil is not disturbed. It may again be sprayed after 75 days by covering the iris plants with alkathene strips at the time of spraying.

2.2.1.5 Irrigation and Nutrition

Irises do not tolerate poor drainage. After planting the Dutch irises, the soil or medium is **watered** thoroughly but afterwards, throughout the growing period, the medium should be kept moist. In winter crops as in the plains, light irrigation is required every week, however, in summer crops as on the hills, it may require light watering every 5 days.

In calcium deficient soils, 'weak necks' may be observed where the stem is too weak to support the flower. In such soils, lime is applied before planting. At the time of soil preparation, nitrogen at the rate of 50 kg through ammonium sulphate, and 60 kg each of P_2O_5 in the form of single superphosphate and K_2O in the form of potassium sulphate or muriate of potash (in potash deficient soil) are given as basal fertilizers. Before flowering, again urea at the rate of 25 g/m^2 may be applied in the field followed with light irrigation.

2.2.1.6 Growth, Development, Dormancy, Flowering and Flower Forcing

In bulbous irises, the planted bulb after the flowering is completely absorbed in the process of the formation of the new bulb which is purely annual in nature hence it may be called an annual bulb. Surrounding the bulb, there is a fibrous tunic consisting of the bases of last season's leaves. To protect the true leaves and as support to the emerging shoot, four sheath leaves emerge from the soil. One full size bulb may form up to 10 leaves whereas a small bulb 3-4. Before growth apex becomes receptive to the flower inducing conditions, the leaf primordia initiation would have gone beyond the stage of 7-8 leaves, hence, for flower bud initiation it is a must to promote the continuity of leaf primordia initiation. The daughter bulbs, situated near the centre of the main bulb in the axils of the true leaf scales, grow rapidly after the flowering and are fully formed by the time of lifting. Several smaller bulbs are also formed in the side. On planting in the plains, the bulbs root immediately and leaves emerge within a few days in the plains but on the hills even October planted bulbs sprout in March - April. The life span of the bulb scales is 21-22 months. New primordial scales are formed primarily after lifting. Bulb size and weight take place after planting, more prominently after flowering. The planted bulb produces at least five leaves and the flowering stem.

Bulbs of critical size will produce a flower after formation of three leaf primordia at relatively high temperatures and then flower induction at low temperatures. Leaf formation will continue if the exposure to low temperature is inadequate. As in the plains, growing at moderate to low temperatures during winters, bulbs require high temperature after lifting for maturation which is met naturally. A part of the high temperature can be substituted through bulb dipping in ethephon solution or exposed to ethylene gas which will help reducing the bud abortion after planting in the following season. Flower formation in stored bulbs (high or moderate temperature) is normally not observed before replanting. Ethylene treatment at prolonged low temperature in the storage will cause flower forming process. The cold treatment of 9°C for 6-13 weeks after the required heat treatment will induce shoot elongation rapidly. Such bulbs flower within 6-8 weeks in the greenhouse, though in the field it may take more than four months. Depending upon the varieties, the floral bud initiation and development requires a period of low temperatures, the optimum being 9-13°C and the flower initiation is normally complete within 3 weeks of cool temperatures. On the basis of natural temperature requirements, through forcing the flowering can be regulated.

Temperature greater than 20°C terminates the leaf initiation process but forces the floral induction process, for which optimum temperature is 30°C. Ethylene gas exposure partially to heat treatment also perfects the process of floral induction and also prevents bud abortion after planting. After high temperature treatment,

a cold treatment of 9-15°C is given to hasten leaf formation and flowering after planting. After 6-13 weeks treatment at 13-16°C, the bulbs are ready to force into flowering in the greenhouse. Bulbs can be retarded by providing long duration of high temperature *i.e.* 30°C.

2.2.1.7 Harvesting of Flowers and Post Harvest Technology

Iris flowers are harvested at the bud stage when the buds start showing true colour i.e. before the falls reflex and the standards expand. In mild weathers, the flowers are picked at pencil stage of development when flower tip has just started peeping out of the green clasping sheath but in winter when the tip has come up 1 cm above the sheath. Certain varieties like 'Professor Blaauw' require even more advance stage *i.e.* when the flower is above 4-5 cm in winter. The flowers can be stored dry at -1 to 0°C for up to 2 weeks, or at 5°C for 4-5 days, but longer stored longer will exhibit poor vase life. Normally the vase life of Dutch irises is 5-6 days. While cutting the flowers, the leaves should not be cut and retained as much as possible as still the bulb is passing through various developmental stages.

Immediately after cutting, the flowers must be kept in water and in cold store also it would be better to store wet. Pulsing fresh cut flowers with 2 % sugar + 2 mg/l citric acid at pH 3.5 is beneficial but storage at 20°C for 2-3 days will negate the effect. GA_3 or GA_{4+7} at 6-10 g/l promotes bud opening and improves flower colour. Dry storage and long duration dry transportation should be avoided. During transportation also, the cut ends should be kept in deionized water. During storage or transportation, irises do not face upward tip bending problem as in case of gladioli.

2.2.1.8 Lifting of Bulbs and Storage

The bulbs of the bulbous irises are lifted when the foliage has completely dried off *i.e.* 6-8 weeks after flowering. Before lifting, all the weed plants and aerial part of the iris should be removed from the field and composted. The lifting should be adjusted at such a time when soil is moist so that lifting is properly facilitated. Through forks, shovel or spades the adjoining soil near the plants are loosened and the bulbs are taken out gently, cleaned of the adhering soil and are kept in trays. Even with a small prick, manually every plant may be taken out, cleaned and kept in the trays. These bulbs are now taken to the storage cum curing room for grading and curing *i.e.* drying at a well aerated place in shade. Healthy bulbs have a clear brown tunic as remnant of the current season's outer dry scale leaves.

Iris bulbs do not have true **dormancy**. Storing them at 30°C forces them to go for rest which is termed as 'imposed dormancy', though even at this temperature new leaf formation continues and length of the internal bud increases. A phenomenon called pupation (not dormancy but may be related to dormancy) is observed when after replanting the bulbs exhibit slow growth even in root formation and leaf growth. However, responses to low temperature conditions are known as dormancy. If the bulbs are lifted prematurely and have been subjected to low temperature treatments for early flowering without an adequate high temperature treatment, they grow slow or take no growth and even ethylene treatment does not help here. It is because that during a certain period of bulb formation, immediate regrowth is not possible. Therefore, for initiating any new growth, a high temperature or ethylene treatment is necessary. In bulbous iris,

the period of bulb enlargement coincides with the period of dormancy, which in fact is a condition of maturity and not true dormancy.

The bulbs after lifting are stored at a well aerated room where 30°C temperature should be provided for about two weeks (10-15 days) and then 9-13°C for 6-8 weeks or exposed for 24 hours at 500 ppm ethylene to promote flower formation but planting stock bulbs are transferred to 5,9,13-15 or 17-23°C, depending on cultivar and bulb size. Temperatures above 25°C will inhibit flower induction but below 15°C will encourage it. This way the flowering is advanced at least by six weeks.

2.2.1.9 Insect-pests, Diseases and Physiological Disorders

i) **Tulip bulb aphid** (*Sappaphis tulipae*) is grayish to puce-coloured and attacks the bulbs and transmits certain viral diseases. The fumigation will clean up the stock in store. Alternatively, nicotine or Malathion spray will also control this. **Narcissus flies** (*Merodon and Eumerus*), though not of much significance but sometimes are observed. Infested bulbs should be burnt. **Iris sawfly** (*Rhadinoceraea micans*) feeds on the leaves which can be controlled by nicotine spraying. **Iris leaf miner** (*Dizygomyza iraeos*) attacks the irises by tunnelling the leaves. If the attack is occasional, such leaves may be hand-picked and destroyed. Nuvacron at 0.1 % spraying will control this pest. **Mealy bug** (*Phenacoccus* spp.) attack can be checked by applying an insecticide that can be vaporized.

ii) **Iris nematode** (*Ditylenchus destructor*) attacks the scales of the bulbs. After removing the outer dried scales of an infested bulb, grey or brownish streaks are seen which afterwards enlarge. The invasion normally starts from the base forming soft brown area of the tissue which afterwards extends into the scales. Affected scales become loose and get separated from the basal plate and the growth above the ground is also hampered. HWT at 44°C for three hours with 0.3 % formaldehyde may give near complete control of this pest.

iii) **Bulb rot** (*Fusarium oxysporum* f. *gladioli*, *Penicillium verrucosum, P. corymbiferum, Rhizoctonia solani, R. tuliparum, Pythium* spp., and *Sclerotium spp.* fungi and *Erwinia carotovora* pv. *Carotovora* bacterium) is caused by many pathogens some in field and others in the storage. Hot water treatment (HWT) at 43°C for three hours will control all these pathogens. While handling, the bulbs should not be injured or bruised and if happens so these may be discarded. Only healthy bulbs should be brought in the curing room and others should be burnt. Curing room should have proper aeration. Proper temperature treatment should be given and that too at the right stage of bulb. Only properly dried bulbs should be stored. In storage also, there should not be relative humidity (R.H.) in excess. Field treatment at fortnightly sprayings of benomyl or bavistin alternate with captafol in the standing crop will not permit pathogens infecting this crop. While keeping in cold storage, 0.2 % captafol dipping for one hour and then thorough drying will prevent the attack of storage fungi.

iv) **Leaf spot** of iris is caused due to *Heteroporium gracile (Didymellina macrospora*, *Mycosphaerella macrospora* or *Cladosporium iridis*). Due to its infection, dark brown or almost black irregular blotches are formed on

the leaves, gradually spreading up and down the leaf blades, and its severity causes spots even on flower stems. Before planting the bulbs should be soaked for one hour in 0.1 % benomyl + 0.5 % captan, and afterwards fortnightly spraying in the standing crop will prevent this disease.

v) **Ink spot** (*Drechslera iridis*) attacks *I. reticulata* more than Dutch iris. It causes black blotches on the bulb scales and on foliage. The above measures will control the incidence of this disease also.

vi) **Iris rust** (*Puccinia iridis*) exhibits small and raised orange spots on leaves and stems. Spraying with plantvax (oxycarboxin) will control this problem to some extent. Immediately after planting, entire foliage of already growing irises should be removed and burnt and then new crop on emergence should be sprayed with oxycarboxin. The attack of this fungus has yet not been observed in the plains. *Botrytis cinerea* causes spotting on the leaves, *Rhizoctonia solani* causes bulb rot and yellowing of the foliage, and *R. tuliparum* causes 'bad-soil disease', neck and bulb rot which can be controlled while controlling other bulb rot and leaf spot diseases.

vii) Iris mild mosaic virus (**IMMV**), narcissus latent virus (**NLV**), iris severe mosaic virus (**ISMV**), and bean yellow mosaic virus (**BYMV**) infect the irises. **IMMV, BYMV,** and **ISMV** are potyviruses and **NLV** is carlavirus, all being transmitted through aphids so control of aphid will control these viruses also.

viii) **Physiological disorders :** Many physiological disorders are found in bulbous irises, and for most of them no reason is known. Blindness (no floral bud formation) may occur due to too short and/or too low temperature, abortion (floral buds are formed but stop developing) due ti insufficient carbohydrate reserves in the bulbs, poor root development, medium too wet, severe water deficiency to the standing crop, forcing temperature too high, in winter low light stress, etc., abnormal flower development (too long bulb retardation, lack of oxygen during transit after cold treatment, severe cold at the time of flower formation), too short floral stem (inadequate cold treatment to the bulbs, delayed flowering, difficulty in emergence of the flowers from the sheath), and too long leaves and floral sheaths (leaf initiation process not checked due to too short or inadequate high temperature and/or ethylene treatment, forced at too cool temperature, and incorrect programming not specific to the cultivar).

Check Your Progress Exercise 1

Note : a) Space is given below for answers.

b) Compare your answer with that given at the end of the unit.

1) Describe bulbous iris propagation through chipping.

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2.2.2 Lilium (Family - Liliaceae)

(Common name **lily**)

2.2.2.1 Classification, Species and Varieties

Lilium is a genus of 80 species of bulbous plants that are generally hardy, only a few species requiring greenhouse protection. Lilies are suitable for massing in mixed borders, grown as pot plants, placed among shrubs and on large rock gardens, suited to wild or woodland gardens, and over all as cut flowers. Flowers are of almost all the colours except true blue. They also vary in size and shape from 2.5 cm wide to long trumpets and bowl-shaped blooms up to 26 cm across, arranged on erect stem on the top. Flowers are fragrant, some providing bad smelling too. According to Royal Horticulture Society and North American Lily Society, these are classified into nine divisions, with several sub-divisions, such as:

Division I : Hybrids and garden forms derived from Asiatic species and hybrid group. Therefore this group is called **Asiatic hybrids.** These are derived from species such as *Lilium cernum, L. davidii. L. lancifolium, L. leichinii, L. maculatum, L. hollandicum, L. concolor, L. bulbiferum*. **Sub-division IA :** Upright flowering. Varieties are Alpenglow, Bravo, Butternut, Charisma, Cherub, Chinook, Connecticut King, Edith, Enchantment, Endeavour, Fireband, Firecracker, Golden Pixie, Halloween, Heritage, Pirate, Rosefire, and etc. **Sub-division IB :** Outward facing flowers**.** Varieties are Connecticut, Lemonglow, Ming Yellow, Orange Glow, etc. **Sub-division IC :** Pendant flowers. Varieties are Burgundy, Citronella, Connecticut Yankee, Debutante, etc.

Division II : Martagon hybrids which include hybrids of *Lilium martagon* or *L. hansonii.* Varieties are Marhan, Paisley hybrids.

Division III : Candidum hybrids, derived from *L. candidum, L. chalcedonicum* and other related European species except *L. martagon*. Varieties are Aries, Apollo, Artemes, Prelude, etc.

Division IV : American hybrids, Varieties are Bellingham hybrids, Bellmaid hybrids, Buttercup, Shuksan, etc.

Division V : Longiflorum hybrids, derived from *L. longiflorum* and *L. formosanum*. Varieties are Formobel, Formolongi, etc.

Division VI : Trumpet and Aurelian hybrids, derived from *L. henryi, L. sergentiae* and other Asiatic species but not *L. auratum, L. japonicum* or *L. rubellum.* **Sub-division VIA :** Trumpet type e.g. Aurelian group (*L. sergentiae* x *L. henryi* x *L. leucanthum*), Golden Clarion group, Black Dragon, Golden Splendour, Green Magic, Pink Perfection, etc. **Sub-division VIB :** Bowl-shaped flowers. Varieties are Heart's Desire, First Love, New Year, etc. **Sub-division VIC :** Pendant flowers. Varieties are Golden Sunburst, Thunderbolt, Christmas Day, Golden Shower, Summer Song, etc.

Division VII : Oriental hybrids, derived from the 4 species excluded from Division VI, including *L. henryi* and others. This has four groups. **Sub-division VIIA :** Trumpet shaped blooms, but not in cultivation now. **Sub-division VIIB :** Bowl shaped flowers, and stem rooting. Varieties are Empress of China, Empress of

Japan, Empress of India, etc. **Sub-division VIIC :** Flowers flat and star shaped with recurved petal tips and stem rooting. Varieties are Imperial Crimson, Imperial Gold, etc. **Sub-division VIID :** Recurved bloom and stem rooting, e.g. Jamboree.

Division VIII : Contains hybrids and forms not listed above.

Division IX : All true species and their botanical forms and varieties, with 8 groups.

Broadly speaking, commercially in India only Asiatic, Oriental and Easter lilies are cultivated and that too on the hills because there is no bulb setting in the plains. Though when full-sized bulbs are planted in the plains, only flowering appears but there is no bulbing.

2.2.2.2 Propagation

This crop can be propagated only on the hills where summer temperature does not exceed 35°C. Lilies can be raised vegetatively through **scales** (for commercial use), **bulblets** formed underground, **bulbils** (in a few cases where these are formed in the axils of leaves on the inflorescence), **leaf cuttings**, **bulb divisions** and **tissue culture** (for quick multiplication).

The storage organ in lily is an imbricated bulb that consists of many fleshy scales, which are modified leaves attached to a basal plate. When the plant has completed flowering, lift it immediately, detach all the outer scales and replant the parent bulb to recover within two years. These **scales** are now planted 6-7 cm deep in open beds or frames, 2.5 cm apart in the rows spaced 15 cm apart. Bulbils are formed in the autumn which can be lifted and replanted in beds for getting flowering size bulbs. In case established plants can not be disturbed just at post flowering, **scales** can be removed in September and placed immediately in 30 cm deep boxes of sand in alternate layers of sand and scales, by keeping the boxes moist and warm until the spring, and thus the bulblets formed on the scales can be planted in the open in the spring. The bulblets formed through this method are smaller than previous method but by first summer many will grow into small saleable size. Another method is to insert the **scales** in single layer in September and then planting out in March the young growing plants still attached to the old scale.

In case where underground **bulblets** are formed around the daughter bulb at lifting, these should be taken out and planted in open ground, boxes or in frames as per convenience. Following season they are ready for planting for cut flower production if optimum conditions for their growing have been met.

Bulbils are just like bulblets, but they are formed in the leaf axils of the aerial stem, so they are grown also like bulblets. They are harvested when they are matured i.e. when bulbs are ready for lifting. It may take 2-3 years to develop flowering size bulbs.

Detached leaves **(leaf cuttings)** of *L. longiflorum* 'Nellie White' root well at 21°C under a 17 h photoperiod where 80 % rooting from the leaves of the upper part of the stem and 40 % from the lower part occurs. Leaf-node cuttings also form bulblets which produce programmed flowering without lifting the bulb or applying any cold treatment.

Through **divisions,** bulbs are also grown to raise the stock. Some lilies increase quite naturally by producing two or more good bulbs every year, congested clumps are divided and replanted in October.

Micropropagation (tissue culture) is the best method to get true to type as well as disease-free plantlets. Segments of bulb scales, stem apices, apical meristem, floral organs, etc. are used as explants.

Seed propagation is a cheap and easy method of propagation and is used only for evolution of new varieties. Seeds with delayed hypogeal germination normally do not produce top growth in the first season e.g. *L. auratum, L. canadense, L. martagon, L. monadelphum, L. speciosum* and *L. szovitsianum*. For getting best results these should be sown in boxes in June. The soil mixture may consist of loam, peat and sand in the ratio of 7:3:2 and this should be sterilized but throughout the growing period the soil should be kept moist. In **hypogeal** germination, there is no cotyledon but the true seed leaves emerge above the ground. Before the emergence of true seed leaves, the food from the seed is transferred to a point which is underground and in between the root tip and true seed leaves. Due to transfer of food material, the point gets swollen and becomes a miniature bulb. If the growth cycle is continuous, it is called **hypogeal immediate** and if an incubation period is necessary after the initial germination, it is called **hypogeal delayed**. In **epigeal** germination, a cotyledon emerges above the ground and the endosperm nourishes the developing seedling. Just above the root tip a small node is apparent which then becomes the bulb. When it has sufficient strength, true leaves are produced. **Epigeal immediate** types may be sown as soon as ripe, but this is not always practical. **Epigeal delayed** requires a definite cold period before germination occurs. The seeds of Asiatic and trumpet lilies have epigeal germination. In March, the seed sown boxes are placed in cool greenhouse where leaf growth should appear.

2.2.2.3 Climate Requirement

It is typically temperate crop; however research efforts of scientists made is possible to grow lilium under northern plains. It cultivation require specific temperature and light for sprouting of bulbs and flower production.

Pre-cooling Requirements

Asiatic and Oriental lilies require a cold treatment of a minimum of 6 and 8 weeks at 2-4°C before planting for rapid shoot emergence and flowering. Additional cooling is not harmful. Bulbs which will be used for late forcing (usually after February) are usually frozen in peat and maintained at -2°C. Keeping the bulbs at this temperature prevents sprouting, reduces loss of the bulb's energy reserves and minimizes disease problems. When frozen bulbs are received from a supplier, defrost the bulbs slowly at 7-13°C for one to three days.

Temperature

Asiatic lilies require a 10-13°C night and 18-21°C day temperature while Oriental lilies require a 15.5-18°C night and day temperature does not exceeds above 29°C. High temperature increase disease incidence, flower colour intensity and cause flower drop.

Light

Lilies need 2000-3000 foot candles of light for quality flower production. In low light conditions such as photoperiod less than 12-14 hours and 8 hours night interruption preventing the bud drop. Lilies require some shading of 30-50 % shade cloth.

2.2.2.4 Soils, Preparation of Land, Planting and Weed Control

Lilium can be grown on a wide range of **soils** but the ideal soil should be free-draining loamy soil with sufficient humus. Most lilies prefer soil with **pH** 6.5-7.5. *Lilium philadelphicum* prefers acidic soil, *L. candidum* alkaline while Easter lilies prefer non-acidic soil with high calcium content. In case of *L. longiflorum,* the soil pH requirement is from 6.5-7.0 and in case of soilless media it is 6.1-6.5 so that the incidence of leaf scorch from fluoride is minimized.

Lilies prefer mild climatic conditions. It would be better to grow them in partial shade as direct sun light may affect the growth adversely. The optimum **temperature** for their growth is about 18°C.

Nearly all the lilies like deep **planting** except *L. candidum*. Subsoil should be mixed up with coarse sand, grits and gravel if it is heavy and enriched with leaf mould, well-rotted compost or peat and the bulbs are planted in October in the plains where bulb size gets so reduced that it can not give flowers the next season, and in February-March on the hills, on mounded rows spaced 40 cm, 15-25 cm below the top of the mound. Stem-rooting lilies require deeper planting. Safe enough is planting the bulb two and a half times the height of the bulb but in case of *L. candidum* the nose of the bulb should be just below the surface of the soil. Young lily bulbs have contractile roots which pull them down to their correct depth. Plant to plant distance may be maintained at 20 cm. Shallow planting increases the incidence of summer sprouting due to warmer soil temperature, especially in early spring and late fall. **Mulching** is done in spring with well-rotted manure, compost or leaf mould.

In the plains it is grown during winter so winter **weeds** come up in plenty whereas on the hills it is grown during summer hence the grower on the hills encounters summer and rainy season weeds. Diuron at 454 g/acre or neburon at 635 g/acre controls all the pre- and post-emergence weeds in lily field. Chloroxuron (tenoran) is also very effective for glasshouse lilies, @ 50 g in10 litre of water/acre, once 6 weeks after planting and the other 2 weeks before start of the harvest. Chlorpropham together with paraquat when weeds are already present but crop is yet to emerge, lenacil at emergence and simazine 3-4 weeks after emergence are quite effective. However, in small manageable fields, weeds may be taken out manually.

Most lilies, especially with arching stems and heavy flower heads e.g. *L. henryi* as well as late-flowering ones require **staking** to protect them against storm and strong winds.

For **pot culture**, single bulb in a 15-20 cm pot or three bulbs in a 25 cm pot may be planted. The pot mixture should consist of 1 part well-rotted manure, 1 part loam and ½ part coarse sand b/v. Stem-rooting lilies should be set well below the pot to accommodate the roots properly. After potting, the lilies should be placed

in a cool place to promote good root system. On appearance of the top growth, gradually bring the plants into full sun and then transfer them to a cold room up to flowering, and then at a shaded spot outdoors but soil should not dry as bulb will shrivel.

2.2.2.5 Irrigation and Nutrition

Fertilization (**nutrition**) is the necessary operation for optimum growth. Most of the lilies are comfortable at 140 kg N, 280 kg P_2O_5 and 200 kg K_2O per hectare. Normally, Indian soils are not deficient in K_2O so it should be applied where the soil is certainly deficient in potash. P and K are given only as basal dose but only little quantity of N at planting whereas remaining one in two split doses afterwards, one when plants are 20 cm tall and the rest before spike emergence. Excessive nutrient levels can reduce plant height. *Lilium longiflorum* requires high level of calcium, lime as pre-plant and calcium nitrate during growth, and high level of nitrate nitrogen for optimum leaf quality, as absorption of nitrogen increases during inflorescence development.

No dry spell should be permitted as this may cause bud abortion or abscission so watering should be carried out regularly but water stagnation should not be allowed to occur at any time. Easter lilies are more tolerant of dry media but excessive drying will cause the lower leaves to yellow and the flower buds to abort.

2.2.2.6 Growth, Development and Flowering

Light and temperature affect the growth and flowering in lilies. If inner daughter scales are treated with red or far-red light, shoot emergence is significantly increased. Long photoperiod promotes stem elongation which shows that long day promotes vegetative growth. Increase of day length beyond 8 hours and up to 18 hours, plant height is increased and flowering is accelerated but number of flowers is decreased.

To some extent, long days substitute the vernalization. During the last two weeks of vernalization, exposure of bulbs to long photoperiod accelerates flowering by suppressing leaf number. Cold moist treatment of bulbs from 2-7°C for 6 weeks (1000 h) controls the flower induction. During cold treatment, bulbs may be packed in cases or planted in pots. If bulbs are harvested, never cooled but exposed to 21°C or above during forcing, regardless of photoperiod they will never flower, though a lower temperature will not put any obstacle. Final plant quality is determined on the basis of cold duration treatment.

Growth regulators play an important role at every stage of lily growth and development. NAA and IBA at 300 and 100 ppm, respectively, promote bulblet formation.

2.2.2.7 Flower Regulation

Lilies with spike length of 50 cm and longer are appropriate for cut flowers, while potted plants having 20-50 cm height are good enough. In potted plants, the height depends on the pot size and the varieties used. It would be better if genetically dwarf varieties are used. Moreover, bulb size, length of storage, temperature, and photoperiod & light intensity all influence height. Both Asiatic

and Oriental hybrid lilies respond to high night temperature of 16°C and low day temperature of 10°C with reduced stem lengths. In case of Easter lilies, temporary leaf necrosis occurs when night temperature is more than day temperature, however, high night and low day temperature or uniform temperature during day and night reduces stem length. A-Rest (ancymidol) concentration of 0.125, 0.25 or 0.50 mg a.i. per plant as a drench at shoot emergence stage reduces plant height. Bonzi (paclobutrazol) at 100-200 ppm for 5 minute bulb dip and sumazic (uniconizole) at 2-5 ppm sprays also reduce plant height. Application of CCC at 500 ppm as soil drench produces dwarf plants with more flowers and increases bulb yield in *L. tigrinum* but in *L. longiflorum* soil drench of CCC at 1000 and 2500 ppm increases number of flowers, and 100 ppm IAA and 500 ppm TIBA accelerate bulb formation.

2.2.2.8 Flower Forcing

Asiatic lilies require 30-35 days to flower from visible bud stage, Oriental lilies 50-55 days and Easter lilies 30-40 days. Asiatic hybrids are cooled at 2-5°C, for 6-10 weeks, Oriental at 2-4°C for 8-10 weeks, depending upon the varieties used, before greenhouse forcing. When *L. longiflorum* (Easter lily) bulbs receive 3 weeks vernalization at 4.5-7.5°C, shoots emerge early and the reduction in the number of flowers is minimal as compared to 6 weeks treatment. Bulbs can be held in moist peat for many months at -4°C than usual -1 or -2°C temperature. For year round production, bulbs are first cooled for 9-12 weeks then frozen, duration of precooling depending on the cultivars used. Mid-Century Asiatic hybrid requires at least 6 weeks of cooling at 5°C for rapid flowering irrespective of the day length. Oriental hybrid var. Sans Souci either subjected to 4.5°C for 9 weeks or at same temperature for 6 weeks followed by 3 weeks of incandescent lighting, takes 118-120 days for flowering. Partial substitution of the cold treatment of the bulb by long photoperiods reduces flower numbers but increases plant height. Increase of the cold store duration of the bulb decreases days to flowering, flower number, plant height and general quality and increases flower bud abortion. Increase in the duration of cooling from 6 to 9 weeks in var. Sans Souci, increases bud numbers from 7 to 11. GA seems to be involved in flower development but not in floral differentiation which shows that the scales may be site of plant growth regulators. Exogenous application of GA_3 enhances only shoot emergence. Days taken to flowering and flower bud abortion are found reduced with improved plant quality in var. Enchantment when subjected to 1000 ppm CO_2 in conjunction with supplemental lighting at 20W/m^2. When CO_2 is used, forcing temperature could be increased from 18-20°C. High temperature induces secondary dormancy as well as bulblet dormancy in *L. longiflorum.* However, flower bud development from visible bud stage to anthesis is accelerated at high temperature.

2.2.2.9 Harvesting of Flowers and Post Harvest Technology

Hybrid lily vars Amourette, Aristocrat, Enchantment, Sunray and Sans Souci when grown under supplemental high pressure sodium (HPS) light give longer vase life.

When the buds are well coloured but yet not open in case of Asiatic & Oriental hybrids and Easter lilies, it is proper stage of flower harvesting but for the local market when one flower is open. At puffy white stage in Easter lilies, the cut flowers can be stored at 0°C for up to 14 days but when 50 fc light is provided

these can be stored up to 2-10°C temperature also. Plants can be stored and shipped at 0-5°C. Normally Oriental hybrids do not store well as lower foliage yellows and drops when taken out from cold room which can be overcome by illuminating fluorescent lamps in the cold room. Promalin (1:1 benzyladenine: gibberellic acid) at 100 ppm spraying at run off stage 4-6 h before placing in cool chamber increases post storage quality. Promalin (1:1 BA:GA_3) sprays to lower foliage at 25 ppm greatly reduces pot production leaf yellowing. Promalin is effective even when sprayed to the foliage already started yellowing.

Asiatic and Oriental hybrids can be stored up to 4 weeks at 1°C if stems are first treated for 24 h in 50 ppm silver nitrate. After cold storage, stems are recut and placed in 30 ppm sucrose and 200 ppm 8-hydroxyquinolin citrate (8-HQC). Long duration of storage will increase the chances of bud blasting and foliar chlorosis.

The lily is considered sensitive to ethylene. Silver thiosulphate (STS) treatment for 24 h at 2°C increases floral longevity and even bulb soaking in STS also increases post harvest life as STS protects flowers from exogenous ethylene. Ethylene evolution and action is increased under low light stress which causes flower bud abscission but injecting 0.2 mm STS into the flower buds abscission is prevented.

2.2.2.10 Lifting, Dormancy and Storage of Bulbs

When the aerial part of the plant dries down, the bulbs are lifted. In case of lilies, delayed **lifting** is preferred as they are more mature with little dormancy. Late lifted bulbs respond effectively to vernalization treatments. Instead of lifting the bulbs in August on the hills of India, these should be lifted in October. Bulbs should be lifted carefully so that these are free from any injury, should be cleaned, graded and treated with some contact fungicide e.g. Captan @ 0.2 % so that these may remain healthy in cold storage. Together, bulblets as well as bulbils should also be taken out. In U.S.A., the commercial grades are 15.0-17.5, 17.5-20.0, 20.0-22.5, and 22.5-25.0 cm in circumference. The bulbs are cooled at 0-2°C before storage but within 3 weeks of lifting. Most of the lilies are **stored** from -2 to 2°C temperature, -2°C for shorter but 2°C for longer duration. Storage duration may be even for more than an year looking into the requirement of forcing, but preferably for 2-4 months. *L. longiflorum* bulbs vernalized for 3 weeks accelerates flowering with minimum reduction of flowers as compared to 6 weeks of vernalization.

Dormancy is the period when most of the physiological processes are slowed down. Since lily is summer flowering plant on the hills, the period of dormancy falls during winter when temperature is quite low. The outer new scales (daughter scales) on the bulbs are site of the maturity factor and if these do not occur there will not be any dormancy but no bulb can be without such scales. The endogenous level of GA-like substance is lower in dormant bulbs compared to non-dormant ones, hence, dormancy can be broken through GA as well as through cold treatment. GA @ 3 mg/l is optimum for breaking dormancy in *L. speciosum* cv. Rubrum No. 10. In cold treatment, bulbs are packed in cases or planted in pots and media in pots and packing material in cases should be moist. While growing the forced bulbs in the greenhouse, the growing temperature range is 13-27°C. However, continuous temperature of 21°C or above and without any cold treatment will not flower at all.

2.2.2.11 Insect-pests, Diseases and Physiological Disorders

Liothrips and Taeniothrips (**thrips**) suck the sap of scales making rust coloured sunken areas on the base of the scales, and such bulbs on planting produce stunted plants. Bulb dipping in hot water at 45°C and stored at 10°C temperature will control this pest. *Rhizoglyphus echinopus* **mite** infests on bulbs and stems causing yellowing of leaves and stems. It can be controlled through hot water treatment (HWT) i.e. 45°C for 1 hour and storing the bulbs at 1.6°C. Certain lepidopterous larvae feed on flowers, leaves and stems and sometimes even bore the stems, a grub of the **beetle** *Agaspherops nigra* feed on stem below the ground, and these can be controlled by keeping the field clean and by spraying of the plants with 0.2 % methyl parathion. *Aphelenchoides fragariae* and *Pratylenchus* **nematodes** infest on bulb, leaves and roots and cause yellow blotches on leaves and such infested bulbs fail to produce the flowers. HWT at 45°C with formalin soaking for 1 h is quite effective. **Slugs** and **snails** feed on the tender shoots and leaves and batter the plants which may be controlled by using formaldehyde baits.

The major fungal **diseases** infecting this crop are **botrytis blight** caused by *Botrytis elliptica*, **grey mould** caused by *B. cinerea***, bulb rot** caused by *Fusarium oxysporum* f. *lilii,* **root rot** caused by *Fusarium oxysporum, Rhizoctonia solani* and *Pythium,* **foot rot** caused by *Phytophthora cactorum,* **black scale** (**anthracnose**) caused by *Colletotrichum lilii* and **scale tip rot** caused by *Fusarium* sp. and *Cylindrocarpon.*

Botrytis blight is probably the most serious disease of field grown lilies. Initially reddish brown spots (red streaks in case of Asiatic lilies) on the leaves are formed but in Easter lily yellow streaks appear. *Botrytis cinerea* causes **grey mould** on flowers. Infection of botrytis occurs between 10-18°C temperature. Proper sanitation of the field as well as greenhouse is necessary. Infected plants should be burnt and copper fungicides are sprayed to control these diseases. **Bulb rot** is most serious disease of Asiatic lilies which infects the bulbs from base of the scales either during storage or transit and causes chocolate brown rot. Over watering should be avoided, healthy material should be planted and before planting soil should be sterilized as it is soil-borne disease. Benomyl treatment of bulbs for 30 minutes at 30°C at 0.2 % before planting and after lifting will prevent the outbreak of this disease. **Root rot** affects the stem at ground level and becomes very serious in over-watered soils, causing withering and ultimate death of the plants. Affected plants along with soil should be removed and burnt. **Black scale** causes blackening and rotting of outer scales and on lifting of the bulbs, brown sunken lesions on scales develop which enlarge in storage and turn black. In *Lilium longiflorum* this causes a serious disease of petal tissues. To get rid of this problem only healthy stock should be planted. **Scale tip rot** is characterized by darkening of scale tips and the surface of outer scales that shrivel and rot. Most of these fungal diseases can be kept in check by spraying the standing crops with 0.1 % Bavistin alternate with 0.2 % Captan, fortnightly.

Bacterial diseases are not the problems of much concern in lily plantings. However, sometimes *Pectofacterium carotovorum* causes bulb decay, and *Bacillus lilii* also attack lilies. Care should be taken not to use the injured bulbs for planting and field should be kept properly cleaned.

Lily symptomless virus (LSV), and little mottle virus (LiMV) produces yellow mottle and mosaic on the leaves and plant stunting, and cucumber mosaic virus

(CMV) exhibits mosaic patterns on the foliage and also necrosis on the plants, vector for which is *Myzus persicae*, etc. attack the lilies. Affected plants become dwarf and deformed. LSV is transmitted through aphids and causes vein clearing. Regular control of visiting pests and destroying the affected plants will ensure healthy stock.

Bud blast or **bud abortion** is the common **physiological disorder** associated with lilies in greenhouse forcing. Bud abortion at an early stage of development or abscission at a later stage is a low light and ethylene mediated phenomenon therefore bulbs are either dipped in STS at planting or STS is applied in the standing crop to protect the lilies against ethylene damage. Higher temperature also causes bud abortion and abscission, probably due to depletion of the carbohydrate supply. Twice shaking of the plants daily also reduces abortion. During winters in nights, long day lighting as well as higher intensity supplemental lighting from various lamp types also prevent abortion. High salinity levels in the soil also cause abortion. Water stress may also abort the buds.

Easter lilies *vis-a-vis* certain Oriental hybrids encounter the problem of **leaf yellowing** as well as **shedding** due to root rot or injury, over watering, moisture stress, high soluble salt accumulation and ethylene evolution, inadequate or excessive fertilizer, and insufficient light at the base of the plant due to more plant density are some of the known causes. BA + GA (10:1, commercially known as Accel) at 50 ppm spray only to the lower leaves, first before 10-14 days of bud visibility and the second 10-14 days after, or BA + GA (1:1, commercially known as Promalin) at 100 ppm spraying to the lower foliage after 2 months of shoot emergence, will prevent leaf yellowing.

Leaf tip burn or **leaf scorch** occurs when more than optimum level of manganese and aluminum salts at low nitrate levels are present in the soil, due to high fluoride levels, high relative humidity and little or no stem root development. This can be controlled by routine spraying of 68-136 mm calcium chloride or calcium nitrate. In fact, leaf scorch on the margins of the leaves occurs only due to fluoride toxicity which is a natural contaminant of phosphate, perlite and irrigation water.

Check Your Progress Exercise 2

Note : a) Space is given below for answers.

b) Compare your answer with that given at the end of the unit.

1) Describe scale propagation in *Lilium*.

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2) What are climate requirements for Lilium flower and bulb production ?

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2.2.3 Narcissus (Family - Amaryllidaceae)

[Common names **Narcissus** (pl. **Narcissi**), large cupped cultivars **Daffodils,** Hindi-**Nargis**].

2.2.3.1 Classification, Species and Varieties

It reigns in supreme majesty over all spring flowers by its unsurmountably strong but pleasing fragrance. Though all types of narcissi grow as cut flowers, the major one being large-cupped trumpets (corona or cup as long as or longer than the surrounding petals but almost non-fragrant) known as **daffodils** which in fact is poetical name given to this type. These can effectively be planted in beds, in edging and borders along the paths or sides, in pots or bowls, in the alpine house, in cool and hot houses, indoors, for naturalizing effects in woodland gardens, pastures and meadows and in the rock gardens (the dwarf ones). In France, Near East and China, essential oil is also extracted from *Narcissus jonquilla, N. poeticus* and *N. pseudonarcissus.* Narcissi have many shades of white, yellow, orange, pink and scarlet colours in their flowers. Wild species provide a wider range of shapes and sizes than the garden cultivars.

In narcissi, about 60 are recognized as true species, with about half the number of natural hybrids, and some over 100 wild varieties and their forms. The Royal Horticultural Society has grouped narcissi into 11 divisions. There may be more than 20,000 varieties under narcissi as listed in R.H.S. Classified List. Its **classification** is being given here.

Division I : Trumpet narcissi which we refer to as **daffodils** of garden origin. They have only one flower to a stem, trumpet or corona as long as or longer than the perianth segments. **Sub-division IA :** Height 35-45 cm, perianth as coloured as corona or paler e.g. Dutch Master, Golden Harvest, King Alfred, etc. **Sub-division IB :** Height 30-48 cm, perianth white and corona bicoloured e.g. Celebrity, Foresight, Oklahoma, Queen of Bicolors, etc. **Sub-division IC :** Height 30-45 cm, perianth and corona white, sometimes yellow in bud e.g. Angel's Wings, Beersheba, Mount Hood, etc. **Sub-division ID :** Height 40-45 cm, any colour combination not falling under A, B or C. Examples are Pink Isle, Rose Caprice, Salmon Trout, Toscanini, etc.

Division II : Large cupped narcissi of garden origin, having one flower to a stem. The corona more than 1/3rd but less than equal to the length of the segments. **Sub-division IIA :** Height 35-55 cm. Perianth segments coloured in shades of yellow, red and orange, corona coloured and darker than the segments e.g. Carlton, Galway, Golden Torch, Armada, etc. **Sub-division IIB :** Height 33-50 cm. Perianth segments white and corona coloured in varying shades of yellow and orange e.g. Duke of Windsor, Green Island, Poliandra, Arbar, etc. **Sub-division IIC :** Height 35-45 cm. Perianth white, corona white but not paler than the perianth e.g. Ave, Castella, Homage, Truth, etc. **Sub-division IID :** Any other combination not falling under A, B or C e.g. Bethany, Charter, Daydream, etc.

Division III : Small cupped narcissi of garden origin with one flower to a stem and corona not more than1/3rd the length of the perianth. **Sub-division IIIA :** Height 43-45 cm. Perianth and corona coloured e.g. Ardour, Doubtful, Varna, etc. **Sub-division IIIB:** Height 35-45 cm. Perianth white, corona coloured e.g. Blarney, Bushmills, Merlin, etc. **Sub-division IIIC :** Height 35-40 cm, perianth

white, corona short and white but not paler than the perianth e.g. Chinese White, Polar Ice, Verona, etc. **Sub-division IIID :** Any colour combination not falling into A, B or C. No cultivar in this group.

Division IV : Double narcissi of garden origin. Height 25-45 cm, e.g. Camellia, Cheerfulness, Golden Ducat, Indian Chief, Texas, Tahiti, etc.

Division V : Triandrus narcissi of garden origin. Several nodding flowers per stem with reflexed or recurved petals, a characteristic of *Narcissus triandrus*. Height 20-30 cm. **Sub-division VA :** Corona not less than 2/3 the length of the perianth segments e.g. Rippling Waters, Thalia, etc. **Sub-division VB :** Corona less than 2/3 the length of the perianth segments e.g. April Tears, Ticleton, etc.

Division VI : Cyclamineus narcissi of garden origin, distinguished by pendant flowers having long trumpet-shaped corona and recurved tepals. Height 20-38 cm. **Sub-division VIA :** Corona not less than 2/3 the length of the perianth segments e.g. Baby Doll, February, March Sunshine, etc. **Sub-division VIB :** Corona less than 2/3 the length of the perianth segments e.g. Kitten, Roger, etc.

2.2.3.2 Propagation

Narcissi are propagated both asexually by bulbs, bulb offsets, bulb division, twin-scaling and through micropropagation (tissue culture), and sexually by seeds.

Mother bulb and bulb offset constitute conventional type of propagation. The narcissi bulb does not renew itself completely every year. This consists of successive generations of bulb units, each comprising bulb scales, leaf bases and (in larger bulbs) flower. The vegetative buds develop in the axils of the fleshy leaves. The apical meristems in the leaf axils of mature bulbs in each season produce 2, 3 or 4 scale leaves, 2-3 leaves and then a flower bud. These new bulbs enlarge and cause gradual disintegration of the previously intact outer bulb scales. With the growing of the buds in the axils of the fleshy leaves, the slabs of small and flattened bulbs are formed so when such bulbs are planted after separation develop into round/double-nose/triple-nose and mother bulb stages, the latter stage requiring about 3 years to develop from a slab. The life span of a bulb unit extends over about 4 years. Mother bulbs, therefore, have a number of noses and offsets (bulbils), and are usually replanted after removing any loose offsets. These provide a high proportion of rounds and many large bulb offsets. Triple-nosed buds have three visible growing points which on replanting produce considerable number of bulbs, likewise double-nosed bulbs have two visible noses. Round bulbs are round in shape but the largest size is only good for production of best flowers and suitable for early forcing whereas the second and third sizes are used for later forcing. The flat-sided rounds and small rounds having few flowers are only replanted. In this cycle, mother bulb may produce many offsets, double- or triple-nosed bulbs and large rounds after one year, whereas large rounds and small rounds produce many double-nosed or rounds in two years and the offsets may produce only rounds in a year. Bulb production in a 2-year period is roughly $2^1/_2$ times of the planted weight. Top size bulbs are known as 'wares'. If the planting is left as such for many years, very rarely the 'wares' are found hence lifting should be done every year to harvest maximum number of 'wares'. Harvesting should also be timely when the bulbs have attained their maximum size but have not initiated dividing. Removal of leaves after 4-6 weeks of flowering promotes bulb multiplication.

2.2.3.3 Climate Requirements

Narcissus grows almost anywhere, but prefer cool temperature, free from water logging and strong winds. It need sunny or light shaded environment for proper growth, development and flowering. Narcissus tolerate partial shade, preferably afternoon shade but need 4-6 hours of sun, not only for bloom but also to store assimilates for the following years bloom. Narcissus requires 1000-2500 ft. candle of light intensity.

Narcissus prefers a temperate climate with long cool springs. Most of narcissus require a temperature of 16-18°C for flowering. Higher temperatures affect the quality and keeping quality of the flowers and increase the risk of flower blast. Narcissus requires a high humidity. If it is too low, crop quality will be impaired. The crop is most comfortable at a relative humidity of 85-90 %.

Scooping and cutting or chipping is done by making conical incision on the basal plate to kill the shoot for breaking apical dominance so that numerous daughter bulbs along the cut edges of the scales are formed. In **scooping**, whole of the basal plate is removed. For cross-cutting or **chipping,** usually large old bulbs (10-18 cm circumference) are chosen. Bulbs may be chipped into half, quarter, 1/8 and 1/16 and incubated in plastic bags like to that of twin-scaling, and planted in a 50:50 grit + peat medium which provides good results.

Twin-scaling is the further exploitation of chipping where many vertical cuts (normally 8-10 in 12-14 cm grade bulb) through apical portion and basal plates are made. From each chip, the scales are so detached from the basal plate that two scales remain jointed at basal plate. These scales when kept in moist sand or vermiculite after disinfection with thiram or captafol, and incubated at 15-23°C for 8-16 weeks in darkness**,** regenerate daughter bulbs, better bulbil formation being in the outer scales than the inner ones, though bulbil size remains better in the innermost. Large size of twin-scales produces more bulbils but the bulbils obtained from smaller scales have high regenerating capacity.

Through **micropropagation (tissue culture),** one gets plenty of disease-free planting material in shorter duration. Scale bases, twin-scale bases, leaf bases devoid of chlorophyll**,** stem from the basal plate, flower stem and elongating shoots are the organs from where explants are taken. Through this method, up to 2000 bulbils can be produced in an 18 month duration.

Narcissi are also raised through **seeds**. Seeds are normally raised for evolution of new cultivars as these do not give true to the type cultivars. Through seeds, flowering size bulbs are obtained in 3-7 years. After 4-6 weeks of capsule formation, seeds ripen, harvested and within a few days are sown in pots, pans or flats, outside or in frames on the hills (temperate climate). A conditioning treatment of 23-27°C temperature to imbibed seeds and then shifting to 5-16°C temperature result in quick germination**.** In pans where seeds are to be sown should be 18 cm deep filled with sifted sterilized loam 2 parts, peat 1 part and coarse sand 1 part. Each cubic metre of the medium, 1 kg of superphosphate and ½ kg of powdered chalk should be mixed. Seeds should be sown leaving 3 cm each way**.** After sowing, the seeds are covered with a layer of soil mixture. The pans should be watered daily with fine mist. From each seed, a thin rush-like leaf appears which dies down late in the season but in the next season seedlings grow stronger with one or two flat leaves. In the third season, the young bulbs may be taken out and

planted at 20 x 10 cm distance where regular cultural operations are carried out until flowering. Seeds can not be germinated in the plains until congenial environment akin to its requirement is provided. However, though most of the species form seeds but only a varieties may form but others not.

2.2.3.4 Soils, Preparation of Land, Planting and Weed Control

After the flower bud initiation, narcissi require low temperature which may be satisfied by growing the bulbs outdoors in the temperate climates. They are usually cooled at 9°C for 6-8 weeks then planted outdoors again at 9°C for further 4-6 weeks for initial foliage, flower and root growth. The site where narcissi are to be grown should have sun shines for about half the day. Longer photoperiods only promote the length of the stem. They are not very demanding about their **soil** requirements but good results are found on well drained soil rich in humus which has a moderate water holding capacity. The pH of the soil should range from 6.0-7.0. Usually lime is not added to soils for narcissi growing.

Potato fields are most suitable for its planting as such soils are rich in nutrients. A weed-free, fertile and well cultivated soil is most suitable for narcissus plantings. First ploughing at 30 cm depth should be carried out to facilitate long root run of narcissi. While **preparing the land**, well rotten farmyard manure at the rate of 200 quintals per hectare should be incorporated in the soil at least one month before planting which apart from providing nutrients; increases soil texture, aeration, and water holding as well as draining capacity. Second and third ploughing should be carried out within 10 days of planting so that at planting there is sufficient moisture in the soil.

Planting of narcissus bulbs is usually rotated every 2-3 years to avoid disease and weed problems. To prevent transmission of bulb and stem nematodes, a period of at least 5 years should elapse between eliminating the last ground keepers and narcissus replanting. Bulbs left in the field up to 5 years may still give reasonable flower production though not of that quality or quantity as in third or fourth year. Spacing of the bulbs depends on the variety, bulb size, soil type, cultivation practices including control, and the number of years these are to be left in the field for perennial cropping. In field, these may be planted on flat beds 10-15 cm deep and 10-15 cm apart in single, double or triple rows separated by 60 cm wide paths. In general, the planting is done keeping two bulb widths between bulbs in the row, and rows spaced 30-40 cm. Ridged plantings may be adopted in marginally drained soils. Planting is done in the month of October in the plains of India, and in March - April or even in October in temperate regions. Some 10-15 tons (one ton may contain from 9,500 to 50,000 bulbs, bulb size ranging from 19 cm to 10 cm in circumference) of bulbs are required for planting one hectare of land but for ridged plantings quite less quantity is required. Large rounds are suitable for early and quality flowers, which become double-nosed the following season and the mother bulbs in the third year. Flat sided mother bulbs with their large offsets and small rounds, produce second grade blooms. The optimum weight of bulb for proper flowering should be around 50 g, though flowering may even be obtained by planting the bulbs weighing merely 14 grammes. The flowering bulb sizes normally used for planting are >16, 14-16, 12-14, 10-12, and 8-10.

Mulching conserves the moisture, checks the emergence of the weeds, protects the crop from cold damage, increases soil temperature and if the mulch is organic,

it decomposes and provides nutrients to the soil. Leaves of various plant species, grasses, saw dust, bark, compost and poultry manure, chopped straw, chopped bagasse, sphagnum peat, and plastic films are the mulches used in narcisssus plantings.

Weeds are fast growing and to sustain the life these have tendency to rob the nutrients in the adjoining area quickly and for photosynthesis work capture the light either by spreading its canopy horizontally or by its taller growth, hence stand of the main crop becomes very poor and flowering is badly affected *vis-à-vis* bulbs also do not take proper growth, hence control of the weeds becomes necessary. Many weeds germinate before the emergence of the narcissus leaves which should be killed through contact weed killers like pentachlorophenol (PCP), paraquat or a mixture of paraquat and diquat applying a few days before emergence of narcissi. Chlorpropham (CIPC) at 2.25 kg a.i. or mixed with 300 g of diuron, if applied to weed-free soil just before crop emergence, gives satisfactory control of annual weeds for many months. Kerb (propyzamide) or surflan (oryzalin) each at 2.25 kg a.i./ha gives satisfactory control of weeds when applied as pre-emergence. In our country, mostly weeding is carried out manually.

2.2.3.5 Irrigation and Nutrients

During rapid bulb expansion, narcissus requires uninterrupted **watering** to ensure even growth otherwise bulbs may result into split scales to uneven growth. Since bulbs at planting have already initiated flowers and leaves so just for the expansion of their tissues these require moist soil during all stages of growth and flowering. This also helps good root formation. In light sandy loam soils, flood irrigation is not harmful.

No **fertilizer** is applied while forcing the crop, and also at the time of rooting because narcissi are very sensitive to chemical fertilizers as sprouting is significantly delayed, therefore, at planting the application is avoided. However, at the time of land preparation or after sprouting, the fertilizers may be applied. High nitrogen level in the soil promotes bulb growth, produces longer flower stem but delayed flowering. Nitrogen in the form of ammonium sulphate at the rate of 120 kg/ha before planting and 60 kg after three months of planting gives encouraging results. P_2O_5 and K_2O at the rate of 120 kg/ha each, in the form of single superphosphate and muriate/sulphate of potash should also be applied as basal dose at the time of land preparation. Deficiency of P_2O_5 and K_2O reduces growth, delays flowering, shortens flower stalks and induces early senescence of foliage. Soil should also not be deficient in calcium and magnesium as these also cause reduced growth while manganese deficiency causes early senescence of the foliage.

2.2.3.6 Growth, Development, Flowering and Flower Forcing

In mature narcissi bulbs, flower buds are initiated before flowering i.e. by December in the plains and by March on the hills and are complete after three months *i.e.* by March in the plains and by June - July on the hills. The process of flower bud differentiation should continue throughout the growing season following initiation, which means that flower bud differentiation for the current season and initiation for the following season go together in the same bulb. The process of differentiation becomes more rapid at 15-17°C. This temperature regime is met naturally in the plains in the month of February and on the hills in

April - May but in early lifted bulbs for **forcing**, they will have to be provided artificially. *Narcissus pseudonarcissus* and *N. cyclamineus* require an absolute cold treatment for further floral differentiation, **development** and rapid emergence while *N. tazetta* does not. All these species require warm temperature for floral initiation and differentiation which occurs prior to harvest and continues afterwards. Cold temperature treatments required for flowering vary from cultivar to cultivar. The cold treatment (9°C) of the bulb should be quite long i.e. from 10-14 weeks. Immediately after bulb lifting, first these should be warm stored at 17°C for 3-4 weeks to accelerate flower bud differentiation, and then hot water treated which avoids the risk of flower damage caused by HWT of the bulbs stored below this temperature and minimises the basal rot problem in store, which is most prevalent in storage at 21-30°C. Bulbs intended for **forcing** are usually 12-14 cm grade and for early forcing, after lifting, these are immediately subjected to 35°C for 5 days and at 18°C for about one month and then at 9°C till planting. Later-forced bulbs are stored at 17°C directly until planting. Eight weeks prior to moving of pots in the greenhouse, the bulbs are potted, watered and placed in the coolers at 5°C to allow bulbs to develop roots and shoots one by one. Cold and dry storage should not extend beyond 8 weeks and then after potting the bulbs in the moist medium are moved for another 8 weeks cold temperature of 5°C.

The cold treatment of the bulbs should be quite long so that when these bulbs are forced at warm temperature of 16-17°C in greenhouses, flowering occurs within 3 weeks. The duration of cold treatment for various varieties may vary, minimum being 13-15 weeks and the maximum17-24 weeks. *N. tazetta* does not require cold treatment but growth *i.e.* emergence and elongation of leaves and scapes may be inhibited at 5°C storage temperature but prolonged treatment hampers the quality and quantity of flower production. However, if *N. tazetta* is stored for 5 months at 25-30°C after HWT, on forcing this will flower rapidly. Similarly, in case of *N. pseudonarcissus* and *N. cyclamineus,* lifting and storing of the bulbs at 35°C for 5 days, results in early forcing and rapid floral development and flowering 2 weeks sooner than not treated ones. The usual way is to pre-cool (to dry and unplanted bulbs at a time when ambient temperature exceeds 9°C) the bulbs at 9°C for 6-8 weeks**,** then planting at 9°C for a further 4-6 weeks for initial growth of root, foliage and flower. Before forcing, root formation is a must. The temperature of 9°C, after planting, should be continued until flower buds are visible *i.e.* 4-6 weeks after planting. Now these pots or flats are shifted to the greenhouse at 13-16°C to force the flower buds to anthesis (it is 35 days at 16°C but 28 days at 18°C with reduced flower quality). However, before 10 days of anthesis, if temperature is again reduced to 9-10°C, the flower quality will be improved.

Bulbs treated with 100-1000 ppm GA solutions for 2-4 weeks for planting outside, shorter treatment gives about one fortnight earlier flowering without affecting the flower production.

Direct successful forcing of narcissus can be attained by subjecting the bulbs to 9°C for 10-12 weeks, and then forcing at 16°C in the polyhouse.

Pot plant forcing is similar to cut flower production. Narcissus as pot plants should be 20-30 cm tall with a large number flowers coming up clear of the foliage. Rooting room temperature should be 5°C where roots emerge from the pots and when shoots are 2.5 cm high it should be brought down to 2°C.

Afterwards, growing temperature should be 16-17°C but not above 18°C. At pencil stage these are marketed or stored at 0-2°C. The life of one potted narcissi plant in flower is from 10-18 days at 16°C temperature, varying from variety to variety. In a 10 cm pot some 3 bulbs and in a 20 cm pot some 6 bulbs of the dwarf varieties are planted. 'Tete-a-Tete', 'Bridal Crown', 'February Gold', 'Jack Snipe', 'Hawera', 'Baby Moon' and 'Ice Follies' are the cultivars which are grown as pot narcissi. Pots should contain black peat as potting substrate, and after potting the bulbs should be covered with sand. Potting mixture may also consist of 1 part leaf mould, 1 part organic manure, ½ part garden soil and ½ part coarse sand. For pot planting, bulbs should be dried for 1-2 weeks several degrees above ambient temperature, then drying at low humidity but at good air circulation and storage at 20 or 25°C, followed by cooling of potted bulbs at 9°C for 14 weeks and then finally at 5°C for early forcing or 5°C then 2°C for late forcing.

Flowering can be **retarded** by continued warm temperature storage at 25-28°C but keeping quality of the bulb is adversely affected. The bulbs are required to be retarded only when the bulbs are to be shipped from one continent to the other. A temperature regime of 30°C for 12 weeks from lifting, 0°C for 9 weeks and then 25°C for 8 weeks will retard anthesis by more than 6 months without affecting the bulbs.

2.2.3.7 Harvesting of Flowers and Post Harvest Technology

Trumpet and cupped narcissi should be cut at the fat goose-neck stage (in mild weather at tight or green goose-neck stage) when the perianth segments are just showing colour whereas polyanthus types (Paper White, Soleil d'Or, etc) at the time when the first two flowers of the trusses are opening. Early picking of both the types will reduce the flower size, stem length and vase life. Green goose-neck stage is most convenient even for packing. For good effect, immediately after cutting the flowers are held in shallow water up to 4 hours or overnight though for local market even dry stored will work provided they are kept in water after reaching the market. After cutting, the flowers are graded and packed in the bundles of tens just by putting one rubber band below the flowers and another near the cut ends. These are either stored in water or dry in polythene wraps or in clean newspaper and kept in corrugated card board boxes either straight or flat. All narcissus flowers can be stored or marketed at 0-2ºC for up to 10-14 days either in water or dry in polythene bags but they are to loose less than a quarter of their potential vase life. Lower temperatures prevent opening of the flowers while higher storage temperature reduces the vase life. A temperature regime of 10-16°C is most suitable for flower opening.

Vase life varies with the cultivar and ranges from 5-11 days, with an average life of 7 days at 15.6-16°C and 65% RH. $AgNO_3$ 25 ppm and sucrose 6% pulsing increases vase life and the flowers after this treatment can be stored longer at 1.1°C. 8-HQC at 200 ppm and sucrose at 2% also increase vase life.

Potted trumpet narcissi are marketed when the flower is in the pencil stage of development *i.e.* when scapes stand quite erect. This takes about 3-4 days for opening. Paper White potted plants are marketed when the leaves and flowering scapes are 20- 25 cm long.

2.2.3.8 Lifting, Dormancy and Storage of Bulbs

Flower initiation in narcissi bulbs normally starts $2^{1}/_{2}$ months before optimum lifting time. **Lifting** is effected when entire foliage have senesced and 95 % have died down or when required especially for early forcing or for export, there will be need to use a desiccant spray to kill non-senesced foliage and weeds, and for this purpose sulphuric acid is used only by an expert. Normally lifting is done in mid-June to late July. Poeticus and Poetaz have very short resting period and often roots begin to develop even before senescence of the foliage. Bulbs should be lifted carefully through forks without injuring them and immediately collected so that narcissus fly may not get time to lay its eggs. Bulbs should be shaken loose to get rid of the adhering soil and then roots should also be removed without damaging the basal plate. Now the bulbs are checked for infection of diseases and injury. If there is any loose scale, that should be taken out and then the bulbs should be divided, graded and kept in storage trays in shade for drying and curing. In the store, bulbs are given frequent fungicidal sprays. First phase of drying is to surface-dry the bulbs but later on the water loss depends on the rate of migration of water from the inner scales. The preferred temperature for storage between lifting and grading is about 18°C. This avoids the risk of flower damage caused by HWT if stored at a lower temperature *vis-à-vis* spread of basal rot which is greatest at 21-30°C. The storage treatments after grading are dependent on grades and their future use. Bulbs meant for sale are usually 14 cm grade and are kept in the store in trays at 18°C with adequate ventilation to prevent premature rooting, while for forcing 12-14 cm in circumference. For early forcing, immediately after lifting, these are subjected to 35°C for 5 days and then at 18°C and finally at 9°C but later-forced bulbs are continuously kept at 17°C until planting. Planting stock, the large bulb clusters and the 8-12 cm offsets are stored at 18°C to prevent the damage of HWT and immediately planted even without drying.

Hot water treatment (HWT) is an essential practice to control narcissus nematodes. While giving HWT to bulbs, apart from controlling nematodes, it also controls narcissus flies, bulb scale mite, leaf scorch, *Fusarium* wilt and certain other insect-pests and diseases which cause considerable loss to narcissus crop. The principle underlying HWT is given to kill the nematodes (eelworms) present in the bulbs without damaging the bulbs. Bulb producers can opt for more severe treatment but flower growers can not because first part to be affected in the bulb is flower bud, but both want to kill the nematodes without damaging the bulb at all. Moreover, the bulb should be treated at a stage when resistance of the flower bud to heat damage is at its maximum. Since narcissus bulbs pass through a stage of development throughout so when base of the bulb is swelling for root emergence, is also not the proper stage. Controlled (warm) storage of narcissi bulbs followed by HWT incorporated with 1 % Bevistan for 30 minutes at 44.4°C within 3 weeks of lifting provides quite satisfactory results. Delayed treatment will facilitate the nematode to make more protective wool hence HWT should not be delayed. On the **storage** of bulbs, it is already discussed under **2.2.3.8.**

Narcissi have 'tulip type' **dormancy**. These have little dormancy and when leaves have senesced, bulbs seem to be dormant but, in fact, inside there is intense activity of primordial initiation and growth of daughter bulb units, shoots and roots.

2.2.3.9 Insect-pests, Diseases and Physiological Disorders

Narcissi are attacked by a number of insect-pests and diseases, some of being highly devastating, and all these are being described here under.

The large narcissus fly [*Merodon (Lampetia) equestris*] resembles a small humble-bee and is about 1.2 cm long, with black, yellow or ginger hairs. It is active in summer and adult females lay their single eggs in the neck of narcissus bulbs which after hatching crawls down and enters the bulb through basal plate and pupates in the soil in the following spring. Infested bulbs become soft. Dieldrin 0.1 % with HWT for 3 hours has been found quite effective. **Small narcissus fly** (*Eumerus tuberculatus and E. strigatus*) resembles large narcissus fly or a house fly and about 6 mm long and the female adult lays eggs in bulbs already damaged by some other pests. The maggots (6 mm long) enter the bulbs normally through the neck and feed inside. Each season this fly breeds a number of generations. The symptoms of damage and control measures are the same as 'large narcissus fly'. **Bulb scale mite** [*Steneotarsonemus* (*Tarsonemus*) *laticeps*] is more devastating in the warmer parts of the temperate regions in the greenhouses attacking forced narcissi. They are 0.2 mm long and enter in between the bulb scales and feed on them adjoining the neck portion and survive feeding on the emerging flowers and leaves, and afterwards these migrate to the foliage. Leaves after emergence develop yellow stripes, peduncles elongate with saw-toothed edges and flowers deform due to their infestation. HWT at 44°C for 3 hours to the dormant bulbs will control this pest. **Bulb mite** (*Rhizoglyphus echinopus*) is a saprofungus pest but in a few cases this attacks the crop as a primary pest. This enters the bulbs through ailing part but after entering these increase rapidly and extend the injured area. On the plants they are detected as a grey powder on a patch of brown. These mites travel far and wide by clinging the narcissus flies. It is controlled as 'bulb scale mite'. **Slugs and snails** attack the crop during damp weather. Slugs enter the bulbs through base giving chance to other insects and pathogens to enter. These can be controlled by mixing 6 Meta (metaldehyde base) fuel pellets in the powdered form to 1 kg of bran and left as heaps in the field near the slug populated corners. Metaldehyde 1 part to 40 parts of bran by volume mixed together causes slugs in dry weather to produce more slime and eventual death. Controlling other insects will also control wireworms and other lepidopterous insects that occasionally feed on the crop.

Stem and bulb nematode (*Ditylenchus dipsaci*) is one of most serious pests attacking bulbs through the soft tissues of the neck and can also enter the rapidly growing leaves and stems causing distortion and discolouration, and their presence is realized by the swellings and the light coloured speckles. In poorly drained soil, its spread is very fast. These also make dry eelworm wool at the base of the dried bulb. Infested bulbs become soft, especially at neck region and on cutting across, concentric browning is apparently seen. It can effectively be controlled by storing the bulbs first at 32.2°C for 1 week, followed by a 3-hour soak in water at 26.7°C and then HWT at 44.5°C for 3 hours. **Bulb and leaf nematode** (*Aphelenchoides subtenuis*) has been attacking only a few cultivars and through its attack, outer scales of the bulbs are scarified with blisters and crinkles and the transverse cutting of the bulb shows grey discolouration. Infested plants show premature yellowing of leaves. Methyl bromide treatment at 100 ml/m^2 controls this pest completely. HWT as defined under **2.2.3.8** will hold good here too. **Root lesion nematode** [*Pratylenchus* (Ditylenchus) *pratensis*] attacks only the

roots and incites a secondary root rot infection of *Cylindrocarpon radicicola* by which leaves yellow prematurely. The treatments suggested for 'stem and bulb' nematode will control this pest also.

Basal rot (*Fusarium oxysporum* f. sp. *narcissi*), formerly known as *F. bulbigenum,* is most serious pathogen of narcissi causing decay of the root plate or scale bases, especially in storage when temperature is above 14°C and more seriously when it rises above 21°C. It also causes rot in the field. The tops of the infected bulbs turn yellow and die before maturing and at digging, the roots and affected scales are found purplish in colour. Infection occurs through the wounds on the bulbs or roots and even through uninjured bulb and roots. The affected bulbs when planted show yellowing of foliage when sprouted. Methyl bromide fumigation at the rate of 50 g/m^2 before planting or aldicarb 10 % a.i. (4g/m^2) application twice during growing season controls this pathogen. HWT with formalin 1 % while treating the bulbs in storage against nematodes will also control this pathogen. **Smoulder** [*Sclerotinia* (*Botrytis*) *narcissicola*] is most prevalent in cold wet seasons and is apparently noticed as spotting as well as rotting of the flowers and leaves. At lifting, affected bulbs bear masses of small, black and flattened sclerotia (resting bodies) under the outer papery scales and on rotting leaves. Infected bulbs produce distorted yellow shoots with withered dark brown or black leaf tips. Wind and rain splashes help this disease spreading to other plants. Storage infection may cause bulb rotting in the godown and when planted, disease spreads in the field. Proper sanitation of the field and stores, and avoiding high humidity in the field or in store will minimise this disease. Within 48 hours of lifting, the bulbs are dipped for 30 minutes in a suspension of 0.2 % benomyl or carbendazim or thiophanate methyl and then bulbs are rapidly dried before storage, but in the following season none of these 3 chemicals are to be applied again. **Green mould** (*Trichoderma viride*) affects the injured or bruised bulbs in storage by causing bright green growth on the wounds and ultimate rotting of the bulb. Bruised bulbs should be discarded and not stored and the others should be treated with thiride or captan. **Penicillium bulb rot** (*Penicillium corymbiferum*) apart from causing bulb rot also causes twin-scale bulb rot which can be controlled through 0.2 % captaf. **White root rot** (*Rosellinia nectarix*) infects the narcissi under moist conditions by causing root rot and black rotting of the outer scales of the bulbs with white fungal strands in the form of woolly mass near the basal plate. Such bulbs should be destroyed. Captan or thiride may also control this disease. **White mould** or **Ramularia blight** (*Ramularia vallisumbrosae*) spreads through winds or water in moist warm weather by producing grey or white powder and destroys the foliage and sometimes even stalk. This can be controlled by 3-4 sprayings of 4:4:50 Bordeaux mixture or tank-mix zineb starting when the leaves are 5-10 cm high. **Leaf scorch** (*Stagonospora curtisii*) survives in the dry papery scales of the bulb, and when leaves emerge, this attacks causing scorched and burnt appearance on the leaf tips but the buds and flowers are attacked in damp weather only. After the death of the foliage, the spores of this fungus remain around the neck of the bulbs. The disease becomes highly devastating in the cool-stored, late-planted narcissi which flower early. HWT with formalin controls this disease in the first year, and spraying with 0.2 % zineb at 10-14 days intervals after removing and burning diseased tips will control in the second year. The control advocated for 'white mould' will also control this disease. **Narcissus fire** [*Botryotinia* (*Sclerotinia*) *polyblastis*] causes pale-brown lesions quickly spreading on the leaves. At the picking time, perianth segments develop pale-brown spots. It causes leaf and

flower spotting and premature death of foliage. Moist weathers enhance the spread of the disease where first flowers are killed and then leaves are infected where it over winters. Proper sanitation of the field and removal of the infected flowers, as well as fortnightly spraying of the crop with Bordeaux mixture (4:4:50) and tank-mix zineb will control this disease.

The **viruses** which attack narcissi are 'cucumber mosaic virus' (**CMV**) causing lighter striping and mottled pale-yellow discolouration of the foliage and flower stalks but not of much significance, 'narcissus yellow stripe' (**NYSV**) spreading through aphids is the most serious viral disease of narcissi showing bright yellow stripes or streaks from emergence to flowering by which yield and quality of the bulbs and flowers are reduced, 'narcissus white streak' or 'silver leaf' (**NWSV**) is seen only during blooming time by developing silvery leaf or white stripe on leaves by which foliage senesces earlier and bulbs also deteriorates rapidly, 'narcissus latent virus' (**NLV**), 'Grand Soleil d'Or and jonquil mild mosaic' (**JMMV**) transmitted through aphids, 'narcissus mosaic' (**NMV**) transmitted mechanically, 'Arabic mosaic' (**AMV**), 'raspberry ring spot' (**RSPV**), 'strawberry latent ring spot' (**SLRV**), 'tobacco rattle' (**TRV**), 'tobacco ring spot' (**TRSV**) and 'tomato black ring or chocolate spot virus' (**TBRV**) shows large dark brown spots, all transmitted through nematodes except where specified. Regular insecticide spray will control the vectors. Moreover, the infected plants should be rogued out and buried to check further spread.

Trumpet narcissi if are forced at 18°C or higher, **bull-nosing** may occur where flowers neither expand properly nor open. Injuries caused by herbicides are **leaf scorch** due to paraquat, **distorted flowers** due to delapon or trichloroacetic acid (TCA), **chlorosis** due to paraquat when it enters the bulb, or triazoles, **reduced growth** after higher rates of chlorpropham, diuron, fenuron or simazine, and damage to the basal meristem resulting in flaccidity due to MCPA and 2,4-D. HWT causes aborted or small 'starry' flowers, dead buds, leaf mottling, roughening, thickening and distortion, grey rings in the scales and grey spots above the basal plate, etc. Formaldehyde treatment injury is caused in terms of brown corky areas around the periphery of the basal plate, reduced flower number and deformed flowers.

Check Your Progress Exercise 3

Note : a) Space is given below for answers.

b) Compare your answer with that given at the end of the unit.

1) Name *Narcissus* spp. used for extraction of essential oils.

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2) How the flowering in *Narcissus* is retarded ?

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2.3 LET US SUM UP

In this unit, we have studied various true ornamental bulbs for their classification, important species and the varieties, their propagational methods, various cultural practices adopted, various factors affecting growth and flowering, flower forcing, stage for harvesting of flowers, their post harvest technologies to increase the vase life, major insect-pests and diseases infesting / infecting these plants *vis-à-vis* physiological disorders and their remedial measures, the stage for bulb lifting, their storage and the breaking of dormancy for induction of flowering.

2.4 KEY WORDS

Bulbils, bulblets, bulbs, diseases, dormancy, flower blasting, flower forcing, holding solution, hot-water treatment, insect-pests, ***Iris, Lilium,*** micropropagation, ***Narcisssus,*** notching, physiological disorders, pulsing, scoring, senescence, storage of bulbs, twin-scale propagation, etc.

2.5 FURTHER REFERENCES

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2.6 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1) Iris bulbs more than 20 cm in circumference may be chipped (cross cut) into half, a quarter and $^{1}/_{8}^{th}$ and incubated in plastic bags and planted in a 50:50 grit + peat medium for good results.

Check Your Progress Exercise 2

1) The storage organ in lily is an imbricated bulb that consists of many fleshy scales, which are modified leaves attached to a basal plate. When the plant has completed flowering, the bulb is immediately lifted, outer scales are detached and the parent bulb is replanted to recover within two years. These **scales** are now planted 6-7 cm deep in open beds or frames, 2.5 cm apart in the rows spaced 15 cm apart. Bulbils are formed in the autumn which can be lifted and replanted in beds for getting flowering size bulbs. In case established plants can not be disturbed just at post flowering, **scales** can be removed in September and placed immediately in 30 cm deep boxes of sand in alternate layers of sand and scales, by keeping the boxes moist and warm until the spring, and thus the bulblets formed on the scales can be planted in the open in the spring. The bulblets formed through this method are smaller than previous method but by first summer many will grow into small saleable size. Another method is to insert the **scales** in single layer in September and then planting out in March the young growing plants still attached to the old scale.

2) Lilium cultivation was earlier restricted to hilly area but now with the advancement of research efforts made at IARI, it is grown under northern plain for flower production successfully but quality bulb production prefer cooler climate.

Check Your Progress Exercise 3

1) *Narcissus jonquilla, N. poeticus* and *N. pseudonarcissus.*

2) Flowering can be **retarded** by continued warm temperature storage at 25-28°C but keeping quality of the bulb is adversely affected. The bulbs are required to be retarded only when the bulbs are to be shipped from one continent to the other. A temperature regime of 30°C for 12 weeks from lifting, 0°C for 9 weeks and then 25°C for 8 weeks will retard anthesis by more than 6 months without affecting the bulbs.