UNIT 5 *TUBEROSE* (POLIANTHES) AND *TULIP* (TULIPA SETELATA)

Structure

5.0 OBJECTIVES

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

- define true bulbous geophytes and distinguish them from other ornamental bulbs,
- know the important species and commercial varieties,
- know dormant period if any in its bulbs and its causes, its storage methods and propagation,
- explain the soil and nutritional requirements and other cultural practices,
- know various factors responsible for its growth, development and flowering,

- describe flower and bulb harvesting and its various post harvest techniques, and
- know various insect-pests and diseases attacking tuberoses and shall be able to overcome them.

5.1 INTRODUCTION

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.

Among the true bulbous geophytes, the cultivation of tuberose is quite old in India and it is grown throughout the country. If watering is not a limitation, it flowers throughout the year though in severe winter and during harsh summer flowering is quite low and that too of poor quality. When there is dearth of flowers (cut flowers or loose flowers) in the market it is tuberose which fills the demand. Its cultivation is very easy that is why it has become most homely flower of India. Its flowers are very fragrant, especially the single ones and its sweet fragrance is admired much in the country**.** Double ones are also fragrant, more intense being in the semi-temperate or in the temperate areas. The flowers start emitting fragrance by the evening which creates a very pleasing environment in the night. During day time also its aroma is noticed but not so intense. For this crop there is no dearth of planting material as from one large bulb it multiplies more than 25 bulbs in a year.

5.2 *TUBERROSE* AND *TULIP*

5.2.1 *Tuberose* (Polianthes) (family - Agavaceae, previously - Amaryllidaceae)

(Common names : **Tuberose,** Hindi - **Rajanigandha**, Malayalam - **Nishigandha**)

5.2.1.1 Classification, Species and Varieties

Tuberose is the most homely flower of India. It is being grown in every part of the country irrespective of the climatic conditions prevailing there. Though its flowers are white but they have intense pleasing fragrance and are available in

two forms - single and double. The intensity of fragrance is more in singles than the doubles. On the temperate region of the country as well as on the lower hills, the doubles are also quite fragrant. There are some 12-15 species under the genus *Polianthes,* nine having only white flowers, but except *Polianthes tuberosa*, others seem to be obsolete. It is being used as cut flowers as well as loose flowers. Essential oil is also extracted from its flowers.

Except *Polianthes tuberosa,* other 11 species are not of any commercial importance. All the varieties available in the country or elsewhere fall under only one species, *P. tuberosa.* Though there is no any special classification of tuberose but on the basis of the flower form, it is classified as 'Single' or 'Double'. Initially only two varieties were introduced in the country *viz.* 'The Pearl' (double) and 'Mexican Single'. Afterwards, two varieties, 'Swarna Rekha' (double) and 'Rajat Rekha' (single) were developed through ^{60}Co gamma treatment from N.B.R.I., Lucknow. These varieties do not have any commercial value as both flower seldom. However, there are golden stripes on the leaves of 'Swarna Rekha' and silver stripes on the leaves of 'Rajat Rekha'. Like to that of 'Swarna Rekha', one more variety was developed in Sikkim which also has golden stripes on the leaves but slightly different, and this is known as 'Sikkim Selection'. I. I. H. R., Bangalore developed four varieties *viz.* 'Prajwal' (quite sturdy, tall and vigorous and the best among all the singles existing in the country), 'Shringar' (single), 'Suvasini' (double) and 'Vaibhav' (double). One variety has been developed by A.N.G.R.A.U., Hyderabad, probably a selection and has been named as 'Hyderabad Single' which is very similar to 'Shringar'. One variety as 'Phule Rajani' has been developed by M.P.K.V. Pune centre. This single is also quite compact and beautiful. This variety at bud stage is green. Many states in the country grow single and double forms except those described above, which they claim their own but, in fact, these are one, the single one is 'Mexican Single' and the double one 'The Pearl'. All the varieties at the bud stage are pinkish except 'Phule Rajani', 'Mexican Single' (Calcutta Single) and 'Suvasini' which are green at bud stage. Thus in real sense only 11 varieties of tuberose exist in the country. The singles being 'Hyderabad Single', 'Mexican Single'(Calcutta Single), 'Phule Rajani', 'Prajwal', 'Rajat Rekha', 'Shringar' and 'Sikkim Selection' while doubles are 'Suvasini', 'Swarna Rekha', 'The Pearl' (Calcutta Double), and 'Vaibhav'.

5.2.1.2 Propagation

Vegetatively tuberose is propagated through bulbs, lateral bulblets forming on the side of the main bulb (also known as offsets), through division of bulbs (bulb segments) and through micropropagation.

The most common method for tuberose multiplication is through **bulbs** and **bulblets**. Spindle-shaped bulbs having diameter of 2 cm are flowering size bulbs but other smaller ones (bulblets) are only planting stocks. The basal plate of tuberose is so formed that one confuses it with a rhizome. Though one year planted bulb is not so confusing but the bulbs taken out from perennial croppings give this impression. The formation of lateral buds is so fast that basal plate extension is necessitated to accommodate these bulblets and on lifting when bulbs and bulblets are taken out one by one, a big chunk of the disc (basal plate) is left in the end. In a two-year cropping, a plant of certain varieties produces about 5-10 large (flowering size) bulbs and about or more than 50 bulblets. On planting, in one year, 2-3 large bulbs and 15-30 small bulbs (bulblets) are formed.

If cared well, bulblets also grow full flowering size bulbs in one year, if planted singly after separating these from the clump. Since tuberoses are grown as perennial croppings *i.e.* 2-4 years so because of their dependency on the mother bulb as these are sharing the same disc for years, the bulblets get only a small share of nutrients hence their development is very slow. Four-year perennial cropping is not profitable as quality of the spike becomes very poor and so is the bulb and bulblet formation. After planting the large-sized bulbs, first year one gets only 1-3 spikes, but second year 4-6 with slightly poor quality of spikes, while the third year though there is increase in the number of spikes, but quality is obviously poor. Therefore, only two-year cropping should be adopted. It would be better if large bulbs are separated every year for flowering and bulblets for raising the stock. If cared well, many of the large bulblets will also provide quality spikes the first year.

Full-sized bulbs and large bulblets may also be **fractionated** into ½-$^1/_8$, each piece having a part of the disc as well as fleshy scales, treated with some effective contact fungicide and planted in sandy loam soil rich in humus. Each segment will provide a new plant.

Micropropagation may also be adopted for quick multiplication. Bulb segments on MS medium, with addition of growth regulators and vitamins and incubating at 22-25°C using continuous fluorescent light of 3500 lux, may provide some 500-800 plants in one year.

Growers should not be concerned with seed propagation as it is a tedious job where there is only little success and that too with time constraints. Moreover, at flowering seed-raised plants may not come true to the type. 'Hyderabad Single', 'Shringar', 'Mexican Single' (Calcutta Single) and 'Phule Rajani', all singles produce seeds which are small, shining black, light and flat. Immediately, when capsules mature, these should be taken out and sown on raised beds having well workable sandy-loam soil rich in organic matter. These beds should lightly be watered daily. Within a month or two, these will germinate.

5.2.1.3 Climate

It is successfully grown under high humid to arid climate for cut flower as well as for bulb production.

5.2.1.4 Soils, Preparation of Land, Planting and Weed Control

Reasonably fertile sandy-loam **soil** which is light and well drained but with good water-holding capacity, having pH range of 6.5-7.5, is most suitable for tuberose growing, though tuberoses can successfully be grown up to 8.5 pH provided the field is rich in organic matter. This prefers a sunny situation. Even partial shade hampers the growth. It grows very well from 18-35°C temperature.

Its proper **planting time** in the subtropical regions is February and in temperate regions when danger of frost is over *i.e.* March-end to early-April. In tropical regions it can be planted any time, preferably from October – January. They are planted shallowly just to cover the tips of the bulb with the soil. For its planting the **soil preparation** should be done as for potato planting. Soil should be well dug up to 30 cm deep thrice, every time followed with plankings. The soil should have sufficient moisture at the time of third ploughing and planking so that after

planting the field may not require immediate watering. Now the beds of convenient sizes are made after leaving the space for bunds and channels. **Planting** is done at 30 cm apart in the rows if it is to be made a two-year crop. However, for a three-year cropping, it requires more distances and that is 40-45 cm apart. After planting, pendimethalin (stomp) pre-emergence **weedicide** at the rate of 3 litre/ ha should be applied evenly in the planted area after mixing the chemical in 5000 litres of water. This will prevent germination of annual weeds up to 75 days. Then after, only stray weeds are to be removed manually because the main crop covers the in-between area with its own growth of leaves which normally does not permit other weeds to grow. In case, weedicide has not been used, organic or polythene mulching as defined under ***Narcissus*** **2.2.3** may be used.

In case weedicide is not used, hoeing and earthing up should also be carried out as and when required. Hoeing will keep down the weeds and will permit aeration while earthing will give good support to the inflorescences to stand erect against winds and rains.

5.2.1.5 Irrigation, Manures and Fertilizers

First light **irrigation** is followed immediately after, if pendimethalin weedicide has been applied in the field. Whether it is temperate or subtropical region but its growing season passes through spring to autumn hence it requires copious watering but shallowly every time, starting from its sprouting to leaf senescence. In completely tropical region also, the watering frequency is the same. In light soils, it should be watered every 6 days while in heavy soils 8 days. Watering very much depends on the prevailing weather conditions. During rains, it does not require watering. If it is watered well regularly, one can get the flowers throughout the year in the tropical regions and from May - June to October - November in the sub-tropical and temperate regions. Erection of polyhouses over the plantings during winter season *i.e.* from November - March in both these regions will make the available flowers regularly for all the 12 months. Even otherwise, the variety 'Mexican Single' which is good only as a loose flower blooms throughout the year under Delhi condition if the crop is not damaged due to frost in winter. If it does not occur, to some extent leaves even of other varieties remain green even during winter otherwise senesce, and new growth starts only by April. Under Delhi condition, there is profuse flowering from September - November.

At the time of preparation of soil, well rotten compost or farmyard manure at the rate of 300 quintals/ha should be incorporated in the soil by mixing thoroughly. Being a perennial crop it requires heavy feeding. Potassic fertilizers should only be incorporated in the soil if soil is deficient in potash. Therefore, it would be better if soil analysis has already been done so that only recommended dose of NPK or any other nutrients may be given. Nitrogen 200 kg and P_2O_5 60 kg/ha will give better yield of flower and bulbs. In potash deficient soils, 50 kg/ha K_2O will benefit the crop. Whole of the potassium and phosphorus and half of nitrogen may be applied in the soil while preparing the land for tuberose cultivation. Half nitrogen may be applied when inflorescence starts emerging. In the standing crop, always after fertilizer application, irrigation should be carried out. Another year also the same quantity of fertilizer may be used if it is a two year crop, and subsequently in the third year also the same quantity if it is three-year crop. Application of *Azospirillum, Azotobacter,* and phosphobacteria alone or in

combination, and also when combined with inorganic fertilizers give excellent results in terms of number of spikes per plant, number of flowers per spike, number of bulbs and bulblets and their sizes per plant. Tuberose responds well to certain micronutrients. Application of zinc @ 15 kg/ha or spraying the crop with 0.25 % $ZnSO_4$ results in better production of flowers, bulbs and bulblets.

5.2.1.6 Growth, Development and Flowering

The bulbs have vegetative apex protected by a layer of 3-4 sheath leaves, and after a certain growth these change to generative phase and from then it takes hardly 25 days to form a complete flower inside. When such bulbs are planted in field, they initiate flowers after 90 days. The growth and differentiation of the apex depends on the supply of soluble carbohydrates from the scales. Storage temperature influences the number of bulbs lifted and the quality of flower spike. Storage at higher temperature (30°C) for longer duration, though advances flowering but reduces the quality of the flower and bulb yield. However, storage at 10°C for one month is optimum which improves the yield of flowers, but prolonged storage decreases bulb yield. Planting of the fresh bulb will lead only to profuse vegetative growth and little flowering, hence, for sometime the bulbs should be rested to encourage better growth and flower production.

For maximum root growth, soil temperature should be above 20°C. For maximum bulb production, atmospheric temperature should be in between 20-30°C. If bulb growth does not terminate soon after flowering, new lateral buds will initiate flowers. After senescence of aerial parts due to frost, flower and bulb growth stops. In tuberose, the lateral bulb production is prolific, and it takes 2-3 seasons to attain the flowering size. In perennial cropping after senescence of the foliage (not chopping of the foliage), certain lateral buds mature by attaining proper growth and start flowering later in the season. Application of GA_3 and chlormequat stimulate the enlargement of laterals as well as the central bud by reducing the number of laterals.

Though tuberose is photo-insensitive, long-day exposure promotes vegetative growth and accelerates flowering with increased spike length while low light intensity and duration promote leaf length.

5.2.1.7 Harvesting of Flowers and Post Harvest Technology

Spikes are harvested preferably in the morning when 2-3 florets have opened. After harvesting, immediately their cut ends are placed in a bucket containing water. Spikes should be harvested from the ground level with a sharp knife or should be taken out by giving a gentle push from the sides at ground level from where it breaks from the plant. Picking for loose flowers may also be done in the morning only for 2 hours and only opened and opening buds are picked. One person can harvest some 15 kg of loose flowers in 2 hours duration. The yield of loose flowers may vary from 12,000 kg/ha to 30,000 kg/ha/year, depending upon the varieties chosen and the cropping year. Care should be taken that picking does not injure the spikes because other opening flowers from the same spike are to be harvested further. These loose flowers are used for various floral decorations, hair adornments and for making garlands. The var. ‘Mexican Single’ (Calcutta Single) is meant only for loose flower production. Loose flowers are packed in hessian cloth lined bamboo baskets of various sizes, holding 5-20 kg of flowers and are transported the same day to the designated market where it is sold by

weight. If these flowers are marketed the next day, there will be weight loss up to 40 %.

After cutting, the flower spikes are also graded (on the basis of flower quality, spike thickness, spike length and rachis length), dressed and bundled in fifties or hundreds, and then wrapped in newspapers, and then finally packed in hessian cloth which may accommodate some 600-1000 spikes, depending on the varieties. The refined way of packing them is to wrap the spikes in tissue paper or corrugated brown paper and then with alkathene papers, and then packed in corrugated boxes, specially prepared for the purpose or in rectangular bamboo baskets lined with hessian cloth These can easily withstand 48 hours of dry storage during transit.

Cut spike post harvest life depends on the variety, the year of cropping, the cultural practices adopted, carbohydrate reserves and endogenous growth regulators present, soil moisture status during whole cropping season, the growing season (status of temperature), photoperiod and light intensity, relative humidity, bulb size and spacing. High nitrogen levels administered to the crop produces tall and succulent spikes which may easily break even without winds. Low light intensity but high temperature and excessive moisture reduce the cut flower life. Attack of pests and diseases also affect flower life adversely. Cut flower life improves when bulbs at planting are treated with daminozide or chlormequat 1,000-5,000 ppm, MH 1,000-2,500 ppm or GA_3 10-1,000 ppm. Benzimidazole or GA_3 (0.01-0.03 %) in combination with daminozide, ascorbic acid, glucose and hydroxyquinoline (0.001-0.003 %) improve the opening of young green unopened buds or matured half-bloomed flowers and increase the vase life. Calcium nitrate 0.01 % + citric acid 250 ppm + sucrose 3 % provide maximum vase life (14 days) to tuberose cut flowers. Normal vase life of tuberose cut flower is 7-8 days. Pulsing with 10 % sucrose + 250 ppm aluminium sulphate for 12 hours and the cut spikes stored for 5 days, prolonged life of the cut spikes and opening of all the florets are obtained.

Tuberose have only white flowers. Hence, for obtaining flowers of various colours *viz*. yellow, rose, red, scarlet and blue, one will have to dissolve chemicals like bromocresol green and bromocresol blue for various shades of blue, phenol red for yellow, erythrocin red for rose, ammonium purpurate for rhodomine red and cosin for scarlet colour when pulsed at 0.1 % each for five hours as water solution. This process is known as **tinting**.

5.2.1.8 Lifting and Storage of Bulbs

After flowering is over, the growth of the plant also ceases and in the sub-tropical region of Delhi as well as whole of North India, the winter also sets in. December becomes very cold (temperature going below 10°C, and sometimes even 5°C, while in January it may go even below 5°C) which forces the leaves to die down though October - November is the peak flowering time. It is therefore advisable to lift the bulbs (clumps) by December to save the crop from rotting. These, if not lifted, will start sprouting by April provided the field has been watered from March onwards. Even after collapse of the foliage, the field should be cleaned of the weeds. In the temperate climate of India, the clumps should certainly be lifted by November as winter sets in there and continues till mid-March. In tropical regions of the country though all the weathers exist but winter is very mild so lifting may be carried out when peak flowering is over.

After harvesting (lifting), the clumps should be dried in single layer under a shed which is well aerated. These clumps are now separated into bulbs and lateral bulblets, are graded and then again dried. Those bulbs which are spindle-shaped and at least 2 cm (>6/8 cm circumference) or above in diameter are flowering size and those less than 2 cm (<6/8 cm in circumference) are planting stock. The grading may be done on the basis of diameter, circumference or weight. The bulbs having circumference of 8/10, 10/12 and 12-14 cm are the commercial grades. Through good cultural practices, below 2 cm diameter bulbs may also produce flowers of commercial grade. However, <1.5 cm bulbs may not produce commercial spikes. Large bulbs produce more laterals than the laterals themselves.

The yield of bulbs per year is roughly 20 tonnes per hectare, if raised through bulbs having diameter of 2.5-3.0 cm. However, the collective yield in a 3-year cropping period will come to about 50 tonnes.

Flowering may be advanced by storing the bulbs at higher temperature *i.e.* 30°C for longer duration, but the quality of the flower will be poor and bulb yield will be reduced. Lower temperature (10°C) for longer duration also hampers the bulb production, but if stored at this temperature only for one month, more flowers with better quality are obtained. Storage temperature of at least 18°C for 4-6 weeks or 30°C for six weeks has been advocated for production of more commercial size bulbs. Initiation and development of the flowers occur after planting of the bulbs. Initiation is affected by physiological stage of the plant (bulb size, number of leaves, soil and air temperature). Earlier planting provides longer harvest duration of spikes, with more number of spikes and better quality blooms. In Delhi, the optimum planting season for tuberose is February when there exists low soil and air temperatures that is why flower harvesting period is prolonged though flowering starts a bit late.

5.2.1.9 Insect-Pests and Diseases

Tuberose is a very sturdy and easy growing crop which is normally not affected by any serious insect-pest or diseases. However, a few observed sometimes are described here under.

Grasshoppers (*Hieroglyphus* spp.) feed on the young leaves and flower buds, especially during rainy season which may be controlled by spraying 0.2 % methyl parathion. The adult **weevils** feed in darkness on the leaves making notches on the edges which may be trapped and killed as they are only a few. Their larvae feed on the roots and tunnel into the bulbs whose attack may be prevented by applying furadan granules @ 3-4 kg/ha at the time of bed making. **Aphids** (*Aphis* spp.) are very small in size and multiply rapidly. They feed on the growing points and floral buds which may be controlled by spraying nicotine solution. **Thrips** (*Taeniothrips* spp.) are minute insects which suck the sap of the leaves, buds and flowers, and act as a carrier agent in causing 'bunchy top' disease where the inflorescence is malformed. While controlling the grasshopper, this will also be controlled. **Red spider mites** suck the sap on foliage causing yellow stripes and streaks, and in severe cases leaves turn yellow, silvery or bronze and finally deformed. Kelthane spraying will prevent its infestation.

Two **nematodes** [*Aphelenchoides besseyi* causes greasy streak, and *Meloidogyne* spp. (*M. incognita, M. javanica, M. arenaria & M. acritata*) cause root galling, poor growth of plants with leaf tip burn and yellowing, and suppress spike

emergence in their severe infestation] infest this crop. The treatment advocated for controlling larvae of the weevil will keep these pests also under check.

Stem rot (*Sclerotium rolfsii*) is caused at the soil level. Leaves loose their greenness and whole leaf rots and gets detached from the plant. Due to its infection, round and brown sclerotia are formed on and around the infected leaves. Ultimately the plants become too weak to produce flowers. Mercuric chloride 0.1 % and commercial formalin 0.2 % have excellent control of the disease. Dusting 20 % brassicol has been found quite effective. **Botrytis spots and blight** (*Botrytis elliptica*) is a problem under cool cum moist growing conditions. Initially when noticed should be controlled by spraying with 0.2 % maneb weekly and the field humidity should be kept under check. Before planting, the bulbs should also be treated by dipping them for one hour in 0.2 % bavistin or benomyl. **Flower bud rot** (*Erwinia carotovora*) sometimes infects the floral buds which may be controlled through mercuric chloride or streptocyclin. Sometimes, leaf mottling is caused due to a virus. Such plants should be destroyed to check further spread.

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) Name all tuberose varieties existing in our country.

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5.2.2 *Tulip* (family - Liliaceae)

(Common name **Tulip**)

5.2.2.1 Classification, Species and Varieties

Tulip is the most prestigious flower in the world among all the bulbous ornamentals but can be grown only in the temperate regions. At the end of the twentieth century, Lucknow (U.P.) growers grew tulips for about two years but stopped growing suddenly afterwards. Actually they were importing the precooled bulbs from Holland which were giving the blooms the first season but there was no bulbing. The cost of bulb was comparatively much higher than cost of the flowers they grew. The climatic conditions of tropical and sub-tropical regions are at all not congenial for tulip growing, and importing the precooled bulbs every year will not be cost effective. Hence this can be grown only on the hills (temperate regions). There is great diversity in the colour, size and form of the flowers. They are grown in town parks and gardens, for they brighten beds and borders during April and May. In Holland they are grown only for cut flowers.

It is a hardy genus of some 100 species, all with bulbs as their rootstock. Royal General Dutch Bulb Growers' Society in collaboration with Royal Horticultural Society has put all the tulips under 15 divisions.

5.2.2.2 Propagation

Tulip bulb is renewed annually. It is propagated through natural division of **mother bulb**. Tulip bulb is an ovoid-conical bud with a rounded base, flattened or slightly grooved on one side, and wholly covered by a tough brownish membranous scale, except where a tiny scar is present at the base from where it was attached to the mother bulb. Withered stub (remnant) of the flower stalk attached to the base indicates that the mother bulb had produced a flower. On removal of the membranous scale, whitish fleshy scales appear with one or more **small bulbs** adhering to the base near the scar which was/were nurtured by the membranous scale when it was also fleshy but for the formation of these small bulbs, this passed on its food reserves rapidly to the buds in its axil. The bulb consists of a series of concentric fleshy scales which are modified leaves containing food reserves, each scale having a **bud** in its axil, outer scales having more. The innermost scale serves as a hood to the central bud which has been clearly formed by September with a short thick stem bearing leaves in the form of rolled umbrella around the flower bud. All these fleshy scales, axillary buds and central bud are situated on the basal plate, the true stem. After planting, the roots emerge from the base of the basal plate, and the central bud as a shoot. The buds present in the axil of the fleshy leaves swell drawing food from the fleshy scales and the aerial shoot, the development being more prominent after flowering. When leaves are senescing, the mother bulb is fully depleted of its food reserves developing into 5-7 **daughter bulbs** on an average, depending on cultivar.

At senescence of leaves or at bulb harvesting, the new leaves or flowers are yet not fully formed, though this occurs within about a month at 18-21°C when the bulbs are in store. After floral bud initiation, the bulbs require a long period of chilling for proper development, especially stem elongation. On planting, a large basal leaf emerges first, and then subsequently the flower stem attached with other leaves. After the flowering, the senescence process of leaves and flowers is quite rapid, especially in warm weather.

A large bulb produces several **daughter bulbs** in the axils of the bulb scales, the innermost (central) daughter bulb being the largest, while other **axillary bulbs** (**daughter bulb offsets**) smaller. The offsets are found either clustered at the base of the flower stems or on stolons or droppers growing outwards from the mature bulbs. Under favourable temperature conditions, the flower bud in the flowering size daughter bulb is completely differentiated by September which on planting in the following season will produce flowers. If other things remain the same, the central bulb is certainly the flowering size, while other axillary bulbs may or may not be, depending on the cultivar. A flowering size bulb contains at least five scales including or excluding the tunic. It is the bulb size which determines the capability of a bulb whether it will flower or not. Generally, the size is determined on the basis of bulb diameter, circumference or its weight. Bulb weighing 6-8 grammes or measuring 6-8 cm circumference may initiate flower though differences between cultivars exist as in var. Aureola this size should be 13-14 cm. smaller ones are the planting stocks which may form only the leaves on planting but not the flowers. The non-flowering ones may attain the flowering size rounded bulbs in one season or the two depending on cultivar and growing conditions.

Through **micro-propagation** also tulips may be regenerated but the work on this line is still in its infancy. Through scale explants, adventitious buds and

bulbs can be produced *in vitro*. Stem segments excised during bulb storage is also an effective way of regenerating tulips *in vitro* as through this way also adventitious buds and bulbs can be produced.

Tulips can be multiplied through **seeds** for evolving new varieties as through seeds these do not come true to the type. Most modern hybrids are sterile but most species and a few varieties set seeds so through artificial pollination seeds may be produced and when capsules are matured i.e. when these start splitting, seeds are collected in paper bags and stored until autumn when these are sown in pots filled with leaf mould, good garden loam, compost and coarse sand, all in equal quantity by volume. Seeds are sown thinly, covered with sand and are kept in frame where these pots are very lightly watered regularly. They germinate well at 5-8°C temperature. After the winter is over, the pots may be shifted to a well ventilated cold house. During the fourth year the small bulbs should be large enough to plant out as the planting stock. These will produce flowers in 5-7 years.

5.2.2.3 Climate

It is typically temperate flower, needs chilling requirement to bloom.

5.2.2.4 Soils, Preparation of Land, Planting and Weed Control

Tulips can be grown at a sunny situation and in a wide range of **soils** provided it is well drained. During the active growth the soil should have the capacity to retain moisture. A pH of 6-7 is most desirable. Soil compaction is also not favourable, and pebbles and stones *vis-à-vis* rootstock of the perennial weeds should also be taken out from the field while **preparing the land** for its growing. Soil should be dug out at a depth of 30 cm, planked, then again ploughing and planking and then followed by third ploughing and planking. Farmyard manure or compost at the rate of 30-50 tonnes per hectare should be incorporated in the soil at the time of third ploughing, and then beds should be prepared of convenient size by keeping provision of bunds (50 cm) and channels (one metre). Planting in beds is generally carried out only in sandy soils while ridge planting is done in heavier soils. If overhead irrigation is to be provided, the length of the beds may run across the whole field while width 1.5-2.0 metres but a path of 60-100 cm between the two beds for cultural operations and movement should be maintained. At the planting time there should be sufficient moisture in the soil so that first irrigation is required only after sprouting.

Planting is carried out in the month of October, when temperature falls below 20°C. **Planting density** affects bulb yield, and a very close density etiolates the flower stalk. The size of the bulb is the main criterion in determining the plant density. In beds, it would be preferable to plant in furrows drawn at a distance of 20 cm depending on the size of the bulb. While drawing the next furrow, automatically the planted bulbs in the furrows will be covered. The **depth** of the furrow should be 8-10 cm. The bulb to bulb distance in the row should be three times the diameter of the bulbs to be planted *i.e.* roughly 10-15 cm, thus accommodating some 50 to 75 flowering size bulbs/m^2 (size being from 7-8 to 12-13 cm circumference). The bulbs above 13 cm circumference produce more progeny bulbs per bulb so they should be retained to maintain stocks. When planting is done in long furrows, every seventh row is kept unplanted which works as paths for cultural operations and movement.

Mulching is usually used to keep down the weeds, to prevent cold injury and to

improve the soil conditions. Organic mulches as defined under ***Narcissus* 1.4.4** are best as these decompose in the field and provide additional nutrients as well as improve the soil texture and structure. Alternatively plastic mulch may also be used. **Weeds** rob the nutrients of the soil and hinder the availability of light to the main crop which should be removed immediately when these are seen. Pendimethalin (stomp) at the rate of 3 kg/ha mixed in water should be sprayed as pre-emergence sufficient to wet the upper surface of the soil. This will not allow any annual weed to germinate up to 75 days. If the herbicide is not used then regular hoeing for aeration is also required.

Regular **rouging** of diseased plants should be carried out to prevent further proliferation of the disease in the following crop.

5.2.2.5 Irrigation, Manures and Fertilizers

High moisture level in tulip planting (not water-logging) encourages faster flowering with increased flower size and stem length, hence adequate water supply is necessary during the entire growing season. Water deficiency causes poor growth with reduced leaf area and other vegetative growth, reduced flowering with short scape and reduced flower size, and reduced bulb yield. Delayed irrigations reduce the number of bulbs showing the flower bud differentiation. High salt levels in irrigation water also reduce yield and cause symptoms akin to drought, as well as early senescence. Tulips tolerate up to 130 ppm of chloride ions during the whole growing season.

In a balanced soil, there should not be less than 3 % of organic matter. Organic matter in the form of farmyard manure, poultry manure or compost should be incorporated in the soil at the time of soil preparation at the rate of 30-50 tonnes/ ha which apart from providing essential nutrients, will also improve texture and structure *vis-à-vis* water holding capacity of the soil. Only through soil analysis, recommendations for inorganic fertilizers for tulip crop may be advocated. However, up to 180 kg/ha **nitrogen** is safe to increase the number of quality flowers and without affecting bulb yield and number. Half of the nitrogen can be applied at the time of third ploughing and the remaining half when inflorescences are to appear. Nitrogen increase in the aerial parts is observed up to peak of flowering but afterwards it translocates in the bulbs, which if analysed after lifting, show 1-2 % of the dry weight, which is indicative of good plant and flower quality in the following season. **Phosphorus** deficiency causes little leaf and reduces weight of the daughter bulbs. Phosphorus (P_2O_5) as well as potassium (only in deficient soils) at the rate of 120 kg/ha each should also be incorporated in the soil at the time of land preparation. Smaller bulbs respond well to P and K application even in excess, than the large bulbs. **Potassium** fertilizers may also induce magnesium deficiency. Leaf paling may be caused due to **Mg** deficiency. Mg should be used only when soil pH is more than 5.8 and soil concentration is less than 30 ppm. The mobility of **Ca** in tulip plants is very low, neither it translocates from the leaves to bulbs nor from roots to bulbs. However, Ca $(NO_3)_2$ decreases flower abortion and topple, and increases flower size and fresh weight. It can be applied in the soil at the rate of 100 kg/ha at the time of preparation of land. **Boron** deficiency causes reduced root growth and bulb weight, short scapes, stem cracking, flower splitting, rough stem base and fading of flower colour. Pre-planting dipping of bulbs in B + Mo + Zn + Cu induces earlier emergence with more vigour.

5.2.2.6 Growth, Development and Flowering

The bulb of tulip has an annual replacement cycle, broadly divided under three phases, *viz.* i) rapid root growth after planting in October though a very slow aerial growth due to a very cold temperature, ii) active plant growth at the rise of temperature in March when scape and floral-buds elongate rapidly and lead to flowering as well as elongation of vegetative buds in the scale axils to form daughter bulbs (outer scale axillary bud is visible in February but the enlargement process is slow than central vegetative bud initiating in July along with the flower bud initiation), more prominently after the flowering, and shrivelling and disappearance of the mother bulb scales, and iii) in summer when aerial plant parts senesce and daughter bulb enlargement ceases, an apparent state of dormancy though inside the daughter bulb an active vegetative and floral bud differentiation is going on, and on the basal plate root initials are also formed. In a flowering size bulb, daughter bulb enlargement coincides with flower bud initiation in May and is over by August in storage. Though outermost axillary buds are older than the central (innermost) but the development in the central bud is very rapid which differentiates a higher number of scale primordia *i.e.* 5-6 by the end of October while smaller bulbs produce only fewer scales.

Small non-flowering bulbs produce only one leaf while flowering bulbs two or more. Outermost bud inside the tunic is larger than other axillary buds except central, and it can produce a leaf and even a flower bud.

Under warm temperature, the flower initiation in dormant bulbs occurs faster but after differentiation of the flower buds they are cold treated, that is why either for natural season flowering or for forcing, the bulbs are usually held in dry storage for 3-4 weeks at 20°C in well aerated 5-8 cm deep trays, which promotes the initiation of leaf primordia followed by flower bud initiation, and then the temperature is reduced to 8-10°C (pre-cooling) for 6-8 weeks to satisfy part of the bulbs cool temperature requirement and to promote rapid flower bud development after planting.

5.2.2.7 Flower Forcing

Many varieties of tulips are programmed for early flowering (forcing), some as potted tulips and others as cut flower tulips. For convenience, it should be understood that forcing has three phases: i) the production phase, ii) the programming phase *i.e.* control of floral and root organogenesis [(differentiation of flower buds and the roots at warm-cool temperatures, and scape elongation) and floral maturation (induction of growth processes at low temperatures)], and iii) the greenhouse phase i.e. when a very active plant growth takes place. The objective of the forcing is obtained by shortening the duration of the natural growth and development cycle. Pre-cooling of bulbs at 8-10°C for 6-8 weeks, the bulbs may immediately be planted in flats which are placed in cold frames or cool position for a further 4-6 weeks or until the leaf growth is seen, and this period encourages root growth, a prerequisite for successful forcing. If temperature during rooting period is too high or rooting period is too short, stunted growth and delayed flowering occur and sometimes the bulbs may fail to produce flowers. When leaves are 3-5 cm tall, the flats should be shifted in a glasshouse where forcing temperatures can be controlled. The forcing temperature for the first two weeks should be kept at 10-12°C to avoid too rapid and soft growth, then followed with the normal forcing temperature of 16-20°C, depending upon the cultivar,

until the bud colour showing stage and then reduced to 13-16°C till full flowering. Lower temperature of 13°C results in delayed but better quality flowers while warm temperature of 18°C hastens flowering but with soft stems. Every 2.5°C increase in temperature after rooting period, one week advanced flowering is observed. Slightly early lifting of bulbs, then storing at 34°C for one week, followed by normal 20°C, and then 8-10°C results in 7-10 days earlier flowering than bulbs stored at 20°C and 8-10°C only. Higher temperature than optimum may kill the initiating flower bud. Direct planting in the field or in the glasshouse beds or flats after 9-12 weeks of pre-cooling at 5°C, quality cut flowers are produced. Cold treatment is given to dry stored bulbs and also to planted bulbs. Standard forcing is when the bulbs, with or without pre-cooling, are planted and given a further cold treatment while direct forcing is when the dry stored bulbs receive the total cold treatment at 5°C or special pre-cooling. In standard forcing, rooting takes place and scape growth begins during low temperatures of the programming phase while greenhouse phase is very short *i.e.* 3-4 weeks only, whereas direct (special) pre-cooling has a long greenhouse phase (at least 50 days) but requires less space for bulb programming. Forced bulbs should not be forced in succession for many years, as for vegetative growth and development growing conditions are not congenial under the forcing environments i.e. temperature, so bulbs once forced should either be replanted in the field to recover or discarded.

Bulbs after lifting, can be **retarded** by storing at 23°C until mid-September, followed by 20°C until mid-October, and then at 17°C until pre-cooled, and then at 5 or 9°C for about four weeks, and then finally at -2°C starting in December, after removing the tunic. This low temperature is given either to bulbs planted and rooted at 9°C or to bulbs packed in moist peat but in both the cases, the boxes are wrapped in polythene paper to avoid desiccation. In comparison to freezing non-planted bulbs, freezing rooted bulbs generally leads to a better quality of the flowers.

5.2.2.8 Harvesting of Flowers and Post Harvest Technology

Flowers are harvested when the petal's colour intensity and development are half complete *i.e.* before one or two days of opening, depending on the market destination and requirements. While cutting, wrapper leaf should not be disturbed and left intact on the bulb. The vase life of tulip cut flower is 4-11 days at 16°C and from three to more than six days at 23.5°C, depending on the cultivar and prevailing weather conditions. Cut flowers can be stored for short periods of time *i.e.* 5 days either in water or wrapped dry in airtight containers or in polyethylene sleeves at 0-1°C. However, for longer storage *i.e.* up to 14 days, they are kept upright with the bulb attached to the scape, though longer storage is, at all, not encouraged. Distilled water, by all means, is better in vase. However, 8-HQC 200 ppm + sucrose 4 % with GA_3 and ethephon in the vase solution is quite good for better display life in vases. $AgNO_3$ 25 ppm + sucrose 1.5% also improve the vase life.

Potted tulips are marketed when the buds have just started showing colour, and at this stage it has 14-17 days display life. If it is removed from the greenhouse at the green bud stage, it can be stored for up to four weeks at 0-1°C but plants require to be treated with maneb or zineb at 0.2 % + bavistin (benomyl) as a protection against *Botrytis* infection in the store room.

5.2.2.9 Lifting of Bulbs and Storage

Forced bulbs are normally not used again and destroyed, but if necessary, these can be used only as planting stock. Field grown planting stock bulbs are harvested after the foliage has senesced. The bulbs which were planted for cut flower use or garden display, while cutting the flowers the wrapper leaf should have been left on the plant for further development of the bulbs. After leaf senescence, these bulbs are also harvested. Each plant may have a cluster of 4-5 bulbs (at the most up to 7) which are collected, separated, cleaned, graded into flowering and non-flowering size and then stored under dry and airy condition at 18-20°C. They should also be treated with some aphicide or placed with fumigant such as dichlorvos strips to have effective aphid control in the store.

After lifting of the bulbs and during dry storage, the process of differentiation of flowers, vegetative buds and roots occur. Storage temperatures influence all these processes and their subsequent development. The apex of a flowering size bulb is usually vegetative at lifting. Non-flowering size bulbs (just smaller than flowering size) which normally do not flower under ordinary conditions, if immediately after lifting are stored at 30°C for several weeks, often they become capable to initiate flower. Flower bud differentiation is quickest at 17-20°C as compared to its higher (even up to 35°C) or as lower as 1.5°C. A short duration temperature of 30-35°C, followed by 15-20°C induces earlier flower bud differentiation and rooting, and if once organogenesis has occurred, it is obligatory to store the bulbs at low temperature in order to promote rapid plant growth after planting. However, the extension of higher temperature beyond a limit than specified to a particular variety will delay the flower bud formation significantly. High storage temperatures (25-30°C) promote more number of axillary buds in the bulbs by reducing the dominance of the central bud and by aborting a few axillary buds, than storing at lower temperature *i.e.* 13-17°C.

In storage, the bulbs with intact tunic will protect them from dehydration, but to avoid excess weight loss at least 70 % humidity should be maintained. More humidity will encourage the attack of certain storage fungi like *Botrytis, Fusarium and Penicillium;* however, for one week of storage at 30-35°C immediately after lifting, there should be a very high percentage of relative humidity *i.e.* 95 %.

5.2.2.10 Insect-Pests, Diseases and Physiological Disorders

Aphids [*Sappaphis* (*Dysaphis*) *tulipae*] of greyish to puce-coloured are found on the bulb itself which can either be controlled through nicotine or through fumigation. This aphid also infests the standing crop along with the **potato aphid** (*Macrosiphum euphorbiae*) which can also be controlled through spraying nicotine or Malathion. **Tulip gall mites** (*Acaria tulipae*) creating problems in stores are controlled through monthly fogging the store with primophos-methyl. Zinc phosphide can be used to control **rats** and **mice** burrowing the field of standing crop.

Stem and bulb nematode *(Ditylenchus dipsaci*) is of different race than the one attacks narcissi. This attacks the bulbs from the base and causes brown or yellow patches on the outermost scale near the base. Symptoms and control measures (except HWT) are the same as described under ***Narcissus* 2.2.3.**

Tulip fire (*Botrytis tulipae*) is the most common disease of tulips causing serious

loss of foliage which ultimately affects bulb yield, and at times pathogen also enters the bulbs. Shiny black sclerotia are formed in large numbers at the base of the scape and on the outer fleshy scales. The disease is favoured by humid conditions of the soil and air. During such weathers or when there is possibility of infection of this disease, zineb and maneb sprayings weekly in inclement weathers will keep this disease under check. **Grey bulb rot** (*Sclerotium tuliparum*) is a soil-borne disease of tulips causing bulb rot. Infected plants should be burnt or buried and field should be kept clean of debris. Regular sprayings with 0.2 % bavistin (benomyl) alternate with 0.2 % captan fortnightly to the standing crop from sprouting until leaf senescence will prove very effective in keeping almost all the fungal diseases under check. **Storage rot** (*Penicillium hirsutum*) causing basal plate rot or other part of the bulb where injury has been caused, *Fusarium oxysporum* f. sp. *tulipae* which apart from causing storage rot under bad ventilation, infects even bulbs in the field through the wounds inflicted on them, and *Rhizoctonia solani* infects bulbs stored at 5ºC and under field conditions where leaves yellow and often have a dead streak along the whole length of the blade, and bulbs on lifting are misshapen and show brown concentric rings in cross section) can be minimised by improving storage conditions, following proper spraying schedule in the standing crop, and the bulb treatment with captan before storage. **Grey brown rot** (*Rhizoctonia tuliparum*) is a serious soil-borne disease which can be controlled by following proper crop rotation, burning of diseased bulbs and by following proper schedule of spraying in the standing crop as advocated for controlling 'grey bulb rot'. **Root rot** (*Pythium irregulare, P. spinosum* and *P. ultimum* var. *ultimum*) causes root decaying more prominently in forced tulips, *P. ultimum* being the most devastating. *Pseudomonas* spp. controls the disease.

Viruses {soil-borne viruses are tobacco necrosis virus (**TNV**) and tobacco ringspot virus (**TRSV**)}, and aphid-borne viruses are tulip breaking virus (**TBV**), cucumber mosaic virus (**CMV**) and lily symptomless virus (**LSV**)} sometimes become serious in tulip plantings therefore regular rouging should be carried out and infected plants should be burnt. Moreover, through spraying with nicotine also will control the viruses by controlling the vector, i.e. aphid.

Flower abortion or **blasting** and **stem topple** are the two major physiological disorders observed in tulip plantings. Abortion is caused due to: i) insufficient state of physiological maturity of the bulbs when they are placed at low temperatures, ii) placed at low temperatures when their flower buds and/or roots are not properly differentiated, iii) when low temperature is given for longer duration, iv) when there are root related problems at planting viz. bruised or broken roots, insufficient due to high soil temperature at planting, delayed planting, infected roots, insufficient soil moisture at planting, high soil salinity, excessive watering and soil compaction, etc., v) when daughter bulbs are developed on the cost of flower scape elongation, before rooting, vi) when during plant growth, the water supply is inadequate and/or temperature is not commensurate to the requirement for a normal stem elongation, vii) when in September, their storage temperature is too high i.e. 25-30°C, viii) when they are exposed to ethylene concentration as low as 0.1 ppm either during storage or in the soil, ix) when the bulbs did not receive optimal ventilation conditions for extended periods, and when nitrogen and calcium content of the bulbs is improper at the time of bulb enlargement. Bud abortion to a great level can be prevented by meeting all the above cited requirements. Apart from these, ethylene build up

in storage and during transit should be controlled by providing proper ventilation and by destroying all the *Fusarium* infected bulbs during storage and before planting as they also produce ethylene. Moreover, for forcing only large size (>12 cm circumference) bulbs should be planted. Stem topple disorder (also called as 'sugar stem', 'leatherneck' and 'wet stem') affects the flower scape and those leaves whose epidermal cell layers have burst. It may occur within 10 days *i.e.* 5-7 days before or 2-3 days after flowering. This happens due to localized Ca deficiency in the area of the toppling. A very rapid scape elongation due to higher forcing temperatures, or very low forcing temperatures and a very high relative humidity preventing transpiration, thereby creates problem in Ca migration. Varietal difference is observed as 'Halcro', 'Kings blood', 'Mrs. J.T. Scheepers', 'Paul Richter', and 'Renown' are highly susceptible to stem topple.

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 symptoms and control of '**tulip fire'** disease.

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5.3 LET US SUM UP

In this unit, we have studied *Polianthes* and *Tulipa,* both 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.

5.4 KEY WORDS

Bulbils, bulblets, bulbs, diseases, dormancy, flower forcing, holding solution, insect-pests, pulsing, physiological disorders, programming, senescence, storage of bulbs.

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5.6 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1) The common varieties of tuberose are: The singles being 'Hyderabad Single', 'Mexican Single'(Calcutta Single), 'Phule Rajani', 'Prajwal', 'Rajat Rekha', 'Shringar' and 'Sikkim Selection' while doubles are 'Suvasini', 'Swarna Rekha', 'The Pearl' (Calcutta Double), and 'Vaibhav'.

Check Your Progress Exercise 2

1) **Tulip fire** (*Botrytis tulipae*) is the most common disease of tulips causing serious loss of foliage which ultimately affects bulb yield, and at times pathogen also enters the bulbs. Shiny black sclerotia are formed in large numbers at the base of the scape and on the outer fleshy scales. The disease is favoured by humid conditions of the soil and air. During such weathers or when there is possibility of infection of this disease, Mencozeb or Bevistan sprayings weekly in inclement weathers will keep it under check.

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