UNIT 4 *ALSTROEMERIA* AND *GLADIOLUS*

Structure

4.0 OBJECTIVES

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

- define rhizomatous and cormous geophytes and distinguish them from other bulbs,
- classify it and will be able to know the important species & commercial varieties,
- know dormancy in rhizomes and corms, its storage and various methods of propagation,
- explain the soil and nutritional requirements and other cultural practices,
- know various factors responsible for its growth, development and flowering,
- describe harvesting of rhizomes, corms and flower and their various post harvest techniques, and
- know various insect-pests and diseases attacking both the crops and shall be able to overcome them.

4.1 INTRODUCTION

Rhizome is usually a thickened horizontally wandering (creeping) underground or soil-surface organ (stem), often spreading widely. It typically has nodes and internodes, with shoots and roots arising from the apex and from adventitious buds, apices (ends) being swollen. On planting the upper part produces the shoots and flowers and the underside the roots, but both arising from the apices. The rhizomes enlarge through their apices and the oldest parts eventually become exhausted as is evident through the clothing with the remnants of enveloping leaf bases. Plants like bearded irises have swollen rhizomes growing on ground surface, some have similar roots growing below ground such as *Hedychium* and *Zantedeschia* while others such as *Anemone nemorosa* are more slender and live below the surface. Asparagus and paeonies produce 'crown' rhizomes which increase in size annually but produce very little extension growth.

A **corm** is a modified condensed stem being formed from the thickened underground base of a stem, orienting in vertical fashion and having shredded tunic around as remnant of the previous year's leaf bases. The normal shape is rounded, flattened on top and a bit concave at the bottom where basal disc is located which produces the annual filiform roots and on the top young buds are found, often forming flowering shoots with lateral buds arising between the segments or nodes forming two opposite rows down the corm. In the process of the formation of the new corm at the base of the new plant being formed on the top of the mother corm, the old corm is fully used up. On the basal plate, stolons are formed on which **cormlets** (**cormels**) arise which are also as senile as the corms. Cormlets are also often produced freely from the base or top of the corm or even in the leaf axils. In certain cormous species, in the axils of the inflorescence, small corms are formed which are in fact **cormules** as in case of certain gladiolus cultivars. These are normally bigger than cormels and have often shredded tunic. The examples are *Crocus, Freesia, Gladiolus, Homoglossum, Watsonia,* etc.

Hereunder *Alstremeria* under rhizomatous and *Gladiolus* under cormous ornamentals are being described in detail.

4.2 *ALSTROEMERIA* AND *GLADIOLUS*

4.2.1 *Alstroemeria* (family Alstroemeriaceae)

(Common names **Inca lily** and **Peruvian lily)**

4.2.1.1 Classification, Species and Varieties

Alstroemeria is of recent introduction into India, so it is yet to make a mark in Indian market. It produces beautifully marked flowers, the hardier species being suited to the herbaceous border and the more tender species for pot cultivation in the cool greenhouse or conservatory. The colour of the flower is white to dark yellow, pink, violet, purple and red. Yellow throat and black dots at the base of the throat and petals make them very attractive. Under protected condition they are grown for cut flowers. It is a crop of the temperate and sub-temperate regions, particularly the higher reaches of the Western Ghats, the Nilgiri hills (Ootacamund and Kodaikanal), higher altitudes of North-East Hill regions, Darjeeling hills of

West Bengal, the higher reaches in Orissa i.e. Koraput regions, Mt. Abu in Rajasthan, upper part of Uttarakhand, and from 1,000-2,000 metres height of Himachal Pradesh and Jammu & Kashmir.

There are about 50 known species of *Alstroemeria* which can be classified into two groups: i) **orchid types**, are developed by using two Chilean species, one of them being *Alstroemeria aurea,* are characterized by tall growing habits (2.5-3.0 metres), produce a large number of flowers in a short duration (3-5 months in spring) after passing through a 10-15°C winter growing temperature but no flowering in summer (when these remain vegetative and are divided for next spring flowering) and other months and have little or no photoperiodic responsiveness, and ii) **butterfly types,** are hybrids of Chilean and Brazilian species, which are characterized by shorter growing habits (good for pot plant production and also for cut flowers) with larger and more open flowers and a different foliage arrangement, where flowering is induced and maintained at 13-16°C temperature and long photoperiods for 9-12 months each year depending upon the cultivar and environmental conditions. These can be planted in any month, but summer planting is best, and when the plants are given long photoperiods, high light intensities and cool temperatures, these flower within 3-4 months.

The most common **species** are: *Alstroemeria aurea* (syn. *A. aurantiaca*) with yellow, orange or deep orange-red flowers, growing to a height of 90 cm and has cultivars like 'Angustifolia', 'Dover Orange', 'Flava', 'Lutea', 'Major'; 'Moerheim's Orange', 'Rubra' and 'Splendors'; *A. brasiliensis* with reddish-yellow flowers having brown spots, and height 90 cm; *A. caryophyllaea* with sepals and lower petals rose while upper petal white in the centre, fragrant and grows to a height of 45 cm; *A. chilensis* with pink to blood-red flowers, and height 60-90 cm; *A. haemantha* (syn. *A. simsii*) having red flowers with yellow streaks, and 75-90 cm in height, and the 'Roseae' is a listed cultivar; *A. hookeri* with pink flowers, 15 cm in height, and summer and early autumn flowering; *A. ligtu* itself a good cut flower species, flower colour pastel in shades of light yellow, pink, red, ivory, and peach and grows to a 40 cm height; *A. pelegrina* bears largest flowers with rose to lilac to yellow and outer petals have large green point while upper inner petals have yellow centre and maroon flecks throughout, and height 30-35 cm; *A. psittacina* (syn. *A. pulchella*) has dark red flowers, tipped green and spotted brown, and height 90 cm; *A. pulchra* (syn. *A. tricolor*) has white to light grayish pink or soft lilac flowers with yellow, red or purple blotches, and height 45 cm; *A. versicolor* which resembles *A. psittacinus* but smaller, flowers yellow or orange, flecked purple and height 20-60 cm; and *A. violacea* with large lavender flowers, two upper petals with yellow centre, flecked dark purple throughout and the height is up to 70 cm. The other **varieties** are:

White : Alaska, Amanda, Apollo, Bianca, Ice Cream, Friendship, Labelle, Casablanca, Maria, Mona Lisa, Nevada, Snow Flake, Snow Queen, Paloma, White Dream, White Swan, etc.

Yellow : Barcelona, Bolivia, Butterscotch, Canaria, Eleanor, La Paz, Minas, Moonshine, Rio, Yellow Crown, Yellow King, Yellow Libelle, etc.

Orange/salmon : Bogota, Comet, Delight, Diana, Flaming Star, Helios, Orange, Monarch, Valiant, Victoria, etc.

Pink : Cinderella, Carola, Elisabeth, Fanfare, Fiona, Leticia, Lorena, Marie, Pink Jewel, Olivia, Pink Triumph, Rose Marie, Rosita, Samora, Serena, Veronica, etc.

Red : Carmen, King Cardinal, Liliana, Marina, Parade, Sangria, Tiara, Vanitas, Wilhelmina, etc.

Lavender : Alicia, etc.

Purple/lilac : Azula, Barbara, Bingo, Bonito, Brocado, Ice Cream, Jubilee, Jupiter, etc.

4.2.1.2 Propagation

Alstroemeria plants consist of a sympodial, fleshy, multistemmed rhizome from which shoots and roots (fibrous) arise, and with the development of the plant this becomes thickened storage roots and is called as 'radices medullosae'. These are white, fleshy, very brittle and densely haired below. As per the environmental conditions, the shoot can be reproductive or vegetative. These **rhizomes** are divided continuously at every 10-12 weeks which cause them to remain vegetative to make the division efficient or these should be divided during dormancy i.e. when they have stopped flowering. The dormant rootstocks should be removed gently and with care as this is a complex mass of storage roots, fibrous roots and rhizomes. The division is made with as much storage and supporting material as possible, kept moist and replanted immediately. For the first nine months the growth is slow but afterwards these may be left in place for several years. While making the division care should be taken that each division contains at least three vegetative shoots. Until the emergence of the new shoot, the growth is subterranean and aerial shoots emerge from a sympodially branching rhizome as well as also from axillary buds located at the base of these shoots, and these buds can develop into rhizomes. Through division, the rate of rhizome multiplication is not rapid; hence **micropropagation** is adopted for commercial cultivation through which 4-7 fold increase in plants can occur every four weeks which will also have an additional advantage of getting material free from viruses and other diseases. For this modified MS medium with 30 g sucrose, 1-5 mg benzylaminopurine, 0.01 mg NAA and 1.2 g Gel Groper litre of medium are added. High levels of cytokinin which hastens vegetative production can also cause *in vitro* mutation.

Propagation through **seeds** causes genetic variability hence growers should not opt for this system. However, one year old seeds will germinate within 8-10 weeks if are subjected to four week's moist and warm (18-25°C) environment, followed by four weeks of moist and cool (7°C) conditions. Fresh seeds will germinate *in vitro* at 18°C within 10-14 days.

4.2.1.3 Climate

It prefer cooler climate and therefore crop is successfully grown at hills.

4.2.1.4 Soils, Preparation of Land, Planting and Weed Control

Alstroemeria can be grown in a variety of **soils** which is loose, well-drained, pH 5.5 to 7.0, and rich in organic matter i.e. to a tune of 3 %. A sandy loam soil with adequate humus is ideal for its growing. It likes cool sub-tropical climatic conditions (15-22°C, 22-35°C being only in summer i.e. sometimes in May -

June) but where summers are not to the extremes, as a very hot persisting condition coupled with dry spell kills it. For their growing, alstroemerias require full light while plants are shaded only to maintain a temperature range of 13-17°C, which is optimum for their growing. Since it perennates for several years after planting once, it would be better to have a deep and rich soil for its growing so that it may sustain producing quality blooms season after season, at least for 3-4 years. For **preparation of land**, the soil should be worked into 40 cm depth 2-3 times with cultivators followed by leveling each time, the rootstocks of perennial weeds including the rhizomes of the nut-grass should thoroughly be taken out with fork or through hands, and then finally leveled and beds are prepared. It would be better if the bed size is sufficiently lengthy but the width may be restricted to two metres to facilitate proper field operations through the clearance left in between the beds. The soil should have sufficient moisture at the time of planting, and the **planting** is done 10-15 cm deep in sandy-loam soil but shallower in heavy soils with a precaution that growing points should not be, in any case, more than 10 cm deep or appropriately to 5-7 cm only, and 45-60 cm apart, depending on the cultivars and the cropping years. The rhizomes are divided and planted at the time when these have finished the flowering, and this may either be after spring or in November looking into the type of cultivars being grown, or at any time as per convenience of the grower but avoiding the peak flowering period. At this time support lines of galvanized or plastic wire are also set up with 20 x 15 or 20 x 20 openings, first two layers at every 20-30 cm above the soil line and subsequent at 50 cm in height. For small plantings, bamboo or *Salix* sticks or string support may be opted. **Pinching** and **disbudding** are normally not required but since a majority of stems that emerge are vegetative so these are removed regularly to maintain production and to stimulate axillary shoot elongation. Older shoots and weak and short stemmed shoots which are not dark green are also thinned out. Depending on the cultivar, the cycles of tall shoots (up to 1.5 m) and thin and short shoots (too short for commercial sale) develop. The tall ones should be cut to the marketing length and remaining stems are left intact for carbohydrate synthesis to help prevent the cycle of short stems. During the next routine thinning (pulling of the stems gently from the rhizomes which have a natural abscission layer at the point of shoot attachment and not by cutting) or when leaf senescence has commenced the flower heads of the short stems are sacrificed, again leaving the shoot for carbohydrate synthesis. Thinning stimulates rhizome branching. In 'orchid-types', flowering is over by the end of summer, so the plants are headed back in July-September, and in winter the thinning may continue by removing 15-25 % of the vegetative shoots until commencement of flowering. 'Butterfly types' are thinned out each month to a tune of 15-25 % during autumn and winter months, till commencement of flowering. In spring or summer plantings, some 10 stems per plant are pinched to build up the crop, and later in the winter these pinched stems are pulled out. Planting in spring and summer produces flowers within 10-12 weeks.

For **potted plants,** rhizomes are planted shallower with growing points 2.5-3.0 cm from the surface which will permit more branching as compared to deep planting. For 6-8 weeks of planting, the newly planted rhizomes should not receive long days of 13-16 hours so that sufficient root system is developed before flower induction, and when planting liners directly in pots, the vegetative shoots arising from the liners should not be cut back as this will delay flowering by 2-3 weeks. To get quick flower production, liners of rhizomes are planted directly in their final pots. When *Alstroemeria* is forced as potted plant, the height control becomes

a major concern. Though many of the retardants fail to express any good effect but damidazide at 200-2,500 ppm exerts favourable effects. For pots, in fact, only genetically dwarf cultivars should be planted where there may not be any need of applying retardants. The standard pot size is 15-18 cm so that developing roots may not face any problem. These plants flower within 90-120 days.

In small holdings, **weeding** is carried out manually but in large holdings, it is done through an effective weedicide. Decamba as a pre-emergence is quite effective weed-killer with no any adverse effects.

4.2.1.5 Irrigation, Manures and Fertilizers

Alstroemeria do not like wet feet. Too much water encourages root rot, especially when the plants are initially planted. In poorly drained soils this crop does not come up well though it requires moist and cool situation. It would be better if this crop is being provided with peripheral system of irrigation with spray nozzles pointed into the centre of the beds or with trickle tubes down the centre of the bed. Frequent but semi-heavy irrigation is required for *Alstroemeria* crop. It is sensitive to salts. Water EC should not be more than 1.3 ds/m and soluble salt (especially Na and Cl) contents not more than 1.2-1.5 mmho/cm.

Farmyard manure or compost at the rate of 50-60 tonnes/ha should be incorporated in the soil thoroughly at the time of land preparation. Since it is grown necessarily as perennial cropping, hence fertigation will be more effective system of fertilization, but before applying any fertilizer to the crop, the optimum quantity of each and every nutrient should be calculated on the basis of soil and leaf analysis. In usual cases, 200-400 ppm N through calcium and potassium nitrate should be applied. Nitrogen has been found to increase flower production and hastens flowering.

4.2.1.6 Growth, Development, Flowering and Flower Forcing

The flowering in *Alstroemeria* is controlled by the temperature of the rhizome getting from the medium or soil and if the temperature of the medium is maintained at 16°C the flowering duration is extended, irrespective of the temperature in the atmosphere. For forcing, they are kept for six weeks at 5°C and then continuously at 13°C. Also forcing from 9-13°C and then continuously up to 17°C produce flowering shoots while at 21°C the rhizomes are devernalized and only vegetative shoots are produced. Greenhouse temperature is maintained at 16-18°C during the day and 10-13°C during night. During the summer mulches in the greenhouse are used with intermittent misting so that through evaporation the medium may remain cool. Incandescent lighting for natural day + day continuation (or night interruption) for 14-16 hours induces earlier flowering but this treatment from April to September results in reduced flower production. Short days delay the flowering with reduced flower production.

4.2.1.7 Flower Harvesting and Post Harvest Technology

Leaf chlorosis, loss of leaf turgidity, flower desiccation and petal shedding are the problems associated with the *Alstroemeria* cut flowers. *Alstroemeria* flowers are harvested when the first florets on the cyme are opening or are fully opened but while transporting to long distances open flowers are not preferred because of the obvious reasons. The flowers are harvested by gentle pulling of the stems

from the rhizome which has natural abscission layer at the point of shoot attachment, and not by cutting but while putting the cut ends in water or vase solution the white portion of the cut ends are removed otherwise the stems will not absorb the solution and collapse. Water absorption is optimum when stems are cut at tepal reflexing stage and are placed in high quality water after removing the white portion at the cut end. Leaves are also stripped from the lower portion of the stem. Thick and taller stems are preferred over weak and smaller ones. Class A stems are 80 cm long, turgid and thick while class B stems have 60-70 cm length, each having three are more trusses of flowers. If the stems are removed from the plant prematurely, there is a problem in opening of the flowers in the cyme as well as pigment development on the petals is also hampered, even after putting such flowers in the vase solution.

Sucrose, 8-HQC and GA_3 in vase solution at pH 3.5 increase the cut flower life. Stems pretreated (pulsed) in silver thiosulphate (STS) 4mM and sucrose 200 g/l solution from 12- 24 hours prolongs the vase life for about four days and decreases flower abscission, and this can also be stored up to two weeks in water at 2-4°C as this reduces ethylene production. STS treated stems should be kept in high quality water before being transported. Leaf chlorosis can also be reduced by using cytokinin and GA_3 (1×10^{-4} M. Since the exudes from the injured portion of *Alstroemeria* cause dermatitis hence while harvesting the flowers, gloves should be used. While transporting, 10 stems are bunched together with bottom leaves up to 10-15 cm removed, then packed in plastic sleeves. Before packing, these are stored at 5-7°C.

4.2.1.8 Lifting of Rhizomes and Storage

Since growing of the *Alstroemeria* is a continuous process and for propagation or for further cropping these are lifted from the soil, divided and planted when flowering in the crop is over. Even these can be lifted and planted throughout the year. However, if by any means field is to be vacated or for marketing or for self growing the bare rooted rhizomes may also be stored though bare rooted storage is not as ideal as in peat moss. The rhizomes can be stored for several months at moderately moist condition at 1-3°C. Thick grade vermiculite and peat moss are ideal to maintain optimum moisture level. Any other light and well-drained compound is also suitable for its storage. The rhizomes can also be wrapped in plastic but this also requires regular checking as rhizomes will spoil under too wet condition for long periods. The moisture level of the stored rhizomes is regularly monitored to ensure that the rhizomes do not dry out or become too wet as both these conditions will spoil them. Under wet condition prevailing for long, root rot may occur. Root development continues during storage.

4.2.1.9 Insect-Pests, Diseases and Physiological Disorders

Leaf aphid deforms the leaves and shoot, and with increase of temperature this becomes very active and builds up the population rapidly. First this attacks the young leaves, and then the flowers when emerge. **Thrips** also feed on the tender part of the plant, especially the young leaves and flowers and the shoot tops are crumpled, and flowers malformed and streaked. **Leaf miners** also damage the crop, adults leave a trail of white dots on the young foliage and the larvae tunnel the foliage irregularly. **Caterpillars** are normally active during summers and autumn and feed on whole plant, first eating the leaves and flowers and then after stems also. Aphids can be controlled through spraying with nicotine sulphate,

thrips with 0.1 % spraying of methyl parathion and caterpillars through 0.2 % spraying of methyl parathion or rogor. Leaf miners are controlled with 0.1 % spraying of vertimec at 5 days intervals. **Red spider mites** attack the plants that are under shaded location and are left uncared. They feed on the underside of the leaves by positioning themselves in the plant cells and suck them until the cells are empty. Their presence may be noticed through the small webs these have made. In their serious attack, foliage turns yellow and ultimately plant dies. Vertimec (abamectine) at 0.1 % sprays at 10 days interval will control the mites. When the crop is being grown close to some marshy places or when humid weather is persisting or if field is not clean, **slugs** and **snails** attack the crop from the underside of leaves during the dark or in nights and batter whole of the plant. Adult females lay its eggs in the soil which hatch and start feeding on the crops. These can be controlled through metaldehyde pellets. **Nematodes** (*Pratylenchus penetrans* and *P. bolivianus*) attack roots and cause root red spots or lesions on roots, stunting and premature yellowing of foliage. Use of soil fumigation, HWT with formaldehyde or soil application of furadan will control the nematodes.

Alstroemerias have relatively only a few disease problems. However, these do have *Pythium* and *Rhizoctonia* root rot problems but if newly planted rhizome divisions are drenched with captan or thiride along with good sanitation of the field, no such problems shall be encountered. These fungi develop under warm humid conditions and stems show rotting just at the soil level. *Botrytis* infects during cool weathers under high humidity conditions and due to overcrowding of the crop which hinders aeration in between the plants. The stubble of the crop also encourages its infection and the disease can attack even the flowers. A great many viruses attack *Alstroemeria,* out of which 'tomato spotted wilt virus' (TSWV) is most devastating and kills the plants. Virus infected plants should be rogued out and burnt.

Abortion or blasting of flowers occurs during periods of low irradiance or when roots are damaged due to excessive watering or water-logging or due to excessive salts in the soil. In this case fully developed buds senesce before opening.

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) Define rhizome.

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2) What are the regions in the country where alstroemerias can be grown?

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4.2.2 *Gladiolus* (family - Iridaceae)

(Common names **Sword lily** and **Gladiolus,** pl. **Gladioli**)

4.2.2.1 Classification, Species and Varieties

Gladiolus is a most popular commercial geophyte in India. Its magnificent inflorescence with variety of colours has made it most attractive for use in herbaceous borders, beddings, rockeries, pots and for cut flowers. Its spike lasts for 10-15 days in vase in winters and 7-10 days during summers.

It lacks universal synchrony for its florist's classification. Europeans and Asians classify them on the basis of flower size *viz.* **i)** '**grandiflorus**' (large or exhibition type) which grows to a height of 90-150 cm with strong and erect stalks, bearing 14-20 cm closely arranged, triangular and symmetrical flowers, but coming up late in the season, **ii)** '**primulinus**', which are free-flowering and daintier than the grandiflorus, growing to a height of one metre, bearing flowers 5-10 cm across with mostly hooded florets of soft colours, and blooming normally in the mid-season, **iii)** '**butterflys**', which are up to 1.25 metre, bearing medium sized flowers spaced closely and marked with attractive blotches and throat markings, and **iv)** '**miniature**' ('**pixiola**'), growing to a height of 75-90 cm with flowers measuring 5-7.5 cm across, similar in arrangements to the 'prims' but frequently ruffled, but flowering early. Australians classify these into formals, informals, intermediates and miniatures, whereas New Zealanders follow both the systems. American system is universal in application as it is more scientific and comprehensive, and it is a 3-digit system, first digit (from 1 to 5) representing floret size, second (0 to 9) the basic hue or colour, and the third (0 to 9) represents the depth of colour. Under the first digit, 1 (100) stands for smallest size of the flower *i.e.* below 6.4 cm (miniature), 200 for 6.4-8.9 cm (small), 300 for 8.9-11.4 cm (decorative), 400 for 11.4-14.0 cm (large) and the 500 for largest size *i.e.* >14 cm floret diameter (giant). Regarding the second and third digits, as white does not fit anywhere hence is placed first as 00 (pure white) or 01 (white with markings). There is no pure green and blues, hence no number has been assigned to them, however, the depth of greenness is defined on the basic colour of 0, *i.e.* 02 light green), 04 (medium green), etc. Other numbers are 1 for yellow, 2 for orange, 3 for salmon, 4 for pink, 5 for red, 6 for rose, 7 for lavender, 8 for violet (no blue) and 9 for tan, and 9-9 odd numbers standing for conspicuous markings. For example, '498 Brown Orchid' Baxter, 64 means the cv. Brown Orchid is of large size (11.4 to 14.0 cm floret size) having inconspicuous deep smoky colouring of the flowers, mostly towards the brown type, and was developed by Baxter in 1964. Europeans use prefatory letters P (Primulinus), B (Butterfly), or FU (Face-ups), and suffix letters E (early), M (mid-season), L (late) and V (very for extremes).

There are more than 30,000 cultivars in gladiolus, and about 200 new ones are added in the list and the same number is being dropped every year due to infection of various diseases. U.S.A., Canada, England, the Netherlands, Australia, Russia, Slovakia, Poland, France, India, New Zealand and Japan are the countries where gladiolus breeding work is going on. Some of the promising varieties are mentioned below:

White : Bush Ballad, Cotton Blossom, Dream Girl, Gambier Pearl, Marjorie Ann, Moon Frost, Morning Bride, Simplicity, Snowdrop, Snow Dust, Snow

Princess, Super Star, White Enchantress, White Friendship, White Oak, White Wonder, etc.

Green : Armstrong, Green Bay, Green Bird, Green Giant, Green Woodpecker, Green Willow, Lemon Lime, etc.

Cream : Ariette, Bonnie, Classmate, Cream Topper, Dairy Queen, Dew Drop, Landmark, Pale Moon, Party Ruffles, etc.

Yellow : Aurora, Brightsides, Chinese Lantern, Fatima, Golden Harvest, Golden Peach, Junior Prom, Lemon Ruffles, Limelight, Morning Sun, Nugget, Royal Gold, etc.

Buff : Adventure, Apricot Delight, Apricot Lustre, Fashion, Happy Birthday, Honeycomb, Micado, Perky, Royal Buff, Royal Glimpse, Sundown, etc.

Orange : Autumn Glow, Coral Seas, Fiesta, Foxfire, Gypsy Dancer, Little Mo, Orange Beauty, Orange Chiffon, Setting Sun, Tangerine, etc.

Salmon : Atom, Big Daddy, Frilled Champion, Goliath, Heritage, Parade, Memento, Salmon Queen, Sister Fortuna, Sugar Babe, Summe4r Garden, Thunderbird, etc.

Pink : America, Dawn Pink, Dresden Doll, Enchantress, Flos Florium, Friendship, Howard, Legend, Marjayne, Miss America, Pink Formal, Pink Cheer, Pink Prospector, Pink Triumph, Powder Puff, Spic & Span, Vicki Lin, etc.

Red : Black Prince, Dixieland, Fatima, Music Man, Oscar, Red Bantam, Redeem, Sans Souci, Sassy Willie, Shirley Cole, The Barton, etc.

Rose : American Beauty, Ecstasy, Mexicali Rose, Patricia Jean, Royal Brocade, Upper Crust, etc.

Lavender and purple : All Aglow, Anniversary, Dawn Mist, Elegance, Lavender Masterpiece, Memorandum, Purple Giant, Purple Moth, Royal Ruffles, Shalimar, etc.

Violet : Angel Eyes, Blue Bird, Blue Isle, Blue Hawaii, Blue Mist, Blue Ruffles, China Blue, Her Majesty, Tropic Seas, etc.

Tan : Hastings, Little Fawn, Papoose, Table Talk, Tapestry, etc.

Smoky : Autumn Charm, Autumn Sensation, Aztec Chief, Blue Smoke, Misty Eyes, etc.

Brown : Brown Beauty, Chocolate Chip, Chocolate Dip, Chocolette, Mystic Glow, etc.

4.2.2.2 Propagation

Usually, gladioli are propagated through corms for **corms**, cormlets and spike production, through **cormlets (cormels)** for raising the flowering size rounded corms, and through **seeds** for evolution of new varieties. Corms have 2-3 prominent buds on the top and many ring-like nodes full of buds all around the body from the top to basal plate, each ring having one prominent bud but situated alternatively to each ring, covered with shredded tunics all around and a disc like root zone at the base. Corm develops at the base of flowering stem and on the top of the planted mother corm, and in the process of its formation; mother corm transmits its food reserves to these developing daughter corms and finally shrivels. The mother corm is thus replaced annually. Though mother corm

produces only feeding roots but new corm when start developing, starts sending out contractile roots which pull it deeper into the soil and for anchoring the plant. Generally daughter corms start forming in the fourth week of planting when formation of contractiles also coincides but stolon formation starts at a later date. These stolons are usually branched, and each branch at its tip bears the cormlets. If corms are harvested after six weeks of flowering when still the leaves are green, all the cormlets are securely attached with the daughter corms through the stolons which can be taken out along with the daughter corms, cleaned, cured, graded and stored, and in the planting time are planted in the prepared field, corms for flowers plus corms and cormlets, and cormlets only for raising the stocks. Cormlets have a very hard tunic (shell or covering) which limits the water absorption, therefore, on planting there is no 100 % sprouting of cormlets and sprouting is also considerably delayed. If these are planted with broken tunic, the sprouting is immediate.

One planted corm produces 1-8 corms and 10-1,000 cormlets, depending upon the variety, soil types, weather conditions and cultural practices adopted. If the soil is sandy loam, rich in organic matter, with a pH of 5.6 to 6.5, and is situated at a sunny location, the smallest cormlets will also produce flowers (though not of marketable quality) the first season itself provided field is kept regularly watered and weed-free, and at lifting such plants will have at least one full developed corm and some 10-50 cormlets. Otherwise, it may take 1-2 years for cormlets to develop into flowering size corms. The cormlet and seedling crops are infected with *Curvularia* and if not controlled whole of the leaves die, hence these crops should be sprayed fortnightly with 0.2 % Dithane M-45. The increase in the size of the corms and cormlets can be encouraged by breaking the spike as soon as these are slipping so that energy required for formation of the spike and further development may be diverted towards corm and cormlet development.

Normally, the cormels less than 1 cm in diameter are discarded, No. 4 (>1.9 to <2.5 cm), No. 5 (>1.3 to <1.9 cm) and No. 6 (> 1.0 to <1.3 cm) are planting stocks as all are quite small, No. 2 (>3.2 to <3.8 cm) and No. 3 (>2.5 to <3.2 cm), the medium-sized ones are flowering stock, and Jumbo (>5.1 cm) and No. 1 (>3.8 to <5.1 cm in diameter) are large sized corms, used for cut flower growing. My personal experience has shown that even the smallest cormlets are worth planting, and smaller the cormlets larger is propagation coefficient. Corms are planted at 10 cm distance within the rows and the rows spaced at 20 cm while cormlets at 8 x 10 cm apart.

Certain varieties in certain conditions (the exact cause is unknown) produce **cormules** at first and/or second and third visible node(s) of the spike which arrest the spike development after a little growth. These look like corms in shape though size may be smaller and have shredded tunic like to those of corms. These also after planting come up like corms (where flower appears if size is large) and cormlets (when the size is smaller), so may be used for propagation, although such formations are not regular.

Through **corm fractionation** (4-16 per corm) about 10 days before planting, their disinfection and suberization and then planting in rich but sterilized soil, each fraction (bit) of the corm will sprout and behave like the fully developed corm in producing the spikes (one each), and corms (one each of high quality, high crowned) and many cormlets, irrespective of the provenance of the pieces. One hour dip of the pieces in 40 ppm indoleacetic acid encourages the process.

Explants from inflorescence stalks of gladiolus when cultured *in vitro* **(micropropagation)**, regenerate new plantlets within 6-7 days on MS medium supplemented with kinetin or kinetin + NAA. Explants from apical meristem or whole terminal bud plus the upper portion of the corm, *in vitro* cultured cormlets, cormlet tips and axillary buds are taken for micropropagation. Apart from quick multiplication, virus-free, as well as *Fusarium*-free foundation stocks can be raised through this process.

Gladioli set copious seeds. The capsule is 3 chambered, each containing normally from 20-50 seeds. Capsules mature within six weeks, and at ripening these turn straw or almond coloured and split from three sides. When these are to dehisce, these should be collected to avoid the attack of a borer *vis-à-vis* shattering. Seeds have wings so it would be better to dehusk these at the time of sowing. These husks as well as the seeds contain some oils. While dehusking with hands, it leaves a scar of oils left on the palms, which comes out bit by bit in the form a crust within a week. Seed sowing should be done on raised beds containing sufficient organic manure *i.e.* 5-6 kg/m^2 so that excess water may drain down easily but soil may not dry out and remain moist throughout. When sowing, dehusked seeds are not misplaced due to winds, and maintain proper distance. These are sown thinly, at 4 cm distance in the rows, and rows spaced at 8 cm, and ½ cm deep, by early October in the sub-tropical regions and in March end in temperate regions. After sowing, the seeds should preferably be covered with sand and then beds are covered with straw. By evening the each day, the beds are watered very lightly with a fine rose can. Before germination, the straw mulch is removed for erect and proper growth. Seeds normally germinate within 10 days. Throughout the growing period, the beds should be kept weed-free and properly watered. In case of *Curvularia* infection on the leaves, the crop should be sprayed fortnightly with Dithane M-45 at 0.2 %. These are lifted by April end in the sub-tropical conditions and by October end under temperate. The cormlets produced from seeds have shredded tunic like to those of the corms, and are quite elongated, though cormlets formed in the sides have a very hard tunic. These may take 2-3 seasons to attain flowering size under ordinary conditions, but under proper cultural conditions *i.e.* weed-free field, proper and timely irrigation, proper soil conditions and timely sowing, and a temperature range of 15-30°C during growth period, will produce the flowering size corms the same season and which would have produced flowers also.

4.2.2.3 Climate

Although crop produce quality bulbs and flower under hilly area, however gladiolus has acclimatize to grow under plain especially during winter season.

4.2.2.4 Soils, Preparation of Land, Planting and Weed Control

Gladioli prefer sunny situation, and require at least 80 % of total sunlight, preferably full forenoon sunlight, for their proper growth and flowering. During winters, the flowers may abort due to lack of sunlight. Constant humid atmosphere is not desirable as it attracts various pathogens, especially *Botrytis and Fusarium*. Gladioli grow comfortably at the temperature range of 18-30°C, and this temperature range is available in the temperate regions during summer seasons. In the plains, it is grown during winter when from mid-December to mid-February it is very cold, the temperature ranging from 10-25°C, normally not going above 18°C, and sometimes even going below 5°C which is very dangerous to the

crop, as due to frost tissues become soft facilitating infection of *Botrytis gladiolorum* and complete devastation of the crop. The very low temperature when persists for three days or more only then it is highly devastating. Urea spray during this period will aggravate the situation.

Gladiolus likes copious watering but not there wet feet. It can be grown in a variety of **soils** ranging from sandy loam to clay loam, but the soil should have good water holding capacity, well drained and porous and should have more than 3 % organic matter. A sandy loam soil with pH range of 5.5 to 6.5 is most preferable though it can be grown up to 8.0 pH with slight amendments.

Soil preparation for gladiolus planting should commence at least two months before planting. Deep ploughing should be carried out two months before planting and green manuring crop should be taken up by sowing the seeds of sunnhemp or *dhaincha* which should be knocked down in the soil when it is 50-60 cm in height. While knocking down, the field should be flooded with water so that it decomposes properly. Now **land preparation** will start. At this time while preparing the land, farmyard manure or compost at the rate of 50 tonnes/ha should be incorporated in the soil, and the soil should be cultivated to a depth of 30 cm, and the rootstocks of the perennial weeds should be taken out with fork. To make the soil perfectly pulverized, it should again be ploughed, followed by rolling and then beds of convenient size are prepared, considering the soil level so that while watering it is even throughout. For **planting**, it would be preferable if width of the bed is kept 1.5 to 2.0 metres while length of any dimensions, looking into the level of the land. At the time of planting i.e. in October in the sub-tropical regions and March - April in temperate regions, soil should have sufficient moisture so that till sprouting no watering is required. Planting is done in double-row system to accommodate more number of plants, one double-row spaced at 40 cm from the other double-row, but in between the double-row it should be spaced 20 cm. Corm to corm distance in the row is kept 10 cm, and the corms are planted 10 cm deep. While planting, the 5-6 cm depth of soil should be removed from the wider space to cover the planted corms with 10-12 cm of soil. This way both the lines in one double row will form one bund and the space from where the soil was taken for earthing will work as water channel from where the bunds will absorb the required water when irrigating the field. Perennial (rattoon) cropping in gladiolus is at all not desirable.

Cormlets for raising the stock should be planted closely, i.e. 5 cm in the rows, and rows spaced 15-20 cm, at a depth of 5 cm. It would be advisable to plant the cormlets after removing the tunic for ensuring cent per cent and timely sprouting.

Jute strings tied with the strong pegs fixed on the four corners of the beds is the most effective way for protecting the plants (spikes) from breaking away due to lodging, winds and storms. The strings should be stretched crosswise in a 3-tier system, first at 30 cm height, second at 55 cm and third at 75 cm length of gladiolus plant. Nylon mesh can also be used for the purpose.

Mulches of composted pine bark, moss peat, straw peat, compost, farmyard manure, leaf mould, dried leaves, river sand, saw dust, rice husk, etc. as organic mulch alone or in combination and 3-5 cm thick are quite favorable for increasing the corm and cormlet production as well as spike quality. The mulch of black plastic sheets also does not allow emergence of weeds which ultimately increases the yield of flowers, and corms and cormlets by 20-40 per cent.

Weeds are innumerable in gladiolus plantings. Gladiolus growing season passes through summer and winter both in the sub-tropical areas so one encounters both types of weeds here though on the hills it is only summer season. Though in India weeding is normally carried out manually, and as one growing season requires some 5-6 weedings so it becomes noneconomical. Use of pendimethalin (stomp) pre-emergence weedicide at the rate of three litres per hectare is quite effective up to 75 days after planting are after application. It should be dissolved in water sufficient to wet the surface of the planted area. It has excellent control of annual weeds. After 75 days, this may again be applied just by protecting the gladiolus plants with polythene sheets. This way the field will remain weed-free. Metaxuron at 3 kg/ha as pre-emergence is very effective in keeping weeds under control up to four months. Simazine or atrazine at 4 kg/ha in 1,000 litres of water, followed by gentle watering with 40,000 litres per hectare is extremely useful in controlling mono and dicotyledonous weeds throughout the cropping period.

4.2.2.5 Irrigation, Manures and Fertilizers

The soil should have sufficient moisture at the time of planting so that it could be watered only when the crop has sprouted. Gladioli require plenty of water during dry months but not a wet foot. Looking into the soil type and weather conditions, the field may require light watering at every 7-10 days. In case pre-emergence weedicide has been used, immediately after light watering is a must. The plants are highly sensitive to water stress at two stages, i) the very early growth stage when flower initiation takes place, and ii) from the fourth leaf stage through flower elongation. Due to soil water stress, yield of flower is more affected than the yield of the corms. Delayed watering may cause blindness. After cutting of the flowers, frequency of watering is reduced. However, at the time of lifting of the corms, there should be sufficient moisture in the soil so that lifting is facilitated.

The soil for gladiolus planting should contain more than 3 % of organic matter. At the time of the first ploughing, the soil should be worked with 40-50 tonnes of well rotten farmyard manure or compost.

Gladioli are heavy feeder, but use of any nutrient should be advocated only after soil and leaf analysis. Excess nitrogen is not desirable as it causes succulence in the plant which attracts infection of *Botrytis gladiolorum* during chilly and humid weathers. Nitrate form of nitrogen is less conducive to *Fusarium* infection than ammonium form of nitrogen. Nitrogen deficiency causes blindness, and reduces number of florets per spike. N, P, K and Ca deficiencies lower the average floret count and N, K, Mg and Ca deficiencies result in smaller spikes. K and Mg deficiencies delay the flowering. N, P, Ca and Mg deficiencies adversely affect the weight of spike while N, P and K deficiencies adversely affect the leaf production. Deficiency of N, K and Ca adversely affect the leaf nutrient contents. The utilization of food reserves in the mother corms is also hampered due to nitrogen deficiency. In deficiency of one nutrient, the effect of other nutrients is not proper. Low N results in low dry matter production and poor utilization of P and K. On dry weight basis, gladiolus leaves should contain 2.5-3.0 % nitrogen, 3-4 % K_2O, 0.2-0.3 % Ca and 0.2-0.4 % Mg.

Indian soils are generally not deficient in potassium. At the time of final bed preparation, a basal dose of nitrogen in the form of nitrate than ammonium @ 140 kg/ha and P_2O_5 160 kg/ha in the form of single superphosphate should be

applied in the soil. It would be better in nitrogen is given in two split doses, half at the time of bed preparation and the remaining half as side dressing before slipping of the spike. A basal dose of K_2O 125 kg/ha should also be applied as basal dose in the form of muriate of potash if soil is deficient in potash. A mild Ca deficiency causes 'topple' disorder after cutting the spikes, however, severe deficiency results into physiological 'bud rot', 'improper floret opening', 'inward petal curving', 'petal tissue breakdown' as water soaked lesions, leaf emerging light-coloured but later turning brown, and sometimes horizontal leaf cracking. High Mg level aggravates Ca deficiency symptoms. These abnormalities may be corrected by spraying 2 % calcium nitrate. Ordinary lime or dolomite at 4.5 tonnes/ha in the soil improves the production of corms and cormlets. Side dressing of calcium nitrate (this contains soluble Ca) 2-3 times between spike emergence and flowering is quite favourable. Mg deficiency causes yellowing between the veins, first appearing on the older leaves, as well as delay in flowering. Its excessive supply interferes with Ca nutrition. Fe deficiency causes interveinal leaf yellowing, and in severe cases whole leaf yellows. High soil pH and higher levels of Cu, Mn and Zn are common causes of its deficiency. Its deficiency can be corrected through application of 55 kg of chelated iron in moist soil near the root zone. Spraying Fe-EDTA at 0.25 ppm corrects its symptoms within four days. Boron deficiency causes horizontal cracking up to midrib, and sometimes translucent areas develop between the veins while its excess (150 ppm) causes scorching on the margin of older leaves and then on younger leaves. Its deficiency is corrected through foliar spraying of borax (11.25 kg/ha), boric oxide (4.5 kg/ha) and boric acid. Availability of Zn is decreased under neutral or slightly alkaline soil condition. Its deficiency is corrected by applying zinc either in soil or as foliar spray. Mn deficiency causes paling of new leaves with green veins. It may be corrected by using those fungicides which contains Mn. Cu deficiency causes weak and soft spikes and flaccid leaves. Application of 22.5 kg/ha of copper sulphate will correct this problem.

4.2.2.6 Growth, Development, Flowering and Flower Forcing

In the temperate region of the country, gladioli are planted in March - April, flowers are harvested from June end to mid - October, seeds in August - September *i.e.* 4-6 weeks of flowering and the corms and cormlets are lifted from September - November while in the sub-tropical region of the country they are planted in October, spikes are harvested from December end to March (only a very few varieties in January as the month is very chilly), the seeds in March - April and corm lifting from April to early May. In the tropical part of the country there is no set time for planting and harvesting but since the same corm cannot be grown twice in the year therefore normally they follow the timings of the sub-tropical region of the country. Seeds germinate within 10-20 days when sown in early April in the temperate areas where temperature range is 15-24°C (night/day) and grow very well up to October when these are lifted and the temperature from May - October ranges from 18-33°C (night/day) while in the sub-tropical region of the country seeds are sown by September end when temperature ranges from 25-33°C (night/day) and the cormels through seeds are lifted in March - April (mid - December to mid - February being very cold). The cormels raised from seeds in the sub-tropical region are very small and most shrivel and finish in storage while in the temperate areas they mostly produce flowering size full developed corms and some cormlets with each plant. Seed germination and further development are greatly influenced by temperature if given full sunlight during

whole growing period.

Corms at planting time possess one or more shoot buds and many root primordia. The apical bud contains some 7-8 sheath leaves and 6-9 true foliage leaves. The inflorescence may also contain 3-4 leaves, called as 'flag leaves' and the nodes where flowers are emerging on the spike these leaves are converted into floral sheaths for keeping securely intact the florets between the two on the node, the last node on the spike also having the two sheaths but no floral bud. The flower differentiation begins within 3-8 weeks after planting, and normally at the end of fourth week they emerge out of the corm, their emergence is greatly influenced by genetic makeup of the varieties, the degree of development of the apex at planting time, the size of the corm and the soil temperature. The differentiation continues until 6-9 true foliage leaves are visible (heading of spike from true foliage leaves at 13th to 15th week of planting) and contractile roots are formed [7-9 weeks after planting in different varieties, contraction starting in the 12th week to 15th week, and collapsing (yellowing) at 13 or 14 weeks, depending on the varieties] at the base of the new developing corms which are produced by the swelling of the base of the shoot. Initiation of stolons (emerging from the buds situated on the new corm) is found at 11th week of planting and completion of the growth is from 14th to 17th week of planting, which may still take some time for maturity.

Temperature affects greatly the growth and development process from planting to flowering. At almost constant light conditions, it is temperature which influences number of days to flowering. All growth and development processes (flowering and maturity) are accelerated by increasing temperatures but quality of spike is hampered. Most active growth in gladiolus is observed from 18-33°C, though temperature below 10°C or above 33°C retards the growth. Under sub-tropical conditions of Delhi, if the corms are room stored from May to September when outside atmospheric temperature ranges from 30-46°C, on planting early, non-vigorous and synchronous flowering is observed with a very poor spike length, however, in temperate regions of the country like Shimla, Katrain (Kullu), Srinagar and upper Uttarakhand, the corms do not require cold storing as there temperature during winter is quite low. Plants become more tender when spike is emerging and become more vulnerable to frost damage. If soil moisture and air humidity are high, gladiolus can tolerate as high as 50°C temperature and may produce normal flowers but high temperatures during flowering sometimes produce crooked stems but corm formation is badly affected and on lifting the diameter of the exposure area on the corm (the point from where the plants from the corms have been twisted off) is almost equal to diameter of the corm which on storage shrivels and dies down due to excessive water loss. Persisting temperature below 6°C, more critical being at or below 4°C damages the plants at any stage but if before the occurrence the corm is already formed, that is not damaged and remains safe. In India, the corms produced during winter as in the sub-tropical regions, the corms have very little dormancy or no dormancy but those producing during summer as in the temperate Himalayas, they have a very deep dormancy, which is technically known as "summer dormancy".

Time of floral initiation proceeds even in dark and the light has nothing to do with it but flower bud development is affected by day-length. Short days though hasten anthesis but decrease the number of flowering plants, number of flowers per spike and spike length, short days coupled with low light intensity from 2-

leaf to 6-leaf stage reduce percentage of flowering plants, and if this regime is given after 6-leaf stage the number of flowers reaching anthesis stage is adversely affected, and under very poor light conditions **flower abortions** can affect the entire inflorescence which becomes shortened with badly affected youngest floral bud, the effect progressing afterwards to the lower florets and this process is encouraged when plants are subjected to poor light conditions at 3-6 visible leaf stage, higher temperature necessitates the greater light requirement to avoid abortion though is cultivar dependent, and low light intensity but prolonged day-length (even as night break) antagonize the abortion process. As a cumulative effect of reduced day-lengths and low light intensities during winter under Delhi conditions, sometimes when weather is cloudy for weeks during flowering period, no normal flower development occurs but sometimes when there are long days though flowering is delayed but normal flowering occurs. The unbalanced relationships between light and temperature lead to etiolated plants possessing short and high placed spikes and weak floral shoots. Short days (8.5 h) when applied to plants after sprouting, new corm growth and cormlet formation are promoted due to branching of axillary buds but final corm enlargement is poor though corm development is at all not affected when short/long days treatments are applied just before or after flower anthesis. During active growth period, the assimilates are partitioned to two competing sinks, the inflorescence and the new developing corms but priority is for primary sink i.e. inflorescence till anthesis but when flowers are cut, damaged or fade the site of sink changes to corm development and so after flowering the growth of new corm is very fast. Shearing of spike, therefore, has a very positive effect on corm development. Photoperiod affects the distribution of assimilates between inflorescence and the new corm, long days favour flowering and corresponding sink, but short days the corm development.

4.2.2.7 Lifting of Corms, Storage and Dormancy

Corms planted under favourable conditions if do not sprout within 10-20 days are dormant, mostly because of the internal factors as till then they have not attained physiological maturity. This **dormancy** is broken more rapidly at low (<10°C) temperature than at high (>20°C). The duration of low temperature depends on the cultivars and physiological state of corms at lifting. Warm moist conditions prolong dormancy, and control of dormancy determines growth after planting. Sprouting is an indication that the corms have acquired capacity i) to grow (dormancy release), and ii) to differentiate, and growth of shoot and roots. The latter processes are temperature dependent as shoot growth is very active at 18-25°C though arrested at 1-2°C or >30 temperature. A high temperature applied after dormancy, not only promotes organogenesis but also affects subsequent plant growth. Shoot emergence, formation and growth of leaf and contractile roots, anthesis, new corm enlargement and cormlet formation are accelerated by warm treatment of corms in storage. Long high temperature treatments cause reduction in foliage and flower number as at the time of differentiation this organ reduction had occurred by the apex, which ultimately results in reduced plant height and its growth duration. High temperature corm storage for a certain duration cause direct corm formation ('pupation') in the form of pupa at the place of central bud and sometimes one or two in the axillary buds without any root or leaf. Long storage at 3-7°C and 70-80 % relative humidity as is the practice in the country, produces slow growth but with maintained vigour and is good for retarded flowering. For delayed flowering, the cured and graded corms are stored

<5°C for a few weeks and then transferred to a 15-20°C for 1-2 weeks before planting. To advance or to retard the flowering for getting cut flowers at a particular period or date, it is the storage temperature of the corms which is manipulated. To advance flowering, the emergence and growth after planting should be very fast. For this the corms are given <10°C treatment for 4-8 weeks (depending on the cultivars, growth conditions of the mother plants, and lifting date) for breaking dormancy after drying and curing, and then 20-30°C for 4-6 weeks during storage to promote shoot and root development and the subsequent growth of the daughter plant, and then these corms are planted at wider spacing in heated greenhouses which has adequate natural illumination or under poly-tunnels or simply covered with white plastic sheets until the plants attain 30 cm height. When light intensity is poor, temperature is also lowered in the greenhouses. To avoid the risk, supplementary lighting in the greenhouses (4-5 hours at 35-150 lux) should be provided.

Lifting of corms and cormlets are carried out in between 40-50 days of flowering as at this time corms and cormlets are fully mature and about 25 % cormlets have turned brown though leaves are still green. Delayed lifting will encourage *Fusarium* infection. While lifting, the still attached cormlets should be removed one by one and in the end the shrivelled mother corm should be removed with the help of thumb and fingers and then finally the daughter corms are removed from the plant by gentle twisting. These corms and cormlets are now dried in shade for at least one fortnight at an aerated place and then dipped for one hour in 0.2 % captan and then again dried the same way and at least for same duration. The temperature of such rooms in the sub-tropical region of the country is around 30°C though in the temperate regions as it is winter so temperature would be below 8°C. More the room drying at ambient temperature in the sub-tropical region more vigorous the crop growth occurs with minimum disease incidence, however, at least two months cold **storage** at 3-7°C and at 70-80 % relative humidity should be given before planting. The cold storage should not be done along with apple, onion, and others which emit more ethylene. Before keeping in storage, they are kept in crates or in gunny bags of convenient size. At about 15 days before planting these should be taken out from the cold storage and spread on the floor for acclimatization and before 5-7 days of planting the corms and cormlets are again dipped for one hour in 0.2 % captan and then again dried before planting.

4.2.2.8 Post Harvest Technology

For distant markets and for export, the spikes are cut when still in tight bud stage but lower florets are showing colour, while for local markets they are cut at a more advanced stage *i.e.* either bottom floret opening or when swelling is sufficient to open the third day, as per the requirement, but at least four leaves should be intact on the plants as still the corm and cormlet growth and development are going on. Immediately after cutting, as well as before and after grading, spikes are placed in fluoride-free water at 4-6°C. Grading is done on the basis of thickness and length of spike, number of florets per spike and overall quality. The 'Fancy' grade should have > 107 cm spike length and a minimum of 16 florets per spike, 'Special' >96 to 107 cm with 15 florets, 'Standard' >81 to 96 cm with 12-14 florets and 'Utility' grade <81 cm with 10-11 florets.

The spikes cut well in advance and wrapped in polythene sheets are cold stored

at 2.3-2.8°C for a week and at 4.5°C for 1-2 days. Through low pressure storage technique, the spikes can be stored up to 30 days but economically it is not feasible.

For local markets, they are packed putting 12 spikes in one bundle where one rubber band may be put below the bottom-most floret, other about 7-10 cm above the cut ends and the third one 7-10 cm below the tip and then these bundles are wrapped in newspaper, and then finally in Hessian cloth, by putting some 40-50 such bundles in one pack, for local market but for distant market they are dry packed in perforated cardboard boxes having 1.2 m length, 60 cm width and 30 cm height, arranged head to tail alternately and tied with cotton wool to remain them in position. Diagonal cut of 2.5 cm at the cut end should be made in dry stored spikes and just placed in water, after reaching destination. While shipping or transporting, the spikes should be positioned straight or the boxes should be kept up with the upper side of the spike if the packing is not head to tail so that spikes may not bend. Pulsing of the spikes with 600 ppm 8-hydroxyquinoline citrate (or 0.1 % aluminium sulphate) + 4 % sucrose for 12 hours increases the vase life. $AgNO_3$ 1000-1200 ppm + 20 % sugar pulsing for 20 h at 20°C temperature improves the opening and the durability of spikes. Sucrose at 3-6 % with 600 ppm 8-HQC at pH 3.0-3.5 holding solution extend the vase life up to 40 per cent.

4.2.2.9 Insect-Pests, Diseases and Physiological Disorders

Aphids (*Aphis gossypii, Myzus persicae, Macrosiphum solanifolii, M. gossypii,* etc. damage the plants by sucking the sap from foliage and stems and by transmitting viral diseases. **Seed corn maggot** [*Hylemya cilicura (*syn. *Phorbia platura)*] enters the capsules in the field and feeds on seeds. It also infests the seeds in storage. **Thrips** (*Taeniothrips simplex*) feeds on flowers and floral sheaths. The yellow nymphs and the dark brown adults rasp the foliage and flowers and cause silvery and whitish streaks. Flower thrips (*Frankliniella* spp.) also feed on florets. Thrips also thrive on corms in storage. **Corn ear worms** (*Helicoverpa armigera*) larvae feed on the flowers, capsules and spikes, and **loopers** (*Trichoplusia ni* and *Pseudoplusia includens* infest the leaves, spikes and florets which can easily be killed through commercial preparation of *Bacillus thuringensis*. Army worms (*Laphygma frugiperda, Prodenia ornithogalli, Spodoptera eridania, S. exigua* and certain other species feed on leaves and spikes. **Cut worms** (*Agrotis segetum*) are nocturnal in habit and feed on corms and stems. These all the pests can be controlled through fortnightly sprayings of 0.2 % methyl parathion.

Mites (*Rhizoglyphus echinopus, Tetranychus urticae, T. telarius, T. bimaculatus,* etc.) feed on gladiolus leaves under warm and shady conditions, causing white specks which change to bronzing or silvering of the affected plants. Any effective acaricide will control this pest.

Slugs and **snails** attack the plants during excessive humid conditions, and batter the leaves leaving only the veins. These may be light trapped or may be killed through metaldehyde poison baits.

Nematodes (*Meloidogyne and Trichodorus*) feed on gladioli corms and roots. They are controlled by hot water treatment (HWT) at 53°C for 30 minutes but only after corms are perfectly cured after lifting.

Fusarium rot and **yellows** (*Fusarium oxysporum* f. sp. *gladioli*) is a soil-borne disease which attacks the vascular system of the gladioli and in its attack plant may yellow and/or bend due to rotting of corms. This disease may be carried over to storage also. *Fusarium solani* attacks the corms in storage and may be carried over to the field. **Dry** or **neck rot** (*Stromatinia gladioli* or *Sclerotinia gladioli*) is symptomised as small, dark, more or less superficial lesions on the corms which also produce collar rot killing the plants in the field and rotting the corms in the storage. *Rhizoctonia solani* causes neck rot, poor growth and 'damping off' in the plants grown from small corms and cormlets, and root rot, brown corm spots and a shredded neck in large plants. The fungus is more active during warm weather. These all the three diseases can be controlled through proper sanitation, burning of the debris and through fortnightly spraying of benlate (bavistin) 0.2 % alternate with captan 0.2 % throughout the cropping season, and one hour dipping in 0.2 % captan at 15 days of drying after lifting and also before planting.

Core or **spongy rot** (*Botrytis gladiolorum*) causes soft corm rot, gray mould, neck rot, floral rot or *Botrytis* blight. It is also soil-borne fungus which is highly devastating during windy, chilly and humid weathers when entire field can be affected in one night. During dry weathers the brown spots do not coalesce but in humid weathers these coalesce and cause rotting of entire aerial part of the plant causing blight. *Curvularia* blight is very serious in cormlet and seed grown crops. This causes serious yellowing and browning of leaf tips initially which afterwards extending on the margin of the leaves lengthwise and if not controlled in time entire crop is destroyed. Both these diseases can be controlled through weekly spraying of dithane M-45 (0.2 %) at the time when the weather is humid, chilly and windy. Excessive moisture in the field is also avoided, and the field is kept quite clean.

Storage rot or **corky corm rot** (*Penicillium gladioli*) is caused in storage with large reddish-brown sunken lesions and numerous cream and pinkish resting bodies are seen on the corms, particularly in the centre of the lesions. At low temperature the lesions are full of greenish mouldy growths and this poses a problem when corms are piled up in heaps after lifting and without any treatment. Usually this pathogen enters the corms through bruises and wounds. *Penicillium funiculosum* causes core rot in the field but is of little importance in the storage. *Rhizopus arrhizus* develops soft rot and covers with black 'bread moulds'. Its attack is observed when corms are injured by artificial heat or sun scald after lifting and during curing by which it causes watery rot of the corms. The attack of all these fungi may be controlled by proper sanitation and by applying all the measures adopted in case of *Fusarium* infection.

Leaf spots are caused by *Alternaria fasciculata* and *A. tenui, Septoria gladioli, Stemphylium botryosum*, *Drechslera bicolor, Colletotrichum* sp., *Phyllosticta gladioloides, Mycosphaerella minimaepuncta* and *Macrosporium candidum,* latter six being of very minor importance. *Alernaria* causes dirty dark brown to black irregular spots in long patches mostly on apical and marginal parts of the leaves, *Septoria* is confined only to the temperate parts of the country and is a very weak parasite which affects the leaves of the plants grown from small corms and cormlets and seeds. Its lesions are circular, brown to purple-brown, medium in size with black spore bodies in the centre of older spots. These all the leaf spot diseases may be controlled through spraying with 0.2 % Dithane M-45.

Bacterial scab blight (*Pseudomonas marginata*) causes 'neck rot', being serious in over-crowded crops, and those grew through seeds and cormels. It appears as red-brown specks on leaves which become dark-brown in the later stages. On corn husks, scab appears as elongated lesions with black rough margins. On corms these lesions are brown, nearly circular and sunken with black raised margins. *Erwinia carotovora* causes soft and flaccid rot of corms. These pathogens can be controlled by dipping the corms in mercuric chloride after lifting and before planting the corms.

Cucumber mosaic virus **(CMV)** produces white discontinuous streaks on foliage and colour break in flowers, 'aster yellows' causes precocious sprouting and grassy top *vis-à-vis* spiral bending of spikes and straw yellowing of leaves and spikes, and bean yellow mosaic virus **(BYMV)** also attack gladioli causing petal greening. Other viruses which infect gladioli are tobacco rattle virus **(TRV),** tobacco ring spot virus **(TRSV)** and tomato ring spot virus **(Tom R).** Through control of leaf hoppers and aphids and through rouging of such plants will keep the viruses under control.

Leaf scorch is caused due to fluoride injury as fluorine from atmosphere is accumulated on the tips of the leaves. Use of superphosphate in the soil also causes fluoride injury to gladiolus plants. Use of calcium, manganese and magnesium salts as foliar spray or calcium sulphate in the soil negates fluoride effect. Leaves are very sensitive to fluoride as when dipped in water containing fluorine, absorb immediately and accumulate in the 4 cm tip portion. The spikes when are placed in fluoride treated water, their floral sheaths also show tip burning. As little as 0.25 ppm fluoride is detrimental to gladiolus crops. **Flower abortion** are most prevalent in winter crops as under sub-tropical conditions were due to poor light conditions either whole of the spike is affected or only the upper florets. Due to poor light intensity, initiated flower buds do not develop further. This disorder has been elaborated in detail under **4.2.2.6 Growth, Development, Flowering and Flower Forcing.** Due to high temperature at the time of flower bud differentiation, certain varieties do not produce spikes at all (a case of **blindness**) or only a few spikes in whole of the plantings is observed and when the plant is dissected in such cases, a dried straw-coloured rudimentary spike is found located in the plant close to soil surface so such varieties should be planted a bit late when temperature is comparatively low.

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 various grades in gladiolus based on spike length and number of florets per spike.

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4.3 LET US SUM UP

In this unit, we have studied about *Alstroemeria* and *Gladiolus*, the former is a rhizomatous while the latter is a cormous ornamental. Their classification, important species, commercial varieties, various methods of sexual and asexual propagation, soil, water and nutritional requirements, and other cultural practices are described. The regulation of flowering is also elaborated as influenced by various factors *viz.* temperature, photoperiod and hormones. Stage and time of flower harvesting and also their post harvest technology are also described. The stage of rhizome and corm lifting, their curing, dormancy and its overcoming, their storage and forcing for regulation of flowering are also described. Various insect-pests, diseases and other abnormalities which are associated with alstroemerias and gladioli are also detailed with their remedial measures.

4.4 KEY WORDS

Alstroemeria, corms, cormlets, development, diseases, dormancy, fertilizers, flowering, *Gladiolus,* growth, holding solution, insect-pests, nutrients, planting, post harvest technology, propagation, pulsing, rhizomes, senescence, soils, storage, vase life, etc.

4.5 FURTHER REFERENCES

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4.6 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1) **Rhizome** is usually a thickened horizontally wandering (creeping)

underground or soil-surface organ (stem), often spreading widely. It typically has nodes and internodes, with shoots and roots arising from the apex and from adventitious buds, apices (ends) being swollen. On planting the upper part produces the shoots and flowers and the underside the roots, but both arising from the apices. The rhizomes enlarge through their apices and the oldest parts eventually become exhausted as is evident through the clothing with the remnants of enveloping leaf bases.

2) It is a crop of the temperate and sub-temperate regions, particularly the higher reaches of the Western Ghats, the Nilgiri hills (Ootacamund and Kodaikanal), higher altitudes of North-East Hill regions, Darjeeling hills of West Bengal, the higher reaches in Orissa *i.e.* Koraput regions, Mt. Abu in Rajasthan, upper part of Uttarakhand, and from 1,000-2,000 metres height of Himachal Pradesh and Jammu & Kashmir.

Check Your Progress Exercise 2

1) Grading is done on the basis of thickness and length of spike, number of florets per spike and overall quality. The 'Fancy' grade should have >107 cm spike length and a minimum of 16 florets per spike, 'Special' >96 to 107 cm with 15 florets, 'Standard' >81 to 96 cm with 12-14 florets and 'Utility' grade <81 cm with 10-11 florets.