UNIT 3 ORCHIDS AND *ANTHURIUM*

Structure

3.0 OBJECTIVES

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

- explain the classification, various important species and commercial varieties of orchids and anthurium,
- know the soils and various other substrates suitable for growing these two crops,
- describe cultural details and propagational methods employed in these two crops,
- know manipulating flowering,
- explain various insect-pests, diseases and physiological disorders and their control, and
- describe stage of flower harvesting, post harvest management and packaging.

3.1 INTRODUCTION

Confucius (551-479 B.C.) mentioned orchids in his writings as Chinese used them to decorate their homes. But only in the 17th century the aesthetic interest in orchids started developing. However, for cut flower, in 1913, the Sun Kee Nursery was established in Singapore to produce spray-type orchids of *Arachnis, Aranda* and *Aranthera.* Singapore,

Hawaii and Thailand grow mainly *Dendrobium* hybrids. Malaysia also grow other cut orchid sprays, apart from Singapore and Thailand and they export these to Europe, the major one being West Germany. *Cymbidium* is being grown in the Southern Hemisphere.

Orchid flowers are highly priced in the international florist trade. Among all the flowering plants on the globe, orchids are most exquisite in nature for their range of delicate colours (white, light to golden yellow, pink, scarlet, salmon, crimson, red, brown, violet, blue, with some of them being sweetly fragrant), the size and bizarre flower forms, their habits and wide geographical distribution, and to some extent for their pharmaceutical uses and vanilla production, aromatic uses and food. In the various parts of NE region various orchids are used as food. The leaves and pseudobulbs of *Cymbidium* being of great nutritive value are used as food and in Arunachal Pradesh, *Anoectochilus* leaves are used as vegetables, *Dendrobium* dried leaves when cooked with rice give delicious food with exotic flavour, and the fragrant fruits of climbing *Vanilla fragrans* and *V. planifolia* are the source of essence i.e. vanillin. Tribal people of NE region use orchids as medicines in various ways; *Vanda coerulea* flower juice is used as eye drops against glaucoma, cataract and blindness, *Dendrobium nobile* flowers for various eye troubles, *Phaius tankervilliae* pseudobulbs along with wild ginger against dysentery and fracture, *Paphiopedilum insigne* whole plant against amoebic dysentery, dried pseudobulbs of some 30 orchids are said to have aphrodisiac properties and are known in the trade as 'SALEP', *Dendrobium nobile* contains alkaloids such as 'dendrobine' and 'nobiline', chewing of seeds of a few orchids mixed with *Hibiscus* leaves works as oral contraceptive in women, and some orchids are reported inducing sterility in the women. They make beautiful cut flowers for flower arrangement which may last sometimes even more than three months, and for corsages. They are also used as potted flowering plants, in window boxes, in hanging baskets and as bedding flowering plants. The orchids have over 800 genera with some 35000 species (India accounting some 1300, out of which around 50 % is found only in NE region, the richest in the word i.e. Sikkim, 450; Assam, 350; Meghalaya 350; Arunachal Pradesh 300; Manipur, Mizoram and Nagaland 150 each; and Tripura 100; many overlapping; the other regions in India being north-western Himalayas and southern parts, especially Western Ghats), being the largest family (Orchidaceae) among the flowering plants. In India, though some genera *vis a vis* species are common for various zones but Eastern India has 107 genera, Western India 44, Southern and Central India 66 and Andaman & Nicobar Islands 18 genera. Most orchids are perennial herbs, a large number of them are epiphytes or terrestrial and a few saprophytes and leafless in nature. Majority of the orchids are native to tropical countries, found especially in the humid tropical forests of South and Central America, India, Sri Lanka, Burma, South China, Thailand, Malaysia, Philippines, New Guinea and Australia. Brazilean *Cattleya*, Mexican *Laelia* and Indian *Dendrobium*, *Cymbidium* and *Vanda* have maximum contribution in the development of global orchid industry.

Anthuriums are evergreen tropical ornamentals, valued for their most beautiful flowers having peculiar but delicate look and for their unusually attractive foliage. Its cut flowers are long lasting and give bold effect in the floral arrangement. South India (Kerala, Tamil Nadu and Karnataka) is the hub of anthurium growing in India. Though ideal growing areas in the country are NEH region (tropical and sub-tropical regions, especially Sikkim, Meghalaya and Arunanchal Pradesh),

Assam, West Bengal (Kalimpong and Darjeeling areas), Orissa (Koraput region and certain other adjoining areas), Tripura, Nagaland, Mizoram, Manipur, Andaman & Nicobar Islands, lower part (foot hills) of Jammu & Kashmir as well Himachal Pradesh and Uttarakhand, Maharashtra and Gujarat, but presently it is being cultivated only in entire Kerala, Yercaud and Ootacamund i.e. Nilgiri hills in Tamil Nadu, Coorg in Karnataka and in a limited part of Maharashtra for commercial use. In fact, there are three major consumer markets in the world, *viz.*, Europe with 47.8 % per capita consumption, USA with 21.8% and Japan with 16.8 %.

The plant is native to Central America, Colombia, Peru, Brazil, Guatemala and Venezuela. Hawaii's main cut flower for export is anthurium. USA (Hawaii, Florida and California), Mauritius and the Netherlands are the major countries for commercial cultivation of anthuriums. Apart from these, Denmark, Italy, Germany, Jamaica, Philippines, Sri Lanka, Trinidad and Tobago also deal with anthuriums as there are many commercial nurseries dealing with anthuriums for export. The Netherlands occupies top position in anthurium production under glass. The most important market for Dutch anthuriums is Western Europe, Japan, Hong Kong and Singapore, Germany being the largest importer. Trinidad is the leading supplier of anthurium cut flowers to United States, Dominican Republic and Jamaica. Among Asian countries, Singaporean growers produce anthuriums in Malaysia for export to other Asian and Middle East countries. Mauritius anthuriums are being supplied mainly to French market.

3.2 ORCHIDS AND *ANTHURIUM*

3.2.1 Orchids (Family - Orchidaceae)

3.2.1.1 Classification, Species and Varieties

The Swedish botanist Carl von Linne, better known as Linnaeus is the first to put system of classification of all the plants then known and he arranged them into several groups as per similarities in stamens and pistils. He described 8 genera and 69 orchid species under his group XX-Gyanandria (stamens adnate to the pistil) and Diandria (two stamens). Olof Swartz (1800) published an exclusive article on orchids, describing 25 genera under two divisions: i) orchids with one anther, and ii) orchids with two anthers, and thus he was honoured as the first Orchidologist. These two divisions are today recognized as Monandrae and Diandrae. John Lindley (1799-1865), an Englishman published '**Genera and Species of Orchidaceous Plants**' during 1830-1840, based of all the orchids collected world over till then, and he put orchids in eight tribes as following:

I) Monandrae (one anther)

A) Pollen masses waxy:

Tribe 1: **Malaxideae:** No caudicle or separate stigmatic gland

Tribe 2: **Epidendreae:** A distinct caudicle but no separate stigmatic gland

Tribe 3: **Vandeae:** A distinct caudicle attached to a deciduous stigmatic gland

B) Pollen masses powdery, granular or sectile:

Tribe 4: **Ophrydeae:** Anther terminal, erect or incumbent, adnate to top of column

Tribe 5: **Aretheuseae:** Anther terminal, operculate

Tribe 6: **Neottieae:** Anther dorsal

II) Diandrae or Triandrae (two or three anthers)

Tribe 7: **Cypripedieae:** Ovary one or three-celled

Tribe 8: **Apostasieae:** Ovary three-celled

Heinarich Gustav Reichenbach or Reichenbach fil (popular name), a German, published an article in form of a synopsis in **Walper's *Annales Botanices Systematicae,*** during 1861-1866. On the system of classification, there had been a lot of advocacies, the latest being by Holttum (1964), who outlined a system of classification based on orchids of Malaysia, and published **'A Revised Flora of Malaya Vol. I – Orchids of Malaya',** classifies orchids as under (in all, having 28 tribes):

Family **Orchidaceae** having 2 subfamilies, i) **Pleonandrae** (Apostasia tribe, more than one anther e.g. slipper orchids, ii) **Monandrae** (one anther) which has two types *viz.* **Basitonae** (anther attached by its base, Habenaria tribe) and **Acrotonae** (anther attached by the top). **Acrotonae** is further divided into two: i) pollinia granular [saprophytes and their allies (4 tribes), Goodyera tribe, Corymborchis tribe], and ii) pollinia waxy which is further divided into i) **Monopodial** (*Vanda-Arachnis* tribe), and ii) **Sympodial orchids** which comprise, **a: mainly terrestrial** (pollinia without disc, *viz. Phaius* tribe, *Nephelaphyllum* tribe, *Arundina* tribe, *Sobralia* tribe, *Liparis* tribe), **b: Epiphytes** (pollinia with no disc, *viz. Coelogyne* tribe, *Dendrobium* tribe, *Bulbophyllum* tribe, etc.), and **c: Epiphytic and terrestrial** (pollinia with disc, sometimes with a stripe, *viz. Agrostophyllum* tribe, *Appendicula* tribe, *Thelasis* tribe, *Eulophia* tribe, *Bromheadia* tribe, *Cymbidium* tribe, etc.).

Though this system is very simple and easy to follow but still the **Classification of Orchids** has to evolve finally to make it more understandable.

The orchids have over 800 genera with some 35000 species, out of which India is native of some 1300 species. Orchidaceae is said to be the largest family among the flowering plants. Almost half the species are **a) terrestrial** (growing on the ground of the forest) and remaining ones **b) epiphytes** [growing non-parasitically on the host plants i.e. tree branches, getting their nourishment from air, from humus in bark crevices through specially adapted roots, and through rain water, and normally consists of an horizontal rhizome from which at intervals arise usually erect and swollen stems or pseudobulbs, and these are of two types: **i) monopodials** growing from a single vegetative apex as they sprout new growth by developing axillary shoots which eventually grow into new plants, the main stem growing continuously year after year and has a dominant apical meristem from where in the leaf axils inflorescence arises, and have neither rhizome nor pseudobulbs e.g. *Arachnis, Chiloschista, Microcoelia, Phalaenopsis, Renanthera, Vanda, Vanilla,* etc. where *Chiloschita* and *Microcoelia* are devoid of leaves and the roots have a photosynthetic action, and **ii) sympodials** growing from a number of vegetative apices present at intervals on the normally branched rhizomes with or without pseudobulbs, where main stem terminates its growth at the end of each season and produces a lead or shoot from the base in the growing season by forming its own bulbous stem (pseudobulb) which eventually flowers e.g. *Cattleya, Cymbidium, Dendrobium, Oncidium,* etc.]. Epiphytic species are rather

easy to grow. Most of the temperate zone orchids are terrestrial, and most of the tropical orchids are epiphytes. Majority of the orchids are tropical and others sub-temperate to temperate, starting from the sea level to 3,500 m altitude. Apart from **a) terrestrial** and **b) epiphytic** orchids, there are: **c) lithophytes** or **epilithic** orchids growing on the surface of the rocks, **d) saprophytic** growing on dead or decaying organic matter, **e) subterranean** growing beneath the surface of the growing medium, and **f) semi-aquatic** orchids growing in water.

The pseudobulb is a single swollen internode appearing as bulb in some genera such as *Calanthe, Coelogyne* and *Maxillaria*. These may be round, ovoid, fusiform, clavate, elongated or cylindrical, depending upon the genera. These pseudobulbs produce a tuft or fan of strap-shaped or elongated lanceolate leaves, while in other genera such as *Cattleya, Dendrobium* and Epidendrum, the pseudobulb is stem-like with a few to many joints, sometimes swollen and the leaves are strap-shaped or lanceolate to oblong, and one being formed at each joint usually. The *Vanda* group of epiphytes *viz. Aerangis, Aerides, Angraecum, Phalaenopsis* and *Vanda* do not form pseudobulbs but elongated stems, with pendulous aerial roots and usually with thick and strap-shaped leaves. The function of pseudobulb or thickened stem is like the bulb, which stores water and nourishments for the new growing shoot.

The roots, in orchids, arise from the axils of basal internodes. They are fleshy and the velamen (the outer spongy tissue around the true roots) that is well developed not only in epiphytes and lithophytes but also in terrestrial orchids absorbs water and nutrients quickly either from the growing media (terrestrial orchids) or from air (epiphytes). The function of the velamen is also the conservation of moisture and protection of the plants from strong light. In certain species that lack leaves photosynthesis is carried out in the entire root structure. Terrestrial orchids such as *Cypripedium*, and all native British orchids, have either a tuft of fleshy roots at the base of the plant or underground tubers. The leaves that are usually strap-shaped but more lax than epiphytic species appear only in the basal tufts.

Orchid flowers comprise of three sepals and three petals, the third petal (often larger) transforming into a lip (labellum) which varies from genus to genus but is often spurred and variously lobed, pouched or keeled. The second unusual characteristic feature is the column (fused style and stamens) which has combination of pollen being formed at the top and the ovary just below. The pollen is not powdery but is found in the form of two, four, six or eight spherical masses, or pollinia which are easily carried to the ovary by insects. They hybridize easily where multigenera crosses are possible, and up to five genera have yet been combined in a single hybrid plant.

The genera of orchids which could be commercially grown under the climatic conditions prevailing in this country are:

Aerides (Foxtail orchid)***:*** This is monopodial and epiphytic orchid (a few lithophytes), closely ailed to *Vanda* and may be grown in temperate as well as in tropical areas, depending on the species. There are some 60 species and the important species are *A. crispum, A. fieldingi, A. maculosum, A. odoratum, A. racemeformis, A. vandarum,* etc. Hybrids are *Aeridachnis (Aerides* x *Arachnis*), *Aeridocentrum* (*Aerides* x *Ascocentrum*), *Aeridofinetia* (*Aerides* x *Neofinetia*), *Aeridopsis* (*Aerides* x *Phalaenopsis*), *Aeridostylis* (*Aerides* x *Rhynchostylis*),

Aeridovanda (*Aerides* x *Vanda*), *Renades* (*Aerides* x *Renanthera*), *Tanakara* (*Aerides* x *Phalaenopsis* x *Vanda*), *Vandopsides* (*Aerides* x *Vandopsis),* etc. Pink Glory, Crestwood, Malibu Gold, Yip Sum Wah, Cherry Blossom, Frank Johnston, Hawaii, Tsuruko Iwasaki, etc. are the varieties developed using *Aerides.*

Anoectochilus (syn. ***Haemaria***, Jewel orchid)**:** It is temperate terrestrial orchid which has some 20 species. It is valued for its most colourful leaves and not for the flowers which are normally insignificant. Important species are *A. geniculatus, A. regalis, R. roxburghii, A. setaceus, A. sikkimensis,* etc. *Anoectomaria* Dominyi is a beautiful hybrid between *Anoectochilus roxburghii* and *Haemaria discolor.*

Arachnis (Scorpion or spider orchid)**:** A genus of about 17 epiphytic, lithophytic or terrestrial species. This is a monopodial tropical orchid**,** flowering almost year round, and prefers bright sunlight and high humidity for its growth and flowering. Spikes are 75 to 100 cm or more in length and bear 8-15 flowers. Important species are *A. annamensis, A. cathcartii, A. clarkei, A. flos-aeris,* hybrids are *Aeridachnis* (*Arachnis* x *Aerides), Arachnopsis (Archnis* x *Phalaenopsis), Aranda (Arachnis* x *Vanda), Aranthera (Arachnis* x *Renanthera), Armodachnis (Arachnis* x *Armodorum), Limara (Arachnis* x *Renanthera* x *Vandopsis), Ridleyara (Archnis* x *Trichloglottis* x *Vanda), Trevorara (Arachnis* x *Paraphalaenopsis* x *Vanda), Ascoarachnis (Arachnis cathcartii* x *Ascocentrum curvifolium,* an intergeneric hybrid), etc. and the prominent varieties are Catherine, Ishbel, Maggie Oei Red Ribbon, Maggie Oei Yellow Ribbon, etc.

Brassia (spider orchid)**:** This is an epiphytic orchid thriving in intermediate temperatures, and possesses large flattened pseudobulbs. This genus contains some 30 species, extending from Mexico to Brazil, and the West Indies. The long-tailed sepals and petals are the characteristic feature of brassias. The important species are *B. brachiata, B. caudata, B. gireoudeana, B. lanceana, B. lawrenceana, B. longissima, B. maculata, B. verrucosa, etc.* Some of the intergeneric hybrids are *Brapasia (Brassia* x *Apasia), Brassidium (Brassia* x *Oncidium), Miltasia (Brassia* x *Miltonia), Odontobrassia (Brassia* x *Odontoglossum), Rodrassia (Brassia* x *Rodriguezia),* etc.

Bulbophyllum: This temperate orchid is the largest genus comprising some 2000 species, having roundish pseudobulbs and basal inflorescence. Important species are *B. affine, B. barbigerum, B. biflorum, B. bracteolatum, B. campanulatum, B. cauliflorum, B. chinense, B. comosum, B. crassipes, B. cylindricum, B. falcatum, B. fascinator, B. hirtum, B. leopardinum, B. lobbii, B. longissimum, B. macranthum, B. maximum, B. medusae, B. ornatissimum, B. parviflorum, B. reticulatum, B. robustum, B. sikkimens, B. umbellatum, etc.* Interspecific hybrids are Fascination (*B. fascinator x B. longissimum),* Louis Sander *(B. longissimum* x *B. ornatissimum)* and David Sander *(B. lobbii* x *B. virescens).*

Cattleya: This epiphytic temperate orchid has sympodial growth and originates in South America. It is the most popular and widely grown in the entire Orchidaceae. It has some 65 species, several thousand hybrids and numerous varieties. Important species are *C. aurantiaca, C. bicolor, C. bowringiana, C. citrina, C. dowiana, C. intermedia, C. labiata, C. lawrenceana, C. leopoldii, C. luteola, C. maxima, C. mossiae, C. multiflorum, C. schilleriana, C. skinneri, C. violacea, C. walkeriana, C. warscewiczii,* etc. A few of the large number of hybrids are Hardyana (*C. dowiana aurea* x *C. gigas),* Guatemalensis (*C. skinneri* x *C. aurantiaca),* Intricata (*C. intermedia* x *C. leopoldii),* Victoria Reginae (*C.*

labitata x *C. leopoldii),* Ballantineana (*C. trianaei* x *C. warscewiczii),* Clotho (*C. enid* x *C. trianaei),* Fabia (*C. dowiana* x *C. labiata),* Iris (*C. bicolor* x *C. dowiana),* Omar (*C. enid* x *C. leda),* Whitei *(C. warneri* x *C. schilleriana),* etc. *Laeliocattleya* is bigeneric hybrid with *Laelia.* With the genera like *Brassavola (Adamara*, a hybrid of *Brassavola, Cattleya, Epidendrum* and *Laelia; Brassolaeliocattleya,* a trigeneric hybrid of *Brassavola, Laelia* and *Cattleya;* and *Potinara,* a hybrid of four genera i.e. *Brassavola, Cattleya, Laelia* and *Sophronitis); Broughtonia, Diacrium, Epidendrum, Laelia (Saphrolaeliocattleya,* a trigeneric hybrid of *Cattleya, Laelia* and *Sophronitis*), and *Sophronitis (Lowiara,* a hybrid from *Sophronitis grandiflora* and *Brassolaelia* 'Helen') , this has produced intergeneric crosses. Some popular varieties are Bob Betts, Bow Bells, Bowrevel, Chickamauga, Diane Salo, Doty Sykora, Empress Bells, Estelle, Margaret Stewart, North Star, White Christmas, White Emblem, etc.

Coelogyne: This orchid is epiphytic or lithophytic and has uninodal pseudobulb. There are some 200 species under this genus, some suitable for the temperate areas while others for tropical conditions. The species can be identified by characteristic positioning of the inflorescence. The important species are *C. barbata, C. corymbosa, C. cristata, C. dayana, C. elata, C. fimbriata, C. flaccida, C. fragrans, C. fuscens, C. nitida, C. ochracea, C. odoratissima, C. peciosa, C. tomentosa, C. uniflora,* etc. Hybrids are Mem. William Micholitz (*C. lawrenceana* x *C. mooreana*) and Stanny (*C. asperata* x *C. pandurata).*

Cymbidium: By and large, this is an evergreen terrestrial orchid though some are epiphytes and still a few others as lithophytes, but in cultivation all are grown only terrestrially. This is a sympodial temperate orchid, with a few also suitable for tropical conditions. These plants are found from Sri Lanka to India and Japan and throughout Malaysia to Australia. It has some 70 species, and forms abundant fleshy roots, and short and stout pseudobulbs. Cymbidiums are generally easy to grow which require cool or intermediate temperatures. The plants under this genus bear loveliest and long lasting (sometimes even more than two months) inflorescences, and therefore is most popular and is being grown on a commercial scale in many parts of the world. Important species are *C. aloifolium, C. bicolor, C. dayanum, C. devonianum,, C. eburneum, C. elegans, C. ensifolium, C. giganteum, C. grandiflorum, C. insigne, C. longifolium, C. lowianum, C. madidum, C. mastersii, C. pendulum, C. simonsianum, C. tigrinum, C. tracyanum,* etc. Though there are several thousand hybrids but a few most popular ones are Angelica Advent, Alexanderi Westonbirt (*C. eburneum* x *C. lowianum* x *C. insigne* Westonbirt*),* Arabian Nights, Arunta Amber, Arunta Lovely Lips, Babylon Castle Hill, Balkies, Baltic, Bengal Bay, California Cascade, Cariga, Carisbrook, Comte de Hemptirne, Flirtation, Great Day, King Arthur, Dingwall Lewes, Mahogany, Marcia, Miretta, Mission Bay, Moriah Hindu, Oriental Legend, Pearl Magnificum, Peter Pan Greensleaves, Prince Charles, Princess Elizabeth, Promona, Pumander (Louis Sander x *C. pumilum),* Putana Showpiece, Queen of Picardy, Red Beauty, Rosanna Pinkie, Rose Beauty, Show Girl, Swallow, Vieux Rose, York, Yule Log, etc. This genus has intergeneric hybrids with *Phaius* and *Cyperorchis.* The top seedling varieties in the Dutch Auctions are Cascade, Golden Fleece, Mieke, Molly, Nederhorst and No. 60.

Cypripedium (Lady's slipper)***:*** Commonly it is known as 'lady's slipper' because of its pouch like leaves, appearing as true lady's slipper. Generally they are deciduous and rhizomatous. Some 50 species are found in this genus which are

mainly terrestrial with only a few lithophytic or epiphytic. It is widespread in North Temperate Zone with a few species extending in warm areas such as Mexico and parts of tropical Himalayas. These like tree shade for their growing. Important species are *C. bellatulum, C. calceolus, C. candidum, C .curtisii, C. insigne, C. parishii, C. parviflorum, C. pubescens, C. reginae, C. spicerianum, C. venustum, C. villosum, etc.* Andrewsii Fuller (*C. candidum* x *C. parviflorum*) and Favillianum Curtis (*C. candidum* x *C. pubescens)* are the interspecific hybrids.

Dendrobium: In the entire Orchidaceae, this is the second largest genus with some 1340 species, widely distributed in tropical Asia from Sri Lanka to the Samoan and Tongan islands and across to Japan in the north and to New Zealand in the south. These are non-bulbous producing slender canes to tiny pseudobulbs, out of the underground rhizomes, with a great majority being deciduous epiphytes while a few the more tropical ones are evergreen. For their growing, these prefer partial shade and high humidity coupled with good air circulation. The important species are *D. aggregatum, D. amplum, D. aphyllum, D. aureum, D. bigibbum, D. bellatulum, D. bensoniae, D. boxali, D. brymerianum, D. canaliculatum, D. chrysanthum, D. chrysotoxum, D. clavatum, D. crepidatum, D. densiflorum, D. devonianum, D. draconis, D. falconeri, D. farmeri, D. fimbriatum, D. formosum, D. gibsoni, D. gouldii, D. grantii, D. jamesonium, D. kingianum, D. loddigesii, longicornu, D. moschatum, D. nobile, D. ochreatum, D. parishii, D. phalaenopsis, D. pierardii, D. primulinum, D. speciosum, D. sulcatum, D. thyrsiflorum, D. undulatum, D. verartifolium, D. victoriae-reginae, D. wardianum, D. williamsoni,* etc.

A few of the thousands of varieties are Album, American Beauty, Banyat Pink, Boonchoo Gold, Candy Stripe, Earsakul, Emma White, Gold Flush, Hawaian Beauty, Hieng Beauty, Jaquiline Thomas, Jurie Red, Kanjana Green, Kasem Gold, Kasem White, Lady Hamilton, Mme Vipor, Nette White, New Pink, New Wanee, Pink Tips, Pramott-II, Renappa, Sabine, Sabine Red, Sakura Pink, Sonia Bom Jo, Sonia 17, Sonia 28, Snow White, Theodore, Tongchai Blue, White Nern, etc.

Epidendrum: This is among the largest genera of the Orchidaceae, containing more than 1000 species, is epiphytic (rarely terrestrial) in nature, and most species behave as weeds in the orchid fields, hence, most of the species are of minor importance horticulturally. The genus contains highly varied forms. Some prefer hot while certain others prefer cool conditions for their growing. Generally, they originate in Central America i.e. New World tropics. Important species of horticultural importance are *E. alatum, E. anceps, E. arachnoglossum, E. ciliare, E. cochleatum, E. difforme, E. endresii, E. fragrans, E. ibaguense, E. parkinsonianum, E. polybulbon, E. prismatocarpum, E. radicans, E. radiatum, E. vitellinum, E. wallisii, E. xanthinum,* etc., the interspecific hybrids are Endresio-Wallisii*,* Burtoni, Charlesworthii, Dellense, etc., and the intergeneric hybrids are *Epitonia* with *Broughtonia, Epidiacrium* with *Diacrium, Epigoa* with *Domingoa, Epilaelia* with *Laelia, Epilaeliopsis* with *Laeliopsis, Epicattleya* with *Cattleya, Epiphronitis* with *Sophronitis, Epiphronitella* with *Sophronitella, Schomboepidendrum* with *Schomburgkia, Kirchara* with *Cattleya* x *Laelia* x *Sophronitis*, etc.

Eria: This genus contains some 550 species, and is native to Tropical Asia, extending from the Himalayas, China and Sri Lanka to the Fiji Islands and Samoa, with greater concentration in Indonesia and New Guinea. This is allied to *Dendrobium* but has eight pollinia. These are either epiphytic or lithophytic. The

flowers are small of brown and white colours. Important species are *E. bambusifolia, E. carinata, E. coronaria, E. dalzellii, E. fragrans, E. nana, E. mysorensis, E. pauciflora, E. polystachya, E. pseudoclavicaulis, E. reticosa, E. spicata, etc.*

Odontoglossum: This very popular orchid is among the loveliest orchids, hence is being widely cultivated in many tropical parts of the world. The genus comprises some 300 species and is allied to *Brassia* and *Oncidium.* This has oval to round pseudobulbs compressed at the sides. The plants of this genus are mostly epiphytic but a few are lithophytic or terrestrial. Important species are *O. bictoniense, O. cirvantesii, O. cirrhosum, O. citrosmum, O. cordatum, O. crispum, O. grande, O. harryanum, O. lindleyanum, O. luteo-purpureum, O. maculatum, O. nobile, O. rossii, O. stellatum, O. triumphans,* etc., a few of the thousands of interspecific hybrids are Adrianae, Alispum, Anneliese Rothenberger, Aspermum, Brandtii, Crispania, Crispelus, Elegans, Elise, Elle's Triumph Dahlenburg, Eudora, Himachal, Humeanum, Maronius, Nisus, Ophoon, Perryanum, Princess Elizabeth, Wilckeanum, etc., and intergeneric hybrids are *Odontioda* with *Cochlioda, Odontocidium* with *Oncidium, Odontonia* with *Miltonia, Odontobrassia* with *Brassia, Adaglossum* with *Ada, Symphodontoglossum* with *Symphyglossum, Beallara* with *Brassia* x *Cochlioda* x *Miltonia, Burrageara* with *Cochlioda* x *Miltonia* x *Oncidium, Sanderara* with *Brassia* x *Cochlioda, Vuylstekeara,* a trigeneric hybrid of *Cochlioda, Miltonia* and *Odontoglossum, Wilsonara* with *Cochlioda* x *Oncidium, Colmanara* with *Miltonia* x *Oncidium,* and *Lagerara* with *Aspasia* x *Cochlioda.* .

Oncidium (dancing lady)***:*** By and large these are evergreen epiphytic (a few terrestrial or lithophytes) orchids with some 750 species found in the American sub-tropics, having compressed pseudobulbs (certain are mule eared i.e. devoid of pseudobulbs) and are highly variable. The elegant flowers are borne in drooping and branched spikes. Common characteristics are the petal-like wings on the column, a bump below the stigma and a large and many-toothed crest at the base of the lip. Usually the flowers are yellow or brown with dark crimson central lobe, bright and showy but small. Important species are *O. altissimum, O. ampliatum, O. auriferum, O. cavendishianum, O. cheirophorum, O. crispum, O. divaricatum, O. forbesii, O. lanceanum, O. macranthum, O. marshallianum, O. ornithorbynchum, O. papilio, O. sarcodes, O. varicosum, O. variegatum,* etc., important interspecific hybrids are Burzeffianum, Haematochilum, Kaiulani, Mantinii, Punctatum, Vizer, Wheatleyanum, etc. and intergeneric hybrids are *Brassidium* with *Brassia, Charlesworthеara* with *Cochlioda* x *Miltonia, Miltonidium* with *Miltonia, Oncidioda* with *Cochlioda, Rodricidium* with *Rodriguezia, Trichicidium* with *Trichocentrum,* etc. Some other popular varieties are Album, Esther, Folksy Misty, Golden Shower, Golden Sunset Robsan II, Gower Ramsay, Irina Murray Orchidglade, Josephine, Potpourri Scarlet, St. Anne, Tiny Tim, Wikki Sunset, Willow Pond, etc.

Paphiopedilum (lady's Slipper)**:** A genus of 50 species of evergreen tropical Asiatic orchids having no pseudobulbs, and the flowers are quite similar to *Cypripedium.* They are mostly terrestrial, a few lithophytic or rarely epiphytic. The spectacular and the long-lasting flowers are produced singly or in few-flowered racemes. Important species are *P. appletonianum, P. barbatum, P. bellatulum, P. callosum, P. concolor, P. fairieanum, P. hirsutissimum, P. insigne, P. lawrenceanum, P. niveum, P. parishii, P. rothschildianum, P. spicerianum, P.*

venustum, P. villosum, etc. A few of thousands of the interspecific hybrids are Aylingii, Arthurianum, Bion, Charles Richman, Demura, Gloriosum, Goultenianum, Harrisonianum, Holdenii, Kowloon, Le Douxiae Leeanum, Lethamianum, New Era, Maudiae, Tesselatum, Vinter's Treasure, Winnipeg Shillington, Wottonii, etc. Two bigeneric hybrids are *Phragmipaphiopedilum* and *Selenocypripedium* which were evolved by crossing with *Phramigpedium.*

Peristeria (dove orchid)**:** A group of stately South American pseudobulbous warm house orchids. Some five species are reported under this genus where only three are cultivated, viz. *P. cerina, P. elata* and *P. pendula,* which bear 6 to 20 flowers per raceme.

Phaius**:** This tropical genus consists of 30 deciduous species of terrestrial (a few species also epiphytes) orchids, having elongated pseudobulbs and typically erect inflorescence with beautiful long-lasting flowers. Important species are *P. amboinensis, P. callosus, P. flavus, P. humblotii, P. longipes, P. maculatus, P. mishmensis, P. pauciflorus, P. sanderianus, P. schnoebrunnensis, P. simulans, P. tankervilliae (*syn. *Bletia tankervilliae, P. grandifolius Lour.), P. tuberculosus, P. wallichii (*syn. *P. bicolor, P. blumei, P. grandifolius* Lindl. *or P. grandiflorus)* etc. Some of the interspecific hybrids are Cooksonii, Marthae, Norman, Phoebe, etc. while intergeneric hybrids are *Gastophaius* with *Gastorchis, Phaiocalanthe* with *Calanthe, Phaiocymbidium* with *Cymbidium,* and *Spathophaius* with *Spathoglottis.*

Phalaenopsis (moth orchid)***:*** Some 50 epiphytic (tree trunks and on the sides of the rocks) species are reported in this genus which are generally evergreen and native of tropical India and Indonesia to the Philippines, New Guinea and northern Australia. The plants of this genus are monopodial in habit, have short rhizomes instead of pseudobulbs and tightly clinging long aerial roots. The inflorescences are lateral, short or long, erect or pendulous and sometimes branched. The flowers of some species are excellent for cutting as they are very attractive and long-lasting. Important species are *P. amabilis, P. fuscata, P. lueddemanniana, P. mannii, P. parishii, P. rosea* syn. *P. equestris, P. schilleriana, P. speciosa, P. stuartiana, P. violacea,* etc. Interspecific hybrids are Alice Gloria, Ann Marie, Artienne, Bride's Maid, Canary, Carreer Girl, Encantadora, Eye Dee, Golden Liz, Golden Pride, Irene Dobkin, Malaysian Beauty, Natasha, Peppermint, Ruby Lip Tip, Samba, Spotted Moon, Spring Shower, Star of Rio, Tammy, Texas Star, Reve Rose, Riea, Tiger Butter, Tiger Butter Larkin Valley, White Goddess, Zada, etc. and intergeneric hybrids are *Aeridopsis* with *Aerides, Arachnopsis* with *Arachnis, Doritaenopsis* with *Doritis , Phaladopsis* with *Vandopsis, Renanthopsis* with *Renanthera, Rhynchonopsis* with *Rhynchostylis, Rhynodoropsis* with *Doritis Rhynchostylis, Tanakara* with *Aerides* x *Vanda* and *Vandaenopsis* with *Vanda.* Certain intergeneric varieties are George Molar Golden Shower, Jerry Sue King, etc.

Renanthera (sun loving orchid)**:** This tropical monopodial orchid possesses some 15 epiphytic, tall (0.6-3.6 m) and climbing species which has good commercial value. Stems are branched and it climbs by means of fleshy roots. Inflorescence is quite large and drooping. Important species are *R. coccinea, R. elongata, R. imschootiana, R. pulchella* and *R. storiei.* Some of the bigeneric hybrids are *Aranthera* with *Arachnis, Leathers* with *Renantherella*, *Pararenanthera* with *Paraphalaenopsis, Renades* with *Aerides, Renanopsis* with *Vandopsis, Renantanda* with *Vanda, Renanthoglossum* with *Ascoglossum, Renanthopsis* with

Phalaenopsis, Renantylis with *Rhynchostylis, Renencentrum* with *Ascocentrum* and *Sarcothera* with *Sarcochilus*. The trigeneric hybrids of *Renanthera* are *Hawaiiara* with *Vanda* x *Vandopsis, Holttumara* with *Arachnis* x *Vanda, Limara* with *Arachnis* x *Vandopsis, Moirara* by crossing *Renanthera* with *Paraphalaenopsis* x *Vanda,* etc. The interspecific varieties are Brookie Chandler, Higgins, Kilauea, Mauricette, Mok York-Seng, Poipu, Tom Thumb, etc.

Rhynchostylis (fox-tail orchid)**:** This monopodial epiphytic orchid is quite robust and has some four species, distributed over tropical Asia from the Indo-Myanmar region to Thailand. Flowers appear from the axils of the leaves, in dense racemes and gracefully drooping. There are four species where *R. retusa* is native to India i.e. Western Ghats. Its various varieties are in trade, *viz. alba, dayi***,** *gigantea, holdfordiana, majus, superba***,** etc. *R. coelistis,* and *R. violacea (*flowers have disagreeable flavour) are the other two commercial species, latter having a var. *harrisonianum*. Its intergeneric hybrids are *Aeridostylis* through *Aerides, Renanstylis* through *Renanthera, Rhynchocentrum* through *Ascocentrum, Vandacostylis* through *Vanda,* etc. Gigantea Red, Gigantea White, etc. are a few most important varieties.

Vanda**:** This sun-loving evergreen, epiphytic and monopodial orchid has highly attractive large flowers in all the species, has some 70 species spread in East India and the Malay Islands with outlying species in China and New Guinea. The species may be short-stemmed and erect (compact) or tall and branched (sometimes climbing to some height) and without pseudobulbs. The inflorescence is erect or pendulous and arises from the leaf axils. There are two types: i) with strap-shaped leaves, and ii) with cylindrical leaves. Important species are *R. alpina, V. amesiana, V. bensonii, V. coerulia, V. coerulescens, V. cristata, V. denisoniana, V. hookeriana, V. parishii, V. parviflora, V. roxburghii, V. stangeana, V. teres, V. tricolor, V. tessellata,* etc. *V. coerulea* is used for breeding blue *Vanda* hybrids, vars 'Bhimayothin' for pink colour, 'Madame Rattana' for pink and blue vandas, 'Pranerm Ornete' for brownish yellow, 'Piyaporn' and 'Prakpetch' for purplish red and blue black, 'Gordon Dillon' and 'Siam Ruby' for pink, and purplish red 'Rassi' for yellow vandas. Two different plants of *Vanda coerulea* when crossed together resulted into a clone 'Buranasin'. 'Miss Joaquim', 'Deva', 'Nam Phung', 'Rasri', 'Kultana', 'Prakpetch', 'Sumon Sophonsiri', 'Kasem's Delight', 'Pissamai', 'Wirat', etc. are the interspecific hybrids. *Aranda* hybrid was evolved by *Vanda* with *Arachnis, Aeridovand* through *Aerides, Ascocenda* through *Ascocentrum, Christieara* through *Ascocentrum x Aerides, Luisanda* through *Luisia, Nakamotoara* through *Ascocentrum* x *Neofinetia, Opsisanda* through *Vandopsis, Renantanda* through *Renanthera, Trichovanda* through *Trichoglottis, Vandanthe* through *Euanthe, Vandofinetia* through *Neofinetis,* etc. are some of the intergeneric hybrids. Some other popular varieties are Ellen Noa, Emily Notley, Evening Glow, Bill Sutton, Hilo Blue, Honolulu, Honomu, John Club, Onomea, Wirat Uchida, etc.

Acacallis, Aerangis, Ancistrochilus, Angraecum, Arachnanthe, Arundina, Ascocentrum, Barkeria, Bletilla, Brassavola, Broughtonia, Calanthe, Cirrhopetalum, Cochleanthes, Cochlioda, Cryptochilus, Diacrium, Doritis, Encyclia, Esmeralda, Euanthe, Habenaria, Helcia, Laelia, Lemboglossum, Lycaste, Macradenia, Masdevallia, Maxillaria, Miltonia (Miltonioda, a bigeneric hybrid between *Miltonia* and *Cochlioda), Monomeria, Mycrostylis, Neofinetia, Neogyne, Paraphalaenopsis, Pleione, Rhisalidopsis, Rodriguezia, Saccolabium,*

Satyrium, Sophronitis, *Spathoglottis, Stanhopea, Thunia, Trichosma, Vandopsis, Vanilla, Zygopetalum,* etc. are other equally important genera.

3.2.1.2 Propagation

Orchids can be propagated through **division**, **offset** (**offshoots** or **keikis**), **cuttings** or **seeds** but the division is the most simple and popular method.

Monopodial orchids are though difficult to propagate vegetatively but such as *Aerides, Arachnis, Aranda, Phalaenopsis, Renanopsis, Renanthera* and *Vanda* are propagated by **stem cuttings** (mostly with 40-50 cm long top cuttings with at least two well developed aerial roots are ideal but smaller cuttings with 2-3 nodes will also serve the purpose though flowering will be considerably delayed), **flower stalk cuttings** (flowered spikes of certain genera like *Calanthe, Phaius, Phalaenopsis* and *Thunia* sometimes produce vegetative shoots) from the flower stalks can be taken and planted horizontally in moist media (sphagnum moss or coconut husk bits) and **layering** (*Vanda* and certain other monopodials) by striking a slanting cut some 20-30 cm below the apex of the stem and wrapping the wound with some moist medium akin to other layers and these should be separated and planted when these strike roots. *Anoectochilus* is though sympodial orchid but also responds more to cuttings than any other method of vegetative propagation.

Most sympodial orchids such as *Cattleya, Coelogyne, Cymbidium, Dendrobium, Epidendrum, Laelia, Oncidium, Paphiopedilum, Zygopetalum,* etc. are propagated through **division** (division of large clumps into smaller units) where without injuring the roots the rhizomes of well established plants are halved, each half having 4-5 shoots (growing points) or in many pieces, each having 2-3 pseudobulbs but for a large number of plants even single pseudobulb sections on the rhizomes may be made from where the older ones may produce new growth, however, bigger the size of the division earlier is the establishment *vis a vis* flowering; **offshoots** (**offsets,** or **keikis** meaning babies) as in case of *Dendrobium* and *Pleione* which produce small bulbils or offsets, which when detached and potted separately flower within 2-3 years but when these are removed from the mother plant after these have once flowered there these respond well; and **backbulbs** as in case of *Cattleya* **(**the physiologically lesser active older shoots or canes of tall and climbing orchids which are sometimes devoid of foliage and green in colour) which do not have visible eyes and may have only a few roots, are separated (lengths being 10-15 cm) and planted horizontally in moist medium and when these sprout from the nodal region and send out roots, they are separated and planted in individual pots. **Offshoots** are also produced in *Phaius* and *Phalaenopsis* if their inflorescences are cut off and laid horizontally in moist sand and sphagnum medium. *Cymbidium* and *Paphiopedilum* also produce offshoots.

In every case, the wounds are treated with effective fungicides if not separated and planted under aseptic conditions.

Commercially, orchids are propagated either through asexual mericlonal technique or through sexual methods (seeds are devoid of endosperm which stores the growth promoting factors, therefore can not grow like seeds of other plants). Some 69 genera and their hybrid varieties are being multiplied through tissue culture method globally. Some Asian countries like Thailand, Singapore, Japan,

Korea, Taiwan and Malaysia multiply some 32.0, 2.0, 2.5, 2.5, 1.5 and 1.7 million tissue cultured plants annually, respectively. The shoot tips of *Aranda, Arachnis, Cymbidium, Lycaste, Miltonia, Odontoglossum* and *Oncidium*; the shoot tips, leaf tips and axillary buds of *Cattleya*; through root tips and shoot tips in *Vanda*; and shoot and stem tips, root tips, leaf tips and inflorescence tips in case of *Phalaenopsis* are used as explants. On commercial level, Knudson C, Arditti or Murasige and Skoog media are used for orchid tissue culturing. Looking into the requirements of the individual species, the nutrients are adjusted in the medium. Whether it is asexual or sexual propagation method, aseptic conditions are required under both the circumstances. Their growth may be promoted by use of certain hormones such as DCPTA [2-(3, 4-dichlorophenoxy) triethylamine], 2, 4-D, IBA, NAA, IAA and 2, 4, 5-T; and cytokinins such as BA, kinetin and 2iP. The concentration differs from species to species, however, the pH of the medium should be slightly acidic *i.e.* 5.8.

Orchid seeds are very tiny and numerous per capsule (1,300-4,000,000) but are devoid of endosperm, hence, are unable to grow on their own. For their germination and survival, these require the presence of a symbiotic fungus which brings about certain chemical changes in the tissue of the seeds and supplies some nutrients including simple sugars for the germination after the protocorm stage. High germination rates are obtained by sowing the seeds in flasks of agar and mineral nutrients under sterile conditions. Seeds are also sown by sprinkling them around the base of a mature orchid plant of the same species or the allied ones where this root fungus (mycorrhiza, especially *Rhizoctonia repens, R. mucoroides, R. languinosa, Mycelium radicis,* etc.) naturally occurs. When these germinate and reach the stage of 3-4 leaves, these are gently shifted singly in 5-cm pot filled with well-chopped compost. Though seeds are quite minute but while seeing microscopically, the fertile ones are browner than infertile ones.

3.2.1.3 Cultural Practices and Growth Factors

Orchids are perennial plants of varying growth habits, *viz.* terrestrial, epiphytic (monopodial or sympodial, and even climbing types), lithophytic (epilithic), saprophytic, subterranean and semi-aquatic; sun-loving or shade-loving; pseudo-bulbous [(0.75 mm, too small) to 5.0 metres in diameter] or non-pseudo-bulbous; leafy or leafless; and temperate or sub-tropical and tropical, hence there are varying requirements of their growth factors, *viz.* growing medium, nutrition, watering, ventilation, temperature, light and humidity as defined here under.

A number of **growing media** are used for orchid growing as per the specification of the individual genus or species; consistent with their place of origin but the pH of the medium should range in between 5.0-6.0 and the E.C. not over 2.0. The medium should provide support to the plants, should be highly porous for proper aeration, should have good drainage facilities, should have adequate water holding capacity and should be rich in nutrients so that roots may not starve. Exchange of gases in the root zone is vital for growth and survival of orchids so the media are designed to hold both *i.e.* water and air, and in case when persisting scarcity of the one occurs the other occupies its place which becomes dangerous. If medium becomes once dry, it is difficult to rewet it and at this stage if it is watered the water just runs through the medium without getting absorbed into it, and scarce results into increased salt concentration which is toxic to the roots and plants. For growing epiphytes, the medium should have adequate capacity

for holding moisture but should not remain soggy and wet. Sphagnum moss or leaf mould in the plains decomposes soon and invites fungal diseases *vis a vis* becomes slimy, hence is not preferred but under cooler climates sphagnum moss is preferred being acidic in nature, also as it contains certain amount of iodine which keeps the compost fresh for long period. Osmunda or polypodium fern fibres alone or in combination with sphagnum moss (2:1 by volume) for improving water holding capacity is the best medium for most epiphytes as this lasts longer and decomposes slowly releasing 2-3 per cent nitrogen but due to its scarcity, now root and trunk fibres of various tree fern species are being used. Apart from these, peat + dried fern + sphagnum moss, the beaten redwood/fir bark or fir bark + peat + perlite, coconut husk + pieces of bricks and charcoal, moss peat, saw dust, rice husks, peanut shells and cork are also used for both *i.e.* epiphytes and terrestrials. The old coconut husks are used in the high rainfall tropics for growing *Phalaenopsis* and Vandaceous plants having no pseudobulbs, and *Phalaenopsis* plants when fixed to mango and other trees grow very well. Perlite: Metromix 700: charcoal (1:1:1) or fir bark: peat moss: perlite grade 3: perlite grade 2: vermiculite: rock wool (4:2:1:1:1:1) provide good yield in *Phalaenopsis. Cypripedium* and *Cymbidium* grow well when $^{1}/_{4}^{th}$ teaspoon of hoof and horn meal, coarse bone meal and leather meal are sprinkled over the drainage layer among the crocks. *Bulbophyllum* does best on soft tree fern stem with a little sphagnum moss around the roots. Terrestrial orchids require loamier compost i.e. equal parts (all by volume) coarse peat or rough leaf mould, fibrous loam, sand and moss. Terrestrial orchids such as *Calanthe, Phaius,* etc. have luxurious growth when grown in a mixture of leaf mould, chopped tree fern, white sand, sandy loam and well rotten cow dung manure or charred cow dung. *Coelogyne* can be grown successfully in a mixture containing equal parts of sphagnum moss, leaf mould, white sand and loamy soil. A porous medium rich in organic matter is excellent for *Habenaria,* osmunda fibre, fibrous loam and sphagnum moss in equal proportion for majority of *Eria* species, a mixture of chopped tree fern fibre, charcoal pieces and sphagnum moss for *Ione* and *Oberonia* species, osmunda fibre, sphagnum moss, charcoal and very small pieces of cork in shallow pans for *Liparis*, a mixture of equal parts of shredded tree fern fibre, leaf mould, sandy loam soil and white sand for *Microstylis,* and small brick chips, white sand, chopped tree fern fibre, leaf mould and a little quantity of charcoal and bone meal in a pot filled to its third with cork is good for *Goodyera.*

Orchids require balanced **nutrition** for about 10 months in a year except in the period when they are in new growth. Like other plants, they also require NPK and minor or trace elements (Mn, Mg, Ca, Fe, Zn, Cu and boron) for their healthy growth. Under natural conditions, orchids draw these inorganic nutrients from the bark of the tree where they are growing *vis a vis* from atmosphere and decaying organic matters (plant parts and bird droppings) but under controlled conditions these are to be supplied separately. During the period of new growth these require nitrogen rich fertilizers but not in excess to avoid salt deposition in the pots as orchids are highly sensitive to excess salt which may result in blackening of roots, burning of leaf tips and white encrustation on the media in the pots. Intake of nutrients in orchids is very little through leaves as compared to roots. Hybrid plants of *Cymbidium* and *Phalaenopsis* respond well to 100 ppm N, 50-100 ppm K and 25 ppm Mg though young *Phalaenopsis* plants require heavy feeding *i.e.* 200 ppm N through 20-20-20 fertilizer with each irrigation whereas *Cattleya* with 50 ppm of N, K and Mg and the levels of P, Ca, Fe, Mn, B, Zn, Cu and Mo are 20, 200, 3, 1, 0.25, 0.20, 0.025 and 0.0001 ppm, respectively. Application of

chicken manure @ 50-100 g per plant on the ground to *Arachnis, Aranda, Aranthera, Dendrobium* and *Oncidium* provide increased inflorescence yield. In case of *Dendrobium,* neither medium nor fertilizer frequency brings the flower initiation of young pseudobulbs but flowering is hastened with increased number when grown in fir bark (small or large grades) amended with 30% peat moss by volume and regular fertilizer application with 200 ppm N from an NPK fertilizer. Liquid manure prepared through cow dung or oil cake @ 1% strength improves growth and flowering in *Aerides multiflorum* and *Dendrobium moschatum.* Application of 5 mmol K/l results in quality and quantity blooms in *Cymbidium sinense.* In fact, orchids prefer frequent weak solutions of fertilizers than the strong ones less often, very little nitrogen during flowering, no high N fertilization to seedlings and no fertilizer to sick plants. Nitrogen deficient plants remain stunted, mature earlier where older leaves turn yellow and fall off whereas excess of nitrogen accelerates excessive vegetative growth, delays flowering and causes rotting of roots and bulbils. Phosphorus deficient plants become stunted but with dark green leaves, sometimes foliage starts decaying. Potassium deficiency also causes stunting but here leaves are frequently scorched and dead on the edges. Calcium is necessary for regulation of cell activities and cell wall formation and its deficiency causes distortion of the plants, discolouration of leaves from margin to midrib due to loss of chlorophyll, purple tinting of the veinlets, mature leaves turning black and dropping off and developing pseudobulbs may also turn black though most orchids require calcium-less water spraying. Deficiency of sulphur may affect root growth. Magnesium promotes uptake of phosphorus and certain other elements whereas its deficiency causes chlorosis in between the veins of the older leaves which may cause ultimate death of the plant. Iron maintains the normal growth of the plant as it is essential for chlorophyll formation but its deficiency causes yellowing of the younger leaves. The role of boron, copper, manganese, molybdenum and zinc is not properly understood in case of orchid cultivation.

Most terrestrial orchids can be grown in ordinary flower **pots** (porous earthen or plastic, earthen being the best) having holes on their sides and bottom but these should be clean, well-drained and crocked. In fact, earthen pots do a lot of breathing while plastic pots do not at all, so earthen pots are more suitable as roots have a much better access to the air for providing good health, though watering to the plants in the plastic pots is less frequent. Baskets for the purpose should be made of hard woods. Epiphytes feel comfortable in specially perforated pots, on pieces of tree trunk, bark, on osmunda fibre rafts, on tree-fern stem bits or in the wooden basket by fixing the plants through wire and such slabs are suspended at a suitable place. The upper portion of the pot should be filled with fresh broken bricks (5 parts small pieces) and fern fibre (1 part). The roots of the Vandaceous plants should not be buried in the compost and instead should be exposed to the air. **Potting** and **repotting** are done when the plant has overgrown its container, preferably just after the flowering or when new growth is appearing. While potting a young plant of an epiphyte, the rhizome is stationed on the drainage material and then all around it the compost is pressed using a strong but blunt stick, putting crown of the plant at the level of the pot. For repotting an established epiphyte, the plant is taken out of container, the soft and rotted compost is teased off, the dead roots are removed, the plant with intact rhizome is then held upside down and the compost is pressed in between and around to make it a ball larger than the size of the pot, and then it is squeezed and pressed firmly in the pot, and then finally some further compost is pressed in the pot to fill in the

gaps. While dividing the plant, each division is treated the same way as for the whole plant. It should be done every three years.

Watering of orchids depends upon the type of species, the plant size and stage (old, adult or young), the type of container [pot (wooden basket, plastic, cemented or earthen), raft or direct in the soil] and/or medium used, existing temperature, the season and the prevailing weather conditions, and the conditions from where these have been originally collected. The watering should be adequate to leach the soil mix periodically to avoid soluble salt build up and to keep the plants uniformly moist. The plants grown on a raft require the spraying of the constituent material several times a day in the growing season and watered every second day. Osmunda fibre (*Osmunda regalis* fern roots), tree-fern fibre (various species of *Dicksonia*), and sphagnum retain moisture much longer than coniferous bark, charcoal and perlite. Young plants of even same species with more delicate growth but less developed root system require watering more often than adults. Plastic pots retain moisture better and longer than the cemented, clay or wooden baskets though there is very poor root aeration in plastic pots. Though there should be copious atmospheric humidity and moisture in the media but these should be watered only 7-10 days after potting. Then these are watered sparingly for a fortnight until the young new roots are well established. However, from April to September i.e. during growing season all the plants should be kept moist if there is no rain. For a few minutes the pots of epiphytes are submerged in water every week in spring and autumn while twice a week in hot months and the terrestrials can be watered by can *in situ.* Most orchids like water less in calcium, magnesium and sodium. A high chlorine level in the water hampers the functioning of the root system. However, good irrigation water is that which has 5.5 to 6.5 pH reaction (though *Cattleya* may be grown from 4 to 9 pH range) and contains soluble salts of less than 125 ppm while that containing 125 to 500 ppm is tolerable, and 500 to 800 ppm should be used with caution but above 800 ppm it is at all not suitable. Collection of water in the cities after the first rain is also ideal for orchids, however, where there is no industrial pollution it can always be collected from the rains. Drinking water is also suitable if stored in the tank for a day or so. Watering in the morning is preferred so that standing water may disappear by the evening. Water deficiency causes decreased CO_2 uptake. *Dendrobium* and *Calanthe* are watered every seven days, *Cattleya, Oncidium* and *Odontoglossum* every five days, *Cymbidium* every three days, and *Cypripedium, Paphiopedilum* & *Phalaenopsis* every two days as these require moist medium throughout.

Proper **ventilation** should be ensured in the greenhouse**.** A rise of 11°C temperature over the minimum given is safe for orchids. However, temperatures higher than this should be controlled through ventilating the polyhouse, even by installing an electric fan. Since epiphytes draw their nutrients from air as this consists of oxygen, nitrogen, carbon dioxide and water vapour, CO_2 being most important as food for the plants, therefore also fresh air movement in the polyhouse should be ensured. Direct contact with too dry and warm winds even to the tropical orchids may kill them or too cold wind entering the warm house will injure the plants. Hot air contains negligible moisture so it absorbs moisture from the tender parts of the plant, and that is why during summer in northern plains of India, orchids either die or highly scorched. However, during cold weather also, the air movement is necessary to avoid *Botrytis cinerea* infection. The constant movement of the air in the orchidarium or greenhouse (cool, intermediate or hot) ensures good health.

The true orchid species as well as their natural hybrids require a **temperature** regime similar to their natural habitats. Some have come from the temperate habitats, some other from sub-tropical regions and the remaining ones from the tropical regions so such conditions are to be created. Therefore, orchid growers throughout the world have created such conditions by constructing **orchid houses**/ **orchidaria.** Orchidarium can be made from the materials like split bamboo, glass, fibre glass, etc. Lath house with inclined or flat-roof is constructed with wooden posts embedded in a concrete base. The floor is made of paved brick, porous gravel, pumice, cinder or similar absorbent material to maintain high humidity inside the house. The roof is made with split bamboos or thin wooden slates but in high rainfall areas, the slate is covered with polythene. Long wooden benches should be provided in the house for displaying potted orchids but in the centre there should be water reservoir or lily pool or small tanks for water spraying and for maintaining humidity inside. Fibre glass houses are just like the lath house except the fibre glass roofing which provides uniform and diffused sunlight. The short walls are there with fixed glass windows all around. In such houses all sorts of tropical and sub-tropical orchids can be grown. Controlled glasshouses are the best as there temperature, humidity, aeration, light and nutrition can be provided as per the specific requirements of the orchid species. Precisely, controlled glasshouses can be categorized in **i) cool, ii) intermediate,** and **iii) summer houses.** The **cool houses** where all the thin leaved orchids such as *Calanthe*, *Cymbidium, Cypripedium,* some *Miltonia, Odontoglossum, Paphiopedilum* with ordinary leaves, *Pleione* and many others collected from higher altitudes are grown, should have winter night temperature of 7-14°C (preferably not below than 12°C) and day time temperature of 20-22°C (preferably not to exceed 24-25°C); **intermediate houses** where night temperature should not fall below 15°C and the day temperature should not go beyond 30°C where *Cattleya, Coelogyne, Dendrobium* species, *Eria, Laelia, Oberonia, Oncidium,* mottled-leaf *Paphiopedilum,* and several others are grown; and the **warm** or **hot houses** where night temperature should not fall below 18°C and day temperature should approximate 25-32°C or even more and here thick-leaved *Arachnis*, *Aerides, Aranda, Cymbidium* (a few tropical types)*, Dendrobium* hybrids, *Mokara, Phalaenopsis, Rhynchostylis, Vanda,* etc. can be grown. Minimum winter night temperature should range from 7-14°C, and the minimum summer night temperature from 14-22°C. They can tolerate a good deal of additional heat as up to a rise of 11°C temperature over the minimum given is safe for orchid growing but the temperature rising beyond this limit should be controlled through ventilation. On cold winter days (especially the temperate regions) when sunshine is to a minimum, in all the three types of greenhouses the heating system is set to create a contrast of at least 5°C between day and night temperatures. Only if the orchids are given proper temperature range they may flower because temperature is not that crucial for growth and survival as that of flowering.

Cymbidium plants at tight (puffy) bud or at first open flower stage can be cold stored for up to 30 days at 4°C and then brought back to growing **temperatures** with no any ill effect, and after opening of the first flower it may again be stored for up to 35 days. Just by selecting early, medium and late cultivars and through aforesaid storage technique, production may be generated throughout the year. *Cymbidium* usually flowers from winter to early summer. *Dendrobium* flowers from late autumn to early spring but through proper scheduling and selection of cultivars, it can also be flowered year round. *D. nobile* can be grown at or above 18°C temperature and then subjecting at 13°C temperature and long days, it can

be flowered four months after LD. Tissue cultured plants of *Phalaenopsis* flower in 18 months. This flowers in 104 days after 25/20°C (day/night) temperature treatment for four months, followed by 28/18°C (day/night) temperature until flowering. *Paphiopedilum* and *Phragmipedium* flower naturally during autumn. In this, flower initiation occurs within six months if grown around 13°C temperature. When inflorescence heads, the development can be hastened by forcing at 18°C. Around 17°C temperature and 8 h days photoperiod hasten flowering in *Cattleya.* LD delays and high light induces flowering.

Shading (50-70 %) of the greenhouse prevents too much direct **sunlight,** and controls temperature generated through direct sun rays, especially during summer. Seedlings require less **light** than adult plants. The standard commercial orchids are normally day neutral with exception of *Cattleya* (2.6-3.9 klx) and *Phalaenopsis* (1.6-1.9 klx) where LD delays flowering and high light encourages flower induction while *Cymbidium* requires high light in the winter and reduced light in the summer. However, this is not true with many of the tropical orchids which respond well to small fluctuations in day length and temperature. The maximum CO_2 uptake (day and night) is found with 650 fc, with no difference between juvenile and older leaves, but in greenhouses, to control temperatures, light is reduced to 1200-2000 fc. The growth in *Cattleya* and *Phalaenopsis* is 2-4 times more in controlled growth chambers than in greenhouses. Recommended light levels in case of *Cattleya* is 1500-3000 fc, in case of *Cymbidium* it is 2400-3600 fc, in case of *Dendrobium* it is 2400-3600 fc, in case of *Phalaenopsis* it is 1200-2000 fc and in case of *Paphiopedilum* and *Phragmipedium* it is 700 fc. *Cypripedium* and *Phalaenopsis* require only 200-300 foot-candles light while genera such as *Aranda* and *Vanda* feel more comfortable under 800 foot-candles. Both, the quantity and quality of light determine potential of blooming in most of the orchids and if a healthy plant is not initiating blooms it means the light received by the plant is improper. Every orchid species, hybrids or varieties should get optimum light conditions as to that of its natural habitat.

Looking into the requirement of **light intensities,** particularly from summer to autumn by various orchid species, they can be put under three groups: i) light shade (20-30 % of outdoor light), ii) medium shade (15-20 % light), and heavy shade (10-15 % light). *Cattleya* and *Cymbidium* can be grown successfully under fluorescent lamps than natural or high density discharge light but *Phalaenopsis* under almost all types of fluorescent lamps. Fluorescent or incandescent (70:30 % of wattage) lamps are necessarily used in aseptic culture conditions for propagation.

A rise of temperature up to 32°C or even more in the warm house during the summer growing season is safe if **humidity** in the polyhouse is around 100 per cent. Moreover, higher temperature undoubtedly encourages the growth provided commensurate humidity is present. Humidity in the orchidarium can be maintained by constructing a pool or water tank in the centre to ensure at least 30 % humidity in the night and 80 % during day time. Misting units or foggers (in the small units) and humidifiers (in the large units) will ensure adequate humidity, and the frequency of the humidifier may be timed depending upon the prevailing weather conditions. The orchids that originally come from tropical zones should in no case have less than 50 % humidity (preferably 50-70 %) in the surrounding with good air circulation to prevent fungal pathogen build up. Monopodials require higher humidity than the sympodials. In the hot climate, the plants may be watered

twice a day as a rise in temperature will lower the humidity. Alternatively, the greenhouse should have provision of cooling system, cladding material made of porous articles with a closed circle supply of water fitted to one end of the greenhouse and an exhaust fan of the size commensurate to the size of the greenhouse and the area of cladding material fitted to another end. This will circulate cool and moist air throughout the greenhouse. In small greenhouses, the cooling effect may be generated through frequent water spraying (twice or thrice a day during summer while once in winter, depending on the type of houses because warm houses require more frequently than the cool houses) on the path and floor which may preferably be of clay, sand or gravel or through open vents on the shady sides.

3.2.1.4 Control of Growth and Flowering

For successful cultivation of orchids, conditions identical to those of their natural environment are provided. The factors which influence their growth and flowering are the genotype (the major factor) and environmental conditions (the key factors) including growing media *vis-a-vis* nutrients as have already been elaborated . Several tropical species are free-flowering apart from having a peak flowering season which is due to their genetic make up. *Dendrobium phalaenopsis* and its hybrids can be flowered throughout the year in the tropical areas regardless of day lengths, main flowering period being from late autumn to early spring. Many species have definite growth and flowering seasons, especially the temperate ones. *Cymbidium* requires cool nights (10-21°C day and night temperatures) and partial shade to full sun for flower initiation in the spring. High light intensities *i.e.* 50 % shade and 15°C day temperature are conducive to good initiation in *Cymbidium,* though slight reduction in light intensity during flower bud development results in better flower colouration and reduces bud blasting in *Cymbidium.* Long days, high light and cool temperatures provide best flowering in *Cymbidium,* though short days result in weak growth and long days stimulate vegetative growth. To extend the flowering span beyond winter and spring in *Cymbidium*, summer temperature is controlled. *Cymbidium* hybrids flower in winter and early spring if flower initiation has occurred in the previous autumn. Mature pseudobulbs usually produce only vegetative shoots which may also produce flowers if climatic conditions are quite favourable but the young developing pseudobulbs of the current growth produce spikes. *Arachnis* and its hybrids require 18°C cultural temperature and 2400-3600 fc light for their optimum blooming. *Oncidium* and *Paphiopedilum* for their optimum flowering require 2400-3600 fc light, and 15-21°C and 18-21°C growing temperatures, respectively. *Paphiopedilum* hybrids generated through extensive hybridization with other genera flower throughout the year though the flowering season of this species is winter and spring. By proper selection of the cultivars, flowering may be obtained for six months i.e. from November to May or even longer. Short days and low temperatures in temperate areas induce flowering in some species of *Cattleya, Dendrobium* and *Phalaenopsis.* In summer, *Dendrobium crumenatum* and *D. flavellum* come in spectacular bloom after two weeks following low temperature and heavy rains. *Cattleya* hybrids also produce abundance of blooms under short normal day lengths. *Vanda* and its hybrids bloom profusely under full sun (at least 10 h of full sunlight). It is possible to have flowers all the year round just by selection of species, hybrids and the cultivars. This may easily be achieved in case of *Cattleya, Phalaenopsis amabilis* & its white hybrids and *Vanda*. *Phalaenopsis amabilis* and its hybrids can give 3-4 crops per plant in a

year, primary spike being produced in the fall which may last for over two months and after the harvesting of the flower the top of the spike is removed from below the first flower bud and so within eight weeks secondary spike will appear, and likewise when this spike is also removed from below the first flower, tertiary spike will also appear.

The variation in the juvenile phase of orchids is enormous among the species as well as cultivars e.g. some of the *Phalaenopsis* hybrid seedlings of the same cross flower within 15 months while certain others require two years or more. Normally it takes 4-7 years for flowering from seeds for many orchids. After passing of the juvenile period, two primary environmental factors *viz.* low temperature and light (photoperiod and light intensity) control the flowering as is elaborated under **3.2.1.3** (**temperature** and **light**).

Vanda Miss Jonquim show inverse correlation of the auxin level in the shoot apex at the time of flowering, more the flowering less is the auxin level, however, at the vegetative phase the auxin level is found increased. *Phalaenopsis schilleriana* is poor in flowering when sprayed with auxin solutions due to excess of it. Induced flowering is obtained in *Aranda* Deborah when treated with anti-auxins and growth retardants or to decapitation but the effect is negated through continuous supply of 10^{-4}M IAA solution. Benzyl adenine causes multiple inflorescences in *Aranda*. *Cymbidium* responds well to GA_3 treatment from 1000-10000 ppm at an interval of 2, 4 or 6 weeks where flower size and spike length are found increased. In *Dendrobium* hybrids, 4000 ppm BA treatment increases the flower number, and also improves the decreased flower number caused by forcing through temperature and lighting. Spraying thrice with tricantanol at 0.01 g / 900 cm^2 on *Dendrobium* seedlings induces earlier flowering *i.e.* 18 months after spraying, and 0.01 mg or 0.05 mg / 900 cm^2 spraying four times induces flowering after 21 months. Ethrel spraying at 1000-4000 ppm once to thrice in *Oncidium* Golden Shower promotes flower induction.

3.2.1.5 Insect-Pests, Diseases and Physiological Disorders

If proper sanitation and care have been taken, there is little scope for the pests to build up in the orchidarium. Environmental conditions suitable for orchid growing though are themselves congenial for harbouring various insects and diseases. Therefore it is essential to regularly monitor orchid planting for any sign of **insect-pest** infestation and **disease** infection.

Insect-pests attacking orchids are **aphids** (*Cerataphis lataniae, Macrosiphum luteum, Aphis gossypii, Neomyzus circumflexus, Myzus persicae*), **thrips** (*Chaetanaphothrips orchidii, Dichromothrips corbetti, D. fenestratus, D. spadix, Frankliniella occidentalis, F. schultzei, Haplothrips* sp., *Microcephalothrips abdominalis, Thrips palmi, T. simplex, T. sumatrensis, T. tabaci,* etc.), **mites** (*Phalaenopsis* mite *i.e. Teniupalpus pacificus,* two-spotted mite *i.e. Tetranychus urticae* and others *viz. Tyrophagus longior, T. neiswanderi, T. curvipenis, Amblyseius longispinosus* and *Breialpus phoenicts*), **scales** (*Asterolecanium russellae,* common armored scale *i.e. Diaspis boisduvalii,* orchid scale *i.e. Furcaspis biformis* or *Conchaspis angraecum, Vanda* orchid scale *i.e. Genaparlatoria pseudaspidiotus,* and brown soft scales i.e. *Coccus hesperidum*), **bugs** (*Tenthecoris bicolor, T. figueiredoi, T. orchidearum, T. vestitus,* etc.), **mealy bugs** (long-tailed mealy bug *i.e. Pseudococcus adonidum,* Baker mealy bug *i.e. P. maritimus, Ferrisia virgata, Nipaecoccus nippae* and *Planococcus citri*),

cattleya fly (a tiny wasp, *Eurytoma orchidearum*), **cattleya midge** (*Parallelodiplosis cattleyae*), **root miner** (*Agromyza orchidearum*), **black twig borer** (*Xylosandrus compactus*), **orchid weevils** (*Orchidophilus aterrimus*), **orchid beetle** (*Stethopachys formosa* and *Lema pectoralis*), **grasshoppers, ants**, **cockroaches** (*Periplanata* spp.), **nematodes** (*Aphelenchoides aligarhiensis, A. besseyi, A. composticola, Helicotylenchus pseudorobustus*), **slugs** (*Slytommatophora* sp., *Deroceras laeve*), **snails** (*Achatina fullica* and *Zonitoides nitidus*), and rats.

Ants transport and transfer aphids and scale insects which can be controlled through use of chloropyrifos in the burrows. Grasshoppers feed on foliage and flowers which can be controlled through sanitation and through spraying with carbamate or organophosphate. Rats cause damage to ground (terrestrial) orchids by eating on foliage, rhizomes and pseudobulbs, and by burrowing the plantings. It can be controlled through poison baits. Attack of slugs and snails is cumbersome for outdoor plantings during night and these create holes in stems, leaves and spikes and also eat on root tips, and through their movement these leave silvery trails. Its menace can be controlled by spreading methylated pellets around the orchid racks or through chemicals like Slugit, methiocarb and aluminium sulphate. These can also be trapped and killed during night. Aphids (nymphs and adults) suck the sap of the tender parts, transmit viruses and secrete honeydew which attracts ants and fungus. These should be destroyed before a colony develops, by spraying with any insecticide, *viz.,* dimethoate or malathion. Thrips (adults and nymphs) feed on buds, flower parts and other tender parts which cause flower withering. This can be controlled by spraying with abamectin 0.15 EC, carbaryl, carbofuran, dimethoate, metasystox, etc. Scales are small and brown and suck the sap from the leaves, stems and roots and induce intoxicants which hamper the plant vigour. These can be controlled through scrubbing with soft brush or by wiping with cotton swabs soaked in methylated spirit, and through organophosphate spraying. Bugs suck sap and cause pale spots on the leaves. Mealy bugs have soft and filamentous body coated with white powdery wax and they look pink to yellow without coating. Mealy bugs are sucking pests, secrete honeydew, attract ants and sooty mould may develop on the leaves in their heavy infestation. These can be controlled by spraying with 0.02 % parathion. Mites also suck sap from leaves; produce fine webs and silvery marks (which afterwards turn brown or black) on underside of the leaves and cause flower damage due to purple brown spots, size reduction and sometimes twisting of petals. Azocyclotin, bromopropylate, cyhexatin, dicofol, ethion, fluvalinate and propargite acaricides can control this pest. *Phytoseiulus persimilis* may also be used to predate upon them. Black twig borer feed on plant twigs which can be controlled with chloropyrifos at preliminary stage. Orchid weevil punctures flower buds, forms white streaks there and lays eggs on depressions caused by adult feeding, and the larvae mine the pseudobulb and pupate there. This can be controlled through chloropyrifos or methyl parathion at 60 g/100 litres of water or acephate or bendiocarb at 1.2 g/l water. Adults of orchid beetle feed on leaves, pedicels, cut the flowers from peduncle or feed on flowers making hole-like structure. Control measures are the same as in orchid weevil. Nematodes produce leaf blotch symptoms which can be kept under check through oxamyl and fenamiphos drenching in the pot-mix. Cockroaches are very harmful and feed on root tips, buds and newly opened flowers in night. These are controlled with boric acid + sugar pellets. Root miner causes wilting of leaves and pseudobulbs which can be controlled through fumigation with methyl bromide 30 g/m^3 for four hours in a

chamber. The larvae of *Cattleya* midge, galls on the *Cattleya* roots which can be controlled with benzene hexachloride. The larvae of *Cattleya* fly, a tiny wasp burrow within the small flower buds or pseudobulbs which can be controlled by spraying with 0.1 % malathion.

Orchids are prone to numerous fungal, bacterial or viral **diseases,** certain being highly devastating. **Leaf spot** is caused by *Cercospora, Colletotrichum, Gloeosporium, Glomerella, Haplosporella* and *Phyllostictina* which is not a serious problem in most cases but within a few days of infection sunken spots on leaves appear which afterwards turn brown. Bordeaux mixture (4-4-50) or yellow oxide of copper controls this problem. **Petal blight** is caused mainly by *Botrytis cinerea* but also with *Cladosporium oxysporum* and *Curvularia geniculata* on *Cattleya, Dendrobium, Oncidium, Phalaenopsis* and *Vanda,* which initially causes spots on flowers but afterwards blights the whole of the flower. Proper air circulation among the plants and keeping water off the flowers during cool weather *vis-a-vis* safe destroying of affected flowers will keep this problem under check. Dithane M-45 is also very effective against this disease. **Black rots/damping off** are caused by *Phytophthora cactorum* and *P. palmivora* in cool weather and are slow in attack while *Pythium ultimum* during warm humid weather on seedling plants which is highly dangerous as infection spreads throughout the plant at a very rapid rate. The symptoms of attack by both the pathogens are almost similar with infected parts (leaves) turning black, sometimes with a yellow margin, and the stems and pseudobulbs also rot. The humid conditions in the greenhouse should be avoided to keep the foliage dry when these fungi are present. Infected plant parts should be removed and destroyed and should be repotted in a sterilized medium. Affected plants should be sprayed with ridomil (metalaxyl) at 0.05% a.i. or ridomil MZ (metalaxyl + mancozeb) at 0.15 % a.i. or zineb (captan) at 0.2 %. **Orchid wilt/basal rot** (*Sclerotium rolfsii* and *Marasmiellus inoderma*) is symptomized by yellowing of plants, rotting of plants, pseudobulbs and roots and ultimate death of the plant; and **collar rot** (*Sclerotium rolfsii*) is symptomized by yellowing or browning of leaf and stem bases, and eventual rotting and death. In the former case the infection spreads through leaf mould or potting mixture so potting media should be heat sterilized to kill the sclerotia, the infected plants should be destroyed, and the benches along with contaminated pots and potting mix should be sterilized with 2 % formalin. In case of collar rot, the plants are dipped in carboxin and repotted in the sterilized media. **Root rot** (*Rhizoctonia solani, Fusarium* sp. and *Pellicularia filamentosa*) initially causes brown root rot which afterwards spreads to rhizomes and eventually plants wither. After removing infected roots, the plants are dipped in thiram and repotted in fresh medium. **Slimy rot** (*Fusarium oxysporum, F. moniliforme* and *F. subglutinans*) is symptomized as slimy rot of entire shoot, but later on lesions at leaf bases and brown lesions on pseudobulbs which can be controlled through proper sanitation coupled with fortnightly sprayings with bavistin 0.1 % alternate with captan 0.2 %. **Rust** (*Coleosporium bletiae, Hemileia americana, Sphenospora mera, Uredo* sp.) is characterized by small raised blister-like pustules of yellow/rust colour on the underside of young leaves, initially appearing as small dots but at a later stage acquires larger dimension of dark brown colour. Affected leaves should be removed and copper fungicide should be sprayed.

Bacterial brown spot (*Xanthomonas cattleyae*) infects young as well as adult plants. An initially water-soaked spot appears on leaves, enlarges afterwards and soon leaves become soft and die. The disease may progress further infecting the

growing point which may kill the plant. Overhead misting should be avoided and proper sanitation should be maintained. **Bacterial soft rot** (*Erwinia carotovora*) is a very serious disease of *Cattleya* which appears from the leaf tip as a small water-soaked darker spot. The pseudobulbs of such plants also turn soft, pulpy (pulp of yellow colour) and foul smelling. Agrimycin spraying is beneficial. **Bacterial brown rot** (*Erwinia cypripedii)* infects the plants through wounds and cracks by which leaves turn yellow and brown and its infection to the crown kills the plant. Its infection may be minimized by submerging the plants in 1:2000 solution of 8-quinolinol benzoate or natriphene for 1-2.5 hours.

Viruses are the worst enemies of orchids. The symptoms produced by one virus on different varieties, species under the same genus and various genera of orchids differ in appearance which gives impression as if all these symptoms have appeared from different viruses. Most prominent ones are *Cymbidium* mosaic virus (CyMV), *Odontoglossum* ring spot virus (ORSV) and tobacco mosaic virus-o (TMV-o). These appear in uneven and unpredictable colour patterns, malformation of leaves and flowers, crinkling and twisting, and reduced quantity and quality of flowers. CyMV produces mosaic patterns on young leaves of *Cymbidium, Cattleya, Phalaenopsis, Spathoglottis* and many others which afterwards turn necrotic and black. ORSV infects *Odontoglossum* and many other cultivated orchids and the characteristic symptoms of its infection are single or concentric necrotic rings of green to black tissue appearing on leaves, on *Cymbidium* leaves it produces diamond mottle while in *Cattleya* a mild colour break. TMV-o produces chlorotic streaks on the leaves of *Cymbidium* while colour break in flowers of *Cattleya.* Viruses are controlled through proper sanitation, careful cutting of the spikes in a way that sap of one cut spike should not touch the other plants through cutter or knife. Therefore, the cutting tools should be dipped in a solution of trisodium phosphate or a saturated lime solution (pH 12) to disinfect them after cutting of every flower. There should be regular spray of some insecticides to control virus vectors. However, virus infected plants should immediately be lifted and buried in the soil to check further spread through such plants.

There can be certain abnormalities other than diseases and insect-pests which in fact are **physiological disorders.** Water stress and high temperature, in general for all the orchids, cause flower bud abortion. In excessive cold temperature, internodes may not elongate, flowers become malformed and may also abort at bud stage. *Phalaenopsis* after inflorescence formation becomes vegetative if temperature is below or above 25-30°C. Rapid change in growing temperature and high temperature coupled with dry air cause floral wilting if ventilation is poor. *Phalaenopsis* exhibits mesophyll cell collapse most frequently during winter months below 7°C temperature and one or a few leaves (other leaves may look normal) on the plant become pitted. The pitted portion may turn yellow to tan and finally black. This malady can be prevented by raising the growing temperature at or above 15°C at night.

Excessive light causes sun burn so proper shading as per requirement of the species should be provided. Ethylene gas generated from industries, automobiles, even heaters kept inside the house, etc. is very dangerous to orchids as they are highly sensitive to ethylene. Other air pollutants also affect the flower buds adversely.

Orchids do not feel comfortable in too large a pot as their roots will not be able to cling on the inside surface of the pot, the pot will have more potting material, and the water in large pots dries off quite slowly.

Use of disproportionate mix of plant protection chemicals injures the plants. Nutrient deficiency or excessiveness also causes various abnormalities. During active growth of certain orchids during warm weather, Ca deficiency causes blackening of young leaves and new leads starting from the tip towards the stem in *Cattleya*. In severe deficiency, the young pseudobulbs also turn black. Ca application at this stage prevents this malady.

3.2.1.6 Harvesting of Flowers and Post Harvest Technology

Mostly orchid flowers do not open properly even in floral preservatives. *Cattleya, Cymbidium, Paphiopedilum* and *Phalaenopsis* mature only after opening of 3-4 flowers, therefore these should not be **harvested** until 3-4 days of their opening but *Dendrobium* should be harvested 1-2 days before full opening. In spray-type orchids, each flower on the inflorescence opens $1^1/_2$-2 days apart so when three or more are open these may be cut and taken dry to the market. However, the spikes with all the flowers open may also be harvested preferably in the evening, only when the flowers are required, so that these may give full instant display, suitable for marriages and other parties or occasions and moreover as also the flowers are long-lived on the plants themselves so one should not get panicky in getting them harvested when these are not required. Immediately after cutting the cut ends of the peduncles should be inserted into a tube (plastic or rubber) of water or should be wrapped around with a little moist cotton and then taped to the bottom of the box. Shredded wax paper should be placed around the flowers to protect sepals and petals from physical injury during transit, carried preferably in a chamber having above 10°C temperature though *Cymbidium* and *Paphiopedilum* can tolerate a storage temperature of -0.5°C. *Cymbidium* flowers in small tubes are **packed** 6, 8, or 12 in glassine-fronted boxes, for instant corsages. Some 100 spikes of *Cymbidium* are packaged in a box and *Cattleya* spikes are also packaged in standard florist boxes. Four dozen sprays are packaged in a standard box (size 75 x 25 x 17.5 cm) in case of *Dendrobium.* The containers should be perforated so that ethylene build up due to removal of pollinium in certain orchids, especially from *Vanda* Miss Joaquim may be avoided as ethylene bleaches the flowers of Miss Joaquim from lavender to dirty white. **Storage** temperature of -1°C is highly detrimental as within three days flowers start turning brown. However, most orchids can be stored safely at 5-7°C for 3-4 weeks. The longevity differs from genus to genus, species to species and variety to variety. *Cattleya* inflorescence may last in the field from 9-60 days (normally 3-4 weeks) and the flowers and plants can be stored from 10-16°C, *Cymbidium* from 15-90 days at 10°C though flowers are tolerant to -1 to 4°C temperature but are highly sensitive to ethylene whose action is negated through STS or GA_3, *Dendrobium* from 19-55 days at 10-13°C with no ethephon problem but microbial blockage of xylem is the major cause of poor vase life though just after cutting the dipping of the cut ends in hot water with a floral preservative and anti-microbial chemical is effective, and *Paphiopedilum* and *Phalaenopsis* from 30-120 days though flowers are highly sensitive to ethylene. In case of *Paphiopedilum*, the flowers on potted plants can last for 90 days and the flowers can be stored up to three weeks in water at -1 to 4°C. *Phalaenopsis* can be stored for 14 days, the vegetative plants at 25°C and the flowers at 7-10°C. Being highly sensitive to ethylene, just

after cutting, the cut ends should be dipped for 10 minutes in STS at 1000 ppm to negate the effect of ethylene. At **consumer** level, immediately after receiving the consignments, the tubes of individual flowers are removed, 0.75 cm of the peduncle is cut off and the stem is put in palatable water with preservative. Spray orchids cut ends are removed at 2.5 cm upon arrival and placed at 38°C warm water with a floral preservative and then hardened off at 5°C. For display, sprays should be kept in water with a preservative for enhancing their shelf life.

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 monopodial and sympodial orchids.

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2) On rocks, brick pieces, charcoal and on wooden blocks, most orchid roots hang in air and are not in the medium so whether they are of some use to the plants or not.

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3.2.2 *Anthurium* (family - Araceae and Sub-family - Pothoideae)

3.2.2.1 Classification, Species and Varieties

Anthuriums are evergreen tropical aroids, all perennial herbs having creeping, climbing or arborescent stems. They can be found growing as an epiphyte on trees not as a parasite but use them as an anchoring foundation, as lithophyte growing on rocks or as terrestrial on the ground. They are native to Central America, Colombia, Brazil, Guatemala, Peru and Venezuela and were introduced into Great Britain during early nineteenth century. Leaves have a thick midrib with some well defined lateral veins radiating from the place where midrib originates and all such veins are also connected with veinlets. Flower is composed of spadix enclosed in a spathe, and fruit is a berry.

There are more than 600 species but only some 50 species are in cultivation out of which only 10-15 species are in trade. They are grown either for their very showy flowers i.e. 'spathes and spadices' or for their showy velvety leaves. Hence, they fall under two natural **groups**, *viz.* i) flowering, and ii) foliage. Though all the anthuriums flower but those having showy and large flowers (spathes and

spadices) are the flowering anthuriums such as ***A. andraeanum*** (painter's palette, oil cloth flower or tail flower, an epiphyte grown as terrestrial) with heart-shaped, waxy red, reddish orange, scarlet or white spathes and yellow and white straight spadix [vars *album* (white), *amoenum* (rose-red), *gameri* (spathe shining red), *Lawrenciae* (pure white, spathe large), *rhodochlorum* (rose and green), *roseum* (spathes shining rose-pink), *salmoneum* (spathes salmon), *sanguineum* (spathes dark crimson), etc.], ***A brownie*** (an epiphyte) with spathe greenish, rose tinted, 15-20 cm long and spadix 25-40 cm long, ***A. regnellianum*** (an epiphyte or terrestrial) with spathe narrow green, some 4 cm long and 0.6 to 1.0 cm wide, spadix dark green and 4-5 cm long, ***A. spathiphyllum*** (an epiphyte) having spathe up to 5 cm long and 2.5-4.0 cm wide**,** narrow, pale green or whitish and spadix 2.5 cm long and pale yellow, and ***A. scherzerianum*** (flamingo flower, a popular house plant of the genus is either epiphytic or terrestrial) with long, waxy and palette-shaped spathes of brilliant scarlet colour and spiral (coiled) spadix of orange-red to golden-yellow colour [vars *album* (white), *album magnificum* (white), *andegavense* (scarlet on the back and white & scarlet spotted above), *bennettii* (sharp pointed leaves and spathes), *giganteum* (very large spathe), *lacteum* (white), *maximum* (very large spathe), *maximum album* (white), *mutabile* (white bordered), *nebulosum* (double white spotted rose), *parisiense* (rose salmon spathe and orange spadix), *pygmaeum* (quite dwarf), *roseum* (rose coloured spathes), *rothschildianum* (creamy white), *sanguineum* (deep blood-red spathes), *wardianum* (scarlet with extra large bracts), *wardii* (very large spathe), *warocqueanum* not the species (white spotted red), *williamsii* (white), *woodbridgei* (very large spathe), *verbaeneum* (white), etc.].

Anthuriums where flowers are insignificant and the foliage is large, handsome and velvety are foliage anthuriums such as ***Anthurium crystallinum*** (an epiphyte) with large heart-shaped deep green leaves (violet when young) having midribs and the veins ivory above and pale pink beneath, ***A. magnificum*** (terrestrial) with some 60 cm long, deep cordate and oval leaves where upper surface is olive-green with white nerves, ***A. regale*** (epiphyte) with cordate-oblong, long-cuspidate, up to 90 cm long leaf blades which are dull green (young ones tinged rose) with white veins, ***A. splendidum*** (terrestrial) with coriaceous, sea-green, glaucous leaves having depressions and nerves brownish, ***A. veitchii*** (terrestrial) having pendent leaf blades, 90-120 cm long and metallic green but marked by deep-sunk nerves, ***A. warocqueanum,*** an epiphyte having a climbing stem is very vigorous with 60-120 cm long, oblong-lanceolate, hanging, tapering and deep velvety green leaves with midrib and other veins of contrast lighter colour, etc.

These all the 11 anthuriums are the most important ones but under flowering anthuriums *A. andreanum* and *A. scherzerianum,* and under foliage anthuriums *A. crystallinum* and *A. warocqueanum* are more admired. Apart from these, *A. aemulum, A. digitatum, A. ferrierense* (*A. andraeanum* x *A. nymphaeiplium*), *A. pentaphyllum, A. radicans* (a terrestrial creeper), *A. scandens* (an epiphytic climber), *A. subsignatum, A. undatum,* etc. are creeping or climbing anthuriums. *A. acutangulum* is an epiphyte (rarely terrestrial), *A. acutifolium* is terrestrial (often epilithic), *A. amnicola* is an epiphyte, *A. andicola* is either epiphytic or epilithic, *A. bakeri* is an epiphyte, *A. bogotense* is epiphytic and terrestrial, *A. clarinervium* and *A. corrugatum* are terrestrial, *A. hacumense* is an epiphyte, *A. hoffmannii* is an epiphyte or terrestrial, *A. hookeri* is an epiphyte or lithophyte, *A. kyburzii* and *A. pedatoradiatum* are terrestrial, *A. pendulifolium* is an epiphyte

(rarely terrestrial), *A. pentaphyllum*, *A. pottery* and *A. spectabile* are epiphytes, *A. watermaliense* is a terrestrial species, etc. The species cross easily among themselves.

The present day anthurium **cultivars** are mostly hybrids of various species involving mainly *A. andraeanum* and *A. scherzerianum.* The cultivars are dwarf types suitable as pot plant, large types with large flowers suitable for arrangement and foliage types as pot plant for indoor decoration.

The pot plant var. 'Red Hot' developed through cv. Southern Blush (an F_1 hybrid of *A. andraeanum* x *A. amnicola)* x Lady Jane (a pink miniature) has medium red (at anthesis) to lighter red (prior to senescence) spathes which are 6-7 cm long and 4-5 cm wide, and spadix red to orange red from base to apex. It attains full marketable quality growth in a 1.6 litre pot in 11 months. 'Showbiz' is another interspecific pot plant hybrid released from Florida that has compact branched growth and produces numerous showy light red spathes. Other pot plant varieties popular in USA are Allura (white), Champion (white obake), Dutch Treat (*A. scherzerianum*, red), Kohara Double (red), Leilani (light lavender), Lollipop (reddish pink and cream), Maize (red and white), Mary Jean (white and pink), Pink Aristocrat (pink), Pink Frost (pink and white)Pixie Pink (pink), Red Hot (red and pink), Shazzam (*A. scherzerianum,* red and pink). University of Hawaii has released some outstanding pot cultivars, *viz.*, *A.* x *atroquiense* (*A. anthrophyoides* x *A. antioquiense,* mini, spathe white, minty scent), *A. amnioquiense* (*A. antioquiense* x *A. amnicola,* mini, spathe light lavender, minty scent), Kalapana (red obake, blight tolerant, cut flower use), Tropic Fire (red, blight tolerant), Tropic Ice (white obake, blight tolerant), etc. *A. andraeanum* x *A. amnicola* hybrids, *A. antioquiens* hybrids and *A. amnicola* hybrids are compact, highly floriferous and make very good pot blooming anthuriums with attractive foliage.

Other cultivars for cut flower use are i) **red** such as Arizona, Avo-Claudia, Avo-Ingrid, Avo-Netta, Avo-Rosette, Avo-Serge, Cancan, Carre, Cherry Red, Chilli Red, Claudia, Dragon's Tongue, Eureka Red, Fla King, Fla Red, Fla Success, Hawaiian Red, Hayashi, Honduras, Honeymoon Red, Jacqueline, Jertrood, Kalimpong Red, Kaumana, Kozohara, Kansako No.1, Liver Red, Madame Butterfly, Magic Red, Mauritius Red, Mickey Mouce, Mirjam, Nova-Aurora, Ozaki, Pohoa, Pompon Red, Pronto, Red Dragon, Red Elf, Scarlet, Scarlet Red, Sikkim Red, Splish Splash, Sweet Heart, Tanake, Temptation, Tina Red, Tropical Red, Violetta, etc., ii) **rose** such as Marian Seefurth (rose pink), Rico, Sarina (white and rose), Tropical, etc., iii) **pink** such as Abe, Abe Pink, Agnihotri, Aneunue (green and coral pink), Avo-Anneke, Blush Marian Seefurth, Calypso (dark pink inside and lighter outside), Candy Queen, Candy Stripe, Cheers, Hoenette, Launette, Magic Pink, Paradise Pink, Passion, Sonata, Spirit, Surprise, etc., iv) **orange** such as Avo-Gino, Casino, Diamond Jubilee, Favoriet, Fla Orange, Horning Orange, Horning Rubin, Kalimpong Orange, Mauritius Orange, Nitta, Nitta Orange, Orangeeth (spathe orange red and spadix yellowish orange), Orange Glory, Ordinary Orange, Sun Burst, Sunset Orange, etc., v) **white** such as Acropolis, Avo-Jose, Avo-Margarette, Bianco, Chameleon, Cuba, Fla Exotic, Gaisha, Haga White, Hidden Treasure, Jamaica, Lima White, Manoa Mist, Mauna Kea (margin green), Mauritius White, Meringue White, Morocco, Myron Moori, Pierrot, Suchiro, Uniwai, Uranus, Trinidad (off white), etc., and vi) **miscellaneous** such as Amigo (red obake), Blush (spathe red-veined), Candy Queen (peach

spathe and yellow spadix), Carnival (pink margined white spathe), Caroline Simmon ((purple), Choco (chocolate brown), Double (various colours), Fantasia (spathe cream veined pink), Farao (orange obake), Fla Rose (peach), Lambada (white obake), Madonna (cream obake), Midori (obake), Midori-Green (green), Pistache (green), President (pink obake), Red Dragon (red obake), Sultan (pink obake), etc.

3.2.2.2 Propagation

Vegetative propagation of anthurium is through rootstock division, stem cuttings, suckers, and through leaf axillary bud. After top cutting, the **rootstock** is removed from the containers in February - March and cleaned off the compost. The fibrous roots are divided in a way that each piece contains a growing point (node). These pieces are dipped in 0.2 % captan or thiride, planted in fresh compost or 1:3 organic matter and sand medium, and are kept in humid conditions until fully established. The most common method of propagation is through **stem cuttings**. Terminal cuttings preferably from older plants with 1, 2 or 3 nodes or leaves and treated with seradix 1 or IBA 500 ppm, provide good rooting if kept under intermittent mist which accelerates rooting and increases survival. Performance of the cuttings taken with 2 or 3 nodes is better than 1-node cutting. However, if such cuttings have intact aerial roots, the success is quite assured under intermittent mist. After taking terminal cuttings, remaining part of the stem develops **side shoots** (**suckers** or **offshoots**) coming up from the base which with aerial roots should also be removed gently and planted in the medium and such plants flower earlier than any other method adopted for its multiplication. However, such offshoots (suckers) when attain 4-5 leaf stage (not the larger size) and 2-3 roots, only then are separated gently and planted in the medium (1 part sand: 3 parts compost, by volume). One normal plant may produce 10-20 offshoots in one year, more being in *A. scherzerianum* and less in case of *A. andraeanum*. The dormant **axillary buds** arising from the leaves are gently removed from the plant along with the leaf and root and planted as for suckers. These buds develop into a new plant. **Tissue culture,** the non-conventional technique is prevalent in anthurium multiplication through which higher production than those from seedlings is obtained. Leaf, spadix and root segments, stem sections, vegetative buds, etc. are used as explants for callus formation on MS or Nitsch medium. Except apical or the axillary bud meristem explants, others will develop into plants through callus where genetic variability may be observed, though apical or axillary bud meristem explants produce true to type plants. The explant from unfolding leaves takes 11 months from leaf explants to complete plantlet formation i.e. sprout induction and leaf development and further two months for root initiation. Rooted tissue cultured plants may be planted in egg trays filled with washed fine and coarse sand 1 part and leaf mould 1 part or in soilrite. Weekly spraying with 0.2 % NPK (3:1:1) mixed with 0.1 % mancozeb fungicide keeps the plants healthy. In a 10-13 cm pot also some 10-20 plants can be planted in the soil mixture mixed with VAM and *Glomus* sp. for better growth of the plantlets *ex vitro*. Synseed (synthetic seed) micropropagation can help multiplying the desired genotype in large scale in short duration at a reduced cost of production.

For developing new varieties and even otherwise, the anthuriums are raised through **seeds**. The seeds raised through crossing or otherwise (open pollinated ones) are sown in peaty compost preferably in a propagating chamber at 21-24°C where these germinate within 10 days. These are transplanted within 4-6

months in the proper medium where these will flower within $1^1/_2$-2 years. In *A. scherzerianum,* if berries are picked at orange-red stage (not the overripe i.e. reddish brown) and fermented only for 4-5 days in water at 22°C to separate out the seeds from the pulp results in good germination within 4-5 days if sown at 20-25°C temperature range though *A. andraeanum* seeds require 28°C temperature, high peat substrate or FYM + peat + sphagnum moss having 4-5 pH range and continuous lighting for seed germination, and other species require 21.1-23.9°C temperature. Berries of the same inflorescence ripe at different times so accordingly these may be collected and stored in water but storage beyond 5 days results in poor germination. Seeds extracted through crushed mature fruits by soaking in 13 % crystalline sodium carbonate for 2.5 h at 20°C or in 6 % pectinase solution for 5h at 26-30°C results in perfect cleaning of the seeds for sowing singly. Thiram dusting of the shade-dried seeds before storage at 10°C and stored for not more than 12 weeks results in 95-100 % germination.

3.2.2.3 Climate, Media, Cultural Practices and Growth Control

Anthuriums are tropical aroids which come up well under high humid conditions, and at constant temperature these continue flowering throughout the year if planted in proper rooting medium. Anthuriums produce aerial roots around the moss-covered tree trunks and branches and draw nutrients and absorb moisture from the air and dead barks. In fact, it produces a flower from the axil of each leaf and together below a thick and succulent root which toughens with age and if this root is not buried at this stage in the compost it will become hard and redundant. Too high a plant produces a few flowers of poor quality until the medium is built up around the stem to facilitate the roots, or the plant is cut over, rooted afresh in sand and planted anew in a pot filled with coarsely chopped sphagnum moss 1 part, coarsely chopped fern roots 1 part, and sand + well decomposed manure 1 part, all by volume, and these plants may require repotting every two or three years but should be top dressed every year before start of the new growth. The life of one anthurium plant is considered only 6-7 years. Their proper growth depends upon optimum conditions, *viz.,* soil and media, nutrients, temperature, relative humidity, light and shade regulation, rainfall and water management, wind management, and CO_2 concentration if planted in greenhouse environment.

Anthurium cultivation requires sufficiently porous **media** for adequate aeration as it is necessity because of the roots which are in natural contact with the outside air (the aerial roots). The media for its growing may be any thing from coco husk to oasis (soil polyphenol foam) via coco peat, rice husk, tree bark, fern root, sphagnum moss, bagasse, wood shaving, rock wool, lava, charcoal, sand and gravels, brick pieces, etc. with certain amendments. Medium should conform to certain qualities, *viz.*, should offer sufficient support to the plants, should be highly porous for adequate root aeration, should be able to hold required water, fertilizers and other necessary nutrients and drain out easily, should have a pH range of 5.7 to 6.2 with EC 0.7-1.3 dS/m, and should be capable to degenerate quite slowly. Rapid degenerating medium will become messy soon which will cause water logging by which its porosity is marred and the scope of aeration is gone which will not permit the roots to function properly for its growth and for drawing nutrients and instead will invite various harmful fungi and algae to develop. The soil will also become sour due to non-leaching of salts. Consequently, the plants will also turn yellow and die. *A. andraeanum* does quite well in gravel than in peat or in a mixture of sphagnum moss and coniferous forest soil. However,

1:1 mixture of soil and wood shavings or 5:1 mixture of wood shavings and cow manure + tree fern fibre, sugarcane bagasse, coffee leaf mould, spent ground coffee, cured coffee pulp/coffee parchment, tree bark, powdered bark, black cinder, chicken manure, top soil + filter press cake, pumice, peat moss or bark-based compost, are equally good for production of anthurium cut flowers. Any substrate described here when is mixed with high peat, the flower yield is found increased with better quality. Peat + pine-bark + perlite (2:2:1), peat + superphosphate + perlite (1:1:1), high peat + perlite + sphagnum moss (2:1:1), powdered bark + perlite + high peat (1:1:2), coir + compost (1:1) or a well-drained spongy compost made of peat and sphagnum moss (1:2) is ideal for most of anthuriums. Coarse leaf mould and sphagnum moss 2-3 parts, turfy loam 1 part and coarse sand 1 part, along with little amount of charcoal also makes an ideal medium for anthurium. However, the presence of salts in the medium hampers the plant growth, soil chloride being more detrimental. A mixture of coarse sand and dried cow-dung (1:1) or coarse sand, coconut husk, cow dung and charcoal/brick pieces (2:2:1:$^1/_2$) is being used in Kerala Agricultural University while the combination of leaf mould and coco peat in Tamil Nadu Agricultural University as the cheapest and best media for better sucker production and cut flower yield. A 25-30 cm pot (preferably earthen which permits adequate breathing by the roots) with a minimum of two holes is first filled with a 2-3 cm layer of coarse sand over the crock pieces, followed by some 3-5 cm thick layer of charcoal or brick pieces upon which root ball is placed by pressing with pieces of coconut husk in the sides of the root ball in the pots. Dried cow dung + coarse sand mixture is evenly spread over the root ball, in a way that sand, brick / charcoal pieces and mixture cover only some $^1/_3{}^{rd}$ - $^1/_2$ depth of the pot, watered and kept under high humid conditions, preferably under intermittent mist. *Trichoderma viride* for better health may be mixed in dried powder of cow dung in 1:100, immediately moistened and is kept under shade by moistening and stirring it daily for 10 days and then it is filled in the pot while planting. Once in every three months, the potting mix is built up around the stem to cover the aerial roots before being redundant, which apart from encouraging the growth will also provide good anchorage to the growing plant.

In the large scale, the anthuriums are grown directly on the raised or even on flat **beds** in the open or in the **polyhouse** equipped with drip system of irrigation and foggers / humidifiers to manage water and humidity requirements. Polyhouse protects plants against adverse weather conditions, especially temperature and to some extent rainfall. The sophisticated polyhouse is equipped with a climate control computer to regulate temperature, humidity, ventilation and CO_2. It would be even better if the polyhouse is also equipped with fertigation system. To protect the plants from a very high temperature and low humidity, the closed polyhouses are constructed even with 'pad and fan' cooling system, pad (cladding material or mattress) with water flowing over it at one end and an exhaust fan (ventilator) to another end i.e. opposite direction so that air can be blown outside by sucking the air through pads, which will ultimately keep the greenhouse cool. If there be further need, shade installation may also be added but in extreme conditions. Making such greenhouses in sub-temperate areas or in the forest will save the energy to a greater extent. The medium used in this case is direct soil or gravel mixed with FYM or leaf mould some 15 cm in depth as is being practiced by commercial growers in the forest near Yercaud (Tamil Nadu). People suggest more depth, even 25-30 cm but that is of no use as root spread of anthurium is not so deep in the medium. The size of the beds is ordinarily 1.5 m in width

while it may be of any length from 1.5-5.0 m, as per the convenience of the grower and the size of the polyhouse. However, the sides of the beds are slightly raised i.e. from 20 to 30 cm. The width is more important as while standing on the paths on both sides of the bed one can attend to all sorts of field operations including flower cutting. The width of the path is normally 80 cm. The planting distance in the beds is kept 30-60 cm apart, generally 30 x 45 cm for most of the varieties, depending upon the growth and the height of the individual varieties. Thick planting hinders the air circulation among the plants and even spraying of insecticide / fungicide in the beds; though to some extent this problem may be overcome through timely thinning of old or even otherwise normal leaves, as more than five leaves are not good for the health of a plant. Thinning is also done to maintain plant equilibrium. Healthy and good looking thinned leaves may also be marketed as cut foliage. Suckering in flowering plants will cost flower production, both in terms of quantity and quality, therefore, when a sucker in a plant appears it should immediately be removed gently by hand pulling.

For proper growth and flowering, anthuriums also need adequate amount of **nutrients**, especially nitrogen, potassium and calcium. Inadequate levels of N and K reduce flower yield and quality. It is suggested that 126 mg N and 225 mg K application in a 12.5 litre container per week improves flower yield and quality in *A. andraeanum.* Annual dressing with 29 g N and 30 g K_2O/m^2 is said to be optimum in *A. andraeanum,* where mature leaves show 2 % N and 3 % K though *A. scherzerianum* provides best results with 21.6 mg N / pot / week. Foliar application of even 0.05 % urea is detrimental to anthuriums, however, earthworm (*Eudrilus eugeniae)* wash 50 % application has been found quite encouraging with cv. Crinkle Red where plants remain healthy with better quality flowers and more sucker production. Cv. Temptation responds well to 0.2 % 30-10-10 NPK + 100 ppm GA_3 which reduces pre-blooming period and provides highest number of suckers. Under 80 % shade, 20-20-40 NPK at 0.25 % at weekly intervals when applied to *A. andraeanum* results in longest vase life. Ca deficiency results in colour break down, collapse of the proximal part of spathe and instability of the middle lamella and the situation aggravates when pH of substrate is in between 3-4. The optimum Ca concentration in the leaf tissues and lobe should be 0.54-0.16 %, respectively. In *A. scherzerianum*, 4 g $CaCO_3$ and 2 mg boron gives largest number and best quality flowers.

Plant growth regulators have been used in anthurium for increasing growth, sucker production, quality and yield of flowers and to reduce juvenile phase. BA at 750 mg/l monthly application, to tissue cultured plants, starting from second month of planting, results into precocious and healthy suckering, each sucker having independent shoot and root system. BA at 100 mg/l induces 3.6 buds per plant as compared to nil in untreated ones. GA_3 at 1000 mg/l application during vegetative stage induces branching while at flowering when applied every month increases yield of the flowers.

Anthurium being a tropical crop does well at constant **temperature** in between 18-28°C. The minimum winter temperature for *A. andraeanum* and *A. scherzerianum* is 13°C, and for *A. crystallinum* 16°C though only for a short duration these may bear 3°C lower temperatures. A temperature from 21.1-23.9°C is favourable for initiation of flower buds in *A. scherzerianum* but in case of hybrid anthurium cultivars a temperature of 30°C is ideal for getting higher flower count of good quality. It can tolerate as high as 35°C temperature provided atmospheric humidity is very high i.e. 80-85 %.

Anthurium loves filtered **sunlight** as it is a plant of semi-shady conditions. Too much light will burn and scorch the flowers as well as leaves. It thrives well at 1500 to 2500 fc light but *A. scherzerianum* requires 1000 to 1500 fc light for good growth and flowering. Direct sunlight can cause severe burn of the leaves as it increases the temperature in anthurium leaves up to 10°C above the air temperature. During summer, it should be given 80 % shade, or even more when it is *A. crystallinum.* Photoperiod and light intensity requirement of the plant though is cultivar dependent but by and large all can do well between 1500-2500 fc light.

Whenever temperature rises above 16°C, the plants are freely **watered**. However, during the growing season these are moderately watered. Watering is dependent on season, the greenhouse climatic conditions, size of the plant and pot and the medium used, plant growth stage, and type of container. During spring and summer the water demand by the plants is much more when plants should be watered twice daily but in winters it reduces and should be watered only when surface of the medium seems to be dry. Optimum value of water EC is 0.6 m mhos / cm and in no case it should rise above 1.5 m mhos / cm. Sodium chloride present in water is highly detrimental to the crop. Likewise, Na_2SO_4 or $MgCl_2$ in the irrigation water also lowers flower production. In commercial cultivation, the irrigation water is economical through sprinkler system but in the polyhouse it should be through drip system. It would be more economical to give them fertigation rather than only irrigation. In fertigation, only a very light concentration of the nutrients should be given. Rains damage the flowers and increase the chance of fungal infection. Therefore, anthurium should be grown under protection. The **relative humidity** requirement by the anthurium is also very high i.e. above 70 % but during bright sunlight it may be as high as 85 %. High humidity may be maintained by damping down the greenhouse twice a day and by syringing the leaves daily during hot weathers. Paths and benches should also be kept moist. For maintaining high humidity levels inside the greenhouse, foggers or humidifiers may be used.

Wind and storms also damage this crop, hence right type of greenhouse should be erected to limit the risk of damage. **CO_2** is already present in the air, normally at 300 ppm concentration but the requirement is up to 800 ppm which can be maintained easily in the greenhouse. The concentration above 800 ppm is detrimental.

3.2.2.4 Insect-pests and Diseases

Anthuriums are attacked by aphids, mealy bugs, thrips, spider mites, cyclamen mites, caterpillars, nematodes and slugs & snails but the crop being highly sensitive to certain pesticides, it is not an easy task to control all these pests effectively.

Green peach **aphid** (*Myzus persicae,* and *M. circumflexus* on *A. scherzerianum*), *Aphis gossypii, Aphis nicotiana, Aulacorthum solani* and *Macrosiphum euphorbiae* infest on anthurium by sucking plant saps from various parts of the plant, inject substances that are toxic to plants, produce honey dew which attracts ants and certain fungal infection and transmit viruses. Being viviparous, these build up their population quickly. Aphids may be light green, yellow, pink or red in colour. Their control on anthurium will not serve the purpose so long other vegetation is nearby where these find an alternate host. Therefore there should

be proper sanitation and then these should be controlled through 0.2 % spraying of some systemic insecticides such as dimethoate or Malathion. **Mealy bugs** suck sap of the leaves from the lower surface producing honey dew which attracts sooty mould. Drenching the media with systemic insecticide like dimethoate will control this pest also. **Thrips** (youngs and adults) are light yellow-brown in colour and for sucking the sap bores through the cells by feeding on leaves and flowers which causes brown stripes on the affected part and mottle them. Control of aphids will control these insects also. **Mites** (cyclamen mite, and red spider mite *Tetranychus urticae*) are tiny, spider-like, 8-legged, white green (sometimes brown-red) and transparent insects which suck up the contents by boring through the plant cells especially on the underside of the leaves or flowers which make the infested part (flowers i.e. spathe and spadix and leaves) discoloured to silver-white (red spider mites cause yellow discolouration by feeding on older leaves), being more serious during summer months and later on make the webs. Spraying of the underside of the leaves and other affected parts with 0.2 % kelthane or vertimec at 0.4 % will control this pest. Kelthane 0.08 % spraying will also control the mites. **Scale insects** suck the sap from stems and leaves which can be controlled by wiping the affected parts with methylated spirit soaked cotton-wool swab or spraying with 0.2 % malathion. **Caterpillars** of the tomato looper, the beet army worms and certain other lepidopterous insects chew various parts of flowers and leaves which may be controlled through catching and killing or through lannate 0.1 % or decis at 0.5 % sprayings. **Slugs and snails** chew over the root tips, leaves, buds as well as flowers, especially during night and batter the leaves which should effectively be controlled through metaldehyde baits. **Nematodes** (*Meloidogyne incognita*, *Aphelenchoides fragariae, Pratylenchus infestans, Radopholus citrophilus and R. similis*, etc.) infest on anthurium. *Meloidogyne* galls on the roots showing brown lesions. *Aphelenchoides* feed in leaves causing necrotic areas between leaf veins. *Pratylenchus* attacks only the roots by which leaves turn yellow and plant may die. *Radopholus* also infests on roots and show dark necrotic lesions which causes stunting and poor growth of the plant with fewer and smaller flowers and premature leaf yellowing. These pests can be put under check by planting comparatively more tolerant species or varieties such as *A. pittieri* and *A. ravenii* instead of *A. andraeanum* cv. Midori, by planting healthy stock in disinfected media through steam or methyl bromide, by treating the cuttings for 10 minutes at 50°C temperature, by separating planting media from the natural soil of the bed, through proper sanitation, and through precautionary measures.

Fungal diseases that attack **anthuriums** are anthracnose caused by *Colletotrichum gleosporioides* (*Glomerella cingulata*), root rot caused by *Pythium splendens*, *P. spinosum, P. vexans, Calonectria crotolariae, Phytophthora* sp., *Fusarium* sp. and *Rhizoctonia* sp., leaf spots caused by *Septoria anthurii* and powdery mildew caused by *Erysiphe communis,* etc. Anthracnose is also known as spadix rot or black nose which occurs in high rainfall areas first as tiny dark spots on the individual flowers of the spadix and afterwards spreading in angular or triangular shapes even on leaves and flower stalks. Maneb or indofil M-45 at 0.2 % spraying will control this disease. Benomyl or bavistin at 0.15 % alternate with captan 0.2 % spraying will also control this problem. The symptoms of root rot are observed as plant stunting, size reduction of leaves and flowers, yellowing and hanging of leaves at the edges and browning of roots and stems. This disease is controlled either by drenching the plants with 0.1 % furalaxyl, mancozeb 0.25 % or thiram 0.25 % or spraying twice at 10 days interval with aliette 0.15 %.

Septoria leaf spot can be controlled as to that of anthracnose, and powdery mildew through 0.1 % benomyl spraying.

Bacterial blight is caused by *Xanthomonas campestris* pv. *diffenbachiae*, initially causing small and angular water-soaked spots on the leaf margins where afterwards after killing the tissues bright yellow halo around the spot will be formed and spadix also starts rotting from tip downwards. The disease is favoured by warm and wet weather. To control this disease, contamination should be checked through tools, water and flower cutting, and by restricting nitrogenous fertilizers, especially the ammonical forms should completely be avoided. **Bacterial wilt** is caused by *Pseudomonas solanacearum* which initially yellows the leaf margins but afterwards covers entire leaf which ultimately results into wilting of the plant. Its occurrence is normally noticed where unfermented bark has been used as mulch. Strict sanitation of the growing area, removal of the affected part or the plants and spraying with streptomycin sulphate or oxytetracycline will keep the bacterial diseases under check. **Viral** (mosaic and malformation of leaves and spathes, mostly in white cultivars) diseases are transmitted through *Bemisia tabaci* and through mechanical tools so controlling the vector will control these problems, and such plants should be uprooted and destroyed.

Physiological disorders, *viz.*, 'flower abortion', 'flower deformation' and 'rosette formation' due to excessive root activity or pressure not in line with the activity of the aboveground plant part which is quite slow and the problem is mainly genetic but to some extent can be overcome by use of restricted amount of media, balance of climatic factors and use of gibberellins; 'folder ears' where basal lobes of flowers do not open properly which may also be genetic; 'sticking' also probably a genetic cause is that where while opening the spathe is stuck which can either be loosened by hand or the lower RH may overcome this; 'jamming' also a genetic problem being encountered under arid conditions in long sheathed cultivars where flowers are jammed too tightly inside the unfolding sheaths and get damaged; and 'cracks' on either or on both sides of the spathe may occur due to active growth of flower when RH is higher for a short duration which may be overcome to some extent by lowering the RH during the night.

3.2.2.5 Post Harvest Technology

Anthuriums are **harvested** with long stalks leaving only 3 cm of stem on the plant to prevent rotting of the stem. Under proper management conditions, an anthurium plant produces some eight flowers per year. When unfolding of the spathe is complete and the spadix is almost fully developed with about $^{1}/_{3}^{rd}$ true flowers on the spadix fully open, the flowers are harvested with a sharp knife. The cut ends of the harvested flowers are kept at 38°C lukewarm water overnight immediately after cutting. The flowers of anthurium can be **stored** successfully at 13-17°C for up to two weeks which may last for 2-4 more weeks in an arrangement. The storage temperature below 13°C may cause blueing of flowers, especially the red ones though some varieties tolerate even 5°C storage temperature. These can also be stored at 2-10 % O_2 and at ambient temperature of 24-25°C where cool chamber is not available. These are **graded** into 'Peewee' having less than 6.25 cm flower size, 'Mini' with 6.25-7.5 cm, 'Small' 7.5-10.0 cm, 'Medium' 10.0-12.5 cm, 'Large' 12.5-13.75 cm, 'Extra large' 13.75-15.0 cm and 'Premium' above 15 cm, and they are packed 50 stems/box, 40 stems/box,

30 stems/box, 25 stems/box, 18 stems/box, 15 stems/box and 8 stems/box, respectively. The most commonly used box sizes for **packing** anthurium flowers are 21.6 x 50.8 x 91.4 cm or 27.9 x 43.2 x 101.6 cm which can accommodate some 120 flowers. Cartons are lined with polythene sheets and insulated with moist paper to maintain proper humidity during transit. The flowers having blemishes, black spots, short stalks, deformity and discolouration are discarded while grading. Cotton swab soaked in water is taped around the cut portion to prevent desiccation and then the flowers are placed into a polythene cover of proper size after putting some soft protective material in between the spathe and spadix to prevent bruising. The open end of the polythene is stapled so that the flower inside the polythene remains in a position.

Vascular blockage in the cut flower stem causes flower senescence. While senescing, there is weight loss of the flower, glowlessness and blueing of spathe, spadix necrosis, stem collapse and abscission of spathe and spadix from the stem. **Pulsing** in 2.25 % 7-Up (a carbonated beverage), 500 ppm benzoic acid, 7.3 ppm of sodium hypochlorite, BA at 50 ppm for 12 h, triadimefon at 25 ppm for 8 h or silver nitrate at 4 mM for 10-60 minutes dip (within 12 h of harvesting) before storage or shipping improves the life of cut flowers significantly but to these treatments varieties differ in their response. The response of anthurium var. Hawaiian Red to BA at 25 ppm and 8-HQ at 30 ppm **holding** solution results in delayed spadix necrosis, spathe blueing and increases vase life up to 27 days as per the findings of Kerala Agricultural University.

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) Name two most important species under each group: the flowering anthurium and the foliage anthurium.

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2) What is the causal organism and the symptoms of bacterial blight on anthurium, and how this may be kept under check ?

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3.3 LET US SUM UP

In this unit, we have studied about the classification, species and varieties, various propagational methods employed including micropropagation and cultivation of orchids and anthuriums. Though anthurium is a crop of tropical and sub-temperate regions, orchids can be grown in the tropical, sub-temperate and temperate regions due to various genera and species. Various climatic and otherwise factors that influence growth and flowering of both the crops are also dealt with in detail, along with their protected cultivation. Their nutritional and water requirements are also given along with time and methods of their potting and repotting. Various insect-pests, diseases (fungal, bacterial and viral) and physiological problems associated with both the crops are also furnished in brief with their control measures. When to harvest the flowers, their grading, storage temperature before shipping, pulsing, packing and other post harvest measures are given in a very lucid and comprehensive manner.

3.4 KEY WORDS

Orchids, anthurium, keiki, offsets, micropropagation, potting, repotting, media, protected cultivation, aerial roots, velamen, post harvest technology, insect-pests, diseases and physiological disorders.

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3.6 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1) Monopodial orchids have neither rhizomes nor pseudobulbs and grow from a single vegetative apex as they sprout new growth by developing axillary shoots which grow into new plants. The main stem of monopodials grows continuously year after year and has a dominant apical meristem such as *Arachnis, Phalaenopsis* and *Vanda.* Sympodials have normally branched rhizome with or without pseudobulbs and grow from a number of vegetative apices present at intervals on the rhizome.

2) Aerial roots in orchids are fleshy and composed of outer spongy tissues around the true roots which is known as velamen. Velamen is well developed, and it absorbs water and nutrients quickly from the growing media as in terrestrials or from the humus in bark crevices and air as in epiphytes and through rain water. Velamen also conserves moisture and protects the plants from strong light.

Check Your Progress Exercise 2

1) Two most important species under flowering anthuriums are *A. andraeanum* and *scherzerianum*, and under foliage anthuriums are *A. cristallinum* and *A. warocqueanum.*

2) The causal organism for bacterial blight in anthurium is *Xanthomonas campestris* pv. *diffenbachiae*. Initially it causes small and angular water-soaked spots but after the death of tissues, bright yellow halo around the spot is formed and together spadix also starts rotting from the tip.