INTRODUCTION
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Beautiful, flamboyant, sometimes bizarre: orchids exert an unique appeal. Everything about them is interesting, from their strange habit of growth, nestling on fallen tree trunks or among rocks or clambering skywards to the tree canopy, to their striking, often intoxicatingly scented flowers. Formerly considered plants for the connoisseur only, nowadays there is a huge range of hybrids that are easy to grow and affordable for all gardeners.

ORCHIDS, the most beautiful flowers in God's creation, comprise a unique group of plants. Taxonomically, they represent the most highly evolved family among monocotyledons with 600-800 genera and 25,000-35,000 species. Orchids exhibit an incredible range of diversity in size, shape and colour of their flowers. They are most pampered of the plants and occupy top position among all the flowering plants valued for cut flower production and as potted plants. They are known for their longer lasting and bewitchingly beautiful flowers which fetch a very high price in the international market.

Theophrastus, who is also called the father of Botany (370-285 BC), gave the name "ORCHIDS" to the group of bizarre plants on the basis of the resemblance of paired underground tubers of these plants to masculine anatomy (the testes). This resemblance was also responsible for the mistaken belief that the orchids posses aphrodisiac properties and eating of underground tubers might "provoke Venus" and they may beget male children.

In the Indian Vedic scriptures there is a mention of the plants under the name "VANDA", which has been adapted as a generic name in one of the most beautiful group of orchids. Most of the orchids are perennial herbs with simple leaves. Although the specialized flower structure conforms to a standard plan, the vegetative parts show great variation, a large number of them being epiphytes, or terrestrial and a few saprophytes and leafless in nature. Majority of the cultivated orchids are native of tropical countries and occur in their greatest
diversity in humid tropical forests of South and Central America, Mexico, India, Ceylon, Burma, South China, Thailand, Malaysia, Philippines, New Guinea and Australia. Brazilian cattleyas, Mexican laelias and Indian dendrobiums, cymbidiums and vandas have played a major role in the development of modern orchid industry in the world.

The evolution of orchid culture from hobbyist to commercial grower was very slow as most of the orchids collected from different regions did not adapt to local conditions and died. The methods of propagation were not known and most of the orchids which flowered under utmost care were found to be self sterile. Further, it was difficult to germinate the seeds, which lack any functional endosperm. The seeds sown in the nursery beds required long periods of germination and any disturbance to the soil or physical environment destroyed the whole population.

It was only in 1821 when Conrad Loddiges and sons started growing orchid plants commercially at their nursery in Hackney, followed by John Daminy of M/s Veitch & Sons who produced the first orchid hybrid between two Calanthe species in 1852, which flowered in 1856 in Veitch Nursery Exeter, England. This was followed by a large number of man made hybrids produced by hobbyists and small growers. In 1913, Sun Kee Nursery, Singapore, started the first cut-flower production of *Arachnis* type hybrids.

The major developments in cultivation of orchids in the world have been due to modern scientific technology which has been suitably used in case of orchid seed germination and meristem culture. Today orchids are grown on assembly-line method in extensive glasshouses with controlled environment and the sale of orchid flowers runs in millions of dollars. The modern methods of propagation have bought orchid cultivation on par with other commercial crops.

The epiphytes, accounting for about 73% of the orchid species, are distributed mainly in the tropical and sub-tropical climates (where congenial growth conditions such as thick vegetation, heavy rainfall and high humidity prevail)
whereas the terrestrials are mostly confined to temperate climates. *Rhizanthella* is sub-terranean in habit and *Corallorhiza* is a rootless parasite.

Orchids account for 2.7% of global cut flower production in terms of value. Thailand alone exports orchids worth more than 26 million (US$). Thailand has more than 700 orchid growers and about 20 commercial tissue culture laboratories producing more than 32 million plants of which 55% is exported. Orchid flower sales in USA for internal consumption alone are valued at US$ 50-60 million. The annual value of export trade in Singapore exceeds US$ 2.3 million.

Some of the best and rare orchids have been made available to hobbyist and growers within an affordable price range. Further the use of *in vitro* culture technology has resulted in the recovery of disease free clone, preservation of valuable germplasm and conservation of many species which were at the verge of extinction. Recently it has been shown that it is possible to isolate protoplasts from the roots, leaf, stem, petals and other parts of orchids and to grow them in cultures. Days are not far off when orchid protoplasts could be made to regenerate tissue or make somatic hybrids and create new variability. The ability of the dermal peels to regenerate vegetative buds demonstrated earlier in carrot has been positively tested in *Rhynchostylis retusa* and *Vanda coerulea*.

**ORCHID RESEARCH IN INDIA**

**ORCHID FLORA**

Orchids form 9% of our flora and are the largest botanical family of higher plants in India. It is estimated that about 1,300 species (140 genera) of orchids are found in our country with Himalayas as their main home and others scattered in Eastern and Western Ghats. The following is the distribution of orchids species in different regions of India:

- North-Western Himalayas ca 200 species
- North-Eastern India ca 800 species
- Western Ghats ca 300 species
North-Eastern India owing to its peculiar gradient and varied climatic conditions contains the largest group of temperate, sub-tropical orchids.

Documentation is well found for the Indian species of orchids, but we are yet to exploit their commercial potential on sound scientific lines. The orchids are being collected and shall continue to be collected, as long as they enjoy an economic status and a commercial demand. Mass propagation of these plants using conventional and biotechnological means, with a view to saving their natural populations from commercial pressures, is, thus, an important strategy for orchid conservation. Biotechniques have been applied for germination and micropropagation of orchids, for several years now, but the attempts are still not commensurate with the size of the orchid family.

India has a very large variety of orchids and hilly regions have one or the other orchid flowering almost throughout the year. The diversity is so large that there are large-flowered, terrestrial, epiphytic and also saprophytic orchids. In general, terrestrial orchids are more common in North-Western India, epiphytic orchids in North-Eastern India and small flowered orchids in Western Ghats. The largest terrestrial genus is *Habenaria* (ca 100 spp.) and the largest epiphytic genus is *Dendrobium* (ca 70 spp.). Most of the *Paphiopedilum* (lady's slipper) species are restricted to N.E Himalayas except for *P. druryi* which has been reported from Kerala but now is almost extinct from its original habitat.

Some orchids are endemic to Indian Species are so ornamental and in demand that their natural populations have been over exploited. Some species in the genera like *Arundina*, *Cymbidium*, *Coelogyne*, *Dendrobium*, *Paphiopedilum*, *Renanthera*, and *Vanda* are almost extinct. The provisional list of 150 endangered plants of India includes many orchids like *Acanthephippium sylhetense*, *Anoectochilus sikkimensis*, *Aphyllorchis montana*, *Arachnanthe clarkei*, *Arundina graminifolio*, *Cymbidium macrorhizon*, *Dendrobium densiforum*, *Didiciea cunninghamii*, *Eria crassicaulis*, *Galeola lindleyana*, *Gastrodia exilis*,
Paphiopedilum fairanum, P. druryi, Pleione humilis, Renanthera imschootiana, Vanda coerulea, V. pumila and V. roxburghii.

The list of plants banned or restricted for export from India formerly included a few orchids but now include all orchids growing wild. The convention of International Trade in Endangered Species of Fauna and Flora (CITES), ratified by India, places all species of Orchidaceae under Appendix II, meaning thereby that their trade will be only through export permits. Steps have also been taken to conserve Indian native species by establishing orchidaria, sanctuaries and germplasm conservation centres. The Botanical Survey of India has established two orchidaria one at Shillong and other at Yercaud to conserve rare and endangered species. The ICAR research complex at Shillong, the Indian Institute of Horticultural Research at Hessaraghatta and the Indian Botanic Gardens at Calcutta maintain collections of orchids in their orchidaria. Orchid sanctuaries are established in Sikkim at Singtom & Deorali and in Arunachal Pradesh at Tapi.

INDIAN ORCHIDS

Some of the Indian orchid species which are of high ornamental value are:


Majority of the cultivated orchids are native of tropical climates and are found in abundance in India in the state of Assam, Meghalaya, West Bengal, Karnataka and Kerala. Kalimpong, Shillong, Trivandrum, Bangalore, Yercaud and almost all the coastal areas of India are the places most suitable for the cultivation of orchids.
Growing of orchids in India is not organised commercially and is still in the hands of hobbyist and few dealers who mainly depend on wild collections from the forest to meet a large part of their foreign and local demands. Due to this fact some of the orchid-growing areas are now without any orchid and very rare species are now facing the danger of depletion.

**CULTIVATION OF ORCHIDS**

**TYPES**

Orchids can be divided into two groups - *monopodial* or *sympodial* depending upon their habit of growth. Monopodial orchids such as *Phalaenopsis*, *Renanthera* and *Vanda* have a main stem which continues to grow year after year and as *Cattleya*, *Cymbidium* which have a main stem that terminates growth at the end of each season. A new shoot then grows from the base forming it's own bulbous stem called pseudo-bulb which eventually flowers. The pseudo-bulbs or thickened stems are very useful devices for the storage of food and water and function like bulbs.

In addition to the epiphytic orchids, there are also ground orchids or terrestrial orchids, which grow like ordinary plants with their roots in soil. Most of the temperate zone orchids are terrestrial and tropical orchids are epiphytes.

**ORCHID HOUSE:**

Orchids in nature grow protected from the tropical sun by the shades of trees. Under controlled condition the orchids can be grown in specially designed orchidaria or orchid houses, running North and South and made from materials like split bamboo, glass, shade-nets, etc. A central tank filled with water or artificial fogging nozzles help in increasing humidity. However, it must be clear that all types of orchids cannot be grown under one roof. While tropical orchids enjoy humid, warm atmosphere and burst into activity during the rainy season, temperate orchids should be growing in cool houses. Orchids dislike sudden
change in temperature, however a difference of 10° C - 20° C between day and night temperature is beneficial. The best suitable range is 18°C to 30°C. Proper ventilation is must to provide fresh air and also to help in reducing the temperature. There are also orchids, which can be grown in open sun. Various terete leaves species of Vanda, Aranda, Arachnis, Renanthera, Kegawara, Mokara etc. can be grown in open trenches filled with brick pieces, charcoal as is done in Ceylon, Singapore and Thailand.

LIGHT
Indirect sunlight is ideal for orchids. Seedlings require less sunlight than adult plants. Very poor light tends to produce weak plants and retards flowering. A plant, which has been grown in shades, should be gradually shifted to sunlight conditions. The optimum requirement of light varies from species to species. Cypripedium and Phalaenopsis require only 200-300 foot candles, whereas genera like Vanda and Aranda thrive best under 800 foot-candles. Majority of orchids are day neutral and are not influenced by day length. But in Cattleya both short-day and long-day plants are found. In the growing areas of Thailand, Malaysia and Singapore, growers have used shade nets in 35% to 85% shade percentage to grow orchids of different genera.

HUMIDITY / WATERING
Humid warm atmosphere is most essential for the growth of most of the tropical orchids, which do not have well-established root system. It is a good idea to have a water tank or pool in the center of the orchidaria to maintain humidity, which should not be less than 30% at night and 80% during day time. The plants should be watered 2-3 times a day and should not be allowed to dry up during hot climate. Plants in active growth require more water. Similarly plants in baskets require more water than those planted in pots. Care should be taken to water the plants with a fine spray by using standard nozzles and not to hit the plants with powerful jets of water. Plants that are freshly potted should be watered very sparingly till the new roots appear and watering should be gradually increased.
POTS / CONTAINERS

Orchids should be potted in small containers/pots according to the size of the plants. As a thumb rule, orchids should be under potted to get more flowers. Any kind of pot/container which can hold medium and provide aeration is suitable. Most of the people prefer plastic pots which retain moisture longer than mud pots. Vandaceous and Sarcenthene orchids can be grown in teakwood baskets. Orchid plants should not be disturbed frequently and repotting done only when absolutely necessary. Orchids like Cymbidium, react favourably when repotted after 2-3 years whereas Vandaceous orchids and Paphiopedilum should not be disturbed unless very necessary.

Terrestrial orchids, like Spathoglottis, Phaius and Calanthe, should be grown in 20-25 cm pots with 1:1:1 mixture of leaf mould, FYM and sand. For Paphiopedilum a mixture of 2 parts leaf mould, 2 parts loam soil and 1 part each of brick pieces and charcoal is recommended. Experiments conducted at Botanical Survey Of India, Calcutta, have revealed that in case of Rhychostylis gigantea, chunks of hard-wood charcoal alone as potting substance was superior to any other potting media. Tree fern fiber also performed better than the other media while coconut husk and over-burnt brick as planting substance had adverse effects on growth and flowering of R. gigantea plants. Some latest media tried for growing orchids are gravel jelly, fir bark, tree fern fibre and polyurethene foam.

MANURING

In nature, orchids obtain their supply of inorganic nutrients like calcium, magnesium, iron, potassium, nitrogen and traces of manganese, boron, copper, zinc etc. from the tree on which they are growing and also from atmosphere and decaying vegetables and dropping of birds. However under controlled conditions they have to be supplied with all these major and minor nutrients. Taking into consideration the special need of different orchids, a large number of fertilizer mixtures, both solid and liquid are available in the market. Liquid fertilizers are much more quickly absorbed and can be applied more frequently. As the orchids
are slow growing, slow release fertilizers like osmocote can be used to get very good results. Usage of fertilizers should also depend on stage of growth. During vegetative growth, large quantities of nitrogen are required while during flowering, nitrogen should be reduced and amount of phosphate increased. Excellent results are obtained by using slow release fertilizer mixtures (NPK 20:20:20) with trace elements and coconut water (20-25%) applied every week for three successive weeks followed by a 10:20:30 (NPK). In general, pH of the nutrient solution should be slightly acidic or neutral but not alkaline.

**DISEASES AND PESTS**

Like all other plants orchids are also prone to a number of diseases caused by fungi, virus, bacteria, insects and pests. The most common diseases in each group are:

**Fungal and bacterial diseases**

Leaf spot - caused by *Colletotrichum* and *Gleosporium*, Leaf blight - caused by *Pythium*
Collar blotch - caused by *Penicillium thomii*, Collar rot - caused by *Sclerotium*, Orchid wilt - caused by *Sclerotium rolfsii*.

Various fungicides like Captan, Dithane, Agrosan and Ceresan are very effective against these diseases.

**Viral diseases**

More than 32 diseases are known to occur in orchids. In some cases the same virus has been known to produce more than one disease in different species, the most common being *Cymbidium* mosaic virus. As control measures, all infected plants should be isolated to prevent spreading of the disease. The most commonly reported insects / pests on orchids are thrips, aphids, spidermite, soft scale, mealy bugs, orchid weevil, snail and slugs. These insects / pests harm the plants in many ways. They feed on tender young shoot, suck the sap and damage the young bud and shoots and also act as the carrier of different diseases. Fortunately all these can be controlled by effective insecticides like
Parathion, Malathion, BHC, Aldrin, Dieldrin, etc. Metaldehyde has proved to be very effective in killing slugs and snails.

**PROPAGATION**

Orchids like other horticultural crops, may be propagated either sexually or asexually. Since most of the commercial orchids are highly heterozygous they are not raised through seed and are propagated through vegetative means to get true-to-type plants. Conventional methods like cuttings, division of shoots or Keikis, are followed along with mericloning through tissue-culture techniques.

**VEGETATIVE PROPAGATION**

**Cuttings**

Orchids like Aerides, Arachnis, Epidendrum, Renanthera, Phalaenopsis, Vanda and Dendrobium can be propagated by cutting. Orchids cutting must be big and should possess one or more roots. Cuttings are usually potted in propagation beds or directly in pots after treating the cut ends with fungicides to prevent rotting.

Cutting of genera, like Aerides, Arachnis, Vanda etc. are very hardy and can be directly potted in pots, whereas those of Dendrobium and Phalaenopsis need special care to root and should be potted in propagation beds. The propagation of orchids through cuttings is getting popular again and some of the nurseries like to propagate their orchids through cuttings to get uniform plants. The percentage of variation through this method is almost nil as compared to in vitro propagation through tissue culture. Further some orchids like Anaectochilus respond more to vegetative propagation through cutting than to any other method. Most of the sympodial orchids, like Coelogyne, Cattleya, Dendrobium and Cymbidium, are propagated through this method. The method involved consists of dividing large clumps into smaller units. However care should be taken not to divide the plants unless there are 8-10 pseudo-bulbs. Dendrobiums which are very fast growing can be divided every year.
**Off-shoots and Keikis**

In some monopodial orchids like *Ascocenda* and *Phalaenopsis*, Keikis or offshoots emerge frequently on the main stem. This usually happens when the apex has lost its effectiveness in suppressing axillary buds. In most of the commercial orchid nurseries topping of the stem is commonly practised to induce Keikis formation. Induction of Keikis can also be induced through the use of cytokinins which force the dormant bud to develop into keikis.

**Aerial shoots**

Most of the Dendrobiums produce aerial shoots or bulbs on old back bulbs devoid of leaves. They usually arise on the upper part of the back bulbs and grow out slowly. These aerial shoots take 90-120 days to develop roots. At this stage, they are detached along with the portion of back bulb and potted as independent plants.

In genera like *Goodyera*, Rhizomes give off special lateral branches which turn up and produce aerial shoots. When they are properly rooted they get detached from the mother plant and establish separately.

**Other methods**

In few genera, like *Peristylis* and *Nervillia*, the roots are produced from above the tubers, each of which ends in a tubercle. These small tubers produce new plants the year after. *Vanda* and other monopodial orchids can also be multiplied by air-layering or marcottage. A cut is given through the stem 20 to 30 cm below the apex and most sphagnum moss is wrapped around the cut portion. The rooting media is kept moist and once the roots are formed, the layer is removed from the mother plant and potted in small-sized pots.

**ORCHID IMPROVEMENT**

**Flower and reproduction**

The orchid flowers are irregular, extremely variable in size and shape with sparkling texture. They may be solitary or in spikes emitting the fragrance of
lemons, cloves or fresh lavender oil. A few are, however, highly malodorous. The flower has its parts in threes, i.e. 3 sepals and 3 petals collectively called as tepals due to their resemblance in texture and colour, similar to each other and sub similar to sepals. It is, however, the third petal which is different and distinctive and is called labellum or the lip. The lip which is highly polymorphous is responsible for the different names of the orchids like 'Frog orchid', 'Dove orchid', 'Spider orchid', 'Lady slipper orchid' etc. The reproductive organs of the orchids, the stamens and pistil, are condensed and form a consolidated complex body and in the column the male and female parts being separated by a flap or projection of a tissue called rostellum.

Orchids are cross pollinated by insects and birds and to achieve this they have adopted many contrivances like mimicry and twisting of flower on its stalk to almost 180° to face its pollinating agent. A Mediterranean orchid Ophyrus shows a fine example of mimicry. It resembles a female wasp and emits a similar odour to attract the male wasp. In this attempt to mate with the plant, the male wasp picks up the pollinia and eventually deposits it on the other flower.

A large number of natural hybrids, both intergeneric and interspecific have been reported in different genera like Odontoglossum, Phalaenopsis, Cattleya, Laelia, Miltonia and Oncidium. Cattleya guatemalensis collected from Guatemala in 1861 by Skinner was found to be a natural hybrid between Epidendrum aurantiacum and Cattleya skinneri. It was later named as Epicattleya. Similarly, Phalaenopsis intermedia is a natural hybrid between P. aphrodite and P. rosea.

**BREEDING OF NEW VARIETIES**

Since 1856 when the first orchid hybrid Calanthe dominyi flowered, a very large number of artificial hybrids have been produced both at intergeneric and interspecific level. To date, more than 125,000 hybrids have been registered with an average of 10,000 or more every year. The success and ease with which such a large number of hybrids are produced every year depends upon the fact that most of the orchids genera and species have no generic barriers and they cross
freely with each other. It must be mentioned that most of the orchid genera are still in the process of evolution and most of the orchid groups are in reality only artificial constructs. The other two factors that have played a major role in the development of orchid hybrids are polyploidy and introgressive hybridization. In some genera like Cymbidium, Paphiopedilum, Phalaenopsis, Cattleya, Laelia, Sophronitis, polyploidy has been of extraordinary effect, and coupled with intergeneric compatibility has culminated in formation of hybrid groups which show both greater size and hybrid vigour as compared to parental species. The important genera, which have given maximum number of man-made hybrids, are Cattleya, Cymbidium, Paphiopedilum, Vanda, Dendrobium etc.

Some of the important intergeneric hybrids are:

- Ascocenda (Ascocentrum x Vanda), Aranda (Arachnis x Vanda), Aeridovanda (Aerides x Vanda), Brassocattleya (Brassovola x Cattleya), Vandanopsis (Phalaenopsis x Vanda), Laeliocattleya (Cattleya x Laelia), Sophrocattleya (Cattleya x Sophronitis)

A few other hybrid evolved for cut flower production on commercial scale are:


**SEED GERMINATION**

**Seed Structure**

The most interesting and adaptive feature of the family Orchidaceae is the physiology of its seed germination. Orchid seeds are unique in several respects. They are exceedingly small and dust like and are produced in very large numbers. As many as 1,300 to 4,00,000 seeds per capsule are produced. Their colour may be white, cream, pale green, reddish orange or dark brown and have
very diverse shapes. Orchid embryos consist of relatively undifferentiated, most isodiametric cells with dense granulated cytoplasm and they usually lose their viability very fast.

**Symbiotic seed germination**

Under natural conditions, the orchid seeds germinate after being infected by fungus, the orchid mycorrhiza (the term coined by Frank in 1885). Most of the mycorrizhal fungi of orchids fall into a non-sporing group known as Rhizoctonia, the major species being *R. repens*, *R. mucoroides* and *R. languinosa*. Subsequent isolates were known as *Mycelium radicis*. For quite some time these fungi were called as Orcheomyces. Later on, however, other fungi were also isolated from orchid cultures. In Japan, 54 different fungi were isolated from 20 orchid species.

Orchid seeds cannot utilize their own reserve or do so very slowly, they can also not hydrolyse large molecules like starch or cellulose. As a result, asymbiotic germination in the absence of sugar proceeds only to the early protocorm stage, after which they wait for external supply of simple sugars through the help of mycorrhizal fungus.

Until the middle of 19th century European growers had no method for germination of orchid seeds, and no hybrid could be produced. The only method followed was sowing of seeds at the base of the mother plant but in most of the cases the seed either did not germinate, got mixed up or took too long to germinate. This was later followed by Bernards method in which culture tubes were inoculated both with seed and fungi but the method was very elaborate and left much to be desired.

**Asymbiotic seed germination**

While working on the influence of the carbohydrates on green plants, Lewis Knudson in 1916 also started experimenting with the germination of orchid seeds on the basis of the analysis of orchid salep which contained starch, protein, sugars and minerals. He formulated a medium and successfully germinated
seeds of *Cattleya, Laelia,* and *Epidendrum* and concluded that fungus was not necessary for orchid seed germination.

This was the breakthrough in orchid seed germination and was followed by others who tried to improve the original media of Knudson in order to germinate other orchid species. When the seeds are planted on a nutrient medium *in vitro* not only is the percentage of germination improved in some cases to 100% but it also takes less time for further development. It may be mentioned here that an orchid seed while growing differentiates both bio-chemically and morphologically.

**DIFFERENT MEDIA**

Since the advent of Knudson medium, a large number of modified media have been standardized and are available in the market even with pre-adjusted pH. The most common media used are Knudson C and Vacin & Went medium.

**Composition of media**

Different media range from simple three-salt solution to complex containing 20 or more salts. Some media are designed for specific genera like *Paphiopedilum,* while other for a broad spectrum. Sugars, are the most common carbon source in different media. Most of the orchids utilise disaccharides such as sucrose. Some of the species of *Cymbidium,* however, prefer glucose to sucrose. After a certain stage of germination the orchid seedlings do not require any exogenous supply of sugars. Appropriate sources of nitrogen are the essential features of a balanced medium. It may be given in the form of nitrate, ammonia, urea, etc.

- Auxins were the first growth hormones added to the orchid cultures in majority of cases. IAA, IBA and NAA enhance seed germination and seedling growth. Bose and Mukherjee found that Knudson C supplemented with 1 ppm NAA or IAA resulted in callus formation in *Vanda* seeds.
- Cytokinins have a different effect on different species. Benzyl Amino Purine (BAP) has known to retard development and differentiation of *Cymbidium* protocorms.
• Among vitamins, Thiamine only appears to be essential. Pyridoxine, nicotinic acid and myo-inositol frequently improve cell growth.
• Micro-elements like boron, cobalt, copper and iodine are known to induce faster growth in orchid seedlings.
• A large number of complex additives like coconut water, banana pulp peptone, tomato juice, salep honey and beef extract have been used in different media to study their effect on orchid seed germination.

PREPARATION OF MEDIA

All the components of the medium should be dissolved one at a time in distilled water. Finally agar is added and the solution is warmed till agar is dissolved. The pH of the media is maintained between 4.5 and 5.8 and the media are autoclaved at 15lb pressure for 20 minutes.

Sowing of seeds and transplanting

Seeds are sown on media under aseptic conditions. Seeds can be either sterilized or sown directly from the green capsules. After 15-20 days, the embryo starts swelling and after 30-35 days 2-leaf stage can be seen. At 4-leaf stage the seedlings are taken out of flask and after thorough washing are planted in community pots in a 1:1 mixture of shredded tree fern fibre or charcoal.

TISSUE CULTURE

Tissue culture techniques were applied to orchids in 1960 when Dr G. Morel, the distinguished French botanist, while trying to figure out a way to prevent virus in potatoes hit upon the idea that the technique of tissue culture can be highly successful in cloning of orchids and to get virus-free plants. Since then the technique has been variously modified and extended from Cymbidium to 56 other genera. This technique was carefully exploited by commercial growers for the rare plants and hybrids which could not be propagated by any other means, but responded very well to tissue culture at a much faster speed. Vacherot and Lecoulfe firm in France has developed a new technique of virus-free plants of
Cymbidium. Today tissue culture is preferred for commercial propagation of orchids.

MEDIUM
Both liquid and solid media are used for orchid tissue culture. The explants after being isolated from the shoot are cultured in or on the desired medium. In most of the cases the simple media used for orchid seed-germination are also used for tissue culture. The same nutrients are used for both liquid and solid media, with the omission of agar on the former. Morel, at first used Knudson C medium for meristem culture of Cattleya, Cymbidium, Dendrobium, Miltonia and Phaius. Later, however, he removed calcium nitrate substituting it with ammonium nitrate. He also found out that plant extracts like tomato juice and coconut water at a concentration of 10% along with IAA, IBA or NAA were helpful in the subsequent growth especially after the division of protocorms. Sagawa used Knudson C medium along with Vacin and Went medium, Scully cultured explants of Cattleya on Vacin and Went medium which was modified by adding 15% coconut water.

PROPOSITION MATERIAL - EXPLANTS
In sympodial orchids like Cattleya, Cymbidium and Dendrobium, a young shoot arising from back bulb provides suitable material for tissue culture. On longer shoots, there may be several axillary buds as well as the apical bud while the monopodial orchids like Vanda, Aerides, Phalaenopsis, nodal sections, shoot apex keikis or offshoots or even flower stalk cutting can be used. The other parts of the plant like leaf and root have also been used by various workers.

INTRODUCTION OF EXOTIC SPECIES AND HYBRIDS
Instead of depending solely on the native species and hybrids it is recommended that a large number of modern hybrids which are used for cut flower production should be imported. At present a lot of bottlenecks are imposed on the import of orchid hybrids such as currency restriction, quarantine and custom clearance and often plants which are introduced through considerable effort and expense reach the indentors in non-viable condition. The procedure for the introduction of
planting material should be simplified and the import of species and hybrids can be achieved through exchange of native germplasm as also with the help of foreign exchange generated from the sale of native species.

**BREEDING OF ORCHIDS**

It takes on an average, 3-4 years from germination of seeds to first flowering. The production of new hybrids is therefore a long-term project. In view of this it is necessary that care be exercised in the selection of parents for hybridization programme. Genera, like *Cymbidium*, *Dendrobium*, *Paphiopedilum*, which have their centre of origin in India, are likely to be more amenable to immediate genetic improvement both for sale of plant material and for flower than the other exotic species. The growing popularity of *Cymbidium* hybrids in the international market can be very well exploited by launching a well-planned breeding programme. Moreover, it is now possible to have *Cymbidium* in bloom from early October-June, a period when the *Cymbidium* cut flower are in great demand in Europe. Demand can further be increased throughout the world if certain hybrids are produced which will flower well in warmer areas as the late bloomers are receiving considerable attention. *Cymbidium simonsianum* can be used as one of the parents for the production of late-blooming hybrids. There is also very good scope for breeding of miniature *Cymbidium* which have a great demand in the international market. Fragrance is another important feature which can be exploited in *Cymbidium* breeding.

**STANDARDIZATION OF TECHNIQUES FOR EMBRYO / SEED AND MERISTEM CULTURE**

The growing of orchid seed with the help of culture media has revolutionized commercial orchid growing and hybridization, as every viable seed can be turned into a new plant. This has put orchid growing on par with other commercial greenhouse crops. A few growers from Kalimpong and Bombay have started seed culture for the propagation of different species. Meristem culture which
enables the production of a much higher number of plantlets of the same clone in a short method has not been tried yet by any commercial grower in India.

CONSERVATION OF INDIAN ORCHIDS

Deforestation through burning of forest trees and felling of forest trees for timber have been the major cause for the depletion of Indian orchid wealth. A large number of orchid species which were present in plenty in Indian forests are now at the verge of extinction and some of them have become so rare that a large number of botanical teams were unable to trace them. To cite an example Paphiopedilum druyyi which was once found in plenty in Agastaya Hills in South India is now difficult to locate. Steps should therefore be taken to conserve this natural wealth.

More recently attempts were made to develop an efficient delivery system for micro-propagants. One such system is the artificial/synthetic seed technology. It involves entrapping embryoids/meristems in a biodegradable synthetic polymer coating that acts as an artificial seed coat. Besides serving as an efficient delivery system of otherwise difficult to transport plant material, the synthetic seeds provide a significant alternative to the perpetual maintenance of living specimens for the conservation and preservation of desired germplasm. This technique of encapsulation would provide an easy and novel way of propagation and delivery system of orchid species and hybrids.

Synseed is referred, in a narrow sense, to "encapsulated somatic embryo which functionally mimic seeds and can develop into seedlings under suitable conditions; in a broader sense, it also refers to 'encapsulated buds, bulbs, or any form of meristems which can develop into plantlets. The first successful example of synthetic seed technology was in alfalfa and celery. In addition to using somatic embryos for the production of synthetic seeds, research has also been focussed on the use of vegetative propagules like axillary buds, adventitious buds, shoot tips, cormlets, bulbs and protocorms (Piccioni and Standardi, 1995:
Rao et al., 1996). Encapsulation procedure has been successfully tried on many agriculturally important plants like alfalfa, sandalwood, carrot, cotton, celery, cardamom, rice, tobacco, tomato, (Redenbaugh et al., 1984). Synthetic 'seeds' have so far been produced in about 12 orchid species (Vij et al., 1992) but studies pertaining to their long term storage are yet to be attempted. Synthetic seeds are a potential delivery system and provide an alternative to current high cost vegetative propagation. They allow for planting of hybrid 'seed' based on estimates for material and labour for embryo production and encapsulation. Synthetic seeds should be available at low cost and high volume while at the same time remaining competitive w.r.t the cost structure of seeds and maintenance of genetic uniformity of the vegetative propagation (Redenbaugh et al., 1988).

For achieving commercialization in synthetic seed technology, large scale production of somatic embryos or propagules is required. Artificial seeds offer the possibility of a low-cost, high-volume propagation system that will compete with true seeds and transplants. The artificial seed coating also has the potential to hold and deliver beneficial adjuvants such as growth-promoting rhizobacteria, plant nutrients and growth control agents, and pesticides.

The potential uses of synthetic seeds are that they help as delivery systems, and reduce the costs of transplants. A direct greenhouse and field delivery of elite, select genotypes and hand-pollinated hybrids, genetically engineered plants, sterile and unstable genotypes, large-scale monocultures, mixed genotype plantations is possible. Synthetic seeds act as a carrier for adjuvants such as microorganisms, plant growth regulators and pesticides. Artificial seeds provide protection of meiotically-unstable, elite genotypes. An unique feature is the production of large numbers of identical embryos. This technique also helps the study of seed coat formation.
Artificial seeds can be produced at any time and in any season of the year. Dormancy is the common feature of natural seeds, but by means of artificial seeds the dormancy period can be reduced to a great extent, thereby shortening the life cycle of a plant. They are also useful in preserving germplasm. The synthetic seeds provide us knowledge to understand the development and anatomical characteristics of endosperm and seed coat formation.

A total of 11 taxa were included under the scope of the present investigation. Different parameters like gelling agents, stage at which the plant part was used for encapsulation, culture media for regeneration, number of days of storage, temperature of storage, and field establishment of the regenerated plants were tried. The observations and results are summarized in the following chapters.