RVS AGRICULTURAL COLLEGE

(Affiliated to Tamil Nadu Agricultural University, Coimbatore-3)
Thanjavur – 613 402

Theory study material

HOR 212 - PRODUCTION TECHNOLOGY FOR ORNAMENTAL CROPS, MAPS AND LANDSCAPING (1+1)

Student Name :

ID No :

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HOR 212 - PRODUCTION TECHNOLOGY FOR ORNAMENTAL CROPS, MAPS AND LANDSCAPING (1+1)

Theory

Unit I: Landscaping

Importance and scope of ornamental crops landscaping. Principles of landscaping. Landscape uses of trees, shrubs and climbers.

Unit II: Production technology of cut flower crops under protected conditions

Production technology of important cut flowers like rose, gerbera, carnation, lilium and orchids under protected conditions

Unit III: Production technology of flowers under open conditions and value addition in ornamental crops

Production technology of important cut flowers like gladiolus, tuberose, chrysanthemum under open conditions. Package of practices for loose flowers like marigold and jasmine under open conditions. Processing and value addition in ornamental crops.

Unit IV: Production technology of medicinal crops

Medicinal crops- importance and scope – current status - soil and climate – varieties – propagation– planting methods – nutrient, irrigation and organic practices – harvest – post-harvest handling – storage, packaging of Periwinkle, Asparagus, Aloe, Costus, Isabgol, Glory lily, extraction and value addition of medicinal crops.

Unit V: Production technology of aromatic crops

Aromatic crops - importance and scope – current status -- soil and climate – varieties – propagation– planting methods – nutrient, irrigation and organic practices – harvest – post-harvest handling – storage, packaging of Ocimum, Mint, Geranium, Citronella, Lemon grass, Palmarosa and Vetiver – Distillation of oil and value addition.

Practical

Identification of Ornamental plants. Nursery bed preparation and seed sowing. Training and pruning of Ornamental plants. Planning and layout of garden. Protected structures – care and maintenance. Intercultural operations in flowers. Harvesting and post harvest handling of cut and loose flowers. Visit to commercial flower unit.

Medicinal and Aromatic Plants

Identification of Medicinal and Aromatic Plants- varieties-propagation-special practices - nutrient management, extraction and distillation of essential oil - Periwinkle, Asparagus, Aloe, Costus, Isabgol,

Glory lily, Ocimum, Mint, Geranium, Citronella, Lemon grass, ,Palmarosa and Vetiver – visit to commercial medicinal and aromatic plants fields and processing units

Theory lecture schedule

1. Importance and scope of ornamental crops and landscaping.
2. Principles of landscaping
3. Landscape uses of trees, shrubs and climbers.
4. Production technology of cut rose under protected conditions
5. Production technology of gerbera and carnation under protected conditions
6. Production technology of lilium and orchids under protected conditions
7. Production technology of gladiolus and tuberose under open conditions
8. Production technology of chrysanthemum and marigold under open conditions
9. **Mid Semester Examination**.
10. Production technology of jasmine under open conditions.
11. Processing and value addition in ornamental crops.
12. Scope and Importance of medicinal & aromatic crops– current status - conservation methods
13. Periwinkle, Asparagus and Aloe - varieties –- soil and climate – propagation- sowing and planting, nutrient, water management – harvest and processing
14. Costus, Isabgol and Glory lily - Propagation- soil and climate – propagation and planting- standards - pollination-nutrient, irrigation management – harvest, yield and processing
15. Ocimum, Mint, Geranium - varieties – soil and climate- propagation - planting - nutrient, water management – harvest - distillation of essential oil
16. Citronella, Lemon grass, Palmarosa and Vetiver - varieties – soil and climate- propagation - planting – nutrient- water and weed management – harvest- distillation of essential oil.
17. Processing and value addition in medicinal and aromatic plants.

Practical schedule

1. Identification, planting, care and maintenance of trees, shrubs and climbers used in garden
2. Identification of varieties in cut flowers under protected conditions.
3. Identification of varieties in flowers under open conditions.
4. Practices of nursery bed preparation, seed sowing in ornamental plants.
5. Training and pruning and intercultural operations in Ornamental plants
6. Planning and layout of garden.
7. Protected structures – care and maintenance.
8. Harvesting and post harvest handling of cut and loose flowers.
9. Identification of medicinal and aromatic plants –economic parts
10. Propagation techniques, planting, cultural operations in Periwinkle, Asparagus and Aloe.
11. Propagation techniques, planting, cultural operations in Costus, Isabgol and poppy.
12. Propagation techniques, planting, cultural operations in Ocimum, Mint, Geranium
13. Propagation techniques, planting, cultural operations in lemon grass, palmarosa, vetiver and citronella
14. Extraction and distillation of medicinal & Aromatic crops.
15. Visit to commercial floriculture and floral oil extraction units
16. Visit to commercial medicinal and aromatic crops field and extraction unit.

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Lecture 1 : Importance and Scope of Ornamental Crops, Medicinal and Aromatic Plants and Landscaping

Important Definitions:

Ornament: A thing that add to grace or beauty.

Ornamental: A plant grown for ornament or beauty.

Floriculture: It is an art and science of growing flowers to perfection. It can be defined as a specialized branch of horticulture which deals not only with the cultivation of flowers, foliage, climbers, trees, shrubs, cacti, succulents,etc., but also with their marketing and production of value-added products from them.

Ornamental Horticulture:

It is a branch of horticulture that deals not only with the cultivation of flowers but also the decorative foliage plants, trees, shrubs, climbers, creepers, lawn, cacti, succulents, palms, ferns, bonsai and also with their marketing and production of value-added products from them.

Commercial Floriculture:

The floriculture which is based on flower production, which is high value added flowers. When export is done, it is known as commercial floriculture.

Cut Flower:

The flower along with stalk is called as cut flowers. eg. Rose, gerbera, chrysanthemum, gladiolus, tuberose, carnation, anthurium, heliconia, bird of paradise, etc. They generally fetch high market price and are exported in other countries. They are used for flower arrangements, preparation of bouquets, bookies, baskets, on table for show purpose, etc.

Loose Flower:

The flower without stalk is called as loose flowers. eg. Marigold, jasmine, gallardia, spider lily, China aster, etc. They generally fetch less market price and are sold in local market.They are used for preparation of floral gardens, gajaras, venis, floral ornaments & worshiping god.

Foliage plants/trees:

These are those plants/trees whose foliage particularly leaves or branches are so attractive and can also be used as a house plant for indoor decoration as well as for outdoor gardening. Eg.

Shrubs: Asparagus, arelea, croton, difenbekia, eranthemum, pothos/money plant, ferns, etc. Trees: Christmas tree, ashopalav, ashoka, casurina, peltophorum, etc.

Garden:

A garden is an area adjunct to the house or any building especially made for the purpose of refreshment and recreation.

Landscape:

A landscape may be defined as any area, either big or small, on which it is possible to mould a view or design with the help of plant material, changing landform, water, stones, etc.

Landscape Gardening:

The application of garden forms, different styles, methods & materials with a view to improving the landscape.

Medicinal plants:

Medicinal plants are those plants rich in secondary metabolites and are potential sources of drugs. These secondary metabolites include alkaloids, glycosides, coumarins, flavanoids, steroids etc. eg. Ashwagandha, guggal, senna, safed musli, etc.

Aromatic Plants:

These plants possess essential oil in them. These essential oils are the odoriferous steam volatile constituents of the aromatic plants. eg. Rose, jasmine, lemongrass, citronella, palmarosa, mint, etc.

Importance of Ornamental Crops:

Besides food and nutritional security, the aesthetic value is also equally important for our daily lively hood as well as for environmental purity. Floriculture is important from the following point of view;

1. Economic point of view
2. Aesthetic point of view
3. Social point of view

1. Economic point of view:

- Floriculture is a fast emerging major venture in the world, especially as a potential moneyspinner for many countries in world.
- Many flowers and ornamental plants are being grown for domestic as well as for export market will provide more return/unit area
- Gestation period of flower crop is very less compared to other crops.
- Now days, flower arrangements/decorations for bouquets preparation and for floral baskets, have increased substantially and its share of the total trade has also improved.
- The present trend in floriculture is for making dry flowers, extraction of natural colours and essential oils.
- There is lot of demand for good quality flower seeds and ornamental planting materials.
- Floriculture generates self employment opportunities round the year. The employment opportunities in the field are varied such as
    i. One can join the floriculture field as farm/estate managers, plantation experts, supervisors and project coordinators and so on.

ii. Teaching, Research and Extension scientists/ teachers are some other avenues of employment in all SAUs. iii. Marketing of Floriculture products for different ventures is emerging as a potential segment of this field.

iv. Besides, one can also work as consultant, landscape architect etc with proper training. v. One can also work as entrepreneur and offer employment to others.

vi. In addition to these careers which involve research and actual growing of crops.

vii. Floriculture also provides service career opportunities which include such jobs like floral designers, grounds keepers, landscape designers, architects and horticultural therapists.

2. Aesthetic point of view:

- The wealth of any nation is linked with the health of its people. Unless we can ensure the healthy development of our citizens, especially for the younger generation, by providing them for open breathing places through bio-aesthetic planning like in Chandigarh city and landscape gardening, we cannot expect to build up a healthy society and prosperous nation.
- Horticultural therapy is the new dimension of horticultural sciences to heal the psychic debility and the science is to use garden, landscape plants, as a new occupational therapeutic tool to restore the lost rhythm and harmony back to human
- It is being utilized in psychiatric hospitals, general hospitals and physical rehabilitation centres, homes for elderly, prisons and schools.
- The patients can achieve higher level of personal development and satisfaction.

3. Social point of view:

- Flowers symbolize the purity, beauty, peace, love, adoration, innocence and passion etc. Hence, many flowers are used to express the most sensitive, delicate and loving feelings where our words fail to express.
- In our society no social function is complete without the use of flowers, floral ornaments, bouquets or flower arrangements they are invariably used in all social functions.
- Used in social gatherings, birthday parties, welcoming friends or relatives and honoring dignitaries. The concept of Valentinesday is fast catching up in India also.
- The arrival of new born is rejoiced with flowers.
- To an Indian, especially for Hindus, flowers have a much greater significance in religions offerings.
- Floral garlands, gajras and venis are required in marriage ceremonies for adornment of hairs by women of all ages, especially in the south India.
- In the present modern era sicks are wished for speedy recovery by offering beautiful cut flowers, while the dead are bidden farewell with flowers along with tear of sorrow.
- Flowers are very closely associated with mankind from the dawn of human civilization. There is increasing habit of saying with flowers.

- **" Any Indians born with flowers live with flowers and finally dies with flowers".**

Bio-aesthetic Planning

The term bio-aesthetic planning, a concept of Prof. Lancelot Hogben, means the proper utilization of the available flora and fauna inthe beautification of the surroundings.

Air Pollution

Air pollution, one of the most-talked-about problems in the present age, has reached disturbing proportions in some of the largest cities of the world and also in some of the metropolitan cities in India.

The role of open spaces such as parks and of living plants in checking air pollution is well known. The parks are considered as the lungs of a city. The barrier of trees checks noise pollution, dust pollution, and air pollution.

Human Welfare

The role oflandscape gardening in human welfarecannot be overlooked. Even in an underdeveloped country as India, people do not live by bread alone. They also need some finer things of life. It is a great tragedy that most of our children in big cities do not have any open space to play and to see colourful flowers, birds, and butterflies. It is the moral duty of our government, through the municipalities, corporations, and such other bodies, to provide the citizens with spacious parks having beautiful trees and flowers where they can relax, find peace of mind, and breathe fresh air after a day's hard work. The children will also be able to play freely in such parks.

Scope of Ornamental Crops in India:

- India is blessed with varied and dynamic agro-climatic condition, good quality soil and water made suitable for floriculture.
- Geographically India is well located between two major markets i.e., Europe and East Asia.
- Winter is being very mild and hence there is lot of scope to export Indian flowers to temperate countries during the winter season, when the demand is in peak because of important winter festivals like Christmas, New Year Day and Valentine’s Day.
- Labour cost is very low in India, nearly 10-15 times cheaper than that of similar employees in the Netherlands, Israel and Japan.
- The Government of India has identified floriculture as "Extreme Focus Thrust Area" for export during IX plan.
- With the implementation of GATT agreement European nations has brought down the import duty on floricultural products, which at present is 15 %.
- The International market is growing @ 8-10 % annually. The International demand is around Rs. 90,000 crore/ year and domestic market at 20-25 %. Hence, the scope to enter floriculture industry in India is unlimited.

- The Govt. of India has setup the infrastructure for floriculture industry in major cities like New Delhi, Mumbai, Kolkata, Chennai, Bengaluru, Pune etc.
- APEDA is giving financial assistance to some extent for various activities connected with export of floriculture products.
- Easy bank financing for hi-tech floriculture.
- For 100 % EOUs the government has allowed to sale 50 per cent of produce in domestic markets.
- 100 per cent tax exemption has given on implements / raw materials used in greenhouses.
- The rules and regulations related to import and exports have been minimized.
- Singapore is the nearest International standard flower auction centre, helpful for Indian exports.
- Floriculture products posses 25-30 time more foreign exchange earning ability than cereals or any other agricultural/horticultural products.
- Floriculture is capable of attracting and retaining large number of progressive farmers / entrepreneurs.
- Due to ample sunlight and optimum temperature during winter, it does not require artificial lighting or heating for green house production of cut flowers.
- The Government of India has identified product specific zones for selective research and development of floriculture.
- APEDA and GOK have established four flower auction centers including one in Bengaluru, Noida (UP), Mumbai and New Delhi.
- APEDA also has setup a marketing center at Aalsmeer (The Netherlands) to promote Indian produce.

Importance & Scope of Medicinal Plants in India:

- India is one of the few countries where, almost all the known medicinal plants can be cultivated in some part of the country or the other. Among the various plants from the country and abroad opium poppy, sapogenin bearing yams, senna, psyllium husk and seeds, cinchona are in great demand.
- The ancient Indian system of medicine (ISM) is predominantly a plant based material medica making use of most of our native plants. It caters to almost the entire rural population of our country mainly because of the scarcity of modern allopathic health care in our villages.
- ISM offers most appropriate or first line therapy against many diseases like Jaundice, bronchial asthma, rheumatoid arthritis, diabetes etc. For which allopathic medicines have as yet no cure. It is well known that most allopathic medicines produce many morbid side effects. For this reason more and more people in the western societies are showing increasing interest and preference for organic drugs and their preparations.
- India has about 2000 species of medicinal plants and a vast geographical area with high production potential and varied agro-climatic conditions. Most of these plants can subsist under stress conditions and are thus suited even for rain fed agriculture. Cultivation of medicinal plants offers considerable scope for rural employment and export for foreign exchange earnings.

- India is already a major exporter of medicinal plants. It is estimated that Rs. 1060 crore worth of raw materials and drugs from medicinal plants are exported from India. It holds monopoly in the production and export of psyllium and senna and is second largest exporter of opium latex.
- Many medicinal plants required by the trade are gathered mainly from the wild growth, thus depleting the vegetation of its valuable medicinal plant wealth (e.g. Rauvolfia, Dioscorea). On account of this practice, many species of medicinal plants in our country have become extinct or endangered. This should be prevented and herbal gardens and gene-banks covering important medicinal plants should be established to conserve them.

Importance & Scope of Aromatic Plants in India:

1. Aromatic plants are from a numerically large group of economically important plants. These are in increasing demand for essential oils, aroma chemicals drugs and pharmaceuticals in the world market since two decades. Aromatic compounds are present in plants i.e. in root, wood, bark, foliage, flower, fruit, seed etc.
2. Aromatic plants produce essential oils, perfumes and flavours are in use with our civilization since several thousand years.
3. Due to vast area and varied agro-climatic condition, they can be commercial cultivated in different part of India successfully.
4. Essential oils and aroma chemicals are indispensable in various human activities.
5. They are adjuncts of cosmetics, soaps, pharmaceutical preparation, perfumer confectionery, ice-cream, aerated waters, disinfectants, agarbatti etc.
6. Some of the important aromatic plants like Lemon grass, Citronella, Palmarose, Vetiver, Geranium, Lavender, Dawana etc. have great demand in our country.
7. Historically, India has enjoyed a pre dominant position as the supplier of natural perfumes in the world. This is true in case of sandalwood oil, lemon grass oil, palmarosa oil, vetiver oil and cedar oil.

Importance & Scope of Landscaping:

1. The prime importance of landscape gardening lies in aesthetic developments and modernization of cities, town, countryside, roadways, airports, railway stations, railway lines, bus terminus, city parks, and educational institutions against industrial fast growing pollution. In recent years, bio-aesthetic planning has wider scope in landscape and gardening.
2. Landscape gardening increases the awareness towards nature developed eco-friendly concept and provide feeling of responsibility towards plants, birds and animals.
3. It also serves as a source of live medicines and herbal taste in prepared food and tea.
4. It also helps in soil-moisture retention; prevent erosion, modifying air temperature, creating microclimate and removal of noise and dust pollution.

5. It also provide habitat for birds and animals.
6. One fully developed large tree in a landscape can change the microclimate and brings down the temperature by 2 to 5^{o}C.
7. The average temperature of concrete urban area devoid of vegetation/green belt is higher compile to a thickly vegetated area.
8. Well planned landscape around building or residence adjoins aesthetic value to it as well as affix real estate value of about 30%.
9. The landscaping profession conveys and directs to make human life more elegant, more satisfying, more eco-friendly and more productive.
10. There is unbound scope in the field of landscape gardening with the increase in demand for attractive parks, landscaped ground of schools and institution, pleasant residential backyards, eco-friendly housing society and towns.
11. Landscape flora industry employs thousands of people through various activities like nursery and rental plant services, besides landscape designing.
12. Landscape gardening also plays a vital role in giving emphasis to the tourist business by improving aesthetic and functional uses of historical places, sea beaches, rivers and dams, hill stations and other tourist places.

Lecture 2: Principles of Landscaping

Principles of Landscape Gardening:

There are some principles keep in mind when landscaping the garden. They are mentioned here.

1) **Axis: -** This is an imaginary line in any garden round which the garden created striking balance.
2) **Unity:-** Unity in a garden is very important and will improve the artistic look of thegarden.

Unity has to be achieved from various angles .It can be achieved by using mass planting and repetition.

3). **Mass effect:-**The use of single plant species in large numbers in one place is done to have mass effect. One should see that such mass arrangements do not become monotonous; the sizes of masses should be varied

4) **Repetition:-** It refers to repeated use of features like plants with identical shape, in form, texture and colour. Eg Hedge, Avenue planting

5) Focal point:-A focal point in every garden is a centre of attraction which is generally an architectural feature focused as a point of interest such as statue, fountain, rockery etc. It involves the leading visual observation towards a feature by placement of the feature e.g. center of the garden, corner of the garden.

6) Space:-The aim of garden design should be such that the garden should appear larger than it actual size. The aim of every garden design should be such that the garden should appear larger than its actual size. One way of achieving this is to keep vast open spaces, preferably under lawn and restrict the plantings in the periphery, normally avoiding any planting in the centre

7) Balance:- It refers to equilibrium or quality of usual attraction, • Correct positioning of plants and features create well balanced design . It is used to maintain optimum symmetry in garden.

8) **Rhythm:-** Repetition of the same object at equal distance is called rhythm.
9) **Divisional Lines:-** a landscape design there should not be such hard and fast divisional lines,the necessity of dividing or rather screening a compost pit or mail's quarter or a vegetable garden from the rest of the garden
10) **Proportion and Scale:-**

- Proportion refers to the size of parts of the design in relation to each other and the design as a whole.Scale refers to the size of an object or objects in relation to the surroundings.

11) **Texture:-** Texture describes the surface quality of an object than can be seen or left, surface in the landscape includes buildings, walks, ground covers and plants
12) **Time and Light:-** A good planner must roughly take in to account the seasonal movement of the sun shade and light area likely to fall during different parts of the season
13) **Colour:-**

Colour can be used to direct attraction in the land scape. Three basic colour schemes are i) Monochromatic ii) Analogous iii) Complementary

14) Mobility:-

- Mobility means gradual changes or sudden change. Garden should be mobile.
- It can be obtained by the arrangement of objects with varying texture, forms or sizes in logical order.

15) Garden style:-

- Garden styles have been changed from time to time with the new ideas and necessities.

Styles of garden are Formal, Informal, and Free style or Wild style.

Selection and finalizing the style of the garden is the first step after seeing site, for planning design on paper. Style should be selected on the basis of purpose, types, landform, interest of owner, maintenance capacity, region (urban or rural area), building structure, etc. One has to be creative to evolve one's own style of gardening according to his budget, taste and the nature of the site. There are three basic garden styles given as under:

Difference between formal and informal garden:

Formal garden		**Informal garden**	
1.	More stress on geometrical balance, each thing use very proportionate.	1.	Stress on natural balance by other principle rather than geometrically.
2.	The figure is more important than idea.	2.	The idea is more important than figure.
3.	Even /leveled land.	3.	Un leveled land is preferred.
4.	More importance on straightness.	4.	More importance on curved and round mass.
5.	Balance is symmetrical.	5.	Balance is asymmetrical.
6.	Annual and perennials both have equal importance.	6.	Perennials have more importance.
7.	Design is prepared according to the plan to be used.	7.	Plan is made fit to the landscape.
8.	Highly dominated by rules.	8.	Less dominated by rules.
9.	It is creation of artificial scenery.	9.	Creation of natural scenery.
10.	Small area is required.	10.	Large area is required.
11	Types: Mughal, Persian, Italian & French garden.	11	Types: Japanese & English garden.

General Principles of Garden Design:

1. Simplicity:

   Garden design should be simple. It should not have scope for under complexity.

   Visitors should catch entire effect. Visitors should know purpose of garden design/plan.

2. Ideal garden should have space i.e. overcrowding of plants should be avoided.
3. Judicious uses of more number of varieties/species of plants, instead of going for few plants go for more number of plants because it serves two purposes.

   a. Increases aesthetic beauty. b) Serves the scientific purpose.

4. Garden path/ drive should not too straight and long.
5. Garden should layout for owners comfort and convenience.
6. Natural grade of greens taken in to consideration.
7. All garden features should be accommodated in proper place in a proportionate manner, careful selection of plant and also increase beauty of garden.
8. It should comfortable to living (Private garden).
9. It should serve perfect place for passing leisure time.
10. Easy to maintain to carry out all intercultural operations.
11. When we say garden is complete garden should look beautiful and should give pleasant look to the garden.

Lecture 3 : Use of Trees, Shrubs and Climber in the landscape/Garden

1.Trees:

Trees are big, tall perennial plants having very thick and hard distinct stems called as trunk and crown at the top. This single main stem i.e, trunk give rises to many branches bearing leaves and fruits.

- Trees are essential feature of a landscape garden, roadside planting, public parks, along railway line, in school and colleges and in private garden also.
- It provides shade, shelter and makes summer pleasant.
- Bears beautiful flowers and foliage.
- Some trees provide fruits.
- Trees plays important role in controlling pollution in cities and town.
- Some species of trees are used for beautification.
- Delight and refresh the eye with their green foliage.
- Trees are used as avenue e.g .Amaltas, Cassia, Gulmohar, Ashok, Rain tree etc

e.g. flowering trees: Gulmohar (*Delonix regia*), Bottle brush *(Callistemon lanceolatus)* Ashoka (*Saraca india),* Pride of India *(Lagerstroemia*), *Spathodea campanulata*, Bahunia, Begonia, Palash (*Butea monosperma,) Casia fistula (garmalo),* etc.

e.g. foliage trees: Ashopalav **(***Polyalthia longifolia),* Silver oak, *Peltophorum inerme,* Sharu (Casuriana equisetifplia), Siris *(Albezia lebbek*), Rain tree (*Samane saman*), Eucalyptus, Vad (*Ficus bengalensis),* Pipal *(Ficus relegiosa), Rubber tree (Ficus elastic), etc.*

2.Shrubs:

- Shrubs are plants with many woody branches arising from the base of the plant and are smaller (1 to 4 m in height) than trees but bigger than herbaceous plants.
  - Shrubs are the chief attraction of ornamental garden with their handsome foliage, colorful flowers and attractive berries.
  - They are perennial habit and need little care.
  - Shrubs are ideally suited for topiary work, formal garden, landscape designing.
  - It can be planted as single specimen in lawns or as tub plants.
  - Shrubs can also be planted to secure privacy in the garden.
  - Shrubs are use as Shrubbery border which is a source of perennial pleaser.
  - Some shrubs can be grown along the paths.
  - Shrubs can effectively break the monotony of a large open space in the garden

e.g. flowering shrubs: Rose, jasmine, hibiscus, ixora, hemelia, lantana, narium, *Tecoma stens,* etc.

e.g. foliage shrubs: Croton, duranta, acalypha, aralia, eranthemum, thuja, etc.

Climbers and Creepers:

- Climbers: Climbers are defined as a plant which possesses special structures to climb over a support. These special structures may be hook-hike thorns.
- Creepers are those plants which are unable to climb vertically on their own because of their weak stems.

Uses of climbers in garden:

1. Certain climbers are grown in gardens for their attractive foliage. e. g. *Asparagus spregeri, Ficus repens, Hedera helix, Scindapsus aureus*.
2. Some light climbers can be trained as 'screens' in gardens. e. g. *Bignonia venusta, Jacquemontia violaceae, Passiflora edulis*.
3. Climbers like *Allamanda, Antigonon, Aristolochia elegans, Solanum seaforthianum* can be used on arches, bowers and pergolas.
4. Heavy climbers like Bougainvillea, *Quisqualis indica, Petrea volubilis, Adenocalymma allicea, Allamanda cathartica,* Scindapsus, *Petrea volubilis* can be trained over strong pergolas or on trees which look very attractive.

- The bare wall of building or boundary wall can be covered beautifully by a colorful climbers or a foliage type of climbers.
- Climbers can be used for the purpose of screening to maintain privacy from the adjacent houses.
- The climbers are also grown to be trained on trellis, pergolas, arches, arbours and against pillars or similar structures.
- Use for climb over net house or conservatories.
- Climbers are also suitable for roof gardens, where vertical growth is preferred because of lack of space.
- All over climber if properly used, they serve to brighten and cheer up a place.

- Climbers are very important ornamental plants and are commonly used on walls, arches and pergolas but in cities their utility is increased for the purpose of screening the premises from adjacent houses and maintaining privacy. Bare walls can be most effectively decorated by growing colorful climbers.
- Climbers and Creepers are important group of plants which add beauty, color in striking way of fragrance in gardens and artificial structures like wall, arches, pergola, pillars; topiary, etc. are well decorated with the help of climbers.

SN	Climbers *Vs*	Creepers
1	They tend to grow vertically.	They tends to spread horizontally along the soil and.
2	They climb on their own .	They required support for climbing.
3	They possess special structures to climb over a support like hook-hike, thorns, tendrils, etc.	Do not posses special structures.
4	Main stem is weak.	Main stem is soft & very weak.
5	eg. Bignonia, Ficus repens, Bougainvillea, etc.	eg. Morning glory, Railway creeper etc.

Lecture 4 : Production technology of cut rose under protected conditions

CUT ROSE

Family : Rosaceae

Importance and uses

- Rose has been a symbol of love, adoration and innocence
- Used as loose flowers for worship, garland making, decorating hair, etc.
- Used in garden display – widely used for edging and pot cultivation
- Cosmetics, perfumes, flavours : Damask rose, Red rose, Edward rose – used in preparation of rose water, rose attar, rose oil (Otto of rose).
- Rose oil is commercially used for the preparation of cosmetics, perfumes and flavors which are exported.
- R. hybrida flowers which are attractive and have long stems are used as cut flowers – in flower arrangements, bouquets.
- Miniature roses / button roses - indoor display, pot culture

Varieties

Group	Varieties	Source
Hybrid Tea	Mother Teresa, Priyadharshini, Jawahar, Arjun, Anurag, Mirnalini	IARI, New Delhi
	Dr.G.S. Randhawa, Kiran,	IIHR, Bangalore
	Mirnalini Stripe, Mirnalini Light pink mutant	NBRI, Lucknow
	First Red, Saffire, Grand Gala	The Netherlands
Floribunda	Manasi, Kavitha, Mohini, Deepika, Dr.S.S. Bhatnagar	IARI, New Delhi
	Sharada, Sukumari, Yellow Contempo	NBRI, Lucknow
	YCD-1, YCD-2, YCD-3	TNAU, Yercaud
Miniature	Windy City mutant	NBRI, Lucknow
Climbers	Climbing Sadabahar	IARI, New Delhi
	Climbing Cri-Cri	NBRI, Lucknow
Scented Rose	Edward Rose, Damask or Bulgarian Rose, Andhra Red	-

Soil: Well-drained, fertile, porous, loamy soil at least two feet deep and with a pH of 6-7.

Climate ; Bright sunshine for minimum of 6 hrs is essential for the cultivation of roses. The optimum day temperature of 26 0 C,and night temperature of 150 C is ideal. An RH of 75 % is necessary for proper growth.

Propagation :

Commercial method of propagation is by cutting and budding.

a) Cutting

- Scented roses are mainly propagated through cuttings.
- Hard wood Cuttings in case of polyanthas, climbers, ramblers and soft or semihard wood cuttings for miniatures are used.
- Cuttings are collected from healthy plants
- Cuttings are prepared with 15-20 cm length and 3-4 nodes.
- Cuttings are treated with IAA, BA 100ppm and planted in mist chamber for easy and quicker rooting.

b) Budding

- Hybrid roses are mainly propagated through budding.
- 'T' budding is the common method.
- R.multiflora, R.indica, R.bourboniana. R. Canina and R. Noisettiana are the commonly used rootstocks.

Planting

- Planting can be avoided during hot summer and heavy rains.
- In plains roses can be best planted during Sep-Oct after the cessation of the rains.
- In hills, planting fan be done during Oct-Nov or Feb-Mar.

Spacing

Vigorously growing cultivars	: 60 x 75 cm / 75 x 75 cm
Miniatures	: 30 cm
Climbing types	: 3 m

Points to remember during planting:

- The plant along with the earth ball is planted
- The bud-union point where the scion joins the stock is kept just above the ground level.
- Suckers originating from the root stock must be removed frequently.

Irrigation :

The newly planted roses require frequent watering in the beginning. After that they may be watered once in five days during summer, and once in ten days during winter. Care should be taken to avoid 'wet feet', i.e. to avoid stagnation of water near the base of the plants as it is harmful to the roots.

Manuring:

Edward Rose and Red Rose	: 6:6:12 g NPK/plant
Hybrid Teas / Polyanthas / Floribundas	: 8:8:16 g NPK/plant

Dose/plant – FYM 10 kg, Urea 65 g, Super phosphate 25 g, MOP 50 g

Application : in 3 splits

- 15 DAP
- After first flush of bloom
- After second flush of bloom
- ✞ Foliar spray of the micronutrients MnSO4 (20g) + MgSO4 (15g) + FeSO4 (10g) + Boron (5g) @ 2g/l of water results in bright coloured flowers.
- ✞ Organic manures such as oil cakes and bone meal may be applied after pruning.

Plant growth regulators :

- **GA 3 @ 250 ppm sprayed during the flushing results in :**
  - ✓ Increase in the length of the stem/shoot
  - ✓ Increase in the no. of shoots/plant
  - ✓ Early flowering
  - ✓ Prolonged flowering period
  - ✓ Higher flower yield
- **CCC 3% results in :**
  - ✓ More no. of flower buds
  - ✓ Higher flower yield
  - ✓ Larger flowers

Pruning

Pruning is done to :

- ✞ Remove unproductive shoots
- ✞ Give the bush a desirable shape and size
- ✞ Open up the bush to receive more solar energy
- ✞ Rejuvenate the old plants
- ✞ Facilitate cultural operations
- ✞ Improve the quality of blooms

Time of pruning :

Exactly 45 days prior to the date of requirement of flowers. Generally done during OctoberDecember.

Method of pruning

1st Year : Cut back the shoots retaining to four developed buds to develop into lateral shoots

2nd Year : Retain all strong shoots and remove weak and diseased shoots. Cut back the strong shoots retaining 4-5 buds

3rd Year : Cut back vigorous shoots to half of the length

Rejuvenation pruning :

After 5-6 years the plants are to be rejuvenated. Cut back all the main branches at 15-20 cm from the base. Apply Bordeaux paste over cut ends to prevent diseases.

Harvesting

- Flowering starts from 1st year onwards.
- Economic yield is obtained from 2nd to 10th years.
- Flowers are harvested when the flower buds are in half open stage.
- For cut flowers, they are harvested at tight bud stage with long stalks.

Post-harvest handling

- As soon as the flowers are harvested, the stems are kept dipped in clean water with preservative.
- The flowers are then cooled down to 2-4 0 C for 5-6 hours.
- The flowers are graded according to the length of the flower stalk. It varies from 40-110cm depending on the variety.
- Packing is done with 20 stems per bunch.

Yield

Loose flowers	:	7.5 t/ha
Cut flowers	:	1st year : 100-120 flowers/m2
		2nd year: 200-240 flowers/m2
		3rd year: 300-360 flowers/m2

Lecture 5 : Production technology of gerbera and carnation under protected conditions

GERBERA

Introduction:

Gerbera (*Gerbera jamesonii* Bolus ex Hooker F.) commonly known as Transvaal Daisy, Barberton Daisy or African Daisy is an important commercial flower among the top ten cut flowers. It is grown successfully throughout the world under a wide range of climatic conditions for its very attractive flowers. The genus Gerbera was named after the German botanist/naturalist, Traugott Gerber, who travelled to Russia in 1743. Gerbera was discovered in 1884 near Barberton, South Africa, by Scotsman Robert Jameson. The first official description of the South African species, *Gerbera jamesonii* was made by J.D.Hooker in 1889, in Curts Botanical Magazine.

Importance and Uses:

- Ranks fifth in cutflower (Rose, carnation, Chrysanthemum, Tulip)
- It is ideal for beds, borders, pots ad rock gardens
- The flowers available in a wide range of colors and lend themselves beautifully to different floral arrangements.
- Used as cut flowers and the cut blooms have long vase life and suitable for floral arrangements Mostly inhabits the temperate and mountain region

Origin and Distribution:

Native – South African and Asiatic region

The market requirement for cut flowers is very specific and it can be met consistently, only when the crop is grown under protected conditions. In places where the natural weather conditions remain considerably cooler for most parts of the year as in parts of USA, UK, Australia, the crop is being grown under fully protected climate controlled greenhouses. In places, near equator, which enjoys warmer sunny climate, semi protected conditions are successfully employed to cultivate the crop.

At present in India, it is cultivated commercially in and around cities like Pune, Ooty and in the parts of Punjab, Kashmir, Sikkim and West Bengal. In Karnataka, it is grown in a few pockets around Bangalore, Dharwad and Belgaum districts

Botany:

Gerbera belongs to family Asteraceae, which consists of many other important flower crops namely, aster, chrysanthemum, dahlia, marigold etc. It consists of about forty species of semi hardy and perennial flowering plants. Out of all the recorded species, only Gerbera jamesonii is under cultivation. The plants are stem less and tender perennial herbs. Flower heads are solitary, based on flower heads they may be grouped into single, semi double and double. The genotypes are available in various unicoloured flowers as well as in bicolour types. Often the same flower can have petals of several different colours.

Floral Biology:

- The flower head is called capitulum consists of ray florets in one or two outer whorls and tubular (disc florets) in inner rows. The head contains outer ray florets which are functionally female and in these flowers, stamens are no more than staminodes made up of thin sterile filaments.
- The florets in the centre are called disc florets, which are tubular and functionally male. In between disc and ray florets hermaphrodite or bisexual flowers are present which are transflorets.
- In these ray florets, three of the five petals are joined to form a broad ligula, the remaining two form a smaller lip.
- Flower stalks are thin, long slender and leaf less. Gerbera produces attractive flowers known as‗head'or capitulum. The plant is dwarf herbaceous perennial and grows in clump with solitary flower heads on a long slender stalk, which grows well above the foliage. The leaves are petioled, entire or pinnatilobed, coarse or some times tubular and two lipped. Achenes are beaked; pappus or rough bristles in two or more rows. The daisy like flowers are available in wide range of colours including yellow, red, orange, cream, white, pink, brickred, scarlet, salmon peach, maroon and variouss other intermediate shades

Species:

The genus Gerbera consists of about 40 species of half hardy perennial flowering plants.

Gerbera asplenifolia :

- Leaves narrow,10-15cm long, leathery gloss above
- Lobes roundish, concave margins
- Revolute flower heads purple on a hairy scape

***Gerbera aurantiaca* (Hilton Daisy)**

- Leaves are lanceolate to oblong, acute 12.5-15 cm long, entire or toothed
- The flowers are not single flowers but a head made up of many tiny florets massed together.
- The 'petals' (ray florets) are usually a striking crimson, but may be orange, pink or yellow on the upper surface and are coppery below

***Gerbera jamesonii* (Barbeton Daisy):**

Single or double flowered cultivars and hybrids in attractive pastel colours

Gerbera kunzeana: a Himalayan species

Gerbera viridifolia:

- Leaves elliptical or oblong, obtuse, green on both sides and smooth or nearly so
- Flowers stalks short.
- Flower heads are dirty white and small

Gerbera hintonii: endemic to Mexico has floral characters that indicate affinities to the genus Gerbera and a new nomenclature.

Gerbera maxima: a rare plant rediscovered after a century from Pauri Garhwal

- Gerbera is a diploid (2n= 50) and basic chromosome number is n= 25. Chromosome phenotypes are influenced by changes in chromosome number.
- Based on the fertility it can be divided into three types, namely, (1) completely self sterile plants, (2) plants with distinct differences in seed set with self or cross pollination, and (3) plants in which these differences were less pronounced. Productivity and other major flower characters are determined by additive gene action. Flower colour is controlled by two pairs of genes
- Gerbera species of Indian origin are Gerbera anandria, Gerbera kunzeana, Gerbera languinosa, Gerbera macrophylla, Gerbera nivea, Gerbera ovalifolia and Gerbera piloselloides. The cultivated speices, however, is Gerbera jamesonii

Various Forms of Gerbera

Single Flowers: Single row of non-overlapping petals (ray florets) with a green center (disc florets).

Double or duplex: Double row of overlapping petals with a green, black, or dark red eye.

Crested doubles: These doubles contain two rows of overlapping petals with one or more inner rows of shorter petals with a green, black, or dark red eye.

Full crested doubles: These have solid overlapping rows of petals with an inner row diminishing in size, covering the eye entirely.

Varieties:

- Red : Ruby Red, Sangria, Dusty, Fredorella, Vesta
- Yellow : Doni,Supernova, Mammut, Talasa, Uranus
- Rose : Rosalin, Salvadore, Flemingo
- Pink : Pink Elegance, Marmara, Esmara, Terraqueen, Valentine
- Orange : Carrera, Goliath,Marasol
- Cream : Farida, Dalma, Snow Flake, Winter Queen

Thallasa, Tara, Sangria, Sunset, Ornella, Lyonella, Diablo, Whitsun, Twiggy, Nevada, Lynx, Macho, Vino, Venturi

Clonal selection:

Two varieties from TNAU released under clonal selection YCD-1

- Selection from OP seeds of germplasm maintained at HRS, YCD.
- Dwarf, herbaceous, perennial, height 39 cm
- Flowers large, double, cherry red
- Petals dense in concentric whorls
- Free from bent neck, petal wilting
- Suitable for cut flower, borders, pot cultivation YCD-2
- Selection from germplasm collection at HRS, YCD

- Blooming throughout the year, peak flowering May- June
- Flowers attractive rosy pink, on long stalk without bend
- Vase life 15 days
- Yield about 80 flowers/ clump/ years

Soil and Climate

- Well drained, rich, light, neutral or slightly alkaline soil is most suitable
- Presence of an impervious layer with in 50cm from surface in any type of soil, affects growth of the crop. The soil pH – 5.5 -6.5
- Day temperature 22-250C and night temperature 12 to 160C is ideal for growth and flower production, flower initiation 23^0C
- The flowering of Gerbera is harmed below 12^0C and above 35^0C
- Humidity – 75- 80%
- Light - 450 - 600 foot candles
- CO2 - 700 ppm

Bed preparation:

- Land ploughed deep 2 to 3 times and brought to a fine tilth.
- Raised beds of 30cm height, 1 m width 30cm passage between beds.
- Media mixture FYM : Sand : Cocopeat / Paddy husk (2:1:1).
- Sterilize the bed with Formaldehyde (100ml in 5L/m2) or Methyl bromide (30g/m2) covered with plastic sheet for 7 -10 days.
- To control soil borne phytophthora, fusarium and pythium

Spacing : 30 to 40cm between rows & 25 to 30 cm between plants

Accommodates : 6-7 plants per m2

Planting Season:

(a) **Open field cultivation**

1. Spring (January-February and March)
2. Summer (June, July and August)

(b) **Protected cultivation** Throughout year

- Planting in raised beds improve drainage and aeration
- Plants are to be planted at shallow depth - crown of plant at the level with soil or just above
- Plant density : 6-7 plants/m2
- Spacing :40X30 cm, 30X30 cm
- Maintain RH 80-90 % to avoid desiccation
- First 3 weeks – overhead irrigation

- Drip Irrigation – 1 drip / plant
- Water requirement – 300 -700 ml/ plant/day
- Never use Excess water . Moderate moisture is enough

Bench System

- A pot size of 3.5 / 4.5 litres and 18-20 cm deep is recommended.
- Between walking path : 75-80 cm.
- Between rows : 75-80 cm.
- Between the plants : 20 cm.
- Distance between the plants is measured from heart to heart of the pot centre

Advantages of Bench system

- A gutter has to be installed under the pots
- Ground under the system stays dry and the chance on Botrytis is therefore reduced
- The leaves can be bent, thus allowing the crop to become more open.
- Improve ventilation between the plants.
- Easy picking of flowers and crop maintenance.
- Efficient crop protection

Propagation:

Commercially propagated through division, suckers or tissue culture plants

- Vegetative – clumps / suckers
- Micro propagation (shoot tips, inflorescence buds, flower heads) popular for rapid, large scale and uniform.
- Division
- Tuber division by separating tuber each with a piece of stem
- Need tuber division
- By placing the tuberous root in a warm moist place for a short time before dividing the tuberous root

Manures and fertilizers:

- Requires plenty of organic matter, macro and micro nutrients
- Organic manure @ 7.5kg/m2
- Ammonium nitrate + Superphosphate + Potassium sulphate @ 4g/lit for better flower yield.
- Above nutrients @ 2g/lit for vegetable growth.
- NPK @ 10:15:20g/m2/month for first three months and 15:10:30g NPK/m2/month after three months resulted in good production of flowers.
- Application of Boran, Calcium Megnesium and copper @ 0.15% (1.5 ml/lit) **Growth Regulators:**
- Nitrogen ,GA3 – Different concentrations

- 30 g N/ sq.m / month + spraying GA3 150 ppm at monthly interval – maximum vegetative growth.

Effect on flowering:

- 6-15 days delay flowering
- SADH 1000-5000 ppm, TIBA 500-2000 ppm and etheral 2000 ppm

Increased flower production

Ethrel 50-100 ppm, CCC, MH, SADH (large flowers)

Special practices Leaf pruning:

- The old leaves from a gerbera plant should be removed well in time.
- This practice allows the plant to produce new leaves.
- It also helps in keeping good sanitation in the green house

Harvesting:

- Flowering Starts 3 months after planting.
- Harvesting is done when Outer 2-3 rows of disc florets are perpendicular to the stalk
- Plants with 14-16 leaves
- Harvest 2-3 times / week
- The heel of the stalk is cut about 2-3cm above the base and kept in fresh chlorinated water
- Average yield in polyhouse around 200 flowers/m2/year and 40 flowers/plant/year

Economic life : 2 years

Harvest Index :

- 2- 3 whorls of stamens are visible
- 2 rows of ray florets perpendicular to stalk
- Pick flower instead of cutting it off

Grading:

Based on stem length and diameter - A, B, C and D grades A good flower is:

Stalk length: 45 – 55 cm. **Diameter of flower:** 10 – 12 cm. **Minimum vase life** of 8-10 days.

Post harvest handling

Packaging

Cover with polythene sleeves 10 flowers/bunch

CFB box (98 x 30 x 12 cm of LWH) Accomodates – 500 flowers/box

Advantage of gerbera cups

- No more damaged gerberas
- Ideal packaging for online sales.
- Reducing transport loss by up to 50%.
- Easy to transport in water.

- The cost of the sleeves are low.
- Easy to remove from the gerbera flower.
- Reduce botrytis or mould in the transport period because the flower stays open
- Gerbera cup-machine to put the cups on, which saves labour.
- Visually more attractive
- Gerberas are phototropic in nature

A tendency to turn to the light To keep the stems straight

- Suspend their heads in a grid wire mesh
- Wrap the stems in damp newspaper
- Stand them upright in a vase of water.

Physiological disorders Preharvest stem break

- Bright sunny weather
- High temperature
- During rehydration – stem elongation due to high water accumulation & breaks
- High root pressure and high humidity in the air. Premature flower wilt
- Cloudy days with low light intensities followed by a clear sunny day
- Lack of stored carbohydrates

Flower bent

- Due to loss of cell turgidity & under nutrition (lack of Calcium)
- Double-faced Gerbera flower
- Due to imbalance of nutrients. Too much growth, too little flower buds.
- Non-uniform flower blooming
- Physical injury to flower stem/pest damage/phytotoxicity
- Short stem length
- High salinity level, moisture stress, low soil temp

Scape bending

- Bending of flower stalk
- premature senescence
- Indication of loss of vase life
- Due to low water potential
- Changes in physiological and biochemical components of the flower

Micronutrient deficiency:

Fe: young leaves – interveinal chlorosis, Maintain pH 5.5 – 6, Foliar spray of 0.5% $FeSO_4$ with 0.5% urea

Manganese : Leaves – yellowish, veins – green, Apply manganese chelates

Pest and Diseases

Whitefly, Leaf minor, Thrips, Aphid, Red spider mite, Bud caterpillar

Diseases

Foot and root rot, Bud rot, Powdery mildew, Leaf spot, Anthracnose

Control measures

Aphids: Apply Imidacloprid 200SL @ 25 g ai/ha or dimethoate 30 EC @ 2 ml/l of water before the opening of flower

Whitefly: Apply Imidacloprid 200SL @ 25 g ai/ha or dimethoate 30 EC @ 2 ml/l of water before the opening of flower

Thrips: Spraying Methyl Demeton 25EC or fenitrothion 50 EC @ 3.5 ml/l Dimethoate 30EC @ 250ml/ha at 10 days interval

Red spider mite: Dicofol@1.5ml/lt or Abamectin @ 0.4 ml or Propargite @ 1 ml/lt.

Flower bud rot: Apply Actimycin 200 ppm / ha

Root and foot rot (Phytophthora):

Soil drenching with copper oxy chloride; Soil application of Thiophanate at 250g/ha

Powdery mildew: Sulphur or Karathane 500g/ha

Carnation - *Dianthus caryophyllus* L.

Importance and uses-origin and distribution-area and production- botany, species and varieties – propagation-media and planting-environmental factors- netting – inter culture - pinching-production constraints-plant protection-harvesting and yield.

Introduction:

Carnation (*Dianthus caryophyllus* L.) is one among the most popular commercial cut flowers of the world, ranking second in commercial importance next only to rose an account of its excellent keeping quality, wide range of forms and colours and ability to withstand long distance transportation. Cut carnations, roses and chrysanthemums contribute close to 50% of the world cut flower trade. As well as remarkable ability to rehydrate after continuous shipping. It is commonly called as Carnation, Divine flower, Clove pink, Gilly Flower.

Importance and Uses

Carnations are excellent for cut flowers, bedding, pots, borders, edging, indoors and rock gardens. They give a unique softness to the rock gardens. Though cut carnations are traded in the world market year round, they are in particular demand for the Valentine‘s Day, Easter, Mother‘s Day and Christmas. Miniature carnations are now gaining popularity for their potential use in floral arrangement.

Carnations are associated with some sentiments and symbolisms. In Korea, red and pink carnations are used in expressing love and gratitude towards parents on Parents‘Day. Pink carnations are symbol of mother‘s undying love. Red carnations are worn on Mother‘s Day if one‘s mother is alive and a white one if she is not. Carnations are also used on Teachers‘ Day to express admiration and gratitude to teachers. Light red carnations represent

admiration, while dark red ones denote deep love and affection. White carnations represent pure love and good luck; striped carnations symbolize regret that a love cannot be shared. Green carnations are used as a secret gay code, while purple carnations indicate capriciousness.

Origin and Distribution

It is native to the Mediterranean region but its exact range is unknown due to extensive cultivation for the last 2000 years. Carnation belongs to the family Caryophyllaceae. The genus name Dianthus‘ is derived from the Greek words dios‘ meaning God‘ or divine‘ and anthos‘ meaning flower‘ and hence known as 'Flower of Zeus' or Divine Flower‘. The species name caryophyllus‘ is derived from the Greek word caryan ‘meaning nut‘ and phylon ‘meaning leaf‘. The name caryophyllus has been chosen by Linnaeus after the genus name of clove, due to the clove-like fragrance of carnation. The common name carnation‘ probably must have come from the Greek word coronation‘ because these flowers were used in decorating the crown of Greek athletes. **Carnation is the national flower of Spain.**

Carnation growing countries are Spain, Kenya, Columbia, Israel, Ceylon, Poland, the Netherlands, France, Germany, Italy, Canary Islands, Australia, Valparaiso, Chile, USA and South Africa. An altitude of 2000-2500m is ideal for carnation cultivation. In India, carnation is grown in Nasik, Pune, Kodaikanal, Nilgiris, Kalimpong, Darjeeling, Bangalore, Solan, Palampur, Shimla, Srinagar, Nainital and Chaubattia. The most suitable climate for commercial carnation flower production in India prevails in the Nilgiris and Kodaikanal of Tamil Nadu and parts of Himachal Pradesh.

Botany:

Carnation is a semi hardy herbaceous perennial with thick, narrow, linear and succulent leaves. Leaf blades are simple, entire, linear, glaucous, arranged in pairs, keeled and five nerved and their colour varies from green to grey blue or purple. The stems are hardy, shiny and have one to three angles with tumid joints. Flowers are bisexual and occasionally unisexual. The flower colour varies from white to pink or purple in colour.

Species:

The basic chromosome number in Dianthus is 15. Carnations are generally diploids (2n=30), though tetraploid forms (4n= 60) have also been identified. Triploid carnations were produced for commercial purpose, but the resulting plants were mostly aneuploid. The majority of cultivable carnations are diploid.

The family Caryophyllaceae consists of 80 genera and 2000 species which are either annual or perennial and most of them occur in the northern hemisphere. The genus *Dianthus* has about 300 species of which only a few are cultivated viz., D. *caryophyllus*, D. *barbatus* and D. *chinensis*.

Modern day perpetual flowering carnation is a cross between *D. caryophyllus* and *D. chinensis*. The species barbatus is commonly known as Sweet Williams‘, which grows readily from seeds. The stem in this species is glabrous, four angled and branched at the top. The leaves are opposite, broad and flat. The flowers are solitary, the petals are broad with frilled margins and the calyx is cylindrical with bracts at the base. The species chinensis is commonly known as Indian Pink‘ or Japanese Pink‘. The plants are glabrous more or less

creeping at the base. The stems are pubescent and grooved. The leaves are flat and broad. The individual petals are hairy towards base. This species is excellent for beds, borders, edging, rock gardens, pots and cut flowers. The two most commonly grown varieties of this species are the Japanese Pink (*D. chinensis* var. *heddewigii*) and the Fringed Pink (*D. chinensis* var. *lacinatus*).

Several other species including *D. arenarius, D. plumarius, D. gratianopolitanus, D. winteri, D. heddewigii, D. laciniatus, D. nobilis, D. superbus,* etc. were utilized for the development of modern carnation cultivars. The other Dianthus species are *D. attenuatus, D. caesius, D. callizonus, D. capitatus, D. carthusianorum, D. cinnabarinus, D. cruentus, D. deltoids, D. diadematus, D. frimbriatus, D. giganteus, D. glacialis, D. grandiflorus, D. hybridus, D. latifolius, D. monspessulanus, D. pancicii, D. petraeus, D. squarrosus, D. sylvestris, D. versicolor* and *D. viscidus*

Types of Carnation

Based on the availability of large number of varieties and diversified cultural requirements, carnations are classified as Chabaud or Marguerite, Border and Picotee, Malmaison and Perpetuals.

1. Chabaud or Marguerite

These are annual carnations developed by crossing of D. chinensis with D. caryophyllus. Flowers are single or double, propagated by seeds. Flowers are large with fringed petals and have shorter post harvest life. The various kinds of Chabaud are Giant Chabaud, Compact Dwarf Chabaud, Entant de Nice, Fleur de Camelia and Margarita.

2. Border and Picotee

The flowers of border type carnations are symmetrical and are the easiest to grow. The flower colour varies from single to blended colour with irregular markings. The petals are broad and smooth edged. The flowers are generally frilled with open centers. In Picotee type ground colour is without spot or bars. The edges are regular and of bright colour. Border carnations are further subdivided according to colour of flowers as Selfs, Flakes, Bizarres and Fancies as indicated below.

a) **Selfs :** The flowers are of a single colour

b) **Flakes :** The flowers have a ground colour striped with another shade

c) **Bizarres :** The flowers have a ground colour marked and flaked with two or three other tints

d) **Fancies :** The flowers which do not come into the above subdivisions

3. Malmaison

These are strong, sturdy and stiff plants with broad leaves. Flowers are large, double with well filled centres and are mainly pink coloured with good fragrance

4. Perpetuals

- They are hybrids involving many Dianthus species.
- Plants are not hardy and flower all round the year.

- ✞ Flower stalks are long and hence suitable for cut flowers.
- ✞ They produce better quality flowers and withstand long transportation.

They are grouped into standards or Sim and sprays.

a) **Standard carnations**

Standard carnations produce larger blooms with longer stems, usually a single large flower on an individual stem

b) **Spray carnations**

Spray or miniature carnations produce smaller sized blooms with shorter stems in bunches. The flowers are borne on short branches of a single stalk. Better adapted to warm climate than standard types.

Varieties:

ii. Spray varieties

Flower colour	Varieties
Red	Red Eye, Red Fuego, Red Vital, Aveiro
White	White Prestige, Milky Way, Elvis, T-587
Pink	Rosa Bebe, Spur, Suprema, D- 925, Celebration, Osiris
Yellow	Stella, Prestige, Mila, Sonia, Abril
Orange	Sunshine, Autumn, Fancy Fuego, Disney, Eilat
Bicolour	Berry, Orbit Plus, Nadeja, Picaro

iii. Cultivars suitable for pot culture

Colour	Variety
Red	Charmptop
White	White Sunny
Pink	Davinci, Maldeves
Fancy	Cerratop

Soil/Growing Media and Preparation of Beds:

Sandy loam soils rich in organic matter content with pH of 5.5-6.5 are most ideal for carnation cultivation. Clay and silt soil can be improved by incorporating organic matter or compost. A soil EC of 0.8 - 1.2 dSm-1 during the vegetative stage and 1.2 - 1.5 dSm-1 during the generative stage is most ideal for carnation cultivation. The soil must be well drained because the crop is highly susceptible to fusarium wilt. Soil should be ploughed upto 80-100 cm deep. Addition of calcium carbonate or dolomite limestone to corrects severe acid condition and also supplies calcium and magnesium for plant nutrition. Addition of sulphur or use of acid forming fertilizers will inturn reduces the soil pH if it is on the higher side. A rich sandy loam or loamy soil is considered to be the most ideal for successful production of carnation. Media have to be sterilized with methyl bromide@ 25-30g / formaldehyde @ 3-7% (7.5 to 10.0 l/100/sq.mt or Basamid (Dazomet) @30-40g/m2.

Generally, the basal fertilizer dose of single super phosphate @ 200 g/m2, potassium sulphate @ 150 g/m2, magnesium sulphate @ 50 g/m2 and borax @ 2 g/m2 should be evenly spread and thoroughly mixed with the media before bed preparation. Apart from the above fertilizers, bio-fertilizers and bio-control agents for the control of pest and diseases can be incorporated to soil at the time of bed preparation. Azospirillum, Phosphobcteria, Trichoderma viridi, Pseudomonas fluorescens, VAM each 1 kg can be added for 500m2 area for enriching the soil. The ideal bed width and height are 75 -100 cm and 30 - 45 cm respectively. The bed length should not exceed 25 m. A path width of 45 - 50 cm is ideal.

Climate:

- Light is the most important factor, which influences growth of the plant. About 21.51 lux is considered to be the minimum natural light intensity required for adequate photosynthesis of carnations.
- Mild climate with a temperature ranging from 5-180C is considered to be the ideal for the crop.
- Day temperature : 28^{o}C (20 -25 ^{0}C)
- Night temperature : 16-18^{o}C (10 -15 ^{0}C)
- Quantitative Long Day plant (long days promote flowering)

Critical photoperiod : 13 hours and light intensity is10 – 15 foot candle.

- Co2 enrichment in greenhouse: upto 500-1000 ppm improves the flower quality.
- RH : 50 -60 %; (Beginning: 80-85%; at full growth: 60-65 %)
- High day & night temperature during flowering leads to abnormal flower opening and calyx splitting
- Growth behaviour of carnation plants is influenced by duration and intensity of light.

Genetically carnation is a quantitative long day plant. Long photoperiod usually promotes flowering while short days tend to delay it. Flower quality can be improved by providing long days only for a short period (4-6 weeks) when the shoots have 4-7 pairs of leaves. Many of the carnation cultivars respond to 15-21 days of lighting. Depending on the cultivars there are differences in requirement of photoperiod. The critical photoperiod for most standard and spray carnations is about 13 hours.

Humidity

The plants must be protected from rain and dew during flowering. Wet buds and flowers are susceptible to fungal diseases. For commercial cultivation, the humidity of greenhouse should be maintained at 80-85% during beginning of vegetative growth and 60-65% during full growth stage.

Ventilation

Free circulation of air inside the greenhouse is essential. In uncooled greenhouses, vents have to be provided on the sides or roofs, whereas in cooled greenhouses, a fan-pad cooling system will cater to the needs of air circulation. A ventilation of 25-30% of the polyhouse ground area is ideal

Carbon dioxide

Carbon dioxide level affects both plant growth and flower quality in greenhouse carnation. The effectiveness of the carbon dioxide treatment greatly depends on the temperature and light conditions. CO2 feeding

encourages more uniform production of flowers coupled with increased yield and reduced time between harvests. The best quality flowers can be produced when CO2 concentration in the greenhouse is maintained at 500 - 750 ppm during day time under high light intensity and in a temperature range of 14-15°C. Under favourable conditions, additional carbon dioxide increases the flower production by 10-30%

Propagation:

Carnation may be propagated by both sexual and asexual methods.

Vegetative Propagation

Using soft terminal cuttings is the common method of multiplication used by commercial growers throughout the world.

- ✞ Cuttings of 10-15 cm with 3-4 nodes weighing around 10g are ideal for multiplication.
- ✞ Rooting hormone such as IBA at 500ppm is used prior to planting of cuttings for rooting.
- ✞ Terminal cuttings give rise to good plants. Cuttings can be stored at 0°C before planting for several weeks.
- ✞ Cuttings are spaced at 5 cm apart and intermittent misting should be used for good rooting.
- ✞ Cuttings normally develop good root system within 21 days.

Planting and Aftercare:

- ✞ Carnation plants are planted in different spacing normally, 30-45 plants per sqm is considered to be ideal.
- ✞ Different spacings 15x8cm, 15x15cm, 15x20cm and 15x10cm, are followed. Alternate ✞ normal method of transplanting wherein the plants are planted firmly to soil, carnation, ✞ Care should be taken to maintain the humidity to prevent plants from drying.
- ✞ Planting should be done preferably in the evening. A spacing of 15 x 15cm is followed. This will accommodate 30 - 33 plants/m2 considering 75% as the net cropping area. In general four row or six row system of planting is adopted. The plants should be removed from the poly bags or rooting trays carefully without damaging the roots.

Special Cultural Practices: a)

Training

Training is a very important and continuous operation in carnation cultivation. This operation helps in keeping the plants within the specified area in the net to grow straight without bending at the bottom. **b) Pinching**

Pinching is an important operation which helps to ensure maximum number as well as quality of flowers. It refers to breaking out tip of budding and encouraging growth of side shoots. Some cultivars do not require pinching but sim cultivars require this operation to encourage branching. 4- 6 well grown laterals are allowed. At six pairs of leaf first pinching has to be done. First pinching done 3 - 4 weeks after planting. Three types of pinching are being adopted in carnation are Single, One and half and Double pinches

Single pinch

In this method, the top of the main or leader shoot is removed leaving 5 pairs of leaves from which 4-5 lateral shoots develop and when the plant attains 6 nodes, the first pinch is given 5 -7 cm of apical portion has to be pinched off. These lateral shoots will produce flowers at the same time. This method is particularly applicable to cultivars which produce higher proportion of quality blooms like the hybrid standard carnations.

Pinch and-a-half

This method is followed to regulate the supply of flowers throughout the year. It involves the removal of main stem tip to induce 4-5 lateral shoots. When these lateral shoots develop 56 pairs of leaves, only half the number of the lateral shoots are pinched. This method provides steady supply of flowers but reduces the quantity of the first crop.

Double pinch

In this method the main shoot is pinched once followed by pinching of all the lateral shoots arising from the first pinch when they are about 6-8 cm long or develop 5-6 pairs of leaves or 3 - 4 weeks after first pinch. This method produces larger number of flower bearing shoots but produce weak shoots and poor quality flowers. So this method is not commonly followed.

Deshooting

Unwanted secondary shoots on the flowering stems are removed when they are about 2-3 cm long.

Disbudding

Disbudding is practiced in standard and spray or miniature carnations. In standard carnations, disbudding is practiced for getting good quality flowers. The axillary/lateral buds are removed just after appearance, without damaging the leaves and stems. Usually those axillary buds about six nodes below the terminal flower buds are removed to encourage the development of the main flower bud. In spray or miniature carnations, the main flower bud (terminal bud) is removed to encourage the lateral flower buds to develop.

Calyx banding

Calyx splitting is a physiological disorder in carnation affecting the flower quality. This disorder can be minimized by calyx banding. Calyx banding is the practice of placing a rubber band or plastic tape around the calyx of the flower bud when it just begins to open.

Application of growth regulators

Growth regulators have been reported to significantly influence flower production and regulation in carnation. Two sprays of GA3 @ 100 ppm each at first pinch and when axillary shoots are 8-10 cm long will produce early flowering and long stems. Growth retardants like chlormequat (CCC @ 0.25%) and diaminozide (SADH @ 0.4%) have been reported to promote flower initiation and increase flower yield. They also cause earlier flowering and improve flower quality by reducing calyx splitting. Application of Malic Hydrazide @500-1000 ppm also increases the number of flowers but delays flowering.

Support Material:

Carnation crop has the tendency to bend unless supported properly. Hence the crop needs support while growing. Good support material is metallic wire woven with nylon mesh. At every two meters the wire should be supported with poles. The poles at both the ends of bed should be strong. Metallic wire is tied around the bed along the length with the support from supporting poles. Across the bed, nylon wires are woven like net. For an optimum support, an increasing width of the meshes can be used bottom net can be of 7.5x7.5cm /10x10cm, then two nets of 12.5x12.5cm and the upper most can be 15x15cm. 4 – 5 layers of nets are to be laid before planting. For every 2.5 to 3.0 m wires to be supported with poles. First net should be fixed at 12 cm above soil. Place remaining nets over first net 15 cm apart.

Manuring:

No inorganic fertilizers in first 3 weeks after planting. Fertilizer application of 40g N, 20g P and 10g K, in addition to 5kg of well decomposed FYM /m2 will increase the yield of flowers. or 250:

80:200:125: 400 g/m^2/ yr N, P2O5, K2O, Ca, Mg application in 24 splits once in 15 days.

Irrigation:

Over watering and poor drainage causes root death and stunted growth. The growing medium should be evenly moist. Drip irrigation can be followed after 3-4 weeks of planting.

Physiological Disorders

a) Calyx splitting

Calyx splitting is an important disorder in carnation, which has been associated with many factors like genetic environmental, nutritional and other cultural practices. The cultivars with short and broad calyx are more susceptible than the ones with long and narrow calyx. Irregular or fluctuating temperature during flowering also induces calyx splitting. Low temperature below 10°C leads to the development of an extra whorl of petals inside the calyx. The calyx unable to hold these extra growing petals splits up.

Nutritional make up of plants also influence calyx splitting. Low nitrogen, high ammonical nitrogen or low boron levels enhance calyx splitting. Closer spacing has also been reported to encourage calyx splitting.

Selection of cultivars that are less prone to calyx splitting, regulation of day (20-25°C) and night (12.5-15.5°C) temperatures and maintenance of optimal levels of nitrogen (25-40 ppm) and boron (20-25 ppm) in the growing medium can minimize this disorder. Spraying of borax @ 0.1% at fortnightly intervals will reduce the disorder. Calyx splitting can be reduced by placing a rubber band around the calyx of the flower which has started opening. This operation is referred as Calyx banding.

b) Sleepiness

Sleepiness causes huge post harvest losses in cut carnation. It occurs due to exposure of flowers to ethylene or water stress. Also, the incidence of sleepiness has been found to be higher when the flowers are stored for a longer period or when they are exposed to high temperature. Spraying of STS

0.4 mM before harvesting the flowers will correct this disorder.

c) Grassiness

Grassiness refers to failure of plants to produce flowers. This is a genetic disorder which varies from variety to variety. Removal and destruction of affected plants is the only way of correcting this disorder.

d) Slabside

This disorder refers to uneven opening of flower buds resulting in the petals protruding on one side only, giving an asymmetrical and lopsided shape to the flower. It is common during cooler periods.

This can be overcome by gradually increasing the temperature to optimum level.

e) Calyx tip die back

Potassium deficiency and water stress cause tip die back. The disorder commences with browning of the calyx tip and it progresses downwards damaging a major part of the calyx. This disorder is often followed by occurrence of secondary fungal infection which makes the flower unmarketable.

Spraying of potassium chloride @ 5g/l two times at 10 days intervals and providing adequate water @ 4.5 l/m2 can minimize this malady.

f) Internode splitting

- Splitting of internodes affects the quality of cut flowers. Splitting is due to boron deficiency.
- Application of borax @ 2g/m2 will correct internode splitting.

Harvesting

Most of the carnation varieties will be ready for harvesting in about 105 to 120 days after planting. There are different stages of harvesting according the market demand. The harvesting stage is fixed depending on the type of carnation and market demand. Bud size and petal growth are used to judge the stage of harvesting.

Harvesting stages based on market demand

S.No	Harvest stage	Target market
1	Tight bud stage	This is for long distance markets. However, it is not practiced in commercial cultivation, since some of the flowers may not open at all after harvest.
2	Paint brush stage	This stage is ideal for long distance markets or for use after a couple of days.
3	Semi-open stage	This is ideal for short distance market. The flowers can be used in a day or two days after harvest.
4	Open stage	This is ready-to-use harvest stage and not suitable for travel

Harvesting stages based on type of carnation

Type	Harvesting stage
Standard carnations	Carnation flowers mature in 4-5 months period. Paint brush stage, when petals have started to elongate outside the calyx
Spray carnations	With two flowers open and rest of them showing colour

Yield:

- On an average 10-20 flowers / plant/year
- Yearly production of 300-400 flower/m2 is ideal and economical.
- After planting normally it takes 110-120 days to come to peak flowering.
- In general 200-350 flowers/m2 can be obtained from standard carnation, while 250 flowers/ m2 can be obtain from spray carnation.

Plant protection

Maintenance of adequate aeration inside the polyhouse and proper hygiene of the beds, implements and workers would help in preventing most of the pest and diseases.

a) Pest management Red spider mite

The red spider mite (*Tetranychus urticae*) is the most serious pest in carnation. The affected leaves turns pale and withered and shows severe webbing. The affected plant becomes stunted and distorted. Mites usually cause severe damage in hot dry conditions. Spraying Dicofol @ 2 ml/l or Wettable sulphur @ 5g/l or Propargite @ 2 ml/l during initial stages and Abamectin 1.9 EC @ 0.5ml/l of water with sufficient amount of surfactants during severe infestation stages will bring desired results. Biological control by releasing the predatory mite *Phytoseiulus persimilis* has also been reported to be effective against mites.

Thrips

Thrips (*Thrips tabaci*) suck the sap from the leaves, causing them to turn yellow and then patchy white, often with black specks and slight wrinkling. They also cause streaks on the flowers making them unmarketable. Spraying Dimethoate 30 EC @ 1 ml/l or Fenitrothion 50 EC @ 3.5 ml/l or Malathion 50 EC @ 2 ml/l of water or application of Aldicarb 10G @ 5 g/m2 will control thrips.

Disease management

Carnations are attacked by a number of diseases which are caused by fungi, bacteria and viruses.

Fusarium wilt

Fusarium wilt (caused by *Fusarium oxysporum* f.sp. *dianthi*) is one of the most serious diseases in carnation. Poorly drained soil and abnormally high temperature are conducive for the development of this disease. The affected plants show foliage wilting, often only on a few branches, followed by death. Rotting of the stem below ground level with internal brown streaking occurs. If the plants are pulled, they break off easily while the firm roots remain in the soil. The best control measures are soil sterilization or chemical fumigation of the soil, soil solarization using clear transparent polyethylene film (0.1 mm thick) for 30 days , use of pathogen free planting materials and general greenhouse sanitation. Drenching the soil with Benomyl (0.1%) or Ridomil (0.2%) at three month intervals starting from two weeks after planting and spraying with Bavistin @ 0.1% will reduce the malady. Biological control with *Bacillus subtilis*, *Streptomyces sp*, *Trichoderma viride* and *Pseudomonas fluorescens* has also been reported to be effective.

Alternaria leaf spot

Alternaria leaf spot (*Alternaria dianthi*) is a very common foliage disease in carnation. The pathogen causes spots on the leaves and stems and the affected leaves wither and die prematurely. The pathogen is present in the dead plant material and spreads by splashing water. Temperature above 23.8°C promotes growth of the pathogen. Foliar application of Dithane M-45 @ 0.2% or Carbendazim @ 0.1% controls the disease.

Bacterial wilt

Bacterial wilt (*Pseudomonas caryophylli*) occurs in places where the night temperature is below 23.8°C. It is more common in older plants. The prominent symptom is wilting of one or more branches or the entire plant. Leaves of the affected plants look dull and greyish green and then turn yellow and finally die.

Viral diseases

The most common ones are streak, mosaic, mottle, ring spot, etched ring and vein mottle. Use of virus free planting material raised through shoot tip culture can eliminate viruses. Vectors can be controlled by spraying Thiomethoxan @ 0.1%.

Post Harvest Operations:

- For a good post harvest life, flower stems have to be trimmed at the base and should be immediately placed in a bucket of preservative solution (Acidic pH 4.5) with 2-5 % sucrose and biocides for 2 to 4 hours.
- Carnation flowers can be stored for 2-4 weeks before marketing.
- Flowers have to be packed in cartons lined with polyethylene be pre-cooled without lid.
- The plastic is then loosely folded on top of the stems and the lid is closed.
- These cartons are stored in cool chambers designed to maintain 0ºC with good air circulation and a constant RH of 90-95 %.
- Floral preservatives like, 8-HQS or 8-HQC @ 200-600 ppm; STS (Silver Thio-sulphate) @ 0.2- 4mM; Cytokinin @ 10-100 ppm; Sugar @ 0.5-2% and Citric acid @50-100 ppm.

Lecture 6 : Production technology of lilium and orchids under protected conditions

LILLIUM - *Lilium spp*

Liliaceae

Introduction

- The five main groups of lilies are Asiatic, Oriental, OT, LO and LA hybrid
- Tamil Nadu ranks first among the flower producing states of India, contributing 25% of the country's flower production with an area of 31, 970 ha under flowers.
- Of this area, around 700 ha are under protected cut flower cultivation.
- In Nilgiri district alone, it has an area of around 70 ha under protected cut flower production which is inclusive of around 11.2 ha of lilium

Order : Liliales

Genus : Lilium (7 subgenera) Family : Liliaceae

Native : Northern Hemisphere Chromosome Number : 2n = 24

Diploids are cross fertile , heterozygosity nature

L. lancifolium – Triploid 2n=36 Native sps – not cultivated

Importance

- Lily (*Lilium spp.*) is the most traditional and beloved ornamental flowers worldwide.
- One among the top five cut flowers & important bulbous crop of the world ○ Lilies symbolise purity and innocence & complete life.
- Used as cut flowers, potted plants and in beds or borders.
- Lilies are dominated in markets of Netherlands.
- Asiatic and Oriental lilies are leading cut flower group in the international market.
- Popularity of Oriental lily is increasing over Asiatic lily

Origin

- Assyrian mountain – 1000 BC – 1st authentic record.
- West Coast of North America and Mediterranean region.
- The Far East is the home of lilies.
- Northern Hemisphere up to South Canada
- Siberia and their southern limit of Florida
- The Nilgiri mountains & North East India. Distribution
- The Northern Hemisphere
- 70 species in Middle and East Asia,
- 10 species in Europe, and
- 30 species in Northern America and Canada.

The only exception L. zairii which has been discovered in Central Africa.

- Grown in hilly regions of Himachal Pradesh (Kulu/ Dehradun), North Eastern Himalayan region and mid - hill/hilly regions of Tamil Nadu (Kothagiri / Ooty / Coonoor in Nilgiris)

Floral Biology

- Terminal, solitary and recemose.
- The large flowers have perfect & 6 tepals.
- 6 Stamens,
- Ovary bears a style with 3 lobed stigma.
- Honey Bearing gland at the base.
- Often fragrant.
- White, Yellow, Orange, Pink, Red & Purple.
- Markings include spots and brush strokes.

Species of the Lilium

Family : Liliaceae Genus : Lilium

About 300 – 400 species have been described. Only less than 100 species are entitled to rank.

L. aurantum

- Bulb spherical or nearly globular, 8 – 12 cm diameter.
- 90 – 180 cm height.
- Flower dia 15 – 25 cm.
- White spotted crimson with yellow band.
- Late flowering (July - August)

L.martagon

- Bulb oval, 8cm l and 5cm w, bright yellow.
- Stem 180 cm height.
- Flowers dull claret purple, spotted purplish black, 8 cm dia.
- Flowering June – July

L.candidum

- Bulb globular, 10 cm dia,
- 60 – 120 cm Stem hight,
- Flowers 10 cm dia, Fragrant,

Pure waxy white

Flowering June - July

L.nepalense

- Bulb globular, 8 – 10 cm dia
- 60 – 80 cm Stem,

- Greenish dark yellow flowers, red inside.
- Fragrant, pendulous, 4-5/plant, 10 – 12 cm long.
- Flowering June – July Profuse fruiting.
- L.elegans L.polyphyllum
- Bulb oblong, 6 – 8 cm long.
- Stem 60 – 100 cm high.
- Flowers pale creamy yellow, tinged and dotted purple, Fragrant, 4 – 5 flowers/plant.
- Flowering June - July

L.formosum

- Bulb spherical with red tinge and 3-5 cm dia.
- 30 – 45 cm Stem height,
- 2 – 4 flowers/Plant,
- 10 – 15 cm dia,
- Orange red, slightly black,
- Flowering June – July

L.henryi

- Bulb globular, large, deep reddish purple, 8 – 10 cm dia.
- 80 – 150 cm Stem length,
- Bright orange yellow flowers, 8 – 10 flowers/raceme.
- Flowering July – August.
- Profuse fruiting

Lilium pardalinum

- Bulb scaly rhizome.
- Stem 90 – 180 cm high.
- Bright yellow flowers with spotted brownish purple, 10 cm dia.
- Flowering late June – early august.

Lilium philippinense

Bulb globular, 4 – 5 cm dia.

Flowers solitary, pure waxy white,

Fragrant, 4 – 5 flowers/plant, 15 – 20 cm long.

- Flowering late June to July.
- Profuse fruiting.

In commercial cut flower growing there are three main types of lilies, with following characterization

Asiatic	**Oriental**	**Longiflorum**

Smaller plants with small saucer-shaped flowers and short narrow leaves	Larger plants with large saucer- shaped flowers and large leaves	Large plants with trumpet shaped flowers
Flowers in 10 – 13 weeks	Flowers in 14 – 19 weeks	Flowers in 14-17 weeks
Generally fetch lower prices	Generally fetch good prices	Generally fetch higher prices
Easy to grow	More difficult and expensive to grow	Easy to grow but more difficult and expensive to handle
Popular varieties	Popular varieties	Popular varieties
Dream land (white)	Stargazer (Pink)	White Europe
Navona (white)	Mero star	Snow Queen
Brunello (Orange)	Siberia	
Connecticut King	Casablanca (White)	

Cultivars

- Asiatic lilies : Early flowering, 12 fragrant flowers/stem
- Oriental lilies : Flower july – september, spotted or striped , strong frangrance
- Tiger lilies : 1.4 m height
- Trumpet lilies : Aurelian lilies,large trumpet shaped blooms, 1.6 m height
- Turk cap lilies : Turban shaped,short stature,only 30 inches

Types & Varieties:

1. Asiatic (Bulb size 10-16 cm) : Dream land (Yellow), Brunello(Orange), Novona (White)

   Pollyanna (Yellow)
2. Oriental (Bulb size 16-22 cm) : Stargazer, Acapulco, Siberia
3. Longiflorum (Bulb size 16-22 cm) : White Heaven, Snow queen
4. LA Hybrids (Bulb size 12-20 cm) : Royal Trinity, Red planet, Best sellar, Indian Diamond

Asiatic hybrids

Derived from species originated in Asia

Bloom early summer

Flowering for over a month

10-15cm blooms face up, out or down

Comes in shades of red, orange, yellow, pink, lavender and white

Plants grows to height from 30-150cm

Suitable for growing in containers & for cuttings

Quite disease resistant

Oriental hybrids

- Derived from L.auratum & L.speciosum
- Plant height from 60-240cm
- Produce huge flowers up to 30cm across
- Flowers in late summer
- Flowers are pleasantly scented
- Flowers are bowl shaped with recurving petals
- Come in white, pink, deep red and bicolours
- Suitable for growing in containers
- Need staking because of their size

Longiflorum hybrids

- Derived form popular *L.longiflorum* (Easter lily)
- Produce aromatic, white, trumpet-shaped flowers
- Grow about 90cm high
- Loom in mid summer
- Can be forced ot bloom indoors for Easter

Top ten varieties of lily grown in Netherlands

Variety	Colour	Type
Star Gazer	Red white	Oriental
Snow Queen	White	Longiflorum
Pollyanna	Yellow	Asiatic
Vivaldi	Pink	Asiatic
Casa Blanca	White	Oriental
Elite	Orange	Asiatic
Acapulco	White	Oriental
Marco Polo	White / pink	Oriental
Le Reve	Pink	Oriental
Montreux	Pink	Asiatic

Asiatic cultivars

- White: Alaska, Lucyda, Marbelle, Pulsar, Sancerre
- Red: Avignon, Grand Paradiso, Monte Negro, Nerone

  Pink: Asurra, Chianti, Geneve, la Toya, Minstreel, Monte Rosa, Montreux, Renee, Sorbet, Vivaldi
- Orange: Apledoom, Bangalope, Elite, Loreto, Prato
- Yellow: Adelina, Grand Cru, London, Mona, Nove Cento, Parma, Polyanna **Bulb:**
- The lily bulb is composed of firm, fleshy scales that store food for the following season‘s growth.The bulb consists of a short stem/ axis to which the scales are attached.

- The axis is also called as the basal plate which produce roots, scales and buds for new growth. The scales are modified leaves. They provide nourishment to the developing plant until it has enough leaf area and root system to take up this task. The color of the scales is one feature by which a lily species is identified. The color of the scale changes on exposure to light.

Soil Preparation:

Lilies prefer slightly acidic, humus-rich soil. If drainage is poor, then plant in raised beds. Turn over the soil to a depth of 12-18 inches. Work humus and Lilies prefer slightly acidic, humus-rich soil. If drainage is poor, then plant in raised beds. Turn over the soil to a depth of 12-18 inches. Work humus and fertilizer into the soil, but avoid the use of fresh manure or other fertilizers high in nitrogen which encourages rot problems **Light:**

Lilies thrive best in sunny conditions. When the light is restricted they lean towards the light. Very few lilies can survive where the shade is dense.

Planting time:

Most lilies do best when planted in early fall. But *L.candidum* must be replanted in late July or August a few weeks after it flowered.

Planting depth:

Cover the bulbs with soil to a to depth equal to 3-4 times of their length. Stem rooting lilies with large bulbs (trumpet hybrids) may be covered with 25 cm (10‖) of soil. Madonna lily can be planted shallow as the roots are produced from the base of the bulb only. Deeper planting keeps the bulb cool during summer

Climate:

Temperature:

It is essential to provide an initial temperature of 12 to13°C until stem roots have developed. During the cultivation stage the optimum daily temperature requirement is between 15 to 22ºC Temperature below 15°C can result in bud drop and yellowing of the foliage in oriental hybrids.

Humidity:

Optimum level of Relative Humidity inside the greenhouse should be 80 to 85 %. It is important to avoid large fluctuation in humidity levels which will cause stress and leaf scorch in susceptible varieties.

CO2:

It has a positive effect on the growth and flowering of lilies. Try to achieve a concentration of 800 to 1000 ppm. A higher concentration (±2000ppm) is needed for the Longiflorum hybrids as this group needed high levels of CO2.

Light Intensity:

Light affect the growth of lilium and their development. Depending on the time of year, the location of production, amount of light penetrating in greenhouse and the variety, lighting may even be essential. The insufficient minimum light intensity in the greenhouse for Asiatic hybrids is 190 Joules/cm2. Insufficient light

results in inadequate growth bud drop. Asiatic hybrids are most susceptible to bud drop as compared to oriental and longiflorum.

Shading Net:

To achieve these temperatures shading net is a must. Not only to reduce temperatures; but also to avoid leaf scorching on the plant, one should not compromise on installing proper shading net. The percentage of shading depends on the light conditions at the site and time of the year. Ideal is a movable shading net, one that opens or closes depending on the light conditions (summer/ monsoon). A cheaper option is to go for a 50% agro white shade net, which should be fixed on top of the polyfilm. During the monsoon the same can be removed depending on the light conditions at that time.

Ventilation:

The disadvantage of polyfilm is that underneath poly a lot of heat is building up. Temperature can rise to record high if no provision is made for proper ventilation. It is advisable to build a structure with a top ventilation gap of minimum 3 feet to have proper ventilation inside the greenhouse. Depending on design and size of the greenhouse one can have a provision for side ventilation as well. If the distance from side to center of the greenhouse is less than 30 feet, side ventilation in combination with top ventilation can be recommended. Never close the sides completely, as to keep the natural airstreams flowing.

Water Quality

Ec of irrigation water should be 0.5 mS/cm or lower. The maximum acceptable Chlorine level of irrigation water used for greenhouse irrigation is 200 ppm.

Bedding Media

Soil:

The soil; used for cultivation of lilies, has good structure particularly the top layers and is also kept well drained during the entire growing period. Maintaining the correct pH of the soil plays a major role in the root development and uptake of nutrients. It is advisable to maintain a pH of 6 to 7 for the Asiatic and longiflorum hybrid groups and a pH of 5.5 to 6.5 for the oriental hybrids.

The Chlorine in the soil should not exceed 1.5 mmol/lit.

Bed composition: Red soil : 60% FYM : 30% Sand : 10% Rice husk : As per requirement

Planting Depth:

Lilium bulbs should initially be planted at a depth of 6 inches. After planting and irrigation the soil will decline about an inch. Height of the bulb is approx one inch, which leaves four inches of soil on top of the bulb. This is sufficient soil in which the stem roots can develop. Shallow planting will result in poor stem root development and hence one compromise on the quality of the flower. Planting depth varies according to the size of the bulb. Generally bulb should be planted to the depth of three times more than the diameter of the bulb

Planting Density: Bulb Size	Bulbs/m2	Planting Distance (cm)
8 -10 cm	49	15X15
10 - 12 cm	42	16X15
12 - 14 cm	36	16X 18
14 - 16 cm	36	16X18

Fertigation:

Soil:

Since lilium is a bulbous crop, most of its nutrients are already present in the bulb itself. Lilium is a very salt sensitive crop and therefore one should take care with applying fertilizers. Especially in the first three weeks when the rooting takes place, no additional fertilizers are required. Good root development is important at this stage. It is however advisable to apply 12:61:00@ 2kg/100m2 at least one week before plantation. - Three weeks after plantation: - Calcium Nitrate @ 1 kg/100m2 - Six week after plantation : - Potassium nitrate @ 1 kg/100m2 If plants are not strong enough during growing period due to Nitrogen deficiency then a top dressing of Ammonium Nitrate@ 1 kg/100 m2 can be applied up to three weeks before harvesting **Fertilizers:**

The kind and amount of fertilizer depend on the soil fertility. A complete well balanced fertilizer with NPK (15 –15 –15) is more suitable. Apply garden lime if the soil is too acidic. Excessive fertilizer is too harmful to lilies. Fertilizer is best applied when lily shoots are at the spear stage just before the leaves unfurl. A suitable six month slow release fertilizer like osmocote (20- 20-20) will keep the lilies happy for the entire season. An old practice is to scrape away a couple of centimeters of soil just as the lilies emerge and replace it with a mulch of well decayed cow/horse manure.

Harvesting & Packaging

The spikes were harvested when the lower first bud turns from green to original colour of the variety, but has not yet opened. The spikes were cut 8 -10 cm above the ground level. After harvesting, cut stems were graded as per the number of buds per stem, length and firmness of the stem. After grading, the foliage was removed upto 10 cm from the bottom of stem before bunching and subsequently sleeved with 10 stems per bunch. It was packed in perforated cardboard box (100 x 60 x 40 cm) for transportation

Harvesting and Post Harvest Treatment for flowers:

- Always harvest the lilies at the cutting stage, i.e. 8 to 10 cm above the ground when lower first bud shows the colour of flower.
- Prevent the stems drying out during and after harvesting.
- After harvesting, stems are graded according to number of flower buds per stem, length and firmness of stem

During bunching, remove 10 cm of foliage from the end of the stems and subsequently sleeve the flowers.

- Immediately after bunching, the cut flowers should be placed in cold water in cold storage room at 2ºC to 3ºC. Add 2% sucrose and 100ppm GA3 as a preservative agent to water to improve vase life of flower.
- When dispatching lily flowers use only perforated boxes to maintain a proper temperature during transport.

Procedure for post harvest treatment of the bulbs:

- Reduce the frequency of irrigation water. Maintain soil moisture level in such a way that bulb scales should not dry out. Excessive moisture may lead to rotting of bulbs.
- Allow bulbs to remain in the beds for 4 to 5 weeks (above ground stem portion should dry out and can be pulled out from bulb easily).
- After 5 weeks remove the bulbs from soil along with dried stem.
- Remove dried stem carefully without damaging the bulb.
- Wash bulbs with clean water and treat with 2% Bavistin solution for 10 minutes.
- Remove the bulb from solution and air dry in shade. Too much drying may lead to loosen root skin. Such bulbs; after planting may develop root rot.
- Immediately after air drying pack the bulbs in plastic crates with moist coco peat wrapped with perforated plastic sleeves.
- Coco peat used for packing must be sterilized.
- Keep the crates in cold storage at 20C for 2 weeks and then at -10C for 6 weeks.
- Keep crates open for one day in cold storage and then close with plastic sleeves

Diseases	**Symptoms**	**Control Measure**
Penicillium	During storage; rotting spots covered first with white and later on with fluffy bluish green fungus are visible on the scales. Affected bulbs produce plants with retarded growth.	Store the bulbs at the lowest recommended temp. Keep soil moist. Remove infected scales.
Bulbs and Scale rot	Underground brown spots on top and side of bulb. Later on start to rot. Retarded growth. Pale foliage.	Soil disinfection. Maintain lowest possible soil and greenhouse temp. Remove infected scales.
Fusarium stem disease	Premature yellowing of the lower leaves which turn brown and then drops to orange to dark brown spots on stem.	Soil disinfection. Maintain lowest possible soil and green house temp

Abnormalities:

1.Leaf Scorch:

Cause: Leaf scorch occurs when there is a disturbance in the balance between absorption and evaporation of water. This is the result of inadequate absorption or evaporation which causes a calcium deficiency in the cells of

the youngest leaves. Cells are destroyed and die. A sudden change in the relative humidity inside the greenhouse can affect this process related to poor root system and high salt level in the soil. Large bulbs are more susceptible than smaller one.

Control:

- Disease and pest which could damage the roots should be controlled effectively.
- Soil should be moistened before planting.
- It is better not to use susceptible varieties but if this cannot be avoided do not use a larger Bulbs as these are extra sensitive.
- Plant bulbs with a good root system.
- Plant to an adequate depth i.e. allow 6 to 10cm of soil on top of the bulb.
- Prevent large differences in greenhouse temperature and air humidity levels during period of increased susceptibility. Try to maintain RH level of approx. 75%.
- Rapid growth must be prevented.
- Ensure that plants maintain even transpiration and avoid excess transpiration by shading.

2.Bud drop and bud desiccation:-

Cause: Bud drop occurs when plants receive insufficient light. In light deficient conditions the stamens in the bud produce ethylene causing the bud to abort. There is an increased risk of bud desiccation if rooting conditions are poor, e.g. too dry soil.

Control:

- Do not allow; varieties susceptible to bud drop to grow in poor light conditions.
- To prevent bud desiccation bulbs should be allowed to dry out during planting. Ensure that the bulbs root well and grow in the most favorable conditions possible particularly as far as lighting and transpiration are concerned.

ORCHIDS

Introduction

Orchidaceae is the largest family of angiosperms with 800 genera and 35,000 species. In India 1300 species and 140 genera are reported. More than 80,000 hybrids are available. Orchids get their name from the Greek Orchis meaning ―testicle. The word ―Orchis was first used by **Theophrastus** (372/371– 287/286 B.C.) in his book ―De historia plan tarun (The natural history of plants) is considered the **father of botany and ecology**. **Swedish botanist Carl Linneaous considered as Fathers of orchidology**

- Al Orchid species are protected for the purposes of International commerce under CITES (Convention on International Trade in Endangered Species) as potentially threatened or endangered in their natural habitat except hybrids
- Orchid exhibit an incredible range of diversity in Size, Shape and Colour.
- Occupy top position among all the flowering plant.
- Valued for cut flower production and as potted plants.

Most African Orchids are white, while Asian Orchids are often multi colored. Dendrobiums, cymbidiums and vandas have played a major role in the development of modern Orchid industry in the world.

Importance

Orchids are the most fascinating and beautiful of all flowers. They exhibit a wide range of diversity of flowers. It constitutes immense horticultural importance and plays a very useful role to balance the forest ecosystem. Cultivation of orchids has become a very profitable occupation. New hybrids and commercial cut flowers expanded tremendously in Europe, USA, South America, Thailand, Singapore, Malaysia, Japan and Srilanka. In spite of their commercial value, the orchids in India have not get gained the attention and popularity they deserve. As compared to the above countries, the export and sale of orchids in India is negligible.

Only few nursery men based at Kalimpong in Darjeeling district of West Bengal and in Sikkim export some orchids but the trade is unorganized like other important orchid growing countries, India is blessed with a wealth of orchid flora, and about 1600 species are estimated to occur in this country. There is tremendous scope for orchid improvement and development of industry based on these wonderful plants.

Many orchids native to this country are important parent plants for the production of several outstanding hybrids in the world. Hybrids of certain Indian orchids like Vanda coerula (Blue vanda or Blue moon vanda) and species of Cymbidium, Dendrobium and Paphiopedilum are considered the monarchs in the orchid world. Due to the diversity of environmental condition in India, it is possible to grow all types of orchids in suitable places without the control of environment.

Export potential of orchids consists of:

- Cut flowers
- Potted plants
- Tissue culture orchid plants
- Medicinal orchids
- Vanillin
- Pressed orchids
- Hybrids

Uses of Orchids

In addition to the pleasure they provide for the eyes of the beholder, several orchid species have other uses.

Food

- Many orchids have been used as food in different parts of the world.
- Anoectochilus leaves are eaten as vegetable in Indonesia and Malaysia.
- Pseudobulbs of Cymbidium and Dendrobium speciosum used as food.
- Dried leaves of D.salaccense imparts a delicate flavour when cooked with rice
- From the dried tubes of Orchids anatolica, a drink is made by villagers in the island of Cyprus.
- Natives of South Australia eat the tubers of Caladenia carnea, Microtis uniflora and Eriochilus cucullatus.

Medicinal Uses

Disease		Orchids
Hysteria	-	*Vanda spathulata* (Flowers)
Clot blood in wounds	-	*Cymbidium giganteum* (Leaves)
Dysentery	-	*C.canaliculatum*, *C.madidum* (Fruits and Pseudobulbs)
Antidote for poisoning and	-	*Vanda tessellata* (Roots) for rheumatic pains
Liver upsets	-	*Dendrobium fimbriatum*
Head aches	-	*D.terratifolium*
Healing of wounds	-	*Cymbidium aloifolium*
Oral contraceptives	-	*Cymbidium madidum*

Orchids have been used in ayurvedic medicines because over 3000 types of glycosides and alkaloids are produced by orchids.

Orchids	Alkaloids
Loroglossum sp.	Loroglossin glycosides
Angraceum fragrans	Coumarin glycosides
Paphiopedilum javanicum	Saponine glycosides
Vanilla spp.	Vanillin glycosides

- *Dendrobium nobile* - Dendrobine and Nobilonine
- *Liparis bicallosa* - Laburnine
- *Malaxis congesta* - Malaxine
- *Phalaenopsis manni* - Phalaenopsine

Vanilla is commercially important used as a foodstuff flavoring. (The Coca-Cola company is the word's largest user of vanilla).The underground tubers of terrestrial Orchids are ground to a powder and used for cooking, such as in the hot beverage salep or ―fox-testicle ice cream *salepi dondurma*. The scent of Orchids is frequently used by perfumists to identify potential fragrance chemicals. Other than this Orchids have virtually no commercial value other than for enjoyment of the flowers

Origin :

Tropical Forests of Amazon & Indo - Malayan region The basic orchid flower is composed of

- Three sepals in the outer whorl
- Three petals in the inner whorl
- However one of the petal, the medial petal is different from the others and is cal ed label um or lip

Most advanced Orchids have five basic features

1. The presence of a column : call gynostemium.
2. The flower is bilaterally symmetric
3. The pollen are glued together into the pollinica, a mass of waxy pollen on filament.
4. The seeds are microscopically small (exception Disa & Vanilla)
5. The seeds can, under natural circumstances, only germinate in symbiosis with specialized fungi.

Distribution

Tropical America	: 300 – 350 Genera
Tropical Asia	: 210 – 300 Genera
Oceania	: 10 – 70 Genera
Eurasia	: 40 – 60 Genera
North America	: 20 – 30 Genera

- In the world, it is cultivated in Central America, Mexico, India, Srilanka, China, Thailand, Phillippines, Australia
- In this, Thailand, Singapore and Malaysia occupy a prime position in orchid production
- America, Japan, England, Germany, Italy, Netherland, Newzealand and Denmark import orchid flowers in a large numbers.
- Orchids are cosmopolitan in distribution. Occurring in every habitat, except Antarctica and deserts.

- The great majority are to be found in the tropics, most Asia, South America and Central America. They are found above the Artic Circle in Southern Patagonia and even on Macquarie Island, close to Antarctica,
- About 800 to 1000 new species are added each year.
- In India, Darjeling, kalimpong, Shillong, Bangalore, Ooty, Yercaud, Cochin, Chennai, orchids are cultivated. In india, more than 1300 species have been found, out of which 600 sp. in NE, 320 sp. in SI. 180 sp. WB, Orissa and Bihar and 200 sp in NW.

Global Orchid Production Production in Asian Countries Tropical Orchids:

Country	Units (Million)	% Production
Thailand	31.6	83.0
Singapore	1.7	4.5
Others	4.7	12.5
	38.0	**100.0**

Temperate Orchids:

Country	Units (Million)	% Production
Japan	2.0	33.0
Korea	2.0	33.0
Taiwan	1.5	26.0
Others	0.5	8.0
	6.0	100.0

Major contributors to the Export trade

India	:	Rs.10 Crores
Thailand (to Europe & Germany)	:	US $ 40 mln.
Singapore	:	US $ 8.3 mln.
Europe	:	US $ 5.3 mln.
Total World Market	:	US $ 30 bln.

In Japan - Market for potted plants

Cymbidiums	:	US $ 105 mln.
Phalaenopsis	:	US $ 103 mln.
Dendrobiums	:	US $ 53 mln.
Cut Orchid Flowers	:	US $ 205 mln

Classification based on growth habit

- Monopodial
- Sympodial

Monopodial (one footed)

It have a main stem which counties to grow year after. (Eg. Phalaenopsis, Renonthera, Vanda, etc)

Sympodial (many footed)

The Plant produces a series of adjacement shoots which grow to a certain size, bloom, then stop growing to be replaced by the next growth. (Eg. Cattleya, Dendrobium, Oncidium, Cymbidium)

Classification based on Habitat

- Terrestrial (or) Ground Orchids
- Epiphytic Orchids
- Saprophytic Orchids
- Lithophytic Orchids
- Subterranean Orchids

Terrestrial (or) Ground Orchids

- Grow in soil. Sympodial and perennial
- Example : *Spathoglottis plicata, Arundina graminifolia, Phaius tankervilleae* etc.

Epiphytic Orchids

- Grow well on other plants. Abundant in humid tropical rain forests of India. Elevation upto 3000m.
- Example: Vanda, Vanilla, Dendrobium, Cymbidium, Cattleya, Oncidium, etc.

Saprophytic Orchids

- Live on dead and decaying organic matter and found on the moist forest floors.
- Example: Neottia, Galeola, Listera etc

Lithophytic Orchids

- Rare and grown in moist, shaded rocks and crevices of walls.
- Eg: Cymbidium munronianum, Diplomeris birsuta

Subterranean Orchids

- Underground orchids, Found in Australia. Eg: Rhizanthella and Cryptanthemis

Classification based on temperature requirements

Cool orchids: Eg. Cymbidium, Paphiopedilum, some Dendrobium

Warm orchids: Eg. Vanda, Phalaenopsis, Dendrobium Intermediate: Eg. Cattleya, Oncidium

	Day temperature	Night temperature
Cool orchids	$15.5 – 21^0$ C	$10 – 12.5^0$ C
Intermediate	$18 – 21^0$ C	$15.5 – 18^0$ C
Warm orchids	$21 – 29^0$ C	$18 – 21^0$ C

Climate

Indirect sunlight is ideal for Orchid. Seedling requires less sunlight than adult plant. Very poor light tends to produce weak plants and retards flowering.

Optimum requirement varies between species to species

- Cypropedium and Phalaenopsis required only 200 – 300 foot candles.
- Vanda & Aranda best under 800 foot candles
- Growers have used shadenets in 35% to 85% shade percentage to grow Orchids of different Genera

Orchids in nature grow pretreated from the tropical sun by the shades of trees.

- Tropical Orchid enjoy humid, warm atmosphere.
- Temperate Orchid should be growing in cool houses.
- Proper ventilation is must to provide fresh air.
- Orchids dislikes sudden change in temperature, the best suitable range is 180C to 300C
- However Orchids likes Vanda, Aranda, Arachnis, Renanthera, Kegawara, Mokara can be grown in open sun in trenches filled with brick pieces and characoal.

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, Under control conditions they have to be supplied these major and minor nutrients.

- Solid and liquid fertilizer mixtures are available in the Market.
- Liquid fertilizers are much more quickly absorbed and can be applied more frequently.
- Usage of fertilizer depends 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.
- NPK 20:20:20 or 18:18:18 is good during vegetative growth.
- NPK 10:20:30 or 7:12:40 is good during flowering stage.
- In general, PH of the nutrient solution should be slightly acidic or neutral but not alkaline.
- Fertilizer should be made on sunny days during 8.00 a.m. – 10.30 am. for better absorption.

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.

- Cutting
- Off shoots and keikis

- Aerial shoots
- Seed
- Tissue Culture

Cutting

Orchid like Aerides, Arachnis, Epidendrum, Renanthera, Phalaenopsis, Vanda and Dendrobium can be propagated by cutting. Cut ends should treated with fungicides to prevent rotting. Most of the sympodial Orchids like Ceelogyne, Catteleya, Dendrobium and Cymbidiun are propagated through this method.

Propagation Division

It is suitable for sympodial orchids. The 4-5 years growth, clump have 8-10 canes and divided to 4-5 individual units with 2 canes per division. Eg. Dendrobium, Cattleya, Epidendrum, Oncidium etc.

Off-Shoots (Keikis)

Off-Shoots are miniature plants with roots from the nodes of old canes. Application of cytokinins like BAP 1g/litre will stimulate new off shoots in Dendrobium, Phalaenopsis, Paphiopedilum etc.

Cuttings

Matured stems - cut neatly into pieces with 3-4 nodes and a few roots. Planted on sand and kept in shade for root development. Eg. Vanda, Arachnis, Ascocentrum etc. Flower stalk cuttings of Phalaenopsis, Phaius etc., are also used. The concentrations of 4000-5000 ppm IBA or NAA enhance root development

Seed

The orchid seeds are very minute, dust like particles. The seeds are lacking nutritive substances to start the plant growth as thousands o seeds are formed in a capsule. Seeds are dispersed by the wind and symbiotic fungi (micorrhiza) provides necessary substances during germinartion and early stage of development.

Propagation

Orchids are propagated by seeds or by vegetative means.

Propagation of monopodial orchids Stem cuttings:

The main method of propagation is through stem cuttings. About 40-50 cm long top cuttings with at least two well-developed aerial roots are ideal. Intermediate cuttings can also be used. If smaller cuttings (2-3 nodes) are used, the time taken to flowering will be longer.

Flower stalk cuttings:

These are also reported to be useful in certain genera like Phalaenopsis, Phaius, Calanthe and Thunia. Sometimes vegetative shoots are produced from the flowered spikes in these genera. Otherwise the flower stalks can be cut off and laid horizontally on moist media, like sphagnum moss or coconut husk bits.

Layering

Air layering was found to give success in monopodials like Vanda. For this, a slanting cut may be given on the stem, at about 20-30 cm below the apex. The wound may be covered with some moist media, as in the case of air layering. The layers can be separated and planted when they strike roots.

Propagation of sympodial orchids Division

The method involves division of large clumps into smaller units. This is the most common method of propagation in sympodial orchids. Care should be taken to see that each unit has at least 4-5 shoots, including the old ones. Large size divisions favour faster establishment and earlier flowering. This method is especially suitable for Cattleya, Dendrobium, Cymbidium, Epidendrum etc. Aseptic conditions are to be followed in cutting and separating in order to prevent transmission of diseases.

Off-shoots or Keikis

Orchids like Dendrobium sometimes produce small plants with roots at the nodes of pseudobulbs. These are called 'keikis' meaning 'babies'. These, when sufficiently grown, are to be separated carefully from the mother plant and potted independently. The performance of 'keikis' is found to be better if they are allowed to flower on the mother plant and then separated and planted.

Same monopodium Orchids like Ascocenda and Phalaennopis, Keikis or off shoots emerge frequently on the main stem

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 dendrobium produce aerial shoots or bulbs on old back bulbs devoid of leaves. Usually arise on the upper part of the back bulbs. In genera like Good year, Rhizomes gives off special lateral branches which turn up and produce aerial shoots.

Seed

Orchids produce seed pods with literally hundreds of thousands of seed that are released and scattered by the wind. (1,300 to 400,000)

- Colour may be white, Cream, Pale green, reddish orange or dark brown and have very diverse shapes.
- Orchid seeds must establish a symbiotic relationship with a special fungus to survive its first year of life.
- The fungi gathers water and minerals for itself and the seedling, and the seedling shares its sugars from photosynthesis with the fungus.
- Only one or two orchid seeds will ever germinate and survive on that perfect crevice or depression that is both moist and has the fungus present.
- Its chances to survive in the wild long enough to bloom are slim
- To avoid this problem, greenhouse growers sow orchid seeds on moist, sugar-rich, sterile agar, or they cut out growing clumps of orchid cells and place them on the agar.
- These techniques allow many hundreds of orchid plants to survive to maturity.
- New and improved hybrids can be mass produced rapidly.
- This is important as orchids are very slow growing as many orchids take five to seven years to mature to flowering.

- Breeding three or four orchid generations could span a person's lifetime just to get one new hybrid propagated sufficiently for sale.

Backbulbs

The older shoots (or canes) of sympodial orchids, which are lesser active physiologically, are called 'backbulbs'. Sometimes these shoots will be devoid of leaves and green in colour. They do not have visible eyes and not too many roots. These 'backbulbs' may be severed off the mother plant and kept horizontally over a moist medium. After sometime they will strike roots and sprout from the nodal region. Then they can be separated and planted in individual pots.

Micro Propagation Tissue culture

Various plant parts like shoot tip or meristems, leaf and leaf segments, stem segments, floral parts, aerial roots, etc. have been used for tissue culture of orchids. Meristem culture is more popular and is extensively used for the commercial propagation of orchids.

- Tissue culture technique were applied to orchids in 1960.
- Tissue culture technique is highly successful to get virus free plants.
- Today tissue culture is preferred for commercial propagation of orchids.
- Both liquid and solid media are used for the orchid tissue culture.
- The explants after being isolated from the shoots are cultured in or on the desired medium – under sterile conditions; offer to produce clones of a plant.

Varieties

Since 1856 when the first Orchid hybrid produced, a very large number of artificial hybrid have been produced both at intergeneric and interspecific level. To date more than 125,000 hybrid have been registered with an average of 10,000 or more every year. The success for the production of such a large number of hybrid in every year is due to the fact that most of the orchids genera and species have no generic barriers and they cross freely with each other.

- Most of the orchid‘s genera are still in the process of evolution and most of the orchid groups are in reality only artificial constructs. Two factors which have played a major role in the development of orchid hybrids are polyploidy and introgressive hybridization. Some genera has been of extraordinary effect and coupled with inter-generic 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.

Ascocentrum X Vanda	Ascocenda
Arachnis X Vanda	Aranda
Aerides X Vanda	Aeridovanda
Brassovola XCattleya	Brassocattleya

Phalaenopsis X Vanda	Vandanopsis
Cattleya X Laelia	Laeliocattleya
Cattleya X Sophronitis	Sophrocattleya

Commercial cut-flowers of different classes of vandaceous orchid cultivars currently exported from Singapore .

Vandaceous hybrids

Aranda (Arachnis x Vanda)	-	22
Mokara (Arachnis x Vanda X Ascocentrum)	-	12
Arachnis (interspecific hybrids)	-	4
Aranthera (Arachnis x Renanthera)	-	2
Renantanda (Renanthera X Vanda)	-	2
Aeridachnis (Aerides X Arachnis)	-	1
Aeridovanda (Aerides x Vanda)	-	1

Holttumara (Arachnis X Vanda x Renanthera) - I Leeara (Arachnis X Vanda X Vandopsis)

Phalaenopsis sp.

Distribution

- Phalaenopsis are widely spread from Southern India to Northern Australia with many species found in the Philippines.
- All are warm growing tropical orchids.
- All the thousands of modern hybrid Phalaenopsis have originated from 62 wild species.
- Their common name is – Moth Orchid‘
- This comes from Phalaen‘ which means moth like‘ and is a reference to the Moth genus Phalaena.

Importance and Origin

- Orchids constitute an order of royalty in the world of ornamental plants and they have immense horticultural importance.
- They play a very useful role to balance the natural ecosystem
- They are most pampered of the plants and occupy top position among all flowering plants valued for cut flower production and as potted plants.
- They are known for their long lasting flowers of myriad shapes, sizes and colours and bewitchingly beautiful flowers which fetch a very high price in the international market
- Orchids are major players in the multibillion dollar floriculture trade in the world

Origin: India

Today, orchid such as, Dendrobium, Cymbidium, Phalaenopsis and Oncidium are marketed globally and the orchid industry has contributed substantially to the economy of many ASEAN (Association of the South East Asian Nations) countries.

- The orchid cut flower industry is growing at the rate 10-20 per cent annually and presently is a US $ 44 billion industry
- Orchids used as a medicine- Dendrobium as a source of tonic, astringent, analgesic and anti- inflammatory substances.
- Used as spice, flavouring agent and food: Vanilla planifolia, V. pompona, V. tahitensis.

History of natural hybridization

The presence of natural hybrids evolved from crosses between two species in the wild is known since the early days of orchid collection.

- In fact, absence of natural hybrids would have been strange.
- Lack of a strong crossability barrier among orchid species coupled with the above fact led to constitution of several natural hybrids in the wild.
- Such natural hybrids often breed true and get established as new species.
- One of the earliest reported natural orchid hybrids was Phalaenopsis intermedia.
- Natural hybrid of Phalaenopsis aphrodite and Phalaenopsis rosea
- Two Masdevallia species, Masdevallia splendida and Masdevallia parlatoreana are also recognized as natural hybrids developed from a cross between Masdevallia veitchiana and Masdeviallia barlaeana.
- A natural hybrid population of Oncidium, arising out of a cross between Oncidium staievi and Oncidium jonesianum, was also reported.
- Veitch, 1886 described a complex of natural hybrids among Mexican and Colombian Odontoglossums.
- In this region, hybridization among
- Odontoglossums crispus, Odontoglossums heterocarpum, Odontoglossums lindleyanum, Odontoglossums odoratum, Odontoglossums triumphans and Odontoglossums prescotria is so common that drawing a clear –cut line between species becomes very difficult.
- At least five different types of hybrids, namely the crispo-odoratum group, crispo – lindleyanum group, crispo-luteopurpureum group and triumphante-prescatoria group are recognized (Abraham and vatsala,1981).
- One of the most popular Vanda hybrids, Vanda Miss Joaquim was found growing between some plants of Vanda teres and Vanda hookeriana and later on it was found to be a hybrid between these two species.
- Vanda xamoena, which is also registered as an artificial under the name Vanda violeta, occurs in nature as a result of hybridisation between Vanda tessellata and Vanda coerulea.

- Natural inter- specific hybrids are also reported in Cattleya, Laelia and Miltonia. Cattleya guatemalensis, collected by Skinner from Guatemala in 1861, was later found to be a natural hybrid between two species from different genera.
- It was developed from a cross between Epidendrum aurantiacum and Cattleya skinneri.
- Presently, this natural hybrid is known under the generic name Epicattleya.
- *Laeliocattelya elegans*, found in brazil, came into existence from a natural cross between *Laeliacattleya purpurata* and *Laeliocattleya guttata*.
- *Laeliacattleya scilleriana* is also a natural cross between *L. purpurata* and *L. intermedia*.
- Another inter-specific natural hybrid Cattleya intricata was developed from a cross between Cattleya intermedia and Cattleya leopoldii.
- One of the most interesting inter –generic natural hybrids spotted in the wild is the one that developed from a cross between Cattleya warneri and Brassovola tuberculata.
- In 1988, the natural hybrid and the parental species were spotted flowering side by side in Rio Doce Valley (Devi and Deka, 2001). Two new natural hybrids are also reported in the genus Ophrys from central Italy.
- Natural hybrids have also been documented in the genus Disa. Existence of bi-directional gene flow between Cypridum candidum and Cypripedium pubescence, wherever the two species were sympatric

History of Artificial hybridization

- The first mane made orchid hybrid, a cross between Calanthe masuca and Calanthe furcate flowered in the year 1856 for the first time.
- The hybrid was named Calanthe dominiyi, in honour of breeder, Mr. John Dominy.

Reports suggest that Rev. William Herbert, Dean of Manchester, attempted orchid breeding even before John Dominy

Species

1. **Aerides**

These are mainly epiphytic orchids and known as Foxtail orchids. They have monopodial pattern of growth. Species are *A.multiflorum, A.fieldingi, A. crispum*

2. **Anoectochilus**

This group of plants are known as Jewel orchids. *A. sikkimensis, A. roxburghii* **3.**

Bulbophyllum

This genus consist of a large number of species. *B.cylindricum, B. cauliflorum, B. sikkimens, B. parviflorum*

4. **Cymbidium** – *C. elegans, C. grandiflorum, C. white*
5. **Cattleya** – *C. multiflorum, C.citrina*
6. **Coelogyne**

7. **Cypripedium** – ladies slipper orchids
8. **Dendrobium** – this is very big genera with more than 1000 species. Tropical orchids.

Piegeon Orchid

Pigeon Orchid *(Dendrobium crumenatum)*

It produces white, fragrant flowers with a yellow tinted throat. The bloom cycle is triggered by sudden drops in temperature (at least 5.5 °C or 10 °F), usually as a result of rain, although the same effect can be artificially created. The plant produces a fragrant smell, but only for two days. A tropical plant, it is the most common orchid in Singapore, found growing naturally on trees as well as being planted onto street trees by the authorities

Renanthera

In allusion to the kidney-shaped pollinia of the original species.

- The name Renanthera is a combination of the Latin "renis" meaning kidney, and the Greek "anthera" or anther, and refers to the distinct kidney shape of the pollinia, characteristic of this genus.
- Renanthera flowers are usually red, red-orange, or yellow, some with red or purple spots or blotches. Texture may be matte or velvety. Some species provide a spectacular display of 100 + flowers on a large branching inflorescence.
- *R. storiei*, the species with the largest red velvety flowers, and unfortunately the largest plant habit, has been the most popular hybrid parent.

Varieties

- Dendrobium species is a typical tropical orchid species suitable for Chennai and other coastal areas where the humidity is high.
- The important varieties of Dendrobium are Sonia-17, Sonia-28, Madam Pampadour, Pravit white, Sarifa Fatima, Emma white, Ekapal Panda etc.

Commercial varieties

Emma White

Creamy white coloured flowers. Creamy white sepals, petals and lip, Creamy white lip with feathery longitudinal situations. Petals are larger than sepals. Ceratobium type. Length of spike ranges from 19.00 to 29.00 cm and seven florets.

Sonia 28

Purple and white coloured flower. Deep purple petals and lip with white colouration towards the centre. Sepals white with a purple tinge. Petals are little larger than sepals. (Intermediate between Ceratobium and Phalaenantha) length of spike ranges from 35 cm to 43 cm with twelve florets.

Sonia -17

White and purple coloured flower. Sepals creamy white with purple marking and petals purple in colour. Lip light purple with cream coloured can be region and feathery outgrowth in lines club shaped pseudobulbs leaves are bright green, broad and acute.

Sakura Pink

Light purple coloured flowers. Light purple coloured petals, sepals and lip. Petals and sepals of almost equal size. Ceratonium type. Length of the spike 24 cm with seven florets.

Growing structure:

Orchids are grown under shade net house conditions. 75% green shade net with a humidity level of 70-80 %, temperature 18- 28 ºC and light intensity of 1500 – 2000 foot candles is ideal for growing Dendrobium orchid.

Containers

All orchids which do not grow very tall are ideal for growing in pots. The desirable qualities of a container are

- It should hold the potting material conveniently
- The type of container should take in to account the conditions under which orchids grow in their natural habitat
- It should drain excess water. They can be provided with sufficient number of holes on the sides and bottom
- Clay pots should not be painted as it may seal the holes
- For hanging purpose light weight containers like wooden baskets or plastic pots are preferred
- The size of the container should be in proportion with the size of plants and their growth habit
- Shallow containers are sufficient for most of the orchids
- Climbing orchids and terrestrial orchids can be generally planted on the ground. Epiphytic orchids are grown in some type of containers or supports.

Earthen or clay pots

The most widely used containers are clay pots. They are porous, stable and absorb excess water. They are cheaper and provide better aeration. They are best suited for terrestrial orchids.

Plastic pots

It is most suited when the plants are grown in hanging pots. They are light in weight, more durable, easy to transport and do not accumulate algae or salts on their sides but expensive too.
They retain moisture for a sufficiently longer period and hence water requirement is less.

Baskets:

Wooden baskets are generally used for Vanda. The basket is very shallow and is made of wood that can withstand continuous wetting for a sufficiently lo0ng period.

Slabs:

Slabs or logs of tree fern are useful especially for hanging purpose. The plants are secured on slabs using hairpins. Slabs need frequent watering and high humidity.

Others

Half or complete portion of coconut husks, wire baskets etc can also be used as containers

Growing Media

Orchids thrive well under a wide range of growing media. Most common mixture consists - charcoal,

- coconut husk pieces,
- dried tree fern roots,
- sphagnum moss,
- broken pieces of bricks and tiles
- perlite pieces etc.,

- Mixture can be used either singly or in combination.
- Medium should have good drainage and water retention.
- Micro climate and aeration within the pot will favour the healthy growth of the plant.

Dendrobium, Phalenopsis, Cattleya, Paphiopedilum and *Cymbidium* grow in coconut husk dust, husks of coir fibre.

Dendrobium grown in brick pieces + coir dust recorded best performance. Cymbidium sp. grew well in bark, leaf mould than in sphagnum moss.

General considerations of the media

Since the epiphytic orchids are the commercially more important ones, we shall consider some of the general qualities required for the components used in their media.

They can be listed as follows:

- They should hold sufficient amount of moisture, which should be released to the plants when needed.
- They should provide adequate drainage.
- They should be easily available locally.
- They should be cheap or less costly.
- They should not contain substances that are toxic to orchids

- They should retain nutrients for a reasonable period of time and at the same time should be easily washable so that the accumulating salts of fertilizers do not build up dangerous levels.
- They should be easily workable since potting is tedious, consuming much labour and time.

Watering

Watering is also one of the important factors

The two questions that arise here are

1. How much water is to be given?
2. When watering is to be done?

- Too much water will encourage fungal and bacterial growth.
- Too little water will stunt the plant.
- The latter is better than excess watering.
- Watering depends on type of orchid, type of pot, potting medium, position of shade house etc.

Containers and supports

- Climbing orchids and terrestrial orchids can be generally planted on the ground
- Epiphytic orchids are grown in some type of container or supports
  - Pots
  - Wooden baskets,
  - Coconut husks
  - Tree fern rafts
  - Pieces of wood etc.

Potting Medium

- Orchids thrive well under a wide range of growing media.Most common mixture consists - charcoal,
  - coconut husk pieces,
  - dried tree fern roots,
  - sphagnum moss,
  - broken pieces of bricks,
  - perlite pieces etc.,

  Mixture can be used either singly or in combination.
- Medium should have good drainage and water retention.
- Micro climate and aeration within the pot will favour the healthy growth of the plant.

Repotting

- Orchids need repotting regularly, usually every two to three years.
- When the plant grows large and overgrows its container.

- When the potting material deteriorates ○ When the plant has to be split or divided
- It is better to repot epiphytes every year.
- The best time for repotting - Fresh roots emerge at the bases of the previous year‘s growth.
- In monopodial climbers, repotting or division has to be done when new leaf growth shows at the top and there is new root growth.

Splitting or division of plants

- Plant grown to a large clump with 2 or 3 old canes and new shoots, divided before repotting.
- Each division - at least one old cane of two years‘ growth, one new shoot & some new roots.
- Monopodial climbers - cut the top region with a few roots and plant it a new. Off-shoots (‗Keikis‘) that arise from the nodes of the stem - cut and potted.

Fertilizer application

In their natural habitats, orchids grow on no special nutrients, depending on decaying tree bark and the atmosphere.

N,P,K at 17:17:17 or 20:20:20, dissolved in water @ 1-5g twice a week.

- To promote flowering, a higher proportion of P and K at 10:20:20
- Organic fertilizers like cowdung, chicken manure, groundnut cake, neem cake etc. can be moderately used.
- It must be soaked in water at 1:10 or 1:20 for 2 to 3 days to allow decomposition of the fertilizer.
- The supernatant solution is used for spraying once / twice a month.

Harvesting and Handling

- Both are very important operations.
- Proper time and method of harvest controls vase life and the quality ○ Dendrobium flower fully matured only 3 or 4 days after it opens.
- A spike can be cut at last 1or 2 buds are yet to open or 20 per cent of flowers are in bud condition.

  Immediately after harvest, the lower 0.75cm of the peduncle is cut off, and the flower is inserted into a fresh tube of water containing preservative.
- Treatment with 8-HQC+5% sucrose improve the flower quality and vase-life of flowers.

Orchid trade in India

Some important orchid species are occupied in flower market : cymbidium, vanda, paphiopedilum and dendrobium Oncidium goldiana, Vanda rothschildiana and dendrobium (madam pumpadour) are three high valued cut flowers for export trade.

Lecture 7 : Production technology of gladiolus and tuberose under open conditions

GLADIOLUS

Importance and uses-origin and distribution-area and production- botany and varieties propagation and planting-media – environmental factors-inter culture - production constraints-plant protection-harvesting and yield.

Introduction:

- It is said to be the **—Queen of bulbous flower crops** and commonly known as **—Sword Lily**: Corn flag‘ is another common name in Europe.
- The name gladiolus was originally coined by Pliny the Elder.
- Gladiolus (Tournefort.) L. takes its name from the Latin word —Gladius" meaning a sword,‟ because of sword- like shape of its foliage
- Majestic spikes of gladiolus has attractive florets
- It is striking and colorful with towering stems
- Occupies 4 th place in International cut flower trade
- Gladiolus primulinus is also known as waterfall gladiolus

Importance and Uses:

- Gladiolus is an important florist crop, most popular as cut flower in the domestic and International market.
- In Netherlands, it ranks next only to tulip in commercial importance
- It is relatively easy to grow and also suitable for bedding and exhibition.
- The fascinating spikes bear a large number of florets which exhibit varying sizes and forms; with smooth, ruffled, deeply crinkled or laciniated tepals.
- The flower spikes are used in flower arrangements, in bouquets and for indoor decoration.
- Grandiflorus and Primulinus types look very attractive in mixed flower borders.
- Spikes of gladiolus have good keeping quality and can be transported to long distances.
- Its flowers open in acropetal succession, one by one and spike lasts for 1 to 3 weeks in ordinary vase water, depending upon the season and variety.
- Practically all colours except true blue and green are available in gladiolus
- Gladiolus corms are used as food G . edulis, G . quartinianus, G . zambesiacus, G . spicatus, G . italicus (Greeks)
- The flowers is used as uncooked salad by nipping of the anthers Psittacinus hybrids - high amount of carbohydrates mostly as

  Starch (65.4 - 78.61%), Protein (12.6 - 18.5%), Fat (0.58%)

Medicinal uses of Gladiolus

G . crassifolius – used for Headache and Lumbago

G . saundersii – Diarrhoea

G . ecklonii – Rheumatism and Allied pains Origin and Distribution:

- It is said to be in cultivation since 1578.
- It was first introduced into France & it spread to England, Germany, Holland & North America.
- No species is known to be native of India.
- In India it was introduced during British period
- In 1816, France, Holland , Belgium started raising hybrids

Taxonomy:

- Gladiolus L. belongs to the family Iridaceae. Basic chromosome number is n=15.
- Ploidy in the genus ranges from diploid (2n=30) to dodecaploid (2n=180)
- The modern garden gladiolus is a complex of at least 12 species and most of the cultivars are tetraploids (2n=60) & highly heterozygous, they will not breed true to the type if grown from seeds.
- Inflorescence has 25 florets arranged on axis
- Sepals and petals are together called as tepals
- Ovary has 75 - 150 ovules
- Fruit is called as a capsule
- Cross pollination is done by bees

Species:

- There are about 226 recorded species scattered in Republic of South Africa.
- There are about 260 species and 30,000 varieties
- Varieties were evolved through conventional and mutation breeding in USA
- Other countries involved in breeding gladiolus are Netherlands, UK, Canada, Russia, Australia, Slovakia, Poland, Japan, New Zealand and India
- Gladiolus natalensis, G. cardinalis, G. communis, G. callianthus, G. arneus, G. recurvus, G. tristis

Gladiolus aureus

- Most striking golden yellow blooms in late winter and early spring
- Unfortunately, it is on the verge of extinction in the wild ***Gladiolus caeruleus***
- Fairly vigorous plant growing to about 18" high when in bloom
- Lower petals are cream colored and marked with many dark blue-violet spots

Gladiolus carneus

- Large flowered, late blooming species.
- Single spike has three buds with large light lavender pink florets
- Lightly ruffled floret had three prominent red-pink darts on the lip
- Flowers have little or no fragrance
- Sets seed when pollinated with Gladiolus tristis

Gladiolus huttonii

- Single slender leaf from which a graceful spike emerges
- The spike has 4 buds and all four flowers open at once
- The species has no detectable fragrance

Gladiolus miniatus

- Vigorous late spring blooming species
- Produces 10-12 bud spikes with medium sized light pink flowers
- Flowers last about four days and the color deepens over time
- Each flower has throat darts similar, but not as conspicous as Gladiolus carneus

Gladiolus teretifolius

- Graceful and very attractive species
- Zygomorphic bright red flowers look like butterflies
- No fragrance (typical with red flowered species)

Gladiolus priorii

- Very early blooming, almost leafless species
- At bloom it produces a sheath and flower stalk right from the start of growth
- Bright red florets bloom at once
- Flowers are somewhat spidery in form and have no fragrance

Gladiolus tristis

- A hardy easy growing species
- Typically 4-6 buds per spike
- Flowers are intensely fragrant, especially at night. The fragrance is similar in scent and intensity to that of a "Stargazer" lily
- Not self fertile, but sets seed readily when crossed with other species

Gladiolus watsonius

- Small plant producing a single round leaf
- Flower spike emerges from the base of the leaf

- Vigorous species
- Flowers are burnt orange in color with the center of the flower, especially the "hood" petal being a pale yellow with some veining of the orange color.

Gladiolus muriale

- Strongly scented and blooms very late in the summer, often just before frost in Northern areas
- Used to develop several hybrids with modern Gladiolus, the best known is 'Lucky Star'.
- Unfortunately the fragrance in the hybrids is not as strong as in the species, and is readily lost in further crosses to the grandiflora type hybrids, and in fact 'Lucky Star' was the only fragrant seedling produced

Other species

Gladiolus alatus, Gladiolus delanii, Gladiolus italicus, Gladiolus illyricus, Gladiolus imbricatus, Gladiolus klattianus, Gladiolus palustris, Gladiolus antakiensis, Gladiolus dubius, Gladiolus palustris Gladiolus flanaganii

Based on plant and flower characters - Six groups

Grandiflorus (large or exhibition type) - which grows to a height of 90 to 150cm with strong and erect stalks.

Primulinus - Florets - 5-9 cm; Spike 40-45 cm and growing to a height of one metre.

Butterflys - which are upto 1.25 metre, bearing medium – sized flowers spaced closely and marked with attractive blotches and throat markings; and miniature, growing to a height of 75 to 90cm with flowers 5 to 7.5cm across.

Miniature hybrids: Florets - 2.5-5 cm; Spikes 40 cm

Face up: Florets - 5-6 cm wide and face upward

Colvillei hybrids:

Varieties

Colour	**Variety**
Pink	America, Applause, Dawn pink, Deciso, Friendship, My love, Powder Puff, Pink, Cheer
Orange	Autumn Gold, Coral Seas, Fiesta, Setting sun, Orange Beauty, Orange Chiffon
Red	Black Prince, Hunting Song, Oscar, Victoria, Red Bantam, Redeem
Yellow	Anglia, Aurora, Folk Song, Golden Harvest, Golden Peach
White	Amsterdam, Classic, Cotton Blossom, White Friendship, Lipstick, Snowdrop
Purple, Violet	Blue Moon, Her Majesty, High Style, Mayru, Pusa Sarang, Pusa Shingarika All Aglow, Lavender Master-piece, Angel Eyes, Blue Bird
Green	Green bird, Green Giant
Cream	Cream Topper, Dew Drop
Buff	Royal buff, Royal Glimpse
Salmon	Frilled Champion, Summer Garden
Rose	American Beauty, Royal Brocade

Tan	Little Fawn, Tapestry
Smoky	Blue Smoke, Misty Eyes
Brown	Brown Beauty, Chocolate Dip

Some of commercial important cultivars belonging to different colour groups

- Pink - America, Dawn pink, Pusa Archana, Suchitra, Pink Friendship , Priscilla, Pink Perfection
- Green - Oasis, Green bay, Green bird, Green giant, forest glade
- Cream - Classmate, Cream topper, Dairy queen
- Yellow - Fatima, Royal gold, Nugget, Medusa
- Orange - Foxfire, Setting sun, Tangerine, Peters pears
- Buff - Adventure, Fashion, Happy birthday, Honeycomb
- Tan - Papoose, Table talk, Little fawn
- Red - Advance, Black prince, Eurovision, Oscar, Red batam, Red beauty, Victoria
- White - Classic, Snow princess, Moon frost, Snowdrop, Snow dust,
- Rose - American beauty, Mexicali rose, Upper crust
- Smoky - Autumn charm, Autumn sensation, Blue smoke, Cosmic
- Brown - Brown beauty, Little tiger
- Purple and violets - Her majesty, Mayur, Purple giant, Pusa sarang, Pusa shingarika, Pusa urmil

Some outstanding cultivars suited to Indian conditions

Eurovision, Snow princess, Rose supreme, Jacksonville gold, Suchitra, Peter pears, Mayur, White prosperty

Pink friendship, Jester, Subhangin

IARI, New Delhi

- Apple Bloom, George Mazure, Goelf Whiteman, Jo Wagenaar, Patricia, Pfitzer‘s Sensation and Snow Princess were the promising varieties
- All are recommended for northern plains

Regional Fruit Research Station, Shimla

- Anne Virginia, Blaur Domino, Cardinal Spellman, Double Frills of Pink, Exotic Double Sister Eliz, Fenny Lind, Florence Nightingale, Gold Dust, Hawaii, Hill Crest, Kenny, King Lear, La Paloma, Spic and Span were the promising varieties

IARI Regional Station- Katrain

Apollo, Candyman, Regency, Souvenir and Enchantress performed well

IARI Regional Station, Shimla

- Evaluation of large no. of varieties resulted in selection of 30 large flowered varieties viz.,

- Apple Bloom, Australian Fair, Blue Lilac, Camellia, Debonair, Fred Tucker, Friendship, George Wagenaar, Lady Killer, Life flame, Lincoln‘s Day, Old Gold, Oscar, Pactolus, Patricia, Prof.Goudrin, Rose Spire, Sam Smith, Scheherzade, Snow Princess, Stromy Weather, Sylvia, Thunderbird, Vink‘s Glory & Winter Gladioli
- 4 miniature var. viz., Canberra, Jolly Jocker, Pisttacinus Hybrid & Red Canna

IIHR, Bangalore

- Large no. of varieties were evaluated and recommended 11 varieties for commercial cultivation
- Beauty Spot, Cherry Blossom, Friendship, Jo Wagenaar, Melody, Picardy, Snow Princess, Tintorente, Tropic Seas, Watermelon Pink and Wild Rose
- All are recommended for Bangalore and other places with identical climatic conditions

Hortl. Experiment and Training Centre, Chaubattia

- Evaluated & recommended 9 varieties for commercial cultivation under UP hills
- Apple Bloom, Australian Dust, Australian Sunday Best, Friendship, Geliber Herald, House of Orange, Mazolia, Oscar and Prof.Goudrin

Punjab Agricultural University, Ludhiana

Emerald Queen, Melody & Snow Princess were recommended for cultivation in Punjab state

IARI, New Delhi

Suchitra – Sylvia x Jo Wagenaar

Neelam- Sylvia x Patricia

Anjali- Sancerre x Rose Spire

Archana- Creamy Green x American Beauty

Chirag- Cygnet x Little Fawn

Gunjan- White Oak x Oscar

Kamini- Ave x Christian Jane

IIHR, Bangalore

Aarti – Shirley x Melody

Apsara – Black Jack x Friendship

Darshan- Watermelon Pink x Shirley

Kum Kum- Watermelon Pink x Lady John

Meera – GP1 x Friendship

Nazrana – Black Jack x Friendship

Poonam – Geliber Herald x RN 121

Sagar- Melody x Wild Rose

Sapna – Green Woodpecker x Friendship

NBRI, Lucknow

Archana – Sylvia x Friendship

Arun – Sylvia x Fancy

Dhiraj- Beauty Spot x Psittacinus hybrid

Hans – Friendship x Gladiolus tristis

Indrani – Friendship x Gladiolus tristis

Kohra – Sylvia x King Lear

Manhar – Friendship x Gladiolus tristis

Manisha – Friendship x Gladiolus tristis

Manmohan - Friendship x Gladiolus tristis

Mohini - Friendship x Gladiolus tristis

Mridula - Friendship x Gladiolus tristis

Sanyukta - Friendship x Gladiolus tristis

Hortl Experiment and Training Centre, Chaubattia Chaubattia

Ankur – Oscar x Friendship

Chaubattia Arunima – Oscar x Mother Fisher

Chaubattia Shobhit – Meria Goretti x Tropic Seas

Chaubattia Tripti – Sunny Boy x Oscar

PAU, Ludhiana

Punjab Dawn- Suchitra x Melody

Punjab Morning- Sancerre x White Prosperity

Shan-e- Punjab- Suchitra x Melody

Hybrids from IIHR

Meera

- Cross from GP1* Friendship
- Flowers after 58 days of planting
- Florets show white – 18 per spike
- Vase life = 8 days
- Good cormel production
- Ideal for cut flower and garden display

Nazrana

- Cross from Black Jack * Friendship
- Production of flowers 57 days after planting
- Florets - cardinal red with barium yellow flash in throat - 18 per spike

- Vase life - 6 days
- Good cormel production
- Suitable for cut flower purpose

Poonam

- Cross from Geliber Herald R. N. 121
- Flowers after 61 days of planting
- Florets - Dresden yellow with Mimosa yellow blotch - 17 per spike
- Vase life = 7 days
- Excellent multiplier
- Tolerant to Fusarium wilt
- Good for cut flower and garden display

Sapna

- Cross from Green Woodpecker * Friendship Requires 54 days to flower
- Florets - barium yellow with primrose yellow blotch and mandarin yellow tinge on margins -17 per spike
- Vase life = 8 days
- Good for cut flower and garden display

Aarti

- Cross from Shirley * Melody Requires 70 days to flower
- Florets - poppy red with reddish purple and canary yellow blotch and mandarin red spots - 11 per spike
- Vase life = 6 days
- Butterfly type, suitable for flower arrangement

Apsara

- Cross from Black Jack * Friendship
- Flowers 45 days after planting
- Florets - ruby red with barium yellow flecks in throat - 18 per spike
- Vase life = 8 days

Varieties from IARI Agni

rekha

- Open pollinated seedling of cv. Sylvia
- Florets – fire red with saffron yellow blotch and scarlet stripes - 18 per spike
- Suitable for cut flower purpose Mayur
- Open pollinated seedling of cv. Sylvia

- Late flowering
- Florets - lilac purple with dark purple throat - 20 per spike .Suitable for cut flower and garden display

Suchitra

- Cross from Sylvia * Jo Wagenaar
- Florets - camellia rose with stripes of vermilion and dianthus purple blotch - 22 per spike
- Good for cut flower purpose

Varieties from NBRI Mukta

- Hybrid from the same cross
- Flowers 90 - 120 days after planting
- Florets - Sulphur yellow throat - 12-15 per spike

Archana

- It is a cross between G. psittacinus 'Sylvia' x G. 'Friendship'
- The spike is branched with a mean spike length of 80cm
- The petals have a central white streak with the throat blotched with prime rose yellow
- There are 16 - 18 florets / spike

Basant Bhar

- It is a seedling produced by selfing G. 'Tunias Challenge'
- Mean spike length is 50cm
- The florets are Empire Yellow with throats speckled magenta
- There are 14 florets / spike

Gazel

- It is a seedling produced by selfing G. 'White Friendship'
- Mean spike length is 35cm
- The florets are Fuchsine pink with darker tips and linear shading while the throat is persian yellow
- There are 14 - 18 florets / spike

Jwala

- It is a seedling produced by Selfing G. psittacinus hybrid
- The spikes are branched with a mean spike length of 65cm
- The florets are Vermilion with sparingly spread long liner streaks of Vermilion ○ There are 14 - 18 florets per spike

Manmohan

- Cross from Friendship * G.tristis
- Blooms 80 - 120 days after planting
- Spikes are one sided

- Florets - primrose yellow - 14-16 per spike

Manohar

- Developed from the cross Friendship * G. tristis
- Florets - orchid purple and at tips orchid purple with primrose yellow throat – 14 - 16 per spike

Manisha

- It is a cross between G. 'Friendship' x G. 'tristis'
- The spikes are one sided with a mean spike length 60cm
- The florets are white with outer three petals splashed with Tyrian Rose colour more towards margins
- There are 14 -16 florets per spike

Pitambar

- It is a cross between G. 'Friendship' x G. 'tristis'
- The spikes are branched with a mean spike length 64cm
- The florets are Uranium Green towards edge with throats having a streak of Orchid purple colour
- There are 15 - 16 overlapping florets per spike

Smita

- It is an Indian bred late season hybrid developed from a seedling of G. 'Lavanesque'
- The mean spike length is 45 cm
- The florets are China Rose in colour with darker margins
- There are 14 - 18 florets per spike

Triloki

- It is an Indian bred late season hybrid developed by crossing G. 'Friendship' x G. 'tristis'
- The spikes are one sided with a mean spike length of 75cm
- The florets are China Rose in upper half portion and Primrose Yellow in the lower half
- The petals have splashes of China Rose along the margins
- There are 14 - 15 florets per spike

Aldebaran

- It is an exotic variety having a mean spike length of 62cm
- The petals are Straw Yellow in colour with throat blotched with Signal red colour
- There are 12 - 14 florets per spike

Mutation Breeding

Gladiolus cvs. Sylvia & Eurovision produced more spike length, rachis length, no. of florets/ spike & flower diameter by radiation with gamma rays at 20-80 Gy

Sl. No.	Mutant	Type of mutation	Remarks
1.	Salmon‘s sensation	Spontaneous mutation	Petals has Salmon Scarlet ring and the petal joints had red streaks (Misra,1975)
2.	Ratna‘s Butterfly	Spontaneous m utation	All the petals has violet colour with lighter flaking in between on the upper half portion (Misra,1982)
3.	Wild rose	Physical (1KR) mutation	Variety named as _Shoba‘. Florets shel pink with empire yellow throat, 18/spike (Raghava *et al.*, 1981)
4.	Cormels of Scarlet	Physical (1KR) mutation	Slight earliness in sprouting, increase in uptake, rise in sugar content

Classes of Gladiolus:

On the basis of floret size, gladiolus has been put into 5 classes, the description of which is as follows:

Class	Designation	Floret size (cm)
100	Miniature	< 6.4
200	Small or miniature	≥ 6.4 to < 8.9
300	Decorative	≥ 8.9 to < 11.4
400	Standard or Large o 14.0	≥ 11.4 t
500	Giant	> 14.0

Climatic requirement:

- Gladioli require full exposure to sunlight for better crop, otherwise blasting may occur or plants may remain blind.
- The long day conditions of 12 to 14 h photoperiod increase number of florets, spike length and percentage of flowering.
- Low light intensity causes failure in flowering.
- High light intensity without proper temperature also affects growth adversely.
- 20 to 30°C accelerate flowering up to 55 days
- Corm storage at 3 to70C is good for better growth and flower production
- Growth and flowering Environmental factors

Light **Photoperiod**

- Earlier flowering 12 h light
- Lengthening the day with artificial light in the winter months increased flower production.

- Shortening the length of day-light period (SD) caused a decrease in either flowering percentage or the number of florets per spike.

Light intensity

- Gladioli prefer high light intensities
- Very high intensities without provision for temperature control adversely affect growth ○ Low light intensity is the main cause for failure in flowering of gladioli.
- Low light intensity during winter lead to serious flower bud abortion during greenhouse forcing of gladiolus.

Temperature

- Temperature was the major factor influencing the number of days to flowering.
- Increased occurrence of flower blasting chilling injury under low light intensity in winter at low temperature of 1-4oC.
- Occurred immediately after planting and at the 7th leaf stage when spike emergence began.
- Variations in response to temperature have been reported in cultivars.

Soil Requirement:

Gladioli can be grown in wide range of soils. The soil should have proper drainage facilities. It should also contain sufficient organic matter. The soil should be sandy-loam and slightly acidic with pH 5-8

Land Preparation:

- Bed size - 6 x 2 meters
- Planting - October in plains and March-April in hills
- Depth of planting - 5 to 10 cm
- Row to row distance is - 40 cm - Plant-to-plant - 15 cm
- Requirement of corms per ha. roughly 1-1.5 lacs

Propagation:

Gladiolus can be propagated through (i) Corms (ii) Cormels (iii) Seeds and (iv) Tissue culture

1.Through Corms

- Propagation of gladiolus through corms is a commercially used method ○ Corm size is 2.5 cm diameter.
- A single corm produces on an average of 1 to 3 flowers along with daughter corms in a season depending upon its size and the variety.
- 10-50 cormels can be obtained from a single corm.

2.Through Cormels

- Cormels from corms are used as planting material.
- The multiplication of gladiolus through cormels is an inexpensive and rapid method which enables build up of large stocks with minimum cost.

- The cormels also tend to escape diseases of viruses even if the parent corm is infected.

Time of Planting of Corms:

- North Western Plains – October (first fortnight)
- Staggered planting can, however, be done at 10-15 day intervals from mid-August to mid- December to get continued supply of spikes over a longer period and to match the market demand.
- In temperate climates, the corms are planted after the winter, i.e. in March and April when frosts are over and climate becomes warm.

Planting of Corms:

- Only the non-dormant corms should be planted
- The emergence of root buds at the base of the corms shows that the corms are ready for planting.
- The corms should be suitably treated with fungicides before planting.
- When planting, the lower portion of the corm should be placed on the soil such that the bud at the top lies straight above.
- It is done to make sure that the stem grows erect and does not show crooked growth.
- At planting time, the soil should contain sufficient moisture to facilitate uniform sprouting of corms.
- The depth of planting depends more on the size of the planting materials. The medium and smaller sized corms are generally planted upto 7 cm deep while large or jumbo corms to a depth up to 15 cm.
- Planting is carried out during October in plains and March-April in hills.
- The row to row distance is normally 40 cm while plant-to-plant is 15 cm.
- The requirement of the corms per hectare is roughly 1, 50,000-2, 00,000.

Irrigation:

- Gladiolus requires water in plenty but does not grow well under water-logged conditions.
- Frequency of irrigation depends upon the soil type, weather conditions and rainfall.
- Normally in sandy soils, the crop should be irrigated at 7-10 day intervals, whereas in heavy soils, at less frequent intervals.
- Irrigation should be withheld at least 4-6 weeks before lifting of corms.

Staking:

- Especially large-flowered varieties of gladioli grown outdoors are susceptible to lodging, hence need staking.
- The stems should be tied with strings to thin but strong supports

Weed Control:

- Pro-emergence herbicides reported for gladiolus are diuron (0.9 kg/ha) (or) linuron (3.0 kg/ha)
- Post-emergence herbicides, 2, 4-D @ 1.5-3.0 kg/ha has been found to reduce weed population.

Nutrition:

- Commonly a 12:12:18 N:P:K compound fertilizer is applied prior to planting at 1 ton per hectare.
- Gladiolus can be damaged by fluorine and phosphatic fertilizers containing fluorine should not be used.
- The crop can be top dressed as required with calcium nitrate at an application rate of 200- 300 kg per hectare.

Growth regulators

- Friendship corms - Soaked in GA3 at 10 or 25 ppm - early sprouting of corms, increased plant height
- Sylvia - 3 applications of GA3 - increased plant height, spike quality in number and size of florets
- Ethylene - activate dormant or inhibited buds - increased flowering

Grading and Packing

International grades for Gladiolus

Grade	Spike length (cm)	No. of Florats/Spike
Fancy (Blue) (grade A)	>107	16
Special (Red) (Grade B)	96-107	14
Standard (Green) (Grade C)	81-96	12
Utility (Yellow) (grade D)	<81	10

Care of Spikes in Vase

- Spikes pulsed with 20 % sucrose + 8-HQC (200ppm) or Aluminium sulphate (300 ppm) or Sodium hypochlorite (50 ppm) for improving vase life
- Holding solution - 4 % sucrose + 8 HQC (200 ppm) or aluminium sulphate (300 ppm)

Post harvest quality requirements

- Straight and strong stems
- Uniformly spread florets
- Turgid florets facing in one direction
- Proper colour of the flower and freshness
- Foliage with proper length and free from damage
- Petals free from discoloration
- Opening of florets - uniform

Floral preservatives

- Chemical formulation used to extend vase life of flowers

Contain 2 basic components

- Sugars - provide extra food for spikes and keeps the stem turgid
- Biocide - checks the microbial growth at the surface of the spike and vase water

Biocides

- Commonly used biocides for gladiolus are
- 8-hydroxyquinoline citrate (8- HQC)
- Physan - 20
- Aluminium sulphate
- Sodium hypochlorite and bleach solution
- Ethylene Sensitivity Although exposure to ethylene does not affect the life of open florets, it can reduce the flower life by causing abortion of unopened buds

Preservative can be used as

- Pulsing solutions
- Holding solutions
- Bud opening solutions

Pulsing solutions

- Short term transit treatment
- Given for 20 - 24 hrs at moderate temperatures (20-35 ^{o} C) and good light
- High levels of sucrose
- Effective tight bud stage
- 8HQC can be replaced by Aluminium sulphate (300 ppm) , NaoCl (50 ppm) or a combination of both
- 10 minutes impregnation with AgNO3 (1000ppm) - pulsing with sucrose (20%) for – effective for gladiolus

Holding solution

- Cut spikes can be permanently put in a preservative solution
- Composition - same as pulsing solution
- Sucrose content - low
- Sucrose (4%) + Aluminium sulphate (300 ppm) / Sodium hypo chloride (50ppm) - opening of florets, improving vase life

Bud opening solutions

- Specific bud opening solutions - not required
- Pulsing/ holding solutions can be used for this purpose

Harvesting of Spikes:

- Gladiolus takes 60-120 days to produce spikes from the corms to become mature and ready for lifting.
- Plant growth stops at this stage
- The spikes of gladiolus generally exhibit vase life of about 7-15 days.
- The spikes should be harvested in the morning or evening hours when temperatures are mild.

- Spikes should preferably be cut with sharp knives or secateurs.
- While harvesting, at least four basal leaves should be retained on the plant to ensure proper development of corms and cormels.
- The stage at which the spike is to be cut should depend upon the transportation distance, consumer requirement and prevailing temperature conditions
- Irrigations should normally be withheld at least 2-3 weeks before harvesting of corms.
- In India, lifting of corms is carried out manua lly with smal garden forks or ―khurpas‖.
- After lifting the corms from the soil, the upper leafy portions should be removed by twisting and breaking the stalk.
- The old withering mother corms attached to the bottom of the newly-formed corms should also be removed similarly with the thumb.
- The cormels should also be separated simultaneously and handled separately.
- The corms usually get damaged or bruised during harvesting and cleaning operations.
- The corms should be cleaned, dipped for 30 min in 0.3% Captan 50 WP and shade-dried at an aerated place for about 15 days.
- Corms are then packed in crates or in net bags and cold-stored at 3-7oC.
- From cold storage, these corms should be taken out one month prior to planting and kept at ambient conditions at an aerated place.
- The corms or cormels of different cultivars must be handled separately and labeling properly so that they do not get mixed up.
- Before planting, these are once again dipped for one hour in 0.3% Captan solution

Disorders

- Fluoride injury has been observed in gladioli.
- Water used for cut flowers should also be low in soluble salts (Waters, 1966, 1968) and free of dissolved fluorides.
- As little as 0.25 ppm fluoride is detrimental for certain cultivars.

Packaging

For local markets spikes may be taken submerged in water

For distant markets.

- Carried dry in cardboard or wooden boxes or in trunks and this way these can easily be retained for 12 hours
- These rectangular boxes may be prepared having 1.2 metre length, 60cm width and 30cm height, perforated at several places for circulation of air.
- Bundles of 50 to 100 spikes are prepared for air lifting in the perforated and lightproof cardboard boxes.
- The upper portion of the spikes may bend downwards if cardboards are not kept vertically.

- One floret ordinarily lasts four days and generally one floret from bottom to top opens every day

Storage

- Gladiolus spikes of cv. White Friendship, wrapped in polythene or kraft paper placed in cartons, were subjected to simulated condition at 4.4oC (40oF) or 10oC (50oF) for 3 days.
- They were than held at 23.3oC (74oF) either in water or in 400ppm hydroxyquinoline citrate (8HQC) + 3% sucrose.
- Floret opening in gladiolus improves by controlled atmospheric storage with 1 per cent O2 and 5 per cent O2 for 6-8 days.
- The storage of flowers can also be extended to over 30 days by low pressure storage techniques.

Corms and cormels Curing

- After lifting and removing the adhering soil, the corms and cormels of each cultivar are kept in trays in a shady but well ventilated place for about a fortnight.
- Corms and cormels are washed after topping.
- These should be dried quickly with the aid of warm dry air or blower but the temperature should never exceed 30ºC

Cleaning and grading

- Fully cured, corms are cleaned diseased ones are discarded.
- Treatment with 0.02 per cent or 0.2 per cent captan 15 days before storage

TUBEROSE

Importance and uses-origin and history-distribution-area and production-botany - species and varieties propagation- season and planting-nutrition and irrigation soil climate – management practices – nematode management -role of growth regulators- plant protection harvest and yield.

Introduction:

- Tuberose (Polianthes tuberosa L.), belonging to the family, Amaryllidaceae
- Chromosome No n = 30
- Single cultivar : 2n=60, fertile
- Double cultivar : 2n=50, infertile
- The generic name Polianthes is probably derived from the greek polios‘ shining or white, and anthos‘, a flower, in alusion to the blooms of the common tuberose and species tuberosa‘, the plant being tuberous in nature. The name, therefore, is tuber-ose, not tube- rose.

Pollination: cross pollination

- It is a half hardy erect perennial herb with fibrous roots, 60 – 120 cm high with stout and short bulbs, leaves basal 6 – 9 in number, 30 – 45 cm long, linear, grass like, hairless, smooth edged or minutely toothed, channeled bright green with reddish tinge near the base, flowers numerous, 4 – 6 cm long, funnel shaped, waxy white, filaments attached on upper part of the corolla, fragrant and borne in pairs on erect leafy flower stalks called scape
- Bulbs are made up of scales and leaf bases and the stem is a condensed structure which remarks concealed with is scales.

Important and Uses

- Tuberose is one of the most important bulbous ornamentals of tropical and sub-tropical areas.
- People all over the world realize that flowers enhance the quality of life and human feelings more than words or other gifts, which results in increased use of flowers and ornamental plants.
- Its blooms are mainly used for making garlands, bouquets, floral ornaments for bridal makeup and other floral arrangements and buttonholes and the long spike of flowers is excellent for table decoration.
- The variegated ones with beautiful golden stripes on foliage margins are very attractive and suitable for garden display.
- The fleshy, white, tubular flowers emit a strong odour and hence are cultivated on a large scale in some parts of the world for the extraction of highly valued natural flower oil, the tuberose oil.
- The tuberose flower oil of commerce is one of the most sought after and expensive raw materials in perfumery.
- The fresh flowers give a concrete yield of 0.08 to 0.11 %, of which nearly 18 to 23% constitutes the alcohol-soluble 'absolute'.

- The essential oil is used in only the highest grade perfumes. Sometimes, the oil is used in flavouring candy, beverages and baked food.

Origin and Distribution:

- The tuberose is a native of Mexico.
- It is grown largely in the southern states of America, Italy, France, Morocco, South Africa, Taiwan, Egypt and many other tropical and subtropical areas in the world.
- The word tuberose is derived from tuberose. This plant is being the tuberous hyacinth and distinguishes from the bulbous hyacinth.
- In India, tuberose is cultivated on a commercial scale in Ranaghat, Kolaghat and Panskura in West Bengal,
- Devanahalli, Tumkur and Mysore in Karnataka;
- East Godavari, Guntur, Chittoor and Krishna districts of Andhra Pradesh;
- Coimbatore in Tamil Nadu and
- Pune and Thane in Maharashtra

Species and Varieties:

- There are about fifteen species under the genus Polianthes, of which twelve species have been reported from Mexico and Central America.
- Of these, nine species have white flowers, one is white and red and two are red.
- Except Polianthes tuberosa L., all the others are found growing wild.

Species

1. ***Polianthes tuberosa*** : An erect herb, flowers funnel shaped, waxy white, the tube bent only near the base, filaments attached on upper part of corolla
2. ***P.palustris*** : This species was collected in swamps on the western foothills flowers in 3 to 5 pairs arising from single bracts;
3. ***P.durangensis*** : Collected on the west slope of the last range of the Sierra Madre in the state of Durango. Flowers arranged in one to six pairs are all sessile, becoming flowers white, become purplish with age.
4. ***P.montana*** : Flowers are short with lobes small, erect and rounded white flower
5. ***P.longiflora*** : Flowers in three to five pairs. Perianth is white tinged with purple colour.
6. ***P.platyphylla*** : Florets are arranged in four to seven pairs with white flower tinged with red colour. Natural crossing of the wild red and white species of tuberose.
7. ***P.graminifolia*** :Deep red species common in Mexico found by Rose in 1987.
8. ***P.geminiflora*** : Flowers are light orange-red in colour and arranged in pairs of 6 or more
9. ***P.gracilis (P.tuberosa var. gracilis)*** :

This species is supposed to be Mexican and is distinguished by slender habit and narrower leaves. Perianth tubes are long and slender. Possibly this was the original form of P.tuberosa.

10. ***P.blissii*** : flowers white & red

11. ***P.pringlei*** : Fragrant and white flower turning purplish on drying

12. ***P.sessiliflora*** : Plants produce flowers of white colour.

13. ***P.nelsonii :*** Flowers are white in colour.

Polianthes tuberosa

There are three types of tuberoses named on the basis of the number of rows of petals they bear. They are, Single, Semi-double, Double and variegated,

Single type.

- Cultivars having flowers with one row of corolla segments.
- Flowers are extensively used for essential oil extraction and also for loose flowers.
- Single types are more fragrant than double.
- Also the per cent seed setting is high in single.
- Its floral buds are greenish white.
- Flowers are pure white with only one row of corolla segment.
- Concrete content has been observed to be 0.08 to 0.11 per cent.
- Loose flowers are used for making floral ornaments.
- Calcutta Single and Single Mexican the single varieties, are being grown in Tamil Nadu.

Single type varieties

Calcutta Single, Mexican Single, Kalyani Single, Hyderabad Single, Phule Rajani, Prajwal, Rajat Rekha, Shringar are main varieties.

Rajat Rekha

Single flowered type with silvery white streak along the middle of the leaf table. It is a mutant evolved by irradiating bulbs of single flowered cultivar. Concrete content has been found to be 0.089 per cent. It has been released by the National Botanical Research Institute (NBRI), Lucknow

Shringar:

- This variety has been developed form a cross between Single x Double‘ from IIHR, Bangalore.
- It bears single type of flowers on sturdy spikes.
- The flower bud is slightly pinkish tinged.
- Florets are bigger and appealing than Calcutta Single‘.
- Resistant to Meloidogyne incognita nematode.
- Loose flowers are ideal for making garland, while spikes can be used as cut flower.
- Yield of loose flowers is about 1500 kg/ha per year, which is 40% higher than _Calcutta or

Mexican Single‘ and the concrete content of the Hybrid is at par with Mexican Single. Shringar is preferred by farmers and perfumery industries.

Prajwal:

- This hybrid from the cross Shringar‘ x Mexican Single‘ from IIHR, Bangalore.
- The flower buds are slightly pinkish in colour while the flowers are white.
- The individual flowers are large in size, compared to Local Single‘.
- It yields twenty per cent more loose flowers than Shringar‘.
- Recommended both for loose flower and cut flower purpose.

Arka Niranthra

- It is an single type, bold flower and highly suitable for loose flowers. It has been released by IIHR, Bangalore.
- Semi-double type
- Flowers with 2-3 rows of corolla segments on straight spikes used for cut flowers

Vaibhav:

This hybrid which bears semi-double flowers on medium spikes is from the cross Mexican Single‟ x IIHR-2. The flower buds are greenish in colour in contrast to pinkish buds in Suvasini‘ and Local Double‘. Flowers are white. Spike yield is 50 per cent higher compared to Suvasini‘. Hence, recommended for cut flower purpose.

Double type

- Flowers with more than three rows of corolla segments on long and sturdy spikes used as cut flower as well as loose flower and for extraction of essential oil.
- Concrete recovery has been found to be 0.06%.
- The double type of tuberose is previously known as pearl.
- It does not open well and is not commercially viable as the single cultivar.
- The flowers tinged with red in the 'Double' type are known as 'Pearl'.
- There are some streaked leaf-forms, known as 'variegated',
- In others the flowers have little tinge of red in the bud-stage, which turns to white when fully open.

Double type varieties

Calcutta Double, Hyderabad Double, Kalyani Double, Pearl Double, Swarna Rekha, Suvasini

Swarna Rekha

Double flowered type with golden yellow steaks along the margins of leaf. It is a gamma ray induced mutant, in which mutation occurred in chlorophyll synthesis resulting in change in leaf colour. Concrete content has been found to be 0.062 per cent. It has been released from NBRI, Lucknow.

Suvasini:

- A multi whorled variety developed form the cross between Single x Double hybridization from IIHR, Bangalore
- Pure white flowers are bold and big, borne on a long spike.
- Spikes are best suited as cut flower.
- Suvasini recorded 25% more yield than cv. Double.
- IIHR, Bangalore has also evolved two more new varieties of tuberose namely Prajwal and Vaibhav recently.

Propagation:

Bulbs are used for commercial propagation. In general, bulbs having diameter between 1.5 and 2.5 cm with 25-30g weight are planted (1.25-1.5 lakh bulbs/ha) having 800-900 kg are required for planting one hectare. On the sides of ridges at 45 x 20 cm spacing are planted during June – July at a depth of 2.5 cm. Bulbs are planted after 30 days of harvest. Dip the bulbs in 5000 ppm CCC (5 g/lit) before planting to increase the yield.

Seed treatment

These bulbs are first thoroughly cleaned and treated with Bavistin (0.2%) for 30 minutes. Dipping the bulbs in 4% solution of thiourea can break the resting period. Pre-plant storage of bulbs at 10°C for a period of 30 days to improve the plant growth, increased spike and flower yield. Preplanting treatment of bulbs with GA3, ethrel or thiourea promoted early appearance of flower and produced highest number of longer spikes with maximum number of florets.

Dormancy breaking

The bulbs remain dormant during the winter months in places where the temperature is low and, If early planting is desired, the dormancy can be successfully broken by dipping the bulbs in 4% Thiourea solution for one hour. Ethylene chlorohydrins can also be used for breaking the dormancy. The bulbs are separated from the clumps by rubbing off the loose scales and the long roots should also be removed. Spindle-shaped bulbs with a diameter of 2.6 to 3 cm size are used for planting.

Soil

Tuberose can be grown on wide variety of soils from light, sandy loam to a clay loam. The soil should be at least 45 cm deep, well drained, friable, rich in organic mater and nutrients with plenty of moisture in it. The soil should have a pH range from 6.5 to 7.5 with good aeration. The crop can be grown even in high saline-alkaline soils with better agronomical practices. It is observed that the vegetative growth and flowering are affected by increasing the levels of NaCI and very a low concentration of CaCI2.

Climate

The crop is best suited for cultivation in tropical to subtropical and temperate climates. The crop is reported to flower profusely throughout the year, if the climate is mild and free from extremes of high and low temperature. In India, commercial cultivation of tuberose is confined to warm humid areas with average temperature ranging from 20-30°C is considered ideal for this crop. If the temperature is above 40°C, the spike length and quality of the flowers are affected. Very low temperature and frost will damage the plants and flowers. Tuberoses grow well in a sunny situation. Although the plant is photosensitive, exposure to a day-length of about 16 hours appreciably promotes vegetative growth and enhances the emergence of the first flower-spike by 10 days. The length of the flower-spike also increases under long days. Tuberose is also grown in hilly areas up to 1200 to 1500 meter height.

Selection of site

For proper growth and high yield of tuberose it is better to choose a place having plenty of sunlight. Tuberose should be grown in well drained place as it cannot tolerate water logging even for a short period. Soil should be thoroughly prepared and clods should be broken properly. Decomposed organic matter or well rotten cow dung manure or FYM should be thoroughly incorporated into the soil.

Land preparation

The land is ploughed deep, twice, to a depth of 45 cm. The first ploughing is done in January and the second about a month before planting. At the time of the second ploughing apply FYM @ 20-50 t/ha and incorporate into the soil.

Planting

The density of planting markedly influences the yield and quality of the flowers. The planting distance varies with the soil and climatic conditions. About 1, 00,000 to 2, 00,000 bulbs are required for planting one hectare of land. A spacing of 15 x 20 cm (Maharashtra), 25 x 25 cm (West Bengal), 30 x 30 cm (Lucknow), 30 x 22.5 cm (Bangalore) and 20 x 20 cm (for other part of South India) have been recommended for this crop. While planting, the bulbs are planted at the recommended plant-spacing, 3.5 cm deep on the sides of the ridges. The plots are irrigated immediately after planting.

Light:

- Tuberose although not strictly photosensitive, long-day exposure promotes vegetative growth as well as early emergence of the first flower spike and also increases the length of flower spike.
- A day length of 16 hours promoted growth and flowering.

Effect of growth regulators

The effects of pre-planting treatment of bulbs with GA3, ethrel or thiourea promoted early appearance of flower and the number of flower spikes but reduced the number of bulbs per plant. Foliar application of GA3 at 50 to 100 ppm thrice at 40, 55 and 60 days after planting. Treatment with GA3 (200ppm) produced highest number of longer spikes with maximum number of florets.

Micronutrients: Foliar spray of ZnSO4 0.5% + FeSO4 0.2% + Boric acid 0.1% **Season of Planting:**

Tuberoses are generally planted in February-March in the plains and April-May in the hills. The bulbs can also be planted during July- August. It can be planted all year round in Bangalore, but a higher flower-yield is obtained from the April-May planting. To obtain flowers almost throughout the year, sequential planting can be practiced.

Nutrition

Tuberose is a heavy feeder and highly exhausting crop, responds well to the application of organic and inorganic nutrients. In general, a basal dose consisting of FYM @ 10kg/sq.m., single superphospate and muriate of potash each @ 80 g/sq.m., 10-15 days prior to the planting of bulbs is recommended. Fertilizer application @ 200 kg N, 400 kg P2O5 and 200 kg K2O per has been recommended. Of the full recommended dose of fertilizers, half the N, the full dose of P and K has to be applied at the time of planting and the remaining half of N is given as a top-dressing after 45 days of planting. Apart from N, P and K, calcium, magnesium, sulphur, iron, zinc, manganese, aluminium, boron and copper have also been found to influence the growth and flowering in tuberoses.

Inter-culture:

- In order to keep the plots free of weeds and to avoid the exposure of bulbs, the plots are weeded and earthed-up once a month.

Earthing-up enables the spikes to grow erect, despite strong winds and rains.

The application of Atrazine (@ 3 kg/ha) as a pre-emergent weedicide keeps the plots weed- free.

- A pre-emergent treatment of Gramaxone (@ 3 kg/ha) followed by three post- emergent sprayings at intervals of 110 days in between the rows also keeps the crop weed free.

Mulching the plots with strips of black polythene, dried grass and chopped straw is effective in controlling weeds.

- The flower-spikes should be supported by stakes after about 2 1/2 months of planting.

Pest Management

The important insects are thrips, aphids and weevil. Thrips and aphids are controlled by the spray of Rogor or Metasystox @ 1.75 to 2.0 ml/litre. The weevils can be controlled by the spray of Thiodon @ 2.0 mg/litre.

Bud borer *(Helicoverpa armigera)*

This can be controlled by the spray of endosulfan (0.2%), monocrotophos (0.2%) or Thiodan (0.5-0.8%).

Nematodes

Tuberose is damage by nematodes and resulting extensive yield losses. Nematodes like root knot nematode (*Meloidogyne incognita* and *M. javanica*) and reniform nematode (*Rotylenchulus renioformis*) and also greasy steak nematode caused by ***Aphelencoids besseyi*** are reported to cause damage to the crop, which is characterized by the stunted growth of the plants. The leaf size is reduced and the flowers look sickly and, ultimately, the roots rot. The application of Thimet or Furadan (20 kg/ha) to the soil has been recommended for control or application of Furadon @ 2 g/plant or carbofuran @ 2-5 kg/ha, neem @ 1 tonne/ha controls nematode infestation.

Disease Management Stem rot

The disease symptom is preceded by the appearance of prominent coarse mycelial masses on leaf surface at or near the soil level. The infection is caused by Sclerotium rolfsii. The disease can be controlled by soil application of brassicol or Zineb (20%) at the rate of 30 kg per hectare.

Also, the incidence can be minimized by reducing soil moisture or planting at wider spacing.

Flower Bud rot

It is caused by Erwinia sp. Results in dry rotting of the buds with brown surched necrotic discoloration of peduncles. The diseased plants should be uprooted and destroyed. The disease can be controlled by the spray of Streptomycin (0.01%)

Leaf blight or Botrytis blight

Fungal disease caused by Botrytis elliptica. The disease can be controlled by spraying the plant with ammonical copper (2%) or Greeno (0.5%). The treatment should be repeated at 15 days interval.

Alternaria leaf spot

The fungi, Alternaria polyantha, causes leaf-spot disease, which is characterized by the appearance of brown spots with faint concentric rings on the mid-rib. Bordeaux mixture (0.4%), Zineb or Ziram (0.5%) and Mancozeb (0.2%) or Iprodione (0.2%) spray will effectively control the disease by the spray of at 10 days interval.

Harvesting and Yield:

The yield of loose flowers/spike depends on variety, planting distance and climate condition prevailing in the area. One hectare of tuberose plantation yield 4-5 lakhs of spikes per year from single varieties, 10.5 tonnes/ha of loose flowers may be harvested. In addition, 20 tones/ha of bulbs may be harvested after 2-3 years.

- Flowering of tuberose starts 80 to 100 days after planting and flowering time is July onwards
- Tuberose flowers all the year round but August-September is the peak period of flowering
- Spikes are harvested at bud-burst stage preferably in the morning before sunrise or late in the evening by clipping with a sharp knife or secateur that gives a clean cut.

- Depending on the purpose, harvesting is done by cutting the fully-opened spikes from the base or single flowers are harvested as they open by day; the picking of individual flowers should be completed by 8.00 a.m.
- The flowers have a shelf-life of 3 days.
- About 4-6 cm basal portion has to be left to allow the growth of bulb.
- The lower portion of the cut spikes immediately after harvest, are to be immersed in water for prolonging life of spikes.
- For loose flower purpose individual flowers are plucked early in the morning and usually packed in bamboo basket which can hold about 10-15 kg of flowers.
- The flower yield ranges from 150 to 200 quintals per hectare in the first year, 200 and 250 quintals per hectare in the second year and 75 to 100 quintals per hectare in the third year.
- Flowers yield up to 17-18 t/ha can be expected from a well-maintained crop.

Handling and Packing of Flowers

- Loose flowers are transported in poly bags to the nearby whole sale market.
- The flower spikes are graded according to spike length, length of the flowering zone and quality of individual flowers
- Bunched in round bundles each having about 50-100 spikes

  The stem portion of the bundle has to be wrapped with news paper.

  To avoid damage of the flowers and buds, the whole bundle may be wrapped with soft, white tissue paper or polythene.

- Bundles have to be packed in card- board boxes for long distance transportation.

Grading

- The flower spikes are graded according to the stalk length, length of rachis, number of flowers per spike and weight of spikes.
- Straight and strong stem of uniform length and uniform stage of development are preferred.
- Flowers should be free from bruises and diseases and pests.
- Florets are graded according to their size for loose flowers.

Packing and Transport

For room decoration, long spikes are preferred and are sold in bundles. Each bundle contain 100 spikes. To avoid damage of the flowers and buds, the whole bundle should be wrapped in soft, white tissue paper or polythene. These bundles are packed in rectangular bamboo baskets lined with Hessian cloth.

For long distance transport, they are packed in square boxes or airy baskets but packing in cardboard boxes is more suitable which can be easily transported by rail, bus or by truck. Loose flowers are packed in bamboo

baskets holding about 10-15 kg flowers and the baskets are covered with muslin cloth and are transported to the nearby wholesale market where they are sold by weight.

Storage of Flowers

The fresh flowers can be stored at 100C.

Holding solutions

A holding solution consisting of sucrose 2% + Al2 (SO4)3 300 ppm was found best for increasing the post harvest life and quality of cut spikes of tuberose

Extraction of Essential Oil

- The flower oil is extracted by effleurage and solvent extraction with petroleum ether. Freshly picked flowers, before they open are effleuraged. About 150 kg of flowers yield 1 kg of the brown, semi-solid absolute of Enfleurage which contains 11-15% of steam volatile oil. Extraction of tuberose flowers with petroleum ether yield 0.08 – 0.14 per cent of concrete.
- In recent years, the process of Enfleurage has been partly replaced by solvent extraction, which requires much less labour though the yield of the absolute reduces considerably.
- The extraction of the tuberose flowers with petroleum ether yields 0.08-0.11 % of concrete, which gives 18-23% of absolute on treatment with alcohol and contains 3% steam distillate.

  The concrete yield is about 17-18 kg/ha which gives 3.5 kg absolute and 0.8 kg distillable oil.

  The concrete contains 3 – 5 per cent of a steam volatile oil.
- Out of the approximate total yield of 30,000 kg of loose flowers from one hectare, in three years, 27.5 kg of concrete‘ could be obtained.
- This concrete in turn will yield about 5.50 kg of absolute. One hectare of tuberose plantation may yield upto 12 kg of concrete.

Ratooning

In November-December, when the temperature drops, the leaves of the plants turn yellow and die and the plants undergo dormancy. Digging of bulbs should be done at this stage. With the increase in temperature the crop regains growth from the previously planted bulbs which is termed as ratooning. The ratoon crop results in more number of spikes but reduces number of florets, length of spikes and weight of flowers. Therefore, ratoon crop should be used only for loose flower or oil extraction purpose.

For ratooning in tuberose, the yellowing plants should be twisted from the ground level which leads to early maturing of bulbs. For the proper growth and development of plants, fertilizer dose as given in the main crop should be applied in two equal split doses in January-February and April. All other cultural practices should be done as in case of main crop. There is early flowering in ratoon crop as compared to main crop

Lifting, Curing, and Storage of Bulbs

- Bulbs reach maturity at the cessation of flowering when the leaves become yellow and dry during winter (February-March) in North India.
- At this stage, irrigation is withheld and the soil is allowed to dry.
- The leaves are cut off at the ground level and the bulbs are dug out.
- After digging, the bulbs are lifted out and the adhering earth shaken off neatly and thoroughly.
- The offsets are then separated out by hand, which are used as seed-stock for the next season.
- The bulbs are the graded based on the size into mature (> 1.5 cm diameter) and immature (< 1.5 cm diameter).
- Cleaned and graded bulbs are placed on sheives to dry or cure.
- To hasten curing, artificial heat of 27 to 350C may be applied.
- The bulbs must be stirred or have their position changed every few days to prevent fungal attack and rotting.
- An ambient air temperature of at least 180C for four to six weeks or exactly six weeks at 300C stimulates the yield of commercial sized bulbs.

  Longer storage at 300C advances flower spike yield but the quality of spike deteriorates and the bulb number decreases.

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Lecture 8: Production technology of chrysanthemum and marigold under open conditions

Chrysanthemum

Family : (Asteraceae)

Botanical name: (*Dendranthema grandiflora*) 2n: 18

Introduction:

- Chrysanthemum is a popular commercial flower crop of the many countries.
- It is next only to rose in value of flower trade in the world market.
- The word Chrysos means "golden" and anthos means "flower".
- It is commonly known as Queen of East/ autumn queen/ guldaudi.
- Japanese National Flower.

The flowers of chrysanthemum possess two kinds of florets;

- The central disc florets which are tubular perfect flowers with both stamen and pistil
- The ray florets which surrounds the disc florets which are comparatively longer, vary in shape, colour and form; pistillate and hence called as imperfect florets

Origin and History

It is native to the northern hemisphere chiefly Europe and Asia. Historically, Confucius the great Chinese philosopher has, in his writing, mentioned chrysanthemum as early as in 500 BC making it one of the most ancient cultivated flower of the world. It has second ranks as commercial crop. In the United States, it is the number one dollar earner flower and the most reliable. It is difficult to say with certainty when its culture began in India. Shant Gyanehswar has mentioned it in his famous Marathi exposition of Gita ―Gyaneshwari‖ written in AD 1290. The Hindi name guldaudi (meaning flower of Daud) suggests that it must have been grown during the Moghul period in this country

Species involved in the development are *C. sinense, C. indicum, C.japonicum, C. ornatum.*

Area and Distribution

The chrysanthemum is one of the most important flower crops commercially grown in different parts of the world. The Netherlands, Italy, Colombia, Spain, Germany and USA are the important countries where it is mainly grown under greenhouse conditions. In India, it is commercially grown in Tamil Nadu, Karnataka, and Maharastra. In different states of India, it is grown with different names, Guldaudi in Hindi belt, Chandramalika, in the eastern state, Samanti in the southern states and Shevanti in the western states. It is grown in on area of about 4,000 ha.

Commercial production centres in India

Karnataka - Bangalore, Kolar, Dharwad, Belgaum & Tumkur

Madhya Pradesh - Ratlam, Indore

Maharashtra - Ahmednagar, Pune & Nasik

Rajasthan	- Udaipur, Ajmer, Jaipur & Kota
Bihar	- Madhupur, Deoghar
Haryana	- Ambala, Gurgaon & Faridabad
Tamil Nadu	- Salem, Shervroy hills, Ooty

Importance and Uses

Chrysanthemum is versatile; it can be planted in the bed, cultured in the pot, used for garland making and also as cut-flower for flower arrangement. In India, large flowered varieties are grown for exhibition purpose while small flowered varieties are grown for cut flower, making garland, wreaths, veni and religious offerings.

- In India too, chrysanthemum occupies a place of pride both as a commercial crop and as a popular exhibition flower.
- It has a wide range of type, size and colour and also ―forms‖.
- Short day plant – ―Photo sensitive‖ (10 hours day light)
- The erect and tall growing cultivars are suitable for background planting in borders or for cut flowers.
- The extra large-bloomed cultivars for their exhibition value.
- Dwarf growing for flower beds and pot culture (pot mums) Loose flowers – garland, veni, worship etc.
- Long stem flowers – cut flowers for Bouquet, Vase etc.
- Chrysanthemum morifolium is also an important source of essential oil and sesquiterpenoid alcohol.
- The species like Chrysanthemum cinerariifolium and C. coccineum are also being cultivated as sources of pyrethrum and an important insecticide.
- It is important both as cut flower and as potted plant in the international market.
- In Dutch cut flower auction, chrysanthemum ranks 2nd after rose.

Botanical description

It belongs to family Asteraceae. The species of chrysanthemum have fibrous root system (shallow rooted plant), herbaceous perennial plant growing to 50-150 cm tall, with deeply lobed leaves and large flower heads, white, yellow or pink.

Classification

- The species of the genus Chrysanthemum are annual, perennial herbs, sometimes partly woody.
- The genus Chrysanthemum belongs to the family Compositae / Asteraceae.

Class 1. Single

- Ray florets in a single row at right angles to the stem.
- Disc is flat to slightly round and may be of contrasting colours, e.g., Potomac.

Class 2. Semi-double

- Ray florets in more than one row at right angles to the stem but may curve downward at the tips.
- Disc as in class 1.

Class 3. Anemone

- Ray florets variable, from flattened, broad and equal in length to reflexing, pointed at tip and unequal in length.
- Disc florets are numerous tube-like and elongated so as to form a prominent disc which may range from flat to hemispherical in form.

Class 4. Pompon

- Bloom globular, somewhat flat in young stage or small button type.
- Ray florets broad, incurved, smooth and firm with good substance.

Class 5. Incurve

- Breadth and depth should be equal to produce a globular bloom.
- Ray florets narrow to broad, smooth and incurve in a regular to an irregular manner without producing an open centre, e.g., Snow Ball, Mountaineer, Nob Hill.
- An Irregular Incurve chrysanthemum, meaning "big chrysanthemum". The size of this flower is around 20cm (about 8 inches).

Class 6. Reflexing incurve

- Ray florets usually broad and smooth. Breadth and depth nearly equal to form a globular bloom, sometimes flattened, may be less compact than incurve.
- All mature florets not completely incurving and not all completely reflexed.
- The lower florets sometimes reflexing to give a skirted effect, e.g., Dream Castle, Indianapolis.

Class 7. Decorative

- Ray florets from short and broad to narrow, long and pointed, they generally reflex, although upper florets may tend to incurve.
- Blooms more flattened than globular e.g., Otome Pink, Princess Anne.

Class 8. Reflex

- Bloom globular with equal depth and breadth and a full centre, or somewhat flattened.
- Ray florets narrow to broad, gracefully overlapping in either a regular or in an irregular manner and reflexed. e.g., Coronation Pink.

Based on the size, shape of flower, arrangements of florets and purpose used, the chrysanthemums are classified into several groups. i) Small flowered types. ii) Large flowered types iii) Classification based on plant growth iv) Based on usage.

I. Small Flowered

1. **Singles –** The petals are arranged in one or not more than five rows with prominent central disc.
2. **Anemones –** Prominent centrally raised hemispherical cushiony disc florets surrounded by short rounded or flat or twisted or quilled ray florets. Ex. Golden sands, White sands.
3. **Korean single** – Small flowers with a prominent central disc, ray florets are flat, number of whorls or ray florets are five and less than five. Ex: Cardinal, Gul-e-Sahir, Chairman.
4. **Korean double** – The number of whorls of ray florets are more than five and the central disc is open. Ex: Flirt, Man Bhawan.
5. **Spoon** – The outer ray florets are tubular with a spatula or spoon like opening at the tips. Ex: Anokha.
6. **Decorative** – Fully double flowers with flat petals and central disc is generally absent or not seen, ray florets are longer. Ex: Aretic, Elegance, Blue chip, Dolly.
7. **Quilled** – Small flowers, ray florets are tubular. Ex: Golden crystal, Snow crystal.
8. **Button** – Very compact, small flowers, produce numerous flowers. Ex: Golden dust.
9. **Pompon** – The flowers small, freely opened, compact, hemispherical or ball shape, the central disc is concealed or absent, florets neatly arranged. Ex: Apsara, Jayanthi, Lameo, Dandy, Eve.

II. Large Flowered

1. **Incurved regular** – The outer ray florets curve upwards and inwards towards the disc florets to forma globular shape. Ex: Snow ball, Sonar Bangla, Chandrama.
2. **Incurve irregular** – The outer ray florets incurve loosely and irregularly and do not from a ball as in case of regular.
3. **Refluxed –** The outer ray florets curved outwards and downward away from the centre so that only their upper surface is seen. Ex: Cresta, City Beauty, Golden Rule, Day dream, Peach blossom, Sweet Heart.
4. **Intermediate** – The inner florets incurved and outer florets are refluxed, they are intermediate in shape to incurved and refluxed. Ex: John Reid, Lady Hope town.
5. **Spider –** The outer ray florets are large, elongated, tubular and curved to form a hook or coil like structure at the tip of the petals. Ex: Rupasi Bangla, Mahatma Ganthi.
6. **Quill –** The outer ray florets are elongated, straight and tubular like a quill with tips open but not flattened.
7. **Exhibition -** The outer florets are refluxed and inner florets incurred, the ray florets are generally twisted, irregularly overlapped each other and looks attractive.
8. **Ball type** – Ray florets are straight and radiated in all directions to give a complete ball shape.

III. Classification based on plant growth

- **Standards** – plants with single flower, other buds are removed if arise from the laterals and produce big flower.
- **Spray –** The main apex bud is removed and lateral buds are allowed.
- **Pot mums** – Small flowered mums with 6-9‖ height are beautiful in decorating the places.

IV. Based on Usage.

Cut flowers –

i) Disbudded inflorescence ii)

Spray inflorescence

Loose flowers

Potted/bed plants

V. Classification of varieties based on duration for flowering

Early varieties	: 90 days (from transplanting)
Medium varieties	: 100-110 days(from transplanting)
Late varieties	: >110 days (from transplanting)

Species and Cultivars

The number of species under the genus Chrysanthemum varied from 100-200. Some important species are: n=9 (2n=18 to 90)

1. *Chrysanthemum boreale* :Abura–Giku
2. *C. carinatum :* Tricolor chrysanthemum
3. *C.coronarium:*Garland chrysanthemum 4. *C.cinerariifolium*:Dalmatian pyrethrum
5. *C. rubellum* – sturdy species used for breeding of hardy cultivars.
6. *C. satsumense* : Satsuma-nogiku
7. *C. sinensis*- One of the sourses of today‟s florists‟ mums.
8. *C. sibiricum* is one of the parents for Korean hybrids.
9. C. coccineunm :Painted daisy
10. *C. indicum* : Chinese/ Japanese mums
11. C. *morifolium* : Florists' chrysamthemum

- C. *morifolium* is a hybrid species and is the result of repeated cycles of inter-specific crossing among elemental species extending over a period of 2500 years.
- Plants are perennial.

Cultivars

- More than 15000 cultivars are listed in Japan alone.

- The National Chrysanthemum Society of Britain lists over 6000 cultivars.
- In India also more than 500 cultivars.
- Major Varieties were developed from IIHR, Bangalore, NBRI, Lucknow, PAU, Ludiana, TNAU, Coimbatore.

Selection

Most of the outstanding spray and loose flower type cultivars evolved in India- Birbal Sahni, Apsara, Kundan, Jaya, Jayanthi, Sharad Singar, CO 1 &CO 2 etc.

IIHR

Chandrakant, Kirti, Chandrika, Indira, Arka Swarna, Nilima, Pankaj, Rakhee, Ravikiran, Yellow Star, Arka Ravi, Arka Ganga, Usha Kiran, Red Gold, Yellow Gold

NBRI

Shanti, Y2k, Kargil, Sadbhavana, Appu, Bindiya

No-pinch no-stake mini chrysanthemums (NBRI, Lucknow)

` NBRI Indiana, NBRI Kusum, NBRI Little Darling, NBRI Mini Jessie

TNAU

CO-1, CO-2, MDU-1

PAU

Punjab Gold, Birbal Sahni, Baggi

Varieties of TNAU,Coimbatore released through selection CO-1(1985):

It is a selection made form a bulk population introduced from Hosur of Krishnagiri district. Flowers are medium sized (2.5g) and attractive (canary yellow) the flowers have thick, sturdy stalks, which are an added advantage for easy tying in the making of garland and other decoratives. It flowers early by about 15-20 days and the blooming period also lasts longer when compared to the other local cultivars. Average yield on main crop is 16.7 t/ha.

CO-2(1989):

This is a clonal selection from among the germplasm type introduced from the National Botanical Research Institute, Lucknow. This selection recorded higher yields than CO .1 and MDU.1. It has several attributes like more number of flowering shoots per plant, more number of flowers per plant, invisibility of the disc in the flower (capitulum) which is considered a desirable feature in the trade circle and a novel new purple colour.

MDU-1(1985):

It is a selection from the germplasm type. It is an early type, coming to first flowering in 104 days as against 120 days in the local type. The flowers are large and attractive sulphur yellow in colour with a diameter of 3.90 cm. It yields 30.59 tonnes per hectare per year in two crops (main and ratoon crop).

Hybrids released from IIHR, Bangalore Arka

Swarna:

A cross between ‗Nanako x CO–1'. This hybrid bears Yellow pompon flowers. It is found superior in respect of plant height, number of flowers per plant, flower size, flower weight, flower yield per plant and flowering duration. This is suitable for both cut and loose flower purposes.

Arka Ravi:

It is a cross between Mundial and Hybrid 87-17-1, flowers in 102 days which is earlier than local varieties. Flowers are semi-double type, each being in 6 cm diameter. It produces 130 flowers per plant. Flowers are attractive peach in colour. It has a vase life of 12 days. Flowers can be used for cut flower purpose.

Arka Ganga:

Bears attractive double Korean white flowers with pink tinge. Flower yield is higher than Local White variety. Suitable for both loose and cut flower purposes.

Chandrakant:

Flowers are decorative, white in colour, takes 124 days to flower. It is dwarf with a plant height of 39cm. On an average, flower diameter is4.7 cm and weighs about 1.85 g. It is floriferous and produces 149 flowers with an yield of 272 g per plant, it produces about 2 times more yield than the local white variety, flowers are more attractive and can be used as loose flower.

Chandrika:

A white flowered hybrid obtained by crossing Angela x GP1. It produces decorative flowers. It takes 92 days to flower. Number of flowers per plant is 130, which is 3.7 times more than the local white variety. It can also be used as cut flower. Its shelf life is 7 days and vase life 10.8 days. It can also be used in flower arrangement, bouquets, can also be used as loose flowers for Pooja and floral decoration.

Indira:

It is a cross betweenan open pollinated seedling of Lord Donex' LD-14 (imperial purple) and ahybrid seedling of Flirt' x Valentine' F x V-1 (beet root purple). It flowers in three months. The flowers are double Koreans,, yellow at bud stage and butter cup yellow at picking stage, fading to aureolin. Each flower is 5 cm in diameter. Produces about 300 g flowers per plant under field conditions. It is a good multiplier and can be multiplied through cuttings. Ideal for cut flower purpose, religious offerings, wreaths, bedding and potting.

Kirti:

It is a hybrid between Angela x G.P.1. It flowers early (88days). It bears white coloured double Korean type of flowers, which fade to a pink tinge. It is floriferous and produces 119 flowers per plant. It yields 168g of flowers per plant, which is 1.71 times more than the Local white. Its shelf life is 7.5 days. It is dwarf (34.5 cm), spreading (41.1 cm) and compact. Therefore suitable for bedding and potting purposes; besides, the flowers canalso be used for floral decoration.

Nilima:

Hybrid produced by cross cvs _Flirt' x _Valentine'. It takes 116 days to flower. It bears purple coloured decorative flowers whose diameter is 4.86 cm and average flower weighs 1.96 g. It is floriferous and bears 144 flowers per plant. On an average its flower yield is 281 g per plant. Suitable for cutflower (spray type) purpose having vase life of 14 days. Flowers are compact and are good for loose flower purpose in floral decoration.

Pankaj:

It flowers early and takes about 114 days to bloom. It bears pink, attractive flowers which are decorative type. Diameter of flower is 4.8 cm which weight 2.68 g. I is high yielding and; produces 140flowers with an yield of 363 g per plant. Its attractive flowers on stiff stalk makes them suitable for cut flower purpose. Loose flowers can be used for floral decoration.

Rakhee:

It is an open pollinated seedling of Lord Donex'(Super yellow with purple stripes). It flowers in 3 months. The flowers are anemone primrose yellow with red stripes on ray florets, each of 5 cm diameter. Plants are bushy, compact with shiny leaves. Produces about 125 flowers in beds but around 100 flowers in pots. It is a good multiplier, is good for potting, veni and religious offerings.

Ravi kiran:

One of the hybrid produced by crossing cvs Flirt' x Valentine'. It takes 122 days to flower. This hybrid is a novelty. It looks like a papery flower. Its flower diameter is 6.12 cm and flower weighs2.48 g. It produces 86 flowers per plant. Flower is grey-red and fading to grey-orange. It is suitable as cut flower and can be used in flower vases or in bouquets. It has a vase life of 12 days.

Red Gold:

It is a cross between Flirt' (Current red) x Valentine'; (amethyst violet). It flowers in 4 months. Flowers are initially greyish-orange and fade to golden yellow double Koreans, 5 cm diameter. Flowers profusely produced at an average of 400 g flowers per plant, can be used for cut flower purpose; good for bedding, potting, wreaths and for religious offerings.

Varieties Developed From - PAU, Ludiana

Baggi

Flowering in Nov-Dec. Flowers snow white , decorative, Flowering in 137 days ,Flower diameter 5.1 cm, Y-143 q/hec ,Plants 64cm tall Upright growth, Leaves simple & deeply lobed, resistance to leaf spot

Birbal Sahni

Flowers – Oct-Nov, snow white , pompon flowers ,Small-4.8cm, Y-32 q/ hec ,65 cm tall and upright ,Early – 121 days to flowering & hence fetch good price, Leaf simple and moderate lobe **Ratlam Selection**

Flowers – Nov- Dec, creamish white , decorative, large size-8.1cm, Y-175q/ hec ,57 cm tall and spreading ,138 days to flowering & hence fetch good price, leaf simple and deeply lobed

Punjab Gold

Flowers – Oct-Nov, Hybrid of Flirt X Gul-e-sahir, Golden yellow semi double flowers ray florets have tinge -coppery red colour at opening, plant dwarf,29.5 cm tall ,Early type,D-5.0cm,Attractive and suited for pot culture, leaf dark green and small

Varieties Developed From - NBRI, Lucknow

Shanti (2000)

Small flowered ,white decorative Profuse branching, long erect stem, uniform blooming, Plant -51.2 cm tall, flower Dia -3.4 cm , 99 fl/pl ,good cut flower and garland type

Y2K (2000)

Small flowered ,dwarf bushy, compact round, white anemone type Profuse and uniform blooming –Early Dec ,Habit and shape suitable for mini culture, no pinch nor staking, Plant 31.6 cm tall,D-3.15 cm , 370 fl/pl

Kargil 99 (2000)

Small flowered , spoon type Single whorl ray florets- yellow disc purplish mauve florets, distinguish feature variegation in leaves which is enjoyed through out the year even when there is no flower, snow white variegation of leaves dwarf bushy, compact round, Profuse blooming – Early Dec, habit and shape suitable for mini culture, Plant -34.2 cm tall,D-4.98 cm , 215 fl/pl

Sadbhavana (2000)

Small flowered ,dwarf bushy, compact round, red, yellow , open disc, double korean type Profuse and uniform blooming –Early Dec, habit and shape suitable for mini culture, no pinch nor staking, Plant -29.1 cm tall,D-3.74 cm , 303 fl/pl

Appu (1982)

Open pollinated seedling selection – Original Dwarf Double, dwarf and early blooming , purple flower compact button type ,habit and shape suitable for mini culture, flower length – 1.5 cm wt -0.4 g/fl

Bindiya

Dark crimson flower double korean type ,habit and shape suitable for mini culture, flower length – 1.1 cm wt -0.3 g/fl

No Pinch No Stake Mini Chrysanthemum

Mini varieties, no pinching No staking, dwarf bushy compact round shaped ,profuse blooming, plant habit and shape attractive, easily transported in mini containers, Bindiya, Mother Teresa, Diana

NBRI Develops New Varieties of Chrysanthemum

The Floriculture Division of NBRI has recently developed new varieties through selective crossing and seedling collection. These varieties are being released as `NBRI Golden Jubilee

Year Varieties. These varieties are NBRI Indiana, NBRI Little Darling, NBRI Mini Jessie, and NBRI Kusum

Varieties released through mutation:

Usha Kiran:

An induced mutant of IIHR cv. Kirti, with more plant height and spread compared to Cv. Kirti. The floral traits were at par with the cv. Kirti, but the flower colour of mutant is yellow. Mutant is dwarf, compact and spreading and found suitable for bedding/ potting and loose flower purposes as it has a shelf life of 7 days as against 5 days in Kirti. The flowers are semi- double with prominent disc

Yellow Gold:

This is a yellow flowered induced mutant of the red flowered variety _Flirt' obtained by gamma irradiation. On an average, it takes 140 days to flower. It bears yellow coloured decorative flowers whose diameter is 5.26 cm and weighs 2.16 g. Petals has Brick Red coloured stripes. It produces 113 flowers per plant. Flower yield is 244 g per plant; good for loose flower purpose but also suitable for cut flower (spray type) purpose with a vase life of 14 days.

Yellow Star:

It is a yellow flowered cultivar. Flowers are decorative, with average diameter of 4.33 cm. It takes 140 days to flower. It produces150 flowers per plant. It is high yielding and produces 272 g flowers per plant, which is 1.3 times more than in the local yellow variety. Flowers can be used as cut flower, in flower arrangement and as loose flowers for garlands, floral decorations.

Batik(1994) :

It is a Gamma ray mutant of Flirt (small, double korean ,red colour),Small flower Double korean Type ,Induced stripes , unique combination of yellow and red colour Yellow mutant

Purnima(1977) :

It is a Gamma ray mutant of OTOME ZAKURA which are large lilac flower pompon type , Purnima flowers white , pompon

Shabnam(1987):

It is a gamma ray mutant of D5, Decorative Type, Mangnolia Purple, Induced flower shape mutation (small appendage like structure at the tip of each floret)

Subarna (1991):

It is a gamma ray mutant of Flirt, a colour mutant, small, Double korean type, Yellow mutant

Propagation

Chrysanthemum can be propagated both by vegetative and sexual methods. Chrysanthemum is propagated vegetatively through suckers, cuttings or by micro-propagation.

Vegetative Propagation

1.Suckers:

Suckers arise from the underground stem and these are separated and planted in prepared nursery beds during January for stock plants. Regular pinching is performed in these plants for vigorous and profuse branching.

2.Cuttings (Terminal Cuttings)

Preparation of cuttings.

The first pinching is performed in April, followed by monthly pinching up to June.
After 3rd pinching in June, cuttings are taken from these mother plants.

Cuttings of 5-7 cm in length are taken form healthy stock plants in June. The cuttings are prepared removing basal leaves and reducing the leaf area of remaining leaves to half. The basal portions (less than half inch) of cuttings are dipped rooting hormone (1000 ppm solution of IBA) for better rooting. These rooted cuttings are ready for planting in the field.

3.Micro propagation

Among these, propagation through cutting is the most common and popular method.

Land Preparation:

The field is ploughed two to three times before preparation of beds for planting. Trials conducted under All India Coordinated Research Project on Floriculture recommended a basal application of FYM @ 5 kg/m2.

Climate Requirement

Chrysanthemum requires long days for good vegetative growth and short days for flowering. The most important environmental factors influencing the growth and flowering of these plants are light and temperature. The rate of vegetative growth and flowering are also affected by temperature. The optimum temperature of 15.6^{0}C is required. The relative humidity of 70 to 90% is suitable for the plants.

- Light and temperature are the two important environmental factors influencing the growth and flowering.
- As far as light is concerned, both photoperiod and the intensity have profound effects on growth and flowering of chrysanthemum.
- It is a short-day plant normally initiates and flowers during September to December under South Indian conditions. Hence, planting during April-May is recommended.

Soil Requirement

The ideal soil for chrysanthemum growing is a well drained, sandy loam of good texture and aeration. Good amount of organic matter and pH of 6.5 is essential. It is a shallow fibrous rooted plant and is very sensible to water logged conditions.

Time of planting and Spacing

- Terminal cuttings of stock plants are taken in June and they are transplanted after rooting. These plants are ready for pinching during end of August or beginning of September May-June planting resulted in well developed plants with good flowers. Cut flower production was the highest from May plantings. 90,000 to 1, 10,000 suckers or slips obtained from 15 cents of the previous crops are required to plant one hectare.
- Before planting, the roots of the suckers or slips are dipped in wet Cerasan or Agallol 0.1% to protect against wilt.

Planting Density

The best plant population was 32 cuttings / m2 and spacing of 30 x 30 cm.

Manuring and Fertilization

Chrysanthemum is a heavy feeder and requires large amount of both Nitrogen and Potassium. Nitrogen is required at early stage and the plants need P throughout the growth period. As the buds appear, the proportion of K should be increased and N should be reduced. Chrysanthemums are heavy feeders and hence they are to be adequately manured at 25 t of FYM along with 250,120, 25 kg NPK/ha.

- Half of the N and the entire quantity of P and K are to be applied basal by just before planting.
- The other half of N is to be applied 30 days after planting the suckers.
- The same dose can be repeated if a ratoon crop is raised and hoeing should be done once in a month.

Micronutrient application by

- Coated fertilizers
- Liquid feeding and foliar feeding

Special practices Pinching

- Pinching is one of most important operations in chrysanthemum culture.
- The operation of removal of terminal growing portion of stem pinching reduces plant height and promotes axillary branches.
- Time and severity of pinching depend on the type of chrysanthemum and the desired objectives.
- After planting, the growth is mostly upward with very little branching.
- To arrest such tall growth, a simple procedure cal ed ―pinching‖ is used. It is also called ―stopping.

Only soft vegetative shoot tips 1.5 to 3 cm long are removed.

Pinching is most essential for small flowered chrysanthemum.

First pinching is done when the plants reach a height of 15-20 cm with 3-4 pairs of leaves.

- A second pinching may be necessary if the plants make straggly and lean growth.

  Pinching increases the number of flowering stems in each plant; it can indirectly control flowering date and bloom quality; and the number of stems to a plant can easily be controlled.

Two types of pinching are performed:

(a) Soft pinching:

By this pinching the top soft tips of the shoot along with 2-3 open leaves are removed;

(b) Hard pinching:

It means removing a longer portion upto hard shoot. Single pinching is done, if two flowers are desired, whereas double pinching is done for four flowers.

- In spray chrysanthemum numerous small to medium sized flowers are produced, therefore, two pinchings are required to encourage lateral growth.
- As a general rule rooted cuttings are pinched two weeks after planting or approximately 100 days before full bloom.

Disbudding and De-Shooting

- These operations are mostly performed for large flowering of decorative type chrysanthemums.
- Many of the standard type varieties are disbudded in which the largest terminal bud is reserved and all auxiliary buds are removed.
- Disbudding of spray varieties is very easy because in this case only the large apical bud is removed and the auxiliary buds are allowed to develop
- For taking three blooms per plant, three lateral strong shoots are allowed to grow and others are removed.
- Lateral buds and side shoots are removed at their early stage of growth from time to time.
- For taking one bloom per plant no pinching is done.
- Only the main stem is allowed to grow.
- Removal of undesirable lateral buds and shoots are done.
- De-shooting is practiced to reduce the number of branches for improving the size and form of the flower.

De-Suckering

During the vegetative growth phase, plants grow upward. New suckers continue to develop from base of plants. For proper and vigorous growth of plants, suckers are removed from time to time. It is practiced to allow single stem to develop up to a certain height. Without de-suckering the main plant will loose vigour and becomes weak.

Staking of Plants

- Staking is necessary to keep plants erect and to maintain proper shape of plants and bloom.
- Stakes are prepared mostly from bamboo sticks.

Green House Cultivation Environmental Factors

Light: Chrysanthemum flowering is very much influenced by the quantum and quality of light. Most of the cultivars require shorter days for flower bud initiation and development. Under long days they tend to remain vegetative.

Light Requirement of Chrysanthemum

- Short day plant - short days for flowering
- long days for vegetative growth
- Most cultivars : <10 -13hrs light - for flower bud initiation & development Importance of long day:
- For adequate vegetative growth
- To maintain stock plants in vegetative phase

Response to light:

Phytochrome - photoreceptive pigment in plant - responds to day length / photoperiod associated with flowering and other photo-morphogenic responses - seed germination, synthesis of plant pigments, stem elongation

What is Phytochrome?

Phytochrome = a chromo-protein existing in 2 forms

- inter convertible by radiation (Butler et al., 1959)

2 forms : pR and pFR

Red light (660nm) Far red light (730nm) pR - absorbs red light; stable & inactive form pFR - absorbs far red light; unstable & active form pFR - continuous darkness pR

Light Regulation In Chrysanthemum

Role of pR : triggers release of ‗Florigen' - flower hormone Light regulation in chrysanthemum:

During early phase

- pFR - for vegetative growth & to prevent flowering
- Availability of pFR - extending light hours and reducing / interrupting continuous darkness
- Exposing to LD conditions : >12hrs light - artificial illumination
- LD conditions - adequate vegetative growth - to build up plants After 6 weeks from planting
- SD conditions : > 12hrs darkness
- Ideal light period for most cvs : <10-13hrs

  SD created by artificial darkening
- Under SD conditions - pFR converts to pR - induces Florigen - flowering

Growth phase	Weeks from planting	Photoperiod

Vegetative phase	Up to 4-5 weeks from planting till the plant attains 50 to 60 cm height	Long day: 13 hrs light and 11 hrs dark
Flowering	5 -6 weeks after planting till harvest	Short day: 10 hrs light and 14 hrs dark

2. Temperature: Based on temperature requirements chrysanthemum cultivars are classified into three.

- Thermo-zero cultivars which flower at any temperature between 10-27^{0}C but most constantly at 16^{0}C night temperature.
- Thermo-positive cultivars in which continuous low temperature between 10-13^{0}C inhibit or delay flower bud initiation and at 27^{0}C there will be rapid initiation but delayed flowering.
- Thermo-negative cultivars in which bud initiation occurs at low temperature delay bud development.
- ✞ The effect of night temperature is more pronounced than day temperature and night temperature of 16-20^{0}C was found optimum for most of the cultivars.
- ✞ High temperature may cause floral distortion and low temperature may some time cause discoloration of the flower.

3. Relative humidity: The chrysanthemum requires a moderate humid condition of 70 to 90 per cent and hence it should be preferably grown in places there will not be any rains during flowering time.

Growth regulators:

- Crop growth regulation and flowering can be modified or controlled by use of growth regulators. the use of regulators.
- The plant starts flowering from 3rd months onwards.

  ✞ GA3 100-400 ppm - 3 DAP and 6DAP - increases stem length ✞ GA3 50 ppm - 30, 45 and 60 DAP - longer stems, higher yield

Harvest Stage of harvest

1. **Standard**

   Distant market – paint brush stage **Local market** – Half opened flower

2. **Spray**

   Local market - Two flowers have opened others have shown colour

   Distant market - 50% flowers have shown colour

- Decorative types are harvested when the petals in the centre of the topmost flower is almost fully developed.
- In standards, harvesting is generally done when outer ray florets ceases to further develop.
- Pot-mums are sent to the market with half to fully opened flowers.

- Spray mums are generally harvested at the two thirds to three-fourths open stage; standard mums at the three-fourths to full open stage of development.
- Yield start from 3-4 months after planting.
- Main crop duration 6 months.
- Ratoon crop 4 months.
- Total duration (6+4) 10 months.

Yield

- Main crop : 9-10t/ha.
- Ratoon crop : 4-5 t/ha.
- Sprays- 1, 00,000 stems can be obtained from one ha.

Postharvest Technology Grading

 Chrysanthemums are graded based on the stem length, flower appearance, number of flowers, stem straightness, colour and freshness of flowers.

- Standard chrysanthemum is graded into Blue, Red, Green and Yellow, whereas spray types are graded into Gold, Silver and Bronze based on the quality parameters.
- spray chrysanthemums are graded into extra grade and shorter grade.
- The lower leaves are stripped off up to 15-20 cm and bundled in units of 5 stems and secured with a rubber band.

Post harvest handling……

Pre-cooling

Flowers are conditioned for 16 hrs at 20^0C

Storage

0°C for 3 to 5 weeks in moisture retentive boxes

Holding solution

10 to 15 days – under holding solution (citric acid 300 ppm + sucrose 1.5 %)

Packing

- Most often standard chrysanthemum are placed in sleeves and packed in display boxes measuring 91 x 43 x 15cm.

  They are placed in the boxes according to the grades.
- For bulk packing of the spray chrysanthemums, 10, 15 or 20 stems are placed in sleeves according to the grades.
- Six sleeves, three at each end, are generally packed in each box, measuring 80 x 50 x 23cm.

Storage

- Chrysanthemum cut flowers can be wrapped in plastics and stored dry for 6 to 8 weeks at a temperature of 0.5^0C.
- Temperature for truck shipments across the country ranged between 2 - 40C.
- The stems in the buckets (after grading) are given a cut using sharp blade and pre cooled at 1°C minimum of 2 hours before packing.
- Chrysanthemum can be stored for 3-6 weeks period at 0-3^0C.

Vase Life

- The use of proper preservative solution throughout the period of post-harvest handing is very important to prolong the life of cut flowers.
- Dipping of the stem for a very short period (5 seconds) in 1200-4800 ppm silver nitrate or soaking the stems in 1000 ppm silver nitrate for 10 minutes.
- Addition of 2 % sucrose to silver nitrate was found beneficial.
- It increased the vase-life from 12 days to 20 days.

Export standards for chrysanthemum

Parameter	***Standard***	***Spray***	***Dwarf***
Stem Length	88-100 cm	75-88 cm	25-38 cm
Weight	30g/stem of 90 cm	30g/stem of 85 cm	30g/stem of 30 cm
Number of flowers	Only 1 flower With 5 buds	10 flowers with 5-8 Buds	10-12 flowers
Diameter of bloom	60-80 mm	35 mm for half	45 mm for full bloom

Floral abnormalities……..

Crown Bud – bud development is severely retarded and invloucral bracts become glossy enlarged - Plants grown in long days after receiving a few short days produce crown buds

- Ca deficiency
- Spray Ca(NO3)2 5 g/l at 10 days interval

Quilling of florets - Boron deficiency

- Spray Borax @ 3g/l (or) 25 to 75 ppm

Bleaching of petals – cause bronze and pink coloured cultivars due to high temperature during floral development

Pink colouration in white petals – low night temperature during flower development

Doubleness – transfer of plants to long days during floret formation Singleness - transfer of plants to short days during floret formation

Crooked Neck

Bending of flower neck in greenhouse chrysanthemum often occurs in the winter crop.

There are 2 types of crooked neck in chrysanthemum.

1. The bending of the flower neck which occurs in the uppermost leaf node.
2. The adhering of the terminal flower neck to an axillary bud.

Blindness

- It occurs when the night temperature is too low and the days are short at the time when flower buds are forming.
- A rosetted type of growth is indicative of this difficulty.

Pests in chrysanthemum Aphids

- Suck the plant sap and excretes honeydew
- Various aphids: *Muzus persicae, Macrosiphonilla sanborni, Brachicaudus helichryse, Aphis gossypii* and *Aphis fabae*

Control Measures

Malathion @ 0.2%, Dimethoate @ 0.3%, Neem oil @ 1%

Red Spider Mite- Tetranychus urticae

Suck plant sap thus making it stunted appearance

Damage : April to July

Flower buds fail to open and dry before opening Management

Spray dicofol(0.05%), wettable sulphur(0.3%), vertimac(0.05%)

Thrips

Nymphs and adults of *Thrips tabaci, Thrips negrophilosus, Frankliniella tritici* and *hercinothrips* feed on tender leaves

Silvering, molting and distortion of leaves

In summer: flowers discolored and dry

Management

- Drenching soil with chlorpyriphos(0.1%)
- Spray acephate or dimethoate @ 0.05% 2-3 times @ 15 days interval

Nematodes

- Caused by : Lesion nematode(Pratylenchus penetrans)
- Symptom : stunting and premature yellowing of plants, dying of leaves, reduced flower size and dark lesions on roots

Management

- Use neem cake@ 1ton/ha

Diseases in chrysanthemum

Fungal diseases

Fusarium wilt

- Fungus: *Fusarium oxysporium f. sp. Tranchiphilum*
- Causes : general chlorosis & stunting of leaves

Management

- Thiram @ 1.5g/l of water with dexon or carbendazim.
- Use disease free cutting from healthy plants in clean soil having pH 6.5-7

Rust

- Caused : Puccinea chrysanthemi
- Symptom : brown spore at the underside of the leaves.
- Spores burst and infect the plant making it weak and fail to bloom.

Management

- Sanitation and clean cultivation
- Zineb and captan(0.15%) spray should be applied.

Leafspot

Two types

Fungus : *Septoria chrysanthemella and Cylindrosporium chrysanthemi*

Causes: 1.withering of leaves

2. At time of flowering infection occurs on buds and rot completely.

Management

- Bavistin or bordeaux mixture @ 0.05%
- Or ancozeb @ 0.2% along with sticker (0.1%)
- Wetting of leaves should be avoided at the time of watering

Bacterial diseases

Bacterial blight

- Caused by: Erwinia chrysanthemi
- Symptom: water soaked lesions which finally splits the stem.

Management

- Disease free cutting should be used.
- Planting material should be treated with streptomycin

Crown Gall

- Caused by: Agrobacterium tumefaciens
- Symptoms : irregular and round gall apears on stem & leaves

Management

- Destroy the infected plant

Viral diseases

1. Chrysanthemum stunt
2. Tomato spotted wilt
3. Tomato aspermy
4. Flower distortion
5. Chrysanthemum mosaic and
6. Chrysanthemum rosette

Marigold

Importance and uses–origin and history- area and production – botany – species and varieties– propagation - season and planting-nutrition and irrigation – management practices - role of growth regulators-pinching and disbudding- plant protection -harvest and yield.

Introduction

Marigold has gained popularity amongst gardeners and flower dealers on account of its easy culture and wide adaptability. Free flowering and short duration. Wide spectrum of colour, shape, size and good keeping quality. Marigold is also known as Friendship Flower in the United States. In language of flowers, marigold, in general, means anxiety but despair or grief, in particular. African marigold represents vulgar minds whereas, French marigold is a symbol of jealousy. Marigold popularly called as ―Yellow Gold **Uses:**

Used for garland, veni and other decorations. The long stemmed flowers used for vase arrangements. It is highly suitable as bedding plant, in an herbaceous border, also as shrubbery in landscaping. French marigold is ideal for rockery, edging, hanging baskets and window boxes. Have medicinal properties to cure boils and carbuncles. Floral extract is used as a blood purifier and cure for bleeding piles. Good remedy for eye diseases and ulcers. Some species of Tagetes are used for essential oil extraction. The Pigments (Xanthophylls) are used as a natural colour to intensify yellow colour of egg yolk and broiler skin, flesh and also for fish. Xanthophylls are the major carotenoid fraction in the flower petals. Lutein accounts for 80 - 90% of total xanthophylls content. Used for colouring the food stuffs, textile industries and pharmaceuticals.

Tagetes patula contain essential oil which can readily be extracted by steam distillation.
The oil has a pronounced odour and acts as a repellent to flies.

Trap crop -It is highly effective in reducing the population of nematodes under control and also attracts the fruit borers in many vegetables, fruits and ornamental plants.

Origin and History

Marigold is native of Central and South America, especially Mexico. From Mexico it spread to different parts of the world during early part of the 16th century. The name Tagetes was given after Tages, a demigod, known for his beauty. African marigold was first introduced into
Spain early in the 16th century and became popular in Southern Europe under the name ‗Rose of the Indies'. This plant was reintroduced into Europe in 1535 under the name, Flos Africonus Emperor Charles V.

Area & Distribution

Cultivation tends to be located close to big cities like Mumbai, Pune, Bangalore, Mysore, Chennai, Calcutta and Delhi. The estimated area on which flowers are grown in India is about 1,10,000 hectares. Major growing states are Karnataka, Tamil Nadu, West Bengal, Andhra Pradesh and Maharashtra. Traditional flowers, including marigolds, occupy nearly two thirds of this area. In northern India in Himachal Pradesh, small scale farmers are growing marigold and other flower crops for garlands and decoration.

Species - (*Tagetes spp.*, Asteraceae)

There are about 33 species of the genus Tagetes. Some of the important are as follows

***Tagetes erecta* (African /Tab marigold):**

The African marigold plant is hardy, annual; about 90 cm tall erect and branched. Leaves are pinnately divided and leaflets are lanceolate and serrated. Flowers are single to fully double with large globular heads. The florets are either 2-lipped or quilled. Flower colour varies from lemon yellow to yellow, golden yellow or orange.

***Tagetes patula* (French / Dwarf marigold):**

The French marigold is a hardy annual, about 30 cm tall, forming a bushy plant. Foliage is dark green with reddish stem. Leaves are pinnately divided and leaflets are linear lanceolate and serrated. Flowers are small, either single or double borne on proportionately long peduncles. The flower colour varies from yellow to mahogany red.

***T.tenuifolia (T.signata)* - Ornamental marigold or Single signet**

It is another dwarf type of marigold. Plants grow 30-35 cm tall, bushy with fine lacy foliage and covered with small single flowers of lemon-yellow, and orange colour. These are grown for pot culture, edging or rock garden

***T.lucida* (Sweet scented marigold)**

The plants are annuals. Leaves sessile, Small, lanceolate, flowers 2-3 rayed in dense, terminal corymbs, with more agreeable odour that other species.

T.lacerata

It was discovered in California. The plant up to 120-150 cm in height, flowers profuse, yellow.

T. limmoni

It is shrubbery plant, grows up to 60-70 cm. leaves slender, opposite; leaflets about 2-3 cm long; flowers showy, 2-3 cm diameter.Other species grown in gardens are T.minuta, T.pusilla and T.corymbosa. In India the cultivation of T. erecta and T. patula are dominant.

Varieties Types and Cultivars

In the two main groups of marigold- African and French, there are many types stains varying in plant height, growth habit, flower shape and size. African marigolds have yellow, and orange colours in various shades – light yellow, canary yellow, golden yellow, bright yellow, cadmium orange, golden orange, deep orange, bright orange. A strain with white and almost with white flowers has been developed. In French marigold, besides the colours mentioned above, the crimson and mahogany red colours are very attractive. Some cultivars have bicoloured flowers like light yellow with maroon blotches, deep crimson-edged yellow, gold and red bicolour. Like many other flowers of commercial importance, marigold has also been classified differently by floriculturalists and seedman in different countries. Therefore, no standard and accepted

classification of marigold is available. However, attempts have been made to include the major groups but the cultivars are not always known or widely accepted in different countries

***Tagetes erecta (*African marigold)**

Cracker jack, Climax, Doubloon, Golden Age, Chrysanthemum Charm, Crown of Gold, Spun Gold. Giant African Orange Double, Gaint Aftrican Yellow Double, Star Gold, Prime Rose, Pista , Pusa Narangi Gainda, Pusa Basanthi Gainda (IARI varieties) and MDU 1

Tall F1 hybrids :

Plants about 3m high, large, fully double, flowers up to 12 cm across. F1 gold coin series and F1 Climax Series

Semi tall F1 hybrids

This is also known as hedge type because of uniform and compact growth, 50 cm high, Double flowers are 10cm across with lemon and golden yellow light orange

Dwarf F1 hybrids

Plants are 15 to 40 cm high, and compact growth; many flowers appear at one time.

Inca series: Flowers are large, fully double and compact,

Space Age Series: Early flowering, dwarf and uniform

Galore series: Long flowering duration, uniform

F1 triploid

Early and very free flowering, large and golden yellow flowers

***Tagetes patula* (French marigold)**

Red Foregate, Rusty Red, Butter Scotch, Valentia, Susana, Corkymenu, Flames Spray.

1. **Dwarf double**

Plants 20-30 cm high, colours – yellow, orange, reddish brown, mahogany-red, golden yellow, bicolour

2. **Dwarf double-scabious flowered**

Flowers with crested centre, wide range of colour- golden yellow, golden orange with red marking, golden yellow with red, brownish red with orange centre, golden yellow with spotted red, etc.,

3. **Dwarf double petite**

Very dwarf plants, 15-20 cm high, bear numerous attractive flowers with golden yellow, orange, yellow and maroon colour

4. **French dwarf single**

Plants 20-35 cm high, compact flowers, single, golden yellow, yellow, golden yellow with maroon eye, mahogany-red with yellow centre, yellow with brown.

5. Dwarf triploid F1 hybrid

Plants 25-40 cm high, extremely early, profuse flowering; colour – yellow, golden yellow, orange and brownish red

6. Dwarf double:

Dwarf all saints – about 20cm high, good for bedding, wide range of colour

Dwarf chrysanthemum – plants are 20cm high, compact and bushy, chrysanthemum flowered, rose crimson.

Tagetes tenuifolia

Golden Gem, Lulu, Pumila, Ursula. However, in the market mostly orange coloured varieties are preferred.

Species:

Towner 1961 compiled the species of Tagetes based on their chromosome number is as follows

Diploid species - 2n : *Tagetes erecta* - 24

Tetraploid species - 4n : T. patula - 48

Diploid species 2n = 24

- *Tagetes erecta* (Eyster, 1939)
- *Tagetes tenuifolia* (Eyster, 1939)
- *Tagetes elongata*
- *Tagetes lemmonii*
- *Tagetes jalicensis*
- *Tagetes lucida* 2n = 22

Tetraploid species 4n = 48

- *Tagetes patula* (Eyster, 1939)
- *Tagetes minuta*
- *Tagetes remotiflora*
- *Tagetes mendocina*
- *Tagetes biflora*

TNAU MDU – 1

It was released during the year 1986 and is a selection from a germplasm type. The plants are medium tall with moderate branching habit. The plant produces on an average 97 flowers weighing 561.40 g/plant, with an estimated yield of 41.54 t/ha. The flowers are large with a stalk length of 8.39 cm. The light orange colour petals are compactly arranged and each flower has 210 petals. The flowers fetch premium price in the market.

IARI

Pusa Narangi Gainda

It is a pedigree selection after 8th generation from a cross between Cracker Jack and Golden Jubilee-8.

Other varieties of IARI are Pusa Basanti Gainda, Pusa Sankar 1 – Pre release

Hybridization:

Hybridization between distantly related types is the most effective and commonly employed tool to induce variation so as to improve the existing cultivars and evolve new, high yielding and better quality of genotypes. Different principles of breeding have successfully been used in marigold which resulted in new cultivars and present day F1 hybrids.

Inter varietal hybridization

Singh and Swarup (1972) observed appreciable heterosis in a well planned breeding studies. F1 hybrids are considerably uniform in size and capable of producing large blooms with high yield potential. In addition, they are characterized by their semitall nature with excellent large full double flowers. Wide range of hybrids are available in both the species, whereas hybrids of Tagetes erecta are larger plants than the French forms. Climax- first F1 hybrid – African marigold. Tetra ruffled Red was the first hybrid in French marigold.

Example

Apollo, First Lady, Orange Lady, Show Boat, Moon Shot, L3

Inter specific hybridization

Towner (1961) suggested that T.patula is an allotetraploid of T.erecta (2n=24) and T. tenuifolia (2n=24). A true breeding, fertile allo tetraploid T.Patula (2n=48) was synthesized by chromosome doubling of the F1 hybrid using colchicine.

Other inter specific hybrids are

- *T.erecta x T.tenuifolia*
- *T.erecta x T.jaliscensis*
- *T.erecta x T.patula* – Red and gold hybrids – red glow, red gold, red seven star, yellow nugget etc.,

Triploid marigold (Signet hybrids)

Triploid marigolds are cross between ***T.erecta x T.patula.*** These triploid plants bloom repeatedly through the summer, even in hot weather. They are sterile and unable to set seed. It has low seed germination rate (50 percent). So they are popularly called as Mule marigolds

Male Sterility

Male sterility was of two types. **Apetalous and fully doubled flowers**. Apetalous type is more preferred than full double type because apetalous type is less attracted by pollinating insects. But full double type is prone to break down exposing disc florets. Male sterility is governed by recessive genes and is incorporated in seed parent and maintained by crossing the heterozygous plants. In a study by Gupta (1999) male sterile apetalous lines , MS7 MS8 of variety T.erecta was crossed with Male fertile petalous line Selection -21. F1

obtained and selfed to get F2 Segregation ratio was 3 :1 (petalous male fertile : apetalous male sterile).So apetalous trait were governed by a single recessive gene. It is maintained by crossing the heterozygous plants with the sterile ones.

Breeding:

- Self incompatible and cross pollinated crop.
- The ratio of CP to SP is 35:65

Climatic Requirement:

- Marigold requires mild climate for luxuriant growth and profuse flowering.
- It ceases to grow at high temperature thereby flower quantity and quality is adversely affected.
- During severe winter including frost plants and flowers are killed and blackened.
- Sowing and planting is carried out during rainy season, winter and summer season.
- Mild climate during growing period (14.5°-28.6°C) greatly improves flowering while higher temperature (26.2°-36.4°C) adversely affects flower production. Hence, flowers of marigold can be had almost throughout the year.

Soil Requirement:

Marigold can be successfully cultivated on a wide variety of soils. However, a soil that is deep fertile and sandy loam, friable having well water holding capacity, well drained and near to neutral in reaction pH of 7.0-7.5 is most desirable.

Preparation of soil:

Land should be well prepared by ploughing 2-3 times and 50 tones of well decomposed farmyard manure should be well mixed. Beds of convenient size are made to facilitate irrigation and other cultural operations.

Propagation:

Marigold is propagated by both methods i.e., Seeds and Cuttings

Seeds:

Nursery beds of 3 x 1 m size are thoroughly prepared and mixed with 10 kg of well decomposed farmyard manure per sqm. For raising crop for an hectare about 8 to 10 beds are prepared. Seed rate is 1 to 1½ kg / hectare. Line sowing at a distance of 15 cm is taken up. After sowing river sand is sprinkled over the seeds and covered. Irrigation is done using rose can. The seeds germinate in seven days. By 30 days the seedlings reach a height of half a foot and is ready for transplanting. A temperature of about 18 to 32 C is required for good germination. Seed treatment with Azospirillum @ ½ kg / seed is recommended for good yield.

Cuttings:

Normally, the presence of adventitious roots along the stem helps in the establishment of cuttings. About 10 cm long cuttings are made and treated with seradix No.1.

Transplanting of Seedlings:

At the time of transplanting, seedlings of one month old at 7 to 10 cm height with 3-4 true leaves have to be selected for proper establishment and higher yield. Aged seedling should not be selected. Transplant should be done early in the morning or late in the evening. One side of the ridges formed. Mid July, mid October and February-March are suitable time for transplanting.

Planting Season

Marigold grows all round the year.

Season	**Month of sowing**	**Month of transplanting**
Rainy season	June last week to July first week	August 1 – 15
Winter season	Mid September	Mid October
Summer season	First week of January	First week of February

Spacing:

In general Tagetes erecta requires wider spacing than T. patula. However a wide range is practiced all over the country for higher yield. They are as follows,

Tagetes erecta	*Tagetes patula*
1) 40 x 40cm	1) 20 x 20cm
2) 45 x 30cm	2) 30 x 30cm
3) 60 x 45cm	

Manures and Fertilizers:

- To get highest flower yield, 100 kg N, 100 kg P2O5 and 100 kg K2O should be mixed at the time of preparation of land.
- Remaining 100 kg N per ha should be applied in 2 splits @ 30 and 40 days after transplanted

Irrigation:

It takes about 55-60 days to complete vegetative growth and to enter into reproductive phase.

Growth Regulators

- Reduction plant height and dark green colour of the foliage in cvs. Moon Shoot, Yellow Galore and First Lady when the plants sprayed with SADH at 2,500 ppm.
- Etherel 250ppm application reduces plant height and increases flower bearing lateral branches.
- After 30 days of planting spray Ascorbic acid at a rate of 1000ppm.
- Spraying cytocyme at a rate of 360 ml / litre of water on 30 & 60 days will increase the number of flower / plant.
- Generally all growth regulators are to be sprayed either in morning or evening.

Micronutrients: Foliar spray of FeSO4 0.5% + ZnSO4 0.5% on 30th and 45th day after transplanting

Biostimulants: Spray Humic acid @ 0.2% on 30 & 45 days after transplanting

Pinching:

- In tall varieties of Tagetes erecta, emergence of side branches and their flowering is influenced by the presence of apical dominance.
- Due to which the plants of marigold grow straight upwards to their final height and develop into terminal flower bud.
- However the apical portion of the shoot is removed at the early stage to get more number of axillaries which in turn produces more flowers.
- Pinching the plants at 40 days after transplanting enabled the plants to yield more flowers.

Flowering

- In summer season crop, - commences by the middle of May with maximum intensity in the month of June and continues till the onset of rains.
- Rainy season crop - by the middle of September and the flowering will continue till December.
- Flowering in winter crop - by the middle of January and will continue till March.

Pests and Diseases:

- Damping off (Rhizoctonia solani) -Seed treatment with capton @ 0.5%
- Collor rot: (Rhizoctonia solani) - Seed treatment with capton @ 0.5%.
- Phytophthora sp. Pythium sp. Sclerotium rolfsi
- Leaf spot (Alternaria tagetica) - Spray with Blitox @ 0.4% or Cercospora spp. Bavistin @ 0.1%
- Blight (Colletotrichum capsia) DM 45 @ 0.2%
- Inflorescence blight (Alternaria zinnac) DM 45 @ 0.2% or Bavistin @ 0.1%
- Powdery mildew (Oidium sp.) Spray with calixin, sulfex @ 0.2% (WS) @ 0.2%

Viral diseases:

Marigold is infected by CMV, Aster yellow virus

Pests

- Red spider mite : Spray Kelthane @ 2ml/l
- Hairy caterpillar: Spray Endosulfan or Ekolux @ 2ml/l
- Leaf hopper : Spray wits Melathian or Rogar @ 2ml/l
- Japanese Beetle
- Tarnished plant bug,
- Slugs

Harvesting

- Marigold flower should be plucked when they attain the full size depending upon the variety.
- Plucking of flowers should be done in cool hours of the day i.e, either in the morning or evening.
- Field should be irrigated before harvesting so that, flowers keep well for longer period after plucking.

- Plucked flowers should be covered with moist gunny bags if kept overnight before taking to market.
- Productivity of plants increases considerably by regular plucking of flowers.

Yield

	No. of flowers Fresh flower	(Million/ha)	(t/ha)
1)	African marigold	(1.5 – 2.5)	(11 – 18)
2)	French marigold	(6.0 – 8.0)	(8 – 12)

Marigold Flower Polysaccharide (MFP):

- MFP can be extracted from the meal with warm (50-55^{0}C) water.
- Petals were separated from the rest of the flower and extracted in a soxhlet apparatus with methanol.

Post harvest processing, grading, packing and storage

After harvesting the flowers they are dried on floor under shade for 2-3 days. Upon drying, the seeds are separated by hammering the flowers and the flower straw is separated out by winnowing of the hammered flowers. The seeds are thoroughly cleaned and graded before packing in poly bags or cloths bags, and are stored in cool places. The moisture contents of the seeds must be examined before the packing.

Extraction of Oil and Quality Control

All parts of *Tagetes patula* contain essential oil, which can readily be extracted by steam distillation. The oil has a pronounced odour and acts as a repellent to flies. It has been reported that Ilimonene, ocimene, I-linalyl acetate and I-linalool have been extracted from Tagetes erecta. While evaluating the different species for essential oil contents, T. signata contained higher essential oil (4.25 of dry matter) of very good quality which can be used in perfume industry.

Seed production

Since marigold is a cross pollinated flower an isolation distance of about 1 to 1 ½ km is maintained. Seed is produced in six months. Winter season is essential for seed production. Long type varieties produce 375 kg / hectare and short type varieties produce about 1,250 kg / hectare.

Lecture 10 : Production technology of jasmine under open conditions.

- Family : Oleaceae
- Botanical name : *Jasminum* spp.
- As many as 40 species of the genus are known to be available in India.
- Important species are :
    1. *Jasminum auriculatum*: Mullai
    2. *Jasminum grandiflorum*: Jathimalli / Pitchi / Spanish jasmine
    3. *Jasminum sambac:* Gundumalli / Malligai / Arabian jasmine

Importance and uses

- Jasmine is one of the important commercial flower crops is cultivated in India.
- Mainly grown as climbers, shrubs and sometimes as pot plants.
- Jasmine flowers, known for their fragrance are used for making garland.
- Used for personal adorning by women and in religious offerings.
- The essential oil extracted from the flowers is a high value perfume.
- There is tremendous scope for the development of jasmine essential oil industry for export.
- Some portion of the flowers are also used for the production of perfumed hair oil and 'attar'.
- The world famous jasmine oil is extracted from flowers of the Spanish jasmine (*J. grandiflorum*).
- The jasmine oil is considered unique as it blends well with other floral extracts to make high grade perfumes and cosmetics.

Soil and Climate

- Jasmine prefers mild tropical climate.
- Loamy (or) red loamy and well drained garden soil is the best suited.
- Since jasmine is commercially grown in India under open field conditions, the ideal requirements for successful cultivation of these plants are mild winter, warm summer, moderate rainfall and sunny days.

Varieties

S.No.	Varieties	Genesis	Characters
***J. auriculatum* - Mullai**			
1.	Parimullai	Selection	Medium round bud Resistant to gall mite Yield 8 t/ha
2.	CO.1	Selection	Long Round type Long corolla tube Yield : 8 t/ha

3.	CO.2	Induced mutant	Long corolla tube Flower buds bolder Tolerant to phyllody Yield : 10 t/ha
***J. grandiflorum* - Jathimalli**			
1.	CO.1	Clonal selection	Pink streaks on outer surface of petals Loose flower production, oil extraction Yield : 10 t/ha
2.	CO.2	Induced mutant from CO.1	Bolder pink buds Long corolla tube Yield : 11.68 t/ha
***J.sambac* - Malligai**			
1.	Ramanathapuram Gundumalli	Selection	Round flowers with good fragrance; yields 7 to 8 t/ha
2.	Khoya	Selection	Bolder buds with less fragrance
Other varieties of *J. sambac* : Ramabanam, Madanbanam, Single Mogra, Double Mogra, Iruvatchi, Kasthurimalli, Oosimalli, Soojimalli.			

Propagation and planting material

- Jasmines are commercially propagated by cuttings and layering.

J.auriculatum	Semi-hard wood cuttings
J.grandiflorum	Terminal cutting cuttings
J.sambac	Terminal and semi-hard wood cuttings.

- Growth regulators : IAA or IBA treated @ 1000 ppm for terminal cuttings and 2500 ppm for semi-hard wood cuttings. The treatment is quick dip method of the basal cut end before planting in the medium.
- Best rooting medium is sand : vermiculate : moss at 1:1:1 ratio.

Planting

Species	Spacing	Density (Plants/ha)	Season of planting
J. auriculatum	1.5 x 1.5 m	4400	June to November
J. grandiflorum	2.0 x 1.5 m	3350	

J. sambac	1.25 x 1.25 m	6400

- The land should have proper drainage, irrigation facilities and sunny location.
- Pits of 45 cm^3 are dug at least one month before planting and exposed to sunlight.
- A few days before planting, pits are filled with 2 parts of FYM and one part each of fresh earth and coarse sand.
- Pits are to be watered for the mixture to get settled.
- Well rooted, healthy and strong plants are planted one in each pit.

Nutrition

Species	Quantity (g/plant) N	P_2O_5	K_2O	Method
J. auriculatum	60	120	120	6 split doses at bimonthly intervals
J. grandiflorum	100	150	100	2 split doses : (1) June - July (2) December - after pruning
J. sambac	60	120	120	2 split doses : (1) June-July (2) November - after pruning

Foliar Nutrition

- Spraying of zinc 0.25% and magnesium 0.5% before flowering increases the yield of flowers.
- Spray $Feso_4$ (5g/)l at monthly intervals until the chlorotic symptoms disappear.

Irrigation

Plants are irrigated by once in a week or once in ten days depending on the soil and climatic conditions.

Pruning

Need for pruning

- In jasmine, flowering habit is terminal and axillary. So increasing the number of shoots is required to increase the yield. This is achieved through pruning.
- Pruning influences growth, flower bud initiation, differentiation and ultimately the flower production. Pruning period

J.sambac - Last week of November

J.grandiflorum - Last week of December

J.auriculatum - Last week of January

- Pruning height : 45-50 cm from the ground level.

Weeding

- Commonly done manually but is expensive.
- Chemical weed control is effective and economical.
- Spraying Oryzalin 1 or 2 application is effective.
- Mulching also reduces weed .

Harvesting

- Jasmine gives economic yield only from the third year and up to 12-15 years and then the yield starts declining.
- The stage of harvest depends on the purpose of flowers to be harvested.
- For fresh flowers, fully developed unopened flower buds are picked in the early morning, while for extraction of concrete only fully opened fresh picked flowers are required.
- Picking of flowers after 11a.m. will considerably reduce the yield and quality of the concrete.
- Damage during harvest and transit will affect post-harvest life of the flowers and concrete recovery.

Grading

- There are no standard grades available for jasmine.
- The flowers may be graded according to the corolla tube length, bud size, shape and freshness.

Packing

- Packing should be functional, economical and attractive besides being acceptable in markets.
- Harvested flowers should be given cold treatment before packing.
- Corrugated cardboard boxes are the proper packing materials for distant market.
- Wholesalers pack flowers in bamboo baskets.
- Provision for air circulation should be provided in the packages.

Yield

- Flower and concrete yield in jasmines vary considerably according to the species and cultivars and management practices.
- The flower yield and concrete recovery in three important species of jasmine are:

Species	Flower yield (T/ha)	Concrete recovery (%)	Shelf life of flowers
J. auriculatum	4.6 - 9.0	0.28 - 0.36	28 - 30 hrs
J. grandiflorum	4.3 - 10.0	0.25 - 0.32	24 hrs
J. sambac	7.4 - 8.2	0.14 - 0.19	28 - 30 hrs

EXTRACTION OF JASMINE CONCRETE

Concrete:

- It is a wax like substance containing the natural flower perfume together with some plant waxes, albumin and colouring matter.
- The natural perfume is available in very small quantity (0.25%) in jasmine flowers in the form of volatile oil.

The concrete is used in the perfumery industry.

Picking of flowers for extraction:

- Freshly picked fully opened flowers are required.
- Jathimalli flowers open in the evening between 5-7 p.m.
- Picking of flowers is before 9.30 a.m.
- Picking after 11.00 a.m. will reduce the yield and quality of concrete.
- Flowers are collected in clean baskets (or) cloth bags without damage and contamination.
- Harvested flowers are kept in cool atmosphere and processed within two hours after harvest.

Processing:

Two steps

- Dissolving the perfume material by treating the flowers with solvent.
- Removal of the solvent from the perfume material by evaporation.

Equipments

1. Extractor (Rotary type of 3 kg capacity)
2. Evaporator (wide mouthed circular stainless steel bowel of 25 litre capacity with air tight lid + hole at the center for the outlet of solvent vapour)
3. Condenser (Stainless steel with 12 small pipes fitted parallelly for solvent vapour passing and circulating cold water to condense the solvent).
4. Vacuum distillation unit.

STEP I – Solvent treatment:

Flowers are soaked in Food Grade Hexane (Having Boiling point of 70°C).

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Mixing Hexane 2 litres / kg of flowers for 30 minutes.

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Rotate the container slowly for 20 minutes in the rotary type of extractor.

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Perfume substance along with wax and pigments dissolved in Hexane.

STEP II - Evaporation

Perfume laden solvent is led into the evaporator

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Evaporation at a constant temperature of 75°C.

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Vapour of the solvent condemned into liquid for recycling

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Liquid (Perfume, wax & pigments) is distilled in a vacuum distillation unit for complete removal of solvent in the still

↓

Floral concrete settled in the still in the form of molten wax

↓

Cooled and Stored in glass (or) aluminium containers