Certified Farm Advisor in Floriculture (Module – II)

Training Manual

Compendium of lectures delivered in the training Programme on Floriculture (Module – II) organized at ICAR – DFR, Pune & sponsored by MANAGE, Hyderabad during November 14-28, 2018

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Preface

Considering the rapid urbanization, increased income levels and change in life style & the habit of saying it with flowers, there is huge scope for expansion of floriculture both for domestic as well as export market. Flower crops suitable for varied agro-climatic conditions of the country were identified and technologies are available for profitable cultivation of flowers. Floriculture as a diversification option in the agri-business can play a vital role in doubling the farmer's income by 2022 as announced by Government of India.

The floriculture industry in India is characterized by growing traditional flowers (loose flowers) and cut flowers under open field conditions and protected environment conditions, respectively. India also has a strong dry flower industry, which provides major contribution to the overall trade. Other segments like fillers, potted plants, seeds and planting material, turf grass industry and value added products also contribute a share in the overall growth of the floriculture sector. Floriculture in India occupies an area of 306000 ha with a production of 2392000 MT which includes 693000 MT of cut flowers and 1699000 MT of loose flowers during 2016-17 (NHB Database 2018). India exported floricultural products worth Rs. 507.31 Crores during 2017-18 (APEDA 2018).

Consistent growth in area, production and exports of floriculture indicate the potential of this sector and necessitates immediate measures for its promotion among the farming community and also calls for capacity building programmes among the stakeholders. In this direction, ICAR – Directorate of Floricultural Research organized a training programme on ***Certified Farm Advisor in Floriculture (Module – II)*** sponsored by National Institute of Agricultural Extension Management (MANAGE), Hyderabad during November 14-28, 2018. This training programme is aimed to train the staff from State Departments of Horticulture/Agriculture, KVKs, and Agri-entrepreneurs and expose them to ***Technologies in Floriculture*** and also recent advances in floriculture R & D so that they may in turn extend these technologies to the farmers of respective regions to enhance the area, production and productivity of flower crops. This is a specialized training focusing on selected components of floriculture as the group is heterogeneous. We hope that the topics covered by distinguished resource persons would certainly enrich the knowledge of participants significantly.

We are thankful to Mrs. V. Usha Rani, IAS, Director General & Ms. Sadalakshmi, Consultant from National Institute of Agricultural Extension Management (MANAGE), Hyderabad, Dr. T. Mohapatra, Director General, ICAR & Secretary, DARE, Ministry of Agriculture & Farmers Welfare, GoI, Dr. A. K. Singh, DDG (HS) & Dr. T. Janakiram, ADG (HS-II), ICAR for supporting us in the conduct of this training programme.

We are also thankful to the resource persons who have spared their valuable time to deliver the lectures on various aspects and also submitted their lecture notes for the preparation of this compendium. We thank all the participants and their sponsoring departments for giving us an opportunity to conduct this training program. Support from all administrative & accounts, technical and contractual staff of ICAR – DFR is duly acknowledged.

We hope that this compendium is useful not only to the trainees but to all those interested in floriculture.

Date: 28.11.2018

Dr. K. V. Prasad

Director

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STATUS OF COMMERCIAL FLORICULTURE IN INDIA

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INTRODUCTION

In India, floriculture is very closely associated with our culture. Earlier, the art and science of growing flowers was mostly restricted to the backyard of individual houses or in the public or private gardens. However with the liberalization of seed policy and the opening up of economy, floriculture became a commercial enterprise during late eighties. A wide range of conducive agro-climatic conditions across the country enable India to cultivate a large number of flowers, potted plants, foliage and aromatic flowers almost throughout the year in one part or the other. The gradual shift from sustenance agriculture to self-sufficiency in agriculture brought about a change in life styles and increased the per capita income which in turn fuelled the growth of floriculture sector in the recent years.

ADVENT OF COMMERCIAL FLORICULTURE

Large scale cultivation of flowers for trade and commerce picked up during 80’s and 90’s. Indian floriculture is predominantly dominated by loose flowers, which are used for worship, decorations and personal adorning. In India no religious ritual or a function is complete without flowers. The flowers are entwined in the social fabric of the entire nation. The advent of state of the art greenhouse technology during early 90’s paved the way for the commercial cultivation of cut flowers for export. A large number of corporate houses established intensive production centers across the country to produce international standard cut flowers. Export of roses, which was almost non-existent 15 years ago, has assumed the distinction of being one of the fastest growing industries in the history of India. Before we understand the intricacies of Indian flori-business, it is important that we understand the magnitude of bloom business in the world.

MAGNITUDE OF COMMERCIAL FLORICULTURE

Globally floriculture is part of Lifestyle Horticulture which is worth US$ 286.7 billion contributed mostly by the developed nations US (US$ 129 Bn); Japan (US$64.8 Bn); Germany (US$ 23.2 Bn); UK (US$19.3 Bn); and Canada ($10.7 Bn) (Floriculture International 2012). Commercial floriculture is dominated by the Netherlands followed by Columbia, Kenya, Ecuador and Ethiopia over the last decade (2005-15) Fig 1.

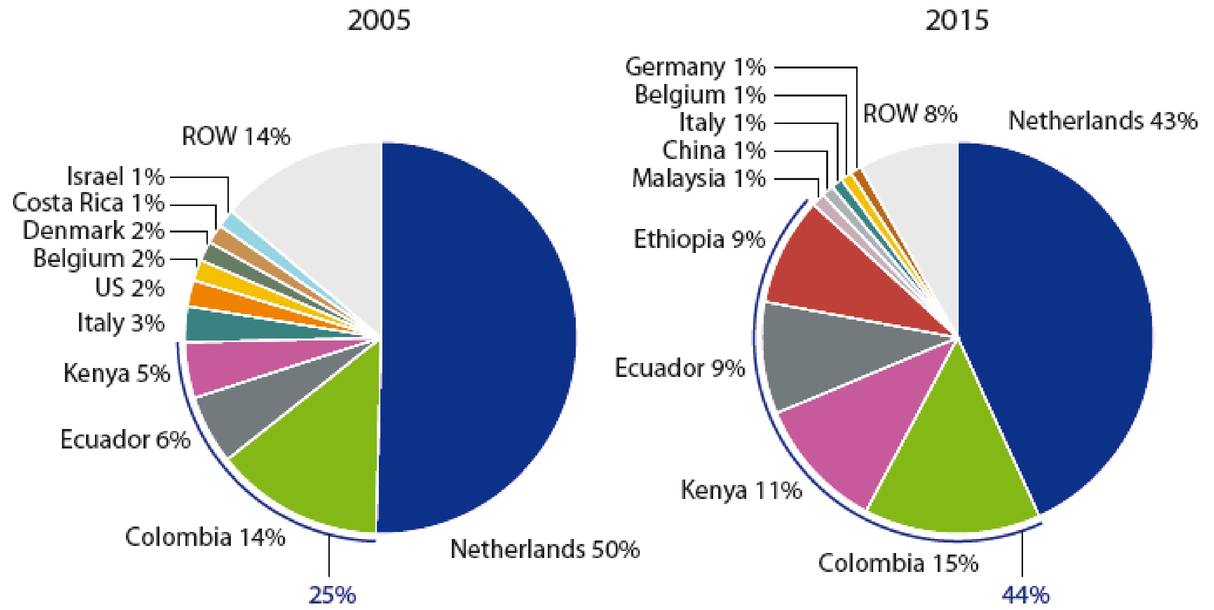

Fig. 1 Comparison of major players in the global floriculture trade during 2005 and 2015

The floriculture industry in India is characterized by growing traditional flowers (loose flowers) and cut flowers under open field conditions and protected environment conditions respectively. India also has a strong dry flower industry, which provides major contribution to the overall trade. Other segments like fillers, potted plants, seeds and planting material, turf grass industry and value added products also contribute a share in the overall growth of the floriculture sector. The traditional flower cultivation, comprising of growing loose flowers mostly for worship, garland making and decorations, forms the backbone of India floriculture, which is mostly in the hands of small and marginal farmers. Globalization of India economy and subsequent liberalization of seed act paved the way for the advent of protected cultivation in India during early 1990s. Over the last 15 years the organized sector of floriculture focusing on exports witnessed an enormous growth to a tune of 500-600%. Today over 50 Export Oriented Units (EOU's) are engaged in cultivation and export of flowers contributing 0.04% to global floriculture trade (Rs.540 crores).

EXPORTS FROM INDIA

The transformation of India floriculture from pushcart transportation to charted flight transportation is phenomenal. Floricultural exports from India comprises of fresh cut flowers (to Europe, Japan, Australia, Middle East and USA) loose flowers (for expatriate Indians in the Gulf) cut foliage (to Europe) Dry flowers (To USA, Europe, Japan, Australia, Far East and Russia) Potted Plants (Limited to very few countries). Out of these components dry flowers contribute a major share (to a tune of 50-60%) to the total export. Due to concerted efforts of research, development and the proactive role played by the Government through various developmental programmes the floricultural industry engaged charted flights to Amsterdam and Alsmeer to transport precious flowers for the first time in the History of India during 2000. The South Indian Floriculture Association in the Bangalore cluster pooled the flowers produced by the member units and transported them by dedicated charted flights to the auction houses on the eve of new year and Valentine's day.

Even after 15 years of steady growth, the Indian floriculture sector remains mostly event oriented rather that a regular exporter. Indian exports mostly target the major floricultural important events like Christmas (December) New Year eve (January) Valentine day (February) and Mother's day (May). The major factor being the unfavorable weather conditions during winter in the major production centers in the Northern Hemisphere limits the production. Therefore the markets are open to produce that comes from more favorable climates from the Southern Hemisphere. India therefore finds itself competing with other equally favorable countries like Kenya, Ecuador, and Morocco etc. during such events.

The floriculture exports from India increased over the years to reach a mark of Rs. 540 crores during 2016-17. The major importers of Indian floricultural produce are the export basket (Fig.2) comprises of dry flowers (71%), fresh cut flowers (18%) live plants (9%), fresh bulbs (1%) and foliage (1%).

	2013-14		2014-15		2015-16	
Country	**Qty (kg)**	**Value US$**	**Qty (kg)**	**Value (US$)**	**Qty (kg)**	**Value (US$)**
United States	5,158.70	13052584	5,490.00	15142123	5,185.09	14934593
Germany	2,841.16	9148187	2,240.04	8559188	2,336.20	8783953
United Kingdom	2,583.87	8505739	2,557.24	9176917	2,197.52	8636012
Netherland	1,983.51	10207190	2,060.74	7907884	1,883.90	8590572
United Arab Emirates	1,026.05	2624702	1,582.65	3400972	1,499.63	4164959
Canada	567.78	2106634	856.16	2373784	945.88	2678799
Japan	727.07	2501697	608.91	2264079	421.97	2463385
Singapore	817.98	1404891	916.94	1647770	1,092.47	2063215
Australia	270.35	1537324	474.72	2250979	380.96	2053186
Italy	682.75	2056673	561.65	1863663	444.91	1752399
Total	**22,485.21**	**72365079**	**22,947.23**	**71995312**	**22,518.57**	**74909375**

Source: DGCIS Annual Export

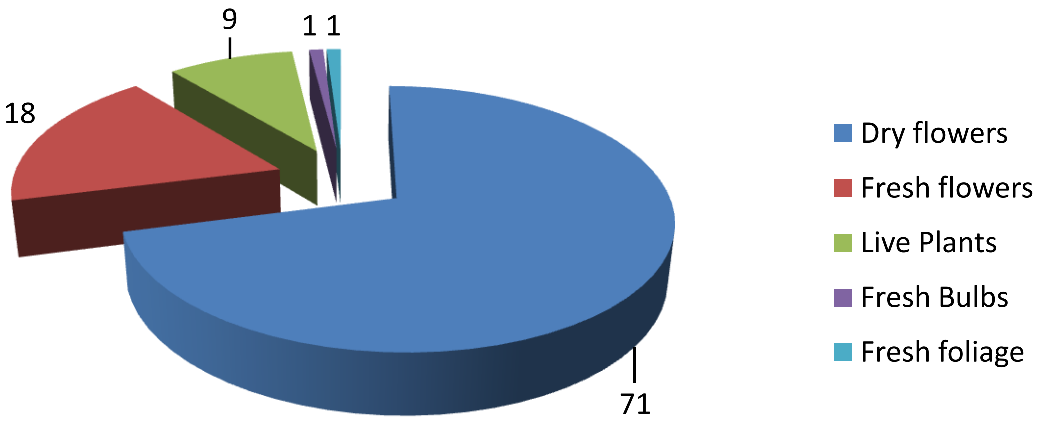

Fig 2. Export basket from India

COMPONENTS OF FLORICULTURE

A TRADITIONAL FLOWERS

The estimates for the year 2017-18 indicate that about 3,42,000 ha of area is under traditional floriculture producing 1760000 MT of loose flowers and 769000 MT cut flowers. The state of Tamil Nadu leads in loose flower production with 55030 ha followed by Karnataka (30900) and West Bengal (25320). World-wide consumption of floriculture products is estimated to be 120-160 billion US dollars by the end of 2020. Cut flowers contribute about 60 per cent of the world trade and the remaining are live plants, cut foliage, dry flowers etc., Since India is situated comparatively closer to major flower consuming countries than its Asian counterparts, it has very good scope and potential in the flower trade. The severe winter in major flower producing European countries is also an advantageous factor to India, especially areas like Bangalore, Pune, Hyderabad, Nasik, North East (for Orchids and Anthuriums) which enjoy moderate climate all through the year.

B CUT FLOWERS

In India nearly 98.5% of flowers are grown under open cultivation and hardly 1.5% flowers are grown under green house cultivation of the total area of 248000 hectares. Hi-Tech floriculture industry is still in its infancy. The corporate sector started its entry into the floriculture sector in the early 1990's. Most of the floriculture projects have adopted technology from either the Netherlands or Israel. The total investment in this sector presently is Rs. 1000-1500 cr. and is spread over 110 greenhouses covering an area of 500 ha mostly under rose cultivation. The average investment in each floriculture project ranges between Rs. 3-4 crores per hectare. Most units are around 3-4 hectares in size.

Even though there has been a sporadic increase in the production of flowers, India's share in global trade is hardly 0.4% compared to the Netherlands 43%, Colombia 15%, Kenya's 11% and Ecuador (9%). The state of West Bengal leads the pack followed by Karnataka. Other major cut flower producing states include Odisha, Uttar Pradesh, Maharastra, Gujarat, Andhra Pradesh, Telangana, Assam etc.

C NURSERY INDUSTRY

i) Pot Plant Production and Rentals

In the global bloom business, the second important segment of floriculture, which contributes a major share after cut flowers, is the sale of pot plants. The pot plants can be either foliage or flowering plants produced and consumed in The Netherlands and the neighboring Germany, Denmark, Italy and Spain. Poinsettia is the single largest flowering pot plant traded in the world and 80% of which is traded in USA alone. Similarly, Kalenchoe is the largest traded commodity among the foliage plants. India has a rich diversity of ornamental wealth and many native plants can be grown as pot plants and can be traded in Domestic and export markets.

Due to rapid urbanization and industrialization the land under agriculture and forestry is fast depleting. In a quest to bring the nature to drawing rooms the urban population is more inclined to purchase and grow plants in their houses, which has opened the avenue for the large scale production of potted plants and their marketing. It has also opened up a newer avenue of plant rentals for interior decoration in corporate houses.

ii) Plug Plant Production

Many bedding and annual flowers are produced in highly automated greenhouses in the west to produce billions of plants for the corporate and public landscaping. Due to increasing fuel costs and labour costs in the west there is little scope for further expansion of these hi-tech industries in the developed world. Due to congenial environment across our country we have the unique advantage of diversifying in to large scale production of seedlings of annual flower crops as well as the vegetable crops.

D Corporate Landscaping

The avenues for corporate landscaping are fast expending due to increasing industrialization and environment regulation and the quest to beautify the surroundings. Progress in the corporate landscaping has synergized the growth of conventional nursery industry, which now specializes on specific items like turf grass, succulents, cacti, aquatic plants etc.

E Plant Tissue culture

Plant tissue culture activities in India are at present confined to production of ornamental and flowering plants, which have a large global export market. Cheap labour and incentives provided by Government are likely to give further boost to setting up of more units for commercial production. Demand for flowers is increasing globally. India is expected to emerge as a strong player in the consumer market of biotechnology products in the coming years. In India there are 90 tissue culture units producing mostly foliage and flowering potted plants. The global biotechnology business is about 150 $ billion and about one tenth of it is contributed by the plant biotechnology alone. The global demand for the tissue culture products is constantly increasing at a rate of 10% per annum. The present installed production capacity is about 100 million plants per annum but only fifty percent of the capacity is being utilized. The R&D efforts in Indian organizations resulted in development of reproducible, high frequency regeneration protocols for most of the ornamental crops, which are tailor made for the Indian conditions and are available for implementation by the Indian entrepreneurs.

F Essential Oil Extraction

The major flower crops that are important for essential oil extraction include rose, jasmine, tuberose, vanilla etc., The major producers of essential oils are Brazil, China, USA, Egypt, India, Mexico, Guatemala and Indonesia. All of them with the exception of USA are developing countries with low cost, peasant type economies. The major consumers are the USA (40%), Western Europe (30%) and Japan (7%). The demand for the essential oils progresses at a rate of 7-9% per annum and offers unique scope for large scale cultivation of essential oil bearing crops and their processing using both conventional and ultra modern vacuum distillation/ solvent extraction/ liquid CO_2 methods

G Dry Flowers

One can enjoy the freshness of a flower garden throughout the year by cutting and drying the favorite flowers. The two easiest and least expensive methods are sand-drying and air-drying. Sand-drying can be used to dry a wide variety of flowers, such as roses, tulips, dahlias, marigolds and snapdragons. Flowers which last only one day, like day lilies, do not dry well. Do not dry asters, azaleas, chrysanthemums, geraniums, petunias, phlox, pinks, poppies or violets. Nearly 50-60% of Indian floriculture exports (Rs. 305 cr during 2016-17) comprise of dry flowers.

Some flowers that can be air-dried well are: Dahlias (*Dahlia hortensis*), Poppy seed heads (*Papaver somniferum*), Roses (*Rosa*), Delphinium, Larkspur (*Consolida ambigua*), Lavender (*Lavandula augustifolia*), African Marigold (*Tagetes erecta*), Strawflower (*Helichrysum bracteatum*), Cornflower (*Centaurea cyanus*), Statice (*Limonium sinuatum*), Globe amaranth (*Gomphrena globosa*), and Lotus pods etc.

Dry flowers constitute nearly 15 % of the global floriculture business and form the major share in Indian floricultural exports as well. At present the industry is not well organized and depends on the plant material available in forests and no systematic growing of specialized flowers exists anywhere in the country. The demand for the dry flowers is increasing at an impressive rate of 8-10% and therefore there is a great scope for the Indian entrepreneurs.

H. Pot Pourri

Flowers, herbs and spices have been used for thousands of years to add fragrance to our lives. From the earliest writings we have found evidence of the importance various scents have played in our history. Pot pourri is a mixture of dried, sweet-scented plant parts including flowers, leaves, seeds, stems and roots. The basis of a potpourri is the aromatic oils found within the plant. These oils are not confined to the flowers, but are at their peak at flowering time.

Two kinds of potpourri can be made - dry and moist. The most common, the dry method, is quicker and easier, but the potpourri does not last as long. Both methods require a "fixative", which is responsible for absorbing the aromatic oils and slowly releasing them. Common fixatives include finely ground non-iodized (pickling) salt, orris root (dried rhizomes of the iris plant), sweet flag (calamus root), gum benzoin, storax (styax) and ambergris. Make sure the fixatives are finely ground so they can better absorb the aromatic oils.

I. Natural Pigments / Dyes from Flowers

At present the technology for isolation of xanthophyll pigments present in Marigold has been perfected and large scale cultivation of Marigold is being attempted in parts of India in association with the extraction Industries. The marigold pigment is widely used in the poultry industry to enhance the color of the meat as well of the yolk of the eggs beside it usage in food and textile industry. Similarly many native flowers possess valuable pigments, which can be isolated and used for varied applications including pharmaceutical.

J. Seed Production

Commercial cultivation of flowering annuals for producing the seeds / F1 hybrids is fast expanding across the country due to promising economic returns. Seed production of marigold, verbena, caladium, pansy, viola, stock etc holds promise for peri urban locations of North India.

K. Lawn industry

The demand for turf grass is increasing day by day as new specialized parks, golf courses and stadia are emerging in different locations of the country. The corporate houses are evincing their commitment to mitigate the pollution by resorting to landscaping the corporate premises and their factories. Such initiate though few in number but rapidly expanding to create enough market for this sector.

Sporting events like the forthcoming Commonwealth games would synergize the demand for specific grass for the stadia to be constructed for the event. Similarly there would be associated beautification activities in the commonwealth games village to be constructed, to augment the need this sector requires huge quantities of various types of turf grass.

L. Florist and Floral Decorations

The demand for floral decorations is increasing rapidly due to lavish arrangements during social, political, entertainment and sports events. This sector though is unorganized the volume of business is quite significant.

Conclusion

Floriculture offers perhaps the largest livelihood opportunities when compared to other branches of agriculture and horticulture. The opportunities are more for the women in harvest, post harvest and value addition in all most all the sub sectors highlighted in this paper.

ADVANCES IN CULTIVATION OF ROSES UNDER OPEN FIELD CONDITIONS

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INTRODUCTION

Rose is one of the most beautiful creations of nature and is universally acclaimed as queen of flowers. Apart from being admired for its beauty, rose is used in worship, garlands, bouquets, cut flowers, preserves and decorations, etc. Because of diversified growth habits, exquisite shape, variation in size and form, attractive colour, delightful fragrance and numeral varieties, rose have gained wide acceptability. It is a good plant for garden decoration and landscaping. Roses can fulfilled the requirement of trees, shrubs, climbers, hedges and edges in the landscape planning and design of gardening. Rose cultivation is done in different parts of the world for commercial purpose. Rose cultivation is also done for the extraction of essential oil from rose petals. Scented roses like *Rosa damascene, R. bourboniana, R. centifolia* are utilized for this purpose. The important points considered for its cultivation are described below.

VARIETIES

Modern roses are classified as hybrid teas, floribunda, polyanthas, climbers and miniatures. Hybrid teas are grown for production of cut flowers and garden display. Floribunda varieties are highly suitable for gardens as bears in clusters. Miniatures are suitable for edges, borders and pot purpose. Climbers can be suitably trained on arches, gates and fences. Some of the popular varieties among different classes are:

Hybrid Teas: First Red, Super Star, Gladiator, Happiness, Raktgandha, Mrinalini

Floribundas: Charleston, Iceberg, Mercedes, Pink Parfait, Sea Pearl, Summer Snow, Banjaran, Pusa Mukan

Polyanthas: Echo, Paul Crampel, Vatertag

Miniatures: Blue Mist, Cricri, Little Eskimo, Little Flirt

Climbers: Cocktail, Golden Showers, MarechalNiel, Pinata

SOIL AND CLIMATE

The ideal soil for rose growing should be loamy having adequate organic matter with a pH of 6.0-6.5. The soil depth should be at least 45 cm. Roses are sensitive to salinity and sodicity. Roses can't with stand water logging even for a shorter duration. Moderate temperature, bright sunshine and high light intensity are good for rose growing. Roses can be successfully grown in different climatic zones of India. Moderate temperature, bright sunshine and high light intensity are ideal for rose growing. At least 6 hours of sunlight is required for healthy growth of roses. Rose bushes not receiving the morning sun perform poorly. A night temperature of 15 – 16° C and day temperature 22-28° C is ideal.

PROPAGATION

Roses are commercial propagated by T- budding. *Rosa indica*varodorata is an ideal rootstock for North Indian plains and *Rosa multiflora* for South India and hills. *Rosa borbouniana* is used for producing standard roses but is highly susceptible to powdery mildew. In North

India, budding is done from January to mid- March. In eastern India budding is done in Oct-Nov and Feb-Mar. In hills spring season is the best. Thorn less *Rosa canina*, *R. manetti* and 'Dr. Huey' are the other rootstocks used for propagation. Climbers and miniatures can be propagated by hard wood cuttings.

PLANTING

The ideal time for planting in North Indian plains is October to November and February to March in hills. Pits of 30 × 30 × 30 cm are prepared. The planting can be done so that bud union should remain 5 cm above soil level. The pit is filled with soil along with 3 kg FYM.

SPACING

Plant density is the most important factor determines the ultimate flower quality and yield and depends on cultivar, soil and environment conditions. A spacing of 60 cm between plants and rows can be given for hybrid teas and floribundas. Polyanthas are planted 45 cm apart, miniature 30 cm and climbers at 3 m or more. For cut flower production, a spacing of 45 × 45 cm can be employed between plants and rows.

PRUNING

In North Indian plains, the rose bushes are pruned once in a year during 2nd and 3rd week of October. While pruning, all dry, diseased, weak and criss crossed branches are removed. Any suckers that arise from rootstock should be removed. The pruning is generally done by giving a cut at about half a cm above a vigorous bud that points in directions that desire one new shoot to grow. While pruning, 4-5 canes are retained to a height of 45 cm. Light pruning gives more number of small size of flowers. Heavy pruning is done to get few exhibition blooms. The cut end should be sealed with blitox paste. In miniatures and climbers, pruning is not done but only dead and diseased branches are removed.

REMOVAL OF SUCKERS

The removal of surplus new growth and suckers appearing from the root stock should be removed for the healthy growth of the plant.

NUTRITION

Nutritional requirements vary with rose cultivars, soil type and its fertility status. The best time for adding manure is before planting and at the time of pruning. Generally 4-8 kg FYM per bush is adequate. A fertilizer dose of 40 gm N, 20 gm P_2O_5 and 20 gm K_2O per bush is to be applied after pruning. A 2nd dose of N (20 gm) is to be given after first flush of flowering is over. In soil deficient in micro nutrients, foliar spraying can be done. Increased flower yield was obtained with 1.0% spray of Iron sulphate and Zinc Sulphate.

IRRIGATION

Roses need plenty of water for their optimum growth and flowering. But they do not like water logging. The frequency of watering is dependent on weather and soil. Generally the rose beds are watered once in 2 weeks in winter and once in a week in summer.

HOEING

Light hoeing is required in roses to improve aeration, moisture retention and keep the bed free of weeds.

WEEDING

Generally hand weeding is employed to keep the rose beds free from weeds. glyphosate 1.0kg a.i /ha and oxyflourfen 0.5kg a.i/ha can be employed for weed control.

HARVESTING AND YIELD

Red and pink cultivars are harvested at a stage when first two petals are beginning to unfold and calyx is in downward position. In yellow cultivars, harvesting should be done slightly earlier than red cultivars. In case of white cultivars, this should be done slightly later than red and pink cultivars. For export purpose, flower stems should be harvested at tight bud stage. Flower picking should be carried out twice a day morning or evening. Immediately after cutting, the flowers are to be placed in a bucket of clean water up to half of flower base. After this, flower stalk should be re-cut 2 cm above to previous cut. About 1.25 to 1.5 lakh cut flowers per hectare are produced in India.

PEST AND DISEASES

There are number of pests infesting roses like aphids, thrips, jassids, red scales, red spider mites and termites. A regular spray of Imidacloprid (0.3 ml/lt) or dimethoate (1.0 ml/lt) will control aphids, thrips, jassids and red scales. Red spider mites can be controlled by using abamectin (1.0 ml/lt) or Propargite 57 EC (2ml/litre). Termites can effectively be controlled by chloropyriphos (4.0 ml/lt).

Most commonly occurring diseases are die back, powdery mildew, black spot and downy mildew. Die back and powdery mildew can be controlled by spraying Carbendazim (1.5 g/lt). Black spot can be controlled by spraying chlorothalonil (1.0 g/lt).

SOIL QUALITY AND SOIL SAMPLING TECHNIQUES

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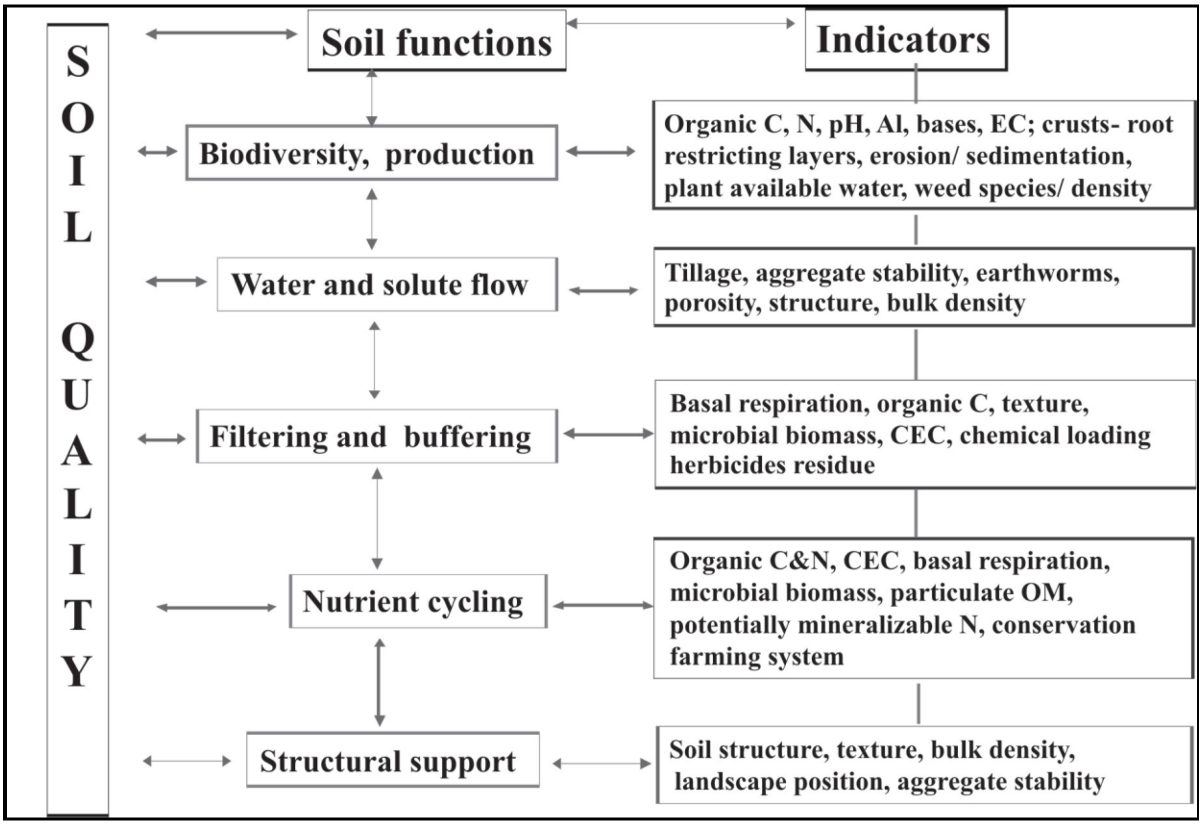
Soil quality is the ability of a soil to perform the functions necessary for its intended use. The term “soil quality” has been coined to describe the combination of chemical, physical, and biological characteristics that enables soils to perform a wide range of functions. The terms soil health and soil quality are often used interchangeably.

Soil functions include:

- sustaining biological diversity, activity and productivity
- regulating water and solute flow
- filtering, buffering, degrading organic and inorganic materials
- storing and cycling nutrients and carbon
- providing physical stability and support

A graphical representation of soil quality concept is presented in below figure



CHARACTERISTICS OF A HEALTHY SOIL ARE

- Supply of plant nutrients in a balanced way
- Improved moisture retention/drainage properties
- More number of beneficial microorganisms
- Reduced number of pathogenic organisms and harmful insects
- Absence of substances toxic to plants and microorganisms
- Reduced weed menace

Maintaining soil in optimum health is a prerequisite to support necessary food grain production and sustain ecological services. Some of the reasons for declining soil health are as follows

- Intense rate of soil erosion
- Reduced application of organic matter
- Imbalanced use of chemical fertilizers
- Impair of physical properties due to faulty tillage and other management practices
- Adoption of mono-cropping

SOIL HEALTH ASSESSMENT

Soil health assessments are conducted by evaluating *indicators*. Indicators can be physical, chemical, and biological properties, processes, or characteristics of soils. They can also be morphological or visual features of plants. Indicators are measured to monitor management induced changes in the soil. Soil quality indicators are selected because of their relationship to specific soil properties and soil quality. For example, soil organic matter is a widely used indicator, because it can provide information about a wide range of properties such as soil fertility, soil structure, soil stability, and nutrient retention. Similarly, plant indicators, such as rooting depth, can provide information about the bulk density or compaction of the soil.
Following lab/field measurements help analyzing and describing state of soil health

PHYSICAL INDICATORS

- Physical indicators are related to the size and the arrangement of solid particles and pores
- Physical indicators primarily reflect limitations to root growth, seedling emergence, infiltration or movement of water within the soil profile

Some examples of physical indicators are: soil structure and macropores, aggregate stability, bulk density, infiltration and available water capacity.

CHEMICAL INDICATORS

- The soil's chemical condition affects soil-plant relations, water quality, buffering capacities, availability of nutrients and water to plants and other organisms, mobility of contaminants. Some examples of chemical indicators are: soil electrical conductivity, soil ph and available nutrients

BIOLOGICAL INDICATORS

- Biological indicators include measurements of micro-and macro-organisms, their activity, or byproducts. Some examples of biological indicators are: total organic carbon, soil respiration, soil enzymes, earthworms and potentially mineralizable nitrogen.

Indicators can be assessed by *qualitative* and/or *quantitative* techniques. A qualitative assessment is the determination of the nature of an indicator. A quantitative assessment is the accurate measurement of an indicator. For example, if erosion is the indicator being evaluated, a qualitative assessment would be the observation of rills and gullies in the field, indicating that erosion is occurring. A quantitative assessment would measure the amount of erosion occurring in the field. In another example, a qualitative assessment of infiltration would be the observation of excessive runoff water from a field. A quantitative assessment would measure the infiltration rate.

Qualitative assessments have an element of subjectivity and, thus, are best done by the same person over time to minimize variability in the results. Indicators measured with a quantitative method have a precise, numeric value. Therefore, different people conducting the same measurement should be able to produce very similar results.

Qualitative assessments usually can be done simply and quickly, and producers can complete them unassisted. If tools are required, they are usually simple and easily obtained. However, because of the subjective nature of the qualitative assessment, results cannot be compared to any target levels for soil properties, nor should results be compared among different users or different farms. Although more time consuming and sometimes more complex, quantitative assessments are more appropriate to use when different people will be conducting the assessment over time or when there is interest in comparing soils to some target level based on soil surveys or other data.

AN USEFUL INDICATOR MUST BE

•Easy to measure

•Able to measure changes in soil functions

•Assessed in a reasonable amount of time

•Sensitive to variations in climate and management

•Assessed by qualitative and/or quantitative methods

DIFFERENT TOOLS USED TO MEASURE SOIL HEALTH ARE

SOIL HEALTH CARDS

The soil health, or soil quality, assessment card is a qualitative tool designed by and for farmers. The cards contain farmer-selected soil quality indicators and associated ranking descriptions typical of local producers. Generally, indicators listed, such as soil tilth, abundance of earthworms, or water infiltration, can be assessed without the aid of technical or laboratory equipment. All cards have a scoring system, which usually includes either a range of poor to good or a numerical scale from 1 to 10 for each indicator. Individual indicator scores are generally not combined or totaled, and there is usually space on each page to record results for each field.

SOIL QUALITY TEST KIT

The Soil Quality Test Kit is an on-farm soil quality assessment tool. Included in the kit are tools to measure standard soil quality indicators such as respiration, water infiltration, bulk density, electrical conductivity, pH, aggregate stability, slaking and earthworms. The kit provides a soil quality assessment method that quickly provides quantitative, reliable data. Most of the tests can be conducted in the field and/Orin the office.

LANDSCAPE LEVEL ASSESSMENTS

Use satellite and remote sensing technology to assess resource quality at large spatial scales. Using remote sensing to predict soil carbon storage is one possible use for this type of assessment.

LABORATORY ANALYSIS

The biggest advantage of a lab analysis is assurance that the results are obtained with quality control and that they are numerically reliable for long-term comparisons. Also, results from fertility related tests are often returned with interpretations and with specific recommendations to help make management decisions.

Some of general soil health management practices are

- ❖ Conservation of top soil-contour cultivation, crop residues
- ❖ Increased use of organic manures, crop residues etc
- ❖ Adoption of integrated nutrient, pest and disease management practices
- ❖ Reduce pressure on land- conservation tillage
- ❖ Adoption of multiple cropping systems and crop rotations

SOIL SAMPLING PROCEDURE FOR NUTRIENT ANALYSIS

Soil sampling is a technique by which a true representative sample of a given area is collected. Collection of representative sample is most important in an effective soil testing programme as the entire analysis and recommendation depends on the sample collected. Unless care is taken in collecting a representative sample, any amount of precaution taken during soil analysis will be a waste.

The type of sample to be collected depends on our objective and the type of crops. (a) for study of soil genesis, soil sampling has to be done horizon wise from a profile, (b) for studying soil fertility, sampling has to be done from the plough layer (0-6 cm), (c) for shallow rooted crops sample has to be collected from the plough layer, but for perennial crops - two samples at two depths (up to 30 cm). Depth of root penetration is an important consideration for deciding the depth of sampling. For field crops a depth of 15-20 cm is desired, for deep rooted crops like sugarcane, red gram, cotton and horticultural crops, it is necessary to have samples from different depths.

The depth of sampling should be decided based on the type of nutrient to be analysed. For immobile elements like PO_4^{3-}, K^+, Ca^{2+} and Mg^{2+} sample up to 15 cm (tillage depth) is enough. But for mobile elements (NO_3^- and SO_4^{2-}), some recent studies have indicated that samples should be taken up to a depth of 60 cm. In case of salt affected soils, visible salt crust on the soil surface should be sampled separately and the depth of sampling recorded.

Factors to be considered while Soil sampling

Some of the important factors considered for soil sampling are

1.	Size of area	:	1 composite sample for every 2 ha
2.	No. of sub samples	:	15 to 20 sub samples per sampling area (2 ha)
3.	Depth of soil sampling	:	Shallow rooted crops: 0-15 cm (plough depth)
			Deep rooted and Horticultural crops: Sample may be taken from different depths or layers depending upon the root penetration of plants.
			Problematic soils: 0-15, 15-30, 30-60, 60-90 cm
4.	Frequency of sampling	:	Once in three years for dry land crops
			Once after three crops in irrigated areas.
5.	Time of sampling	:	Ideal time is before the onset of monsoon or immediately after the harvest of the crop
6.	Sampling in standing crop	:	Field crops: Between rows
			Plantation/ fruit crops: On the canopy circumference

SAMPLING TOOLS

Depending upon the soil condition and the amount of sample require, a suitable tool can be chosen from the following.

1. Augers

a) Screw Auger: Fine textured soils, when soil is moist
b) Post hole auger: Large quantity of sample can be collected even in dry condition. It can be used in coarse textured soils.
c) Tube auger: For puddle paddy/ water logged soils. From this equal amount of sample can be collected from all the spots.

2. Core sampler: Sample can be collected without disturbing the soil and using this one can measure the volume of sample collected and it is useful in calculating bulk density of the soil.

3. Other tools: Pickaxe, Spade, Shovel, Khurpi (soft and moist soil)

SAMPLING MATERIALS

Bucket, scale, polythene bags, cloth bags, polythene sheet, labels and information sheet.

PROCEDURE/ STEPS IN SOIL SAMPLING

1. Divide the field into sampling areas so that each sample represents an area of not more than 6 acres. Each sample area should be uniform in soil type, slope, cropping pattern and past fertilizer management.
2. Fix sampling spots (about 15 or 20) at random in a zig-zag pattern to represent the entire area taking care to avoid sampling near field bunds, wet places, trees, roads, drainage ditches etc.
3. Scrape away the surface litter, stones etc. and collect samples into a bucket from each spot upto the required depth by making a 'V' shaped cut upto the required depth using a spade and take a slice of soil from both the sides. Collect same quantity of sample from each of the sampling spots.
4. Place the sample on a plastic sheet and mix by discarding stones, roots, etc. and take out the required quantity of soil into a polyethylene bag by adapting quartering technique.

Fill in the information sheet giving the following details:

1.	Name of the farmer	:	
2.	Village	:	
3.	Taluk	:	
4.	District	:	
5.	Area and location	:	
6.	Survey No.	:	
7.	Date of sampling	:	
8.	Area (in acres)	:	
9.	Slope	:	Level/ undulating
10.	Depth of sampling (cm)	:	0-15/ 15-30
11.	Elevation	:	Upland/ low land
12.	Irrigation and their source	:	Irrigated/ Rainfed
13.	Soil type	:	Coarse or heavy, water logged or salt affected
14.	Drainage	:	Good/ Poor

15.	Crop growth	:	Good /Poor/ Average
16.	Crops to be grown	:	
17.	Sample No.	:	
18.	Label No.	:	

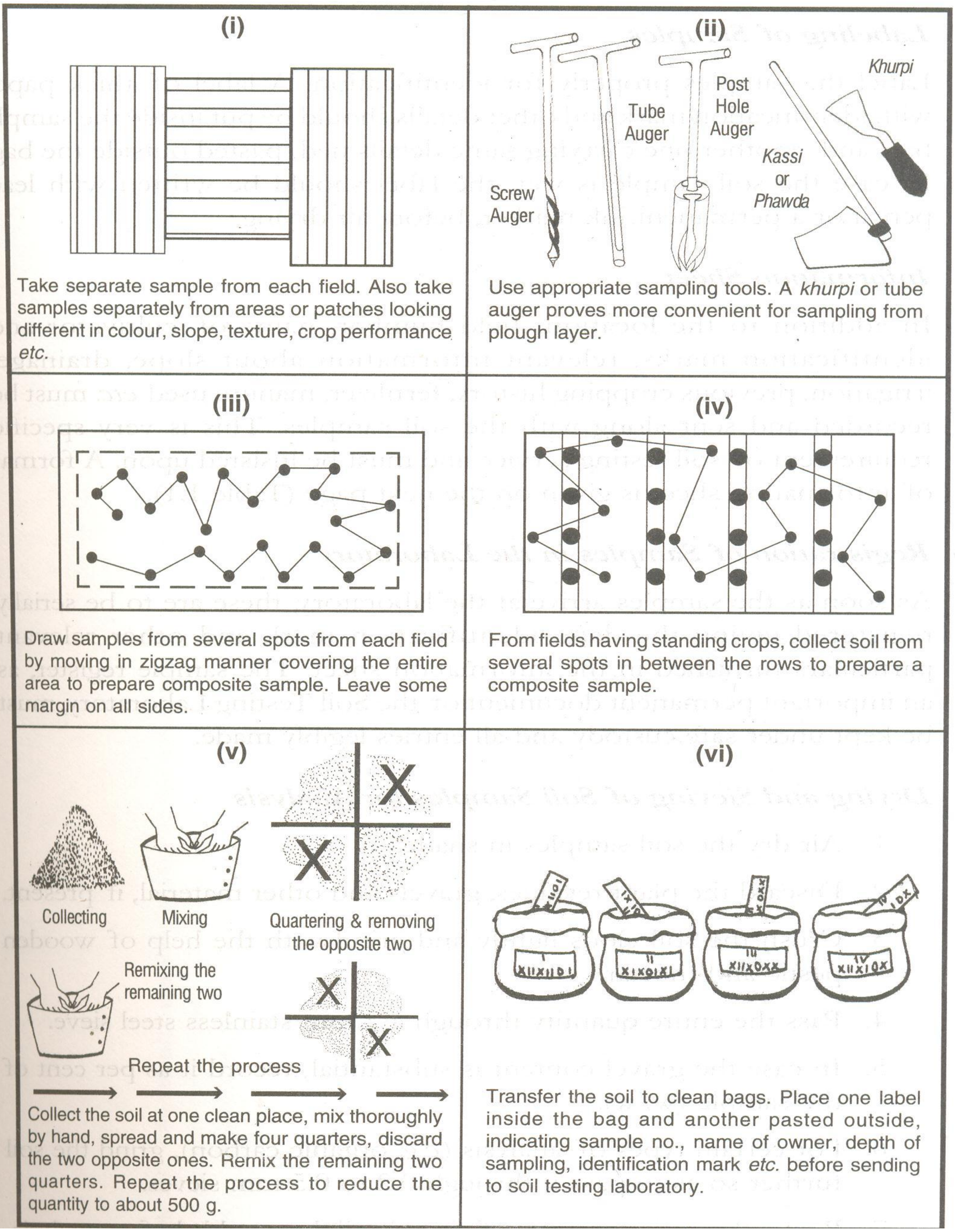
PREPARATION OF SOIL SAMPLES

a) **Air drying:** Air dry the samples in shade for 4-5 days in the laboratory.
b) **Grinding and sieving:** Air dried soil sample is powdered by pounding with wooden pestle and mortar. Sieve the sample through 2 mm sieve and efforts should be made to repeatedly crush and pass the whole of the soil sample through the sieve. Crushing primary sand and gravel particles is avoided.
c) **Mixing and storage:** Mix well and store in suitable bottle with proper coding and labelling.

PRECAUTIONS TO BE TAKEN WHILE SOIL SAMPLING

a) Avoid collecting soil sample near bunds, near roads, near FYM/ compost pits, below the trees, near buildings, near nalas/ streams/ ponds/ wet spots, irrigation canals and drainage lines and other unrepresentative spots.
b) Do not collect soil sample immediately after application of fertilizers, manures and amendments. There should be minimum 3 months gap after application of fertilizer manures and amendments.
c) If the soil sample has to be analysed for micronutrients, avoid tools made of iron, copper and brass. Use only stainless steel, wooden, aluminium and plastic tools.
d) If soil sample is moist, dry it under shade before sending to laboratory and avoid drying near fertilizer/chemicals/Pesticides godowns
e) All sampling tools and storage bags should be perfectly clean to avoid contamination.
f) For micronutrient analysis like Cu, Fe etc metals sieves should not be used. Plastic or nylon sieves are preferred.

PROCEDURE FOR DRAWING A REPRESENTATIVE SOIL SAMPLE



YEAR ROUND CULTIVATION OF MARIGOLD FOR LOOSE FLOWER PRODUCTION

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Marigold is one of the very important traditional flower crop extensively used in religious and social functions across the country. Marigold (*Tagetes spp)* flowers are used for garland making, decoration and petals are used for flower arrangement. Besides that marigold is extensively used as bedding plant, pots and in garden display. Beautiful yellow, orange and maroon coloured flowers on lush green backdrop makes it aesthetic appealing and adds colour diversity in the landscape. In genus Tagetes there are 33 species out of which *T. erecta* and *T. patula* is commercially cultivated in India. Theother species introduced in India are *Tagetes signata Linn*. *Tagetes minuta Linn, Tageteslucida and Tagetes tenuifolia*. Marigold has its own importance and is called as 'poor man's crop'. It is a universally a popular seasonal flower grown as an ornamental, loose flower, bedding, pot or landscape plant, easy to cultivate with worldwide adaptability to varying soil and climatic conditions. Marigold with its bright colours ranging from yellow to orange is the best for combination in any colour scheme. The attractive and brilliantly coloured flowers are the most valuable economic part of the plant, used for garland making, religious offerings, exhibitions, decorations etc. Apart from this, 'Thiopenes', a chemical compound extracted from the leaves of marigold is used as mosquito repellent. The whole plant is a source of an essential oil used in perfume industry; the roots of *Tagetesspp*. secrete an alkaloid which has strong nematicidal property.

Marigold is commonly used for the extraction of 'Xanthophyll' pigments which are used to intensify the yellow colour of egg yolks and broiler skin, it is also a potential source of emulsifying gum. Wild marigold (*T. minuta*) is considered as best source of valuable essential oil among all the other species of this genus. Yellow corn and marigold serve as a natural source ofXanthophylls. Marigold plants are grown for pigment production in Mexico, Peru and India. The Xanthophyllcan be utilized as colouring agent in food and textile where artificial colours are banned.

Marigold cultivation is highly profitable and many farmers have adopted this crop due to many advantages like easy to grow and short in duration which can fit into existing cropping system, hardy crop require less investment crop as compared to other commercial flower crops, can be grown in wide agro-climatic conditions, it has specific market demand during festivals like *Dasshera*, *Diwali* and wedding ceremonies which fetches good economic returns in short span of time, good market acceptance across the metro cities to very small towns and even rural areas.

SOIL

Marigold is fast growing crop hence required fertile soil which should be rich in organic content. Loam to clay loam soils are considered good as compared to light and heavy soil.

Field should be well drained and having assured irrigation facility. Acidic and alkali soils should be avoided.

CLIMATIC

It required mild to moderate climate in term of temperature because lower temperature inhabits the crop growth and high temperature favours the infestation of mites. Excessive rain and stagnated water hamper the growth and affect the flower quality due to the inflorescence blight. Strong winds at flowering caused toppling of the plant if earthling up has not been done and breaking of branches.

VARIETIES

Many marigold varieties have been release from AICRP on Floriculture developed by ICAR institute like IARI, New Delhi, IIHR, Bengaluru and other SAUs through systemic breeding programme over the years. There are also hybrids which are released by various private seed companies. Based on the need, location and market preferences farmers are adopting various varieties as well as hybrids from public as well as private sources. Some of the varieties popular among farmers are listed below. The choice of variety is limited for field cultivation in marigold as compared to garden varieties being limited breeding programme have planned and developed. The varieties developed through systematic breeding are as follows.

1. **Arka Agni-**Arka Agni is developed from hybridization between IIHRMGYP-1 and 9-2 by ICAR-IIHR, Bengaluru. It is a petaloid male sterile line multiplied by vegetative propagation. It has medium plant height (80-85 cm), flower colour is orange (RHS colour N25C, orange group), petaloid male sterile flowers. Flowers are compact, large (7.5-8 cm), high yielding (7-7.5 tons/acre). Flowering starts 40-45 days after planting and continues to flower for 60 days. It is a vegetatively propagated.'Arka Agni' rich in carotenoid (1384 mg/ 100gm of dry petals) and zeaxanthin (1.75 mg/ 100g of dry petals) have potential to be used in production of natural dye. Arka Agni is also rich in lutein content (1140 mg/ 100 g of dry petals) and have the commercial potential to be used by Pharmaceutical companies. It produces large, orange (N25C) coloured petaloid-type male-sterile flowers with ligulate florets. It yields 118.9 flowers/plant with a larger flower diameter of 6.8 cm, and this is also multiplied by stem-cuttings.

2. **Arka Bangara-**Developed from hybridization betweengermplasm linesMG-87 and MG-32 by ICAR-IIHR, Bengaluru. The variety comes to flowering by 40-45 days and continues to flower for next 65-70 days. Flowers are medium in size (5-6.5 cm). Yield potential of the variety is 10 tons/acre in winter and 5 tons/acre in summer. It has petaloid sterile flowers and ability to multiply by vegetative propagation. Flowers are of yellow gold colour (RHS colour 12-A, yellow group).

3. **Pusa Deep:** Pusa Deep is an early flowering variety of French marigold, which flowers in 85-95 days after planting. The variety produces medium statured spreading plants having 55-65 cm plant height and 50-55 cm plant spread. It produces compact and medium sized flowers of maroon colour. The variety is very floriferous and produces on an average 80-90 flowers per plant resulting in high flower yield (18-20

t/ha). In Northern plains it flowers during October-November. It is suitable for loose flower production and profitable as it flowers during festive season.

4. **Pusa Arpita-** Flower is orange in colour, small in size, less number of floret as compared to PNG & PBG. The plants have dense foliage. It is also an open pollinated variety. It is released and recommended in Northern plains. The yield is about 18-20t/ha and flowers are medium sized with light orange coloured. The main flowering season is mid December to mid February in northern plains of India.

5. **Pusa Narangi Gainda:** Flower is orange in colour, compact and medium in size. Suitable for growing in North India from September to April while March to July in hills. It is free from single type of flowers.

6. **Pusa Basanti Gainda:**Flower is lemon in colour, very compact, attractive and profuse in flowering. Suitable for growing during winter season in plain and summers in hills. It is free from single type of flowers.

PROPAGATION

SEEDS

150-200g quality seed/acre sufficient for growing the commercial crop. It can be reduced to 75-100g if improved nursery raising technology adopted and seed treatment with thiram/captan (2g/kg of seed) was practiced.

VEGETATIVE

Generally, marigold is propagated by seeds. However, true-to-type plants cannot be obtained through seed propagation because it is an often cross pollinatedcrop. Hence for perpetuation of all characters of a particular plant and to obtaintrue-to-type plant one should follow asexual propagation i.e cutting. Presently the vegetative method of reproduction is getting popular among the nurserymen's and farmers. The new hybrids of marigold are mostly propagated vegetatively to avoid the difficulties in hybrid seed production. With standardization of nursery raising through cuttings the hybrids are getting more popular among farmers due to early flowering, uniform flowers size and extended blooming period.

NURSERY RAISING FOR SEEDS

The seedling should be raised over the raised beds and sowing of the seed in line 2-3" apart and ½" deep. The raised beds should be 50-60cm wide, 3-5m in length and 15cm in height. Well rotten and sieved FYM should be mixed before sowing of the seed and after sowing the seed should be covered with fine soil/mixture followed by covering with paddy straw to conserved the moisture 4-5 days after sowing of seed or after the emergence of the seedling the bedding material must be removed to avoid the damage to the seedling. To avoid the early damage soil should be sterilized and fungicides may be used before planting of seeds. 21-25 days old seedling of (8-10m heights) should be used for transplanting.

NURSERY RAISING FOR CUTTINGS

Vegetative propagation through terminal cuttings in marigold is quite new technology. For taking terminal cuttings we need to have the month block/plants from which we can take the soft terminal cuttings of about 5-7 cm length. For the plants are raised initially and after one monthpinching is done to encourage the development of lateral branches.So that we can take the maximum terminal cuttings. Immediately after taking cutting kept in water and treated with rooting hormone before planting. The plug trays are filled with standardized media, such as coocpeat, perlite, vermiculite, vermicompost, sand, FYM, etc. in different proportions. The rooting starts from 10-15 days and get ready for planting in 25-30 days. The healthy uniform plants grown in plug trays are highly suitable for transportation and seedlings quality is also good. That's the reason this technology is getting popular among nurserymen's and growers.

TRANSPLANTING

Planting should be done in line with the spacing of 45x45cm in flat beds. An early winter crop planting should be done over the ridge or raised beds while in winter and summer transplanting can be done over the flat beds but earthing up at 35-40 days after transplanting should be done. The job of transplanting should be carried out in afternoon and watering should be through cane watering upto 2-3 days of transplanting followed by flood irrigation to get higher plant establishment. The seedling should be placed in hill firmly to avoid the fall of the seedling.

MANURE AND FERTILIZER

The following quantity of manure and fertilizer should be applied to get good growth and flowering.FYM- 8-10 cart load/acre 15 days before the final preparation. DAP- 50kg/acre during field preparation/before planting and 50kg/acre during earthing up.MOP-50kg/acre during earthing up.Urea-75kg/acre (A dose of 25kg/acre as top dressing at 30,60 and 90 days after transplanting.

WEED CONTROL

Spray of pendimethilin (stamp) 30 EC @ 3ml/liter of water before transplanting can control the weed up to 25-28 days a from planting followed by two hand weeding then earthing up.

IRRIGATION

Marigold required frequent and light irrigation but water stagnation should be avoided otherwise damage to the crop will realized. Moisture stress during flowering should be avoided.

PINCHING

To promote growth and for profuse flowering pinching of main shoot 35-40 days after transplanting is essential and second pinching after 25-30 days after first pinching could be practiced to increase the number of flower and reduced the size of flower.

HARVESTING AND PACKAGING

Fully open flower should be harvested in afternoon and flowers should be placed in shade or ventilated place to avoid the building up the heat and moisture. The flowers should sorted out by hand on the basis of size and any damage/disorder etc. The flower should be packed in hasten jute sheet or wooden box with a paper of layer. 6-8 time harvest of flower at 8-10 days interval is required to be done in good managed crop.

FLOWER YIELD AND RETURN

Good crop management practice in PNG/PBG can assured 75-90q flower yield/acre with average flower yield of 80q/acre. The average sale of flower @ 10-15 Rs/kg can gave gross return of Rs. 80,000-120000/acre and net profit of Rs. 50000 to Rs.80000 could be obtained.

PEST, DISEASE & THEIR CONTROL

Drenching of Bavistin (0.1%) was done 10 days after transplanting to prevent soil borne disease like *Sclerotium* rot. In later stage of growth Dithane M - 45 (0.2%) and Bavistin (0.1 %) were sprayed alternately at an interval of 8 – 10days to avoid the incidence of Alternaria leaf spot. For mites spray Dicofool or Oomit (2.5ml/liter) and spray of sulphur power @ 2.g/liter of water at 10-12 days interval.

CULTIVATION OF CHRYSANTHEMUM

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INTRODUCTION

Chrysanthemum (*Dendranthema grandiflora* Tzvelev), which occupies a prominent place in ornamental horticulture, is one of the commercially important flower crop. It is native to the northern hemisphere and is widely distributed in Europe and Asia. As a short-day plant, it naturally flowers in the autumn and winter. It belongs to family 'Asteraceae' and is popularly known as 'Queen of East'. It is often described as the "Autumn Queen" as it blooms in November-December. There is hardly any other garden flower which has such diverse and beautiful range of colour shades, shapes and height range as chrysanthemum, making it suitable for various purposes e.g. pot culture, field culture, for garland making or cut flowers or simply bedding purpose, long post-harvest life, predicable response to environment and amenability to different attractive training methods or styles. The fact is that chrysanthemum show draws biggest crowds in exhibition everywhere, which is an ample proof of the popularity of this flower.

USE OF CHRYSANTHEMUM

1. Garden decoration:

Chrysanthemum is grown in gardens in all parts of the world and it fills the garden with rainbow of colours. It can be grown for an effective display of colour in the shrubbery, rock gardens, mounds and borders and it will continue to flower during the late autumn and early winter.

2. Pot Plants:

Chrysanthemum in pots is very useful in decorating steps, porches, garden paths and beautifying grounds for ceremonial purpose. The flowers stay well in sun and shade and the buds continue to open for a long period. Almost all types of chrysanthemum grow and flower well in pots.

3. Cut flower:

Chrysanthemum is considered as one of the best cut flowers which often remain in good condition for 7 to 10 days. The flowers are displayed in attractive manner in bowls and vases. The flower decorators in all parts of the world find various types of Chrysanthemums very useful for floral arrangements in different styles.

4. Exhibition:

Exhibition of potted plants and cut flowers are also popular features in cities and towns and the competition to grow plants of outstanding quality and merit has caused marked improvement in cultural practices. The exhibitor train the plants in a special way for the display.

5. Medicinal Uses:

Though its is not commercially unsed, the Chrysanthemum flowers have reputation for reducing high blood pressure, improving eyesight, relieving eye fatigue, aiding liver functions and treating cases of wind-heat syndrome that are accompanied by sore throat and fever. The herb is recommended for cooling the body in hot environments, relieving headaches in the presence of fever, and aiding deafness in some cases. It is also used as an antidote to depression and nervous disorders, and as a general tonic.

6. Drinks:

Chinese teas are made from a variety of plants for a variety of reasons. Chrysanthemum flower tea is one very common type. Drunk with meals it helps to aid digestion, especially of greasy foods. It is also commonly taken to help strengthen the lungs and relieve head congestion. When made from fresh flowers, the flowers can be applied to the eyes to relieve dryness and itching.

7. Insecticidal Property:

The chrysanthemum plant is known to possess insecticidal property and is used in powder form. This is commonly known as insect powder due to its insecticide properties. An advantage is that the powder is completely harmless to humans, and so does not have side effects (as is the case with all chemical insecticides), and can be used as a lotion and applied to the skin as an insect repellant. If the flowers are burned, the smoke that is given off can be valuable in exterminating insects.

CLASSIFICATION OF CHRYSANTHEMUM

The chrysanthemum flower is technically a composite of many individual flowers (florets). The central florets, called disk flowers, have no petals. The outer or peripheral florets, called ray flowers, have a single petal. A composite flower may be composed of all ray florets, a single outer row of ray florets, or any combination of ray and disk florets. The commonly accepted classification of garden chrysanthemum is based on bloom shape and size and relative number of the two kinds of florets, their shape, arrangement and direction of growth. They are mainly classified under two categories: Large flowered and Small flowered. Large flowered chrysanthemums are further classified into 13 classes and small flowered ones into 10 classes.

LARGE FLOWERED:

Class – 1. Regular Incurve

Ray florets are narrow to broad. Florets are very smooth incurved in a regular pattern to form a perfect ball. All the petals point upwards in close formation, so that no gaps are apparent between the petals. Average bloom size varies from 10-15 cm. disc not visible. Examples – ‘Gairik’, ‘Shin Mei Getsu’, ‘Casa Grande’, ‘Kokka Soun’, ‘Snow Ball’, ‘S.S. Arnod’, ‘Autumn King’, Chandrama’, ‘Sonar Bangla’, ‘R Venkatraman’, ‘Dream Castle’, ‘Bharat Ratna’, ‘Queen of Tamluk’, ‘Belur Math’, Super Giant’, and ‘Adventure’.

Class – 2. Irregular Incurve
Ray florets are usually broad and smooth. Florets are incurved and arranged in an irregular manner. The bloom size is very large and the breadth and depth of the blooms are almost equal. The disc florets are entirely covered by the upper florets. The bloom size varies from 15-20 cm. Examples – 'Audrey Shoesmith', 'Hommand Philips', 'J.S. Salesbury', Kiku Biyori' and 'Mountaineer'.

Class – 3. Skirted Incurve
The lower florets, mostly the basal florets bend downwards in an irregular fashion to give a skirted shape. Bloom size varies from 15-20 cm. Example – 'Dream Castle'.

Class – 4. Incurving
Ray florets are incurved upward in indefinite manner. The bloom is not compact ball due to loose fitting arrangements of florets. Examples – 'Classic Beauty', 'Pink Cloud', 'White Cloud', 'Scarlet Waltz', 'Gusman Red', 'Hanayome Sugata', 'Dr. S. Mukherjee', 'Leading Lady', and 'Hommand Philips'.

Class – 5. Reflex
Ray florets are narrow to broad. Ray florets bent backwards and downward. Inner florets remain incurved at the early stage concealing the disc florets of the bloom. Outer florets turn outward away from the central tuft. Blooms look globular but may be somewhat flattened. Average bloom size 15-20 cm. centre or disc of the flower in not visible. On the basis of arrangements of ray florets this class is further sub-classified as follows:

a. Regular reflex: Ray florets are bent back and downward in a regular arrangement.
b. Irregular reflex: Ray florets are bent downward in a twisted and irregular way.
c. Reflexing: Ray florets are like aster and have a tendency to reflex. The bloom appears flat in shape.

Examples – 'Imperial', 'Dee', Mrs. A.I. Miller', 'John Webber', 'Julios Brinas', 'President Viger', 'Rose Day', 'Star of India', 'Hope', 'Mrs. Roager Thompson', 'Ashok Pillar', 'Mrs. Eleston', 'Kansya', 'Kasturba gandhi' and 'Beatrice May'.

Class – 6. Intermediate
This class represents blooms intermediate between 'Incurved' and 'Reflex'. Ray florets are narrow to broad and may be short. Few outer ray florets are partially incurve but lower ray florets are reflex. Inner florets are incurved. Disc in concealed, centres may be slightly flattened or depressed. The bloom shape gives a globular effect. Bloom size 15 cm or more. Examples – 'General Petain', 'Mrs. W.A.Reid', 'T-1', 'Cloth of Gold' and 'Sun Flight'.

Class – 7 Ball

The ray florets are straight and densely packed. These radiate uniformly in all directions to give the bloom a ball/ovoid/roundish shape. Examples – ‘W-23’, ‘Pride of madfor’, ‘Nigeria and ‘Red Jack’.

Class – 8. Quilled

The ray florets are tubular and elongated with tips open or closed. The thickness of the tube varies from thin to medium to thick. Examples – ‘W-11’, ‘Red Quill’, ‘Green Sensation’, ‘Tribhuban’ and ‘Pradhan’s Pride’.

Class – 9. Spider

The florets (same as class-8) are large, tubular and elongated. Tips may be open or closed but in either case they are coiled or hooked. The rays may either fall or spread. Examples: ‘Sunder Calcutta’, ‘Geetanjali’, ‘Achievement’, Innocence’, ‘Carnation Gold’, ‘Icicles’, ‘Tokyo’, ‘Senkyo Emaki’, ‘Florida’, ‘Manick’, Senkyo No Rya’, ‘Miss Universe’, ‘Valiant’, ‘M-30’, ‘Flirtation’, ‘Kogen No Hoshii’, ‘Diamond Jubilee’ and ‘T-8’.

Class – 10. Spoon

The ray florets are tubular with spatula like open tips. The size of open portior varies. Disc visible.Examples – ‘Pink Casket’, ‘M-24’, ‘Crimson Tide’, ‘Carnation and ‘Pusphahans’.

Class-11. Anemone

The ray florets are ligulate or quilled. Here disc is noticeably developed with florets. Disc usually hemispherical and raised.Examples – ‘007’, ‘Cloud Bank’ and ‘Red Admiral’.

Class – 12. Single

Ray florets are long, elongated and straplike. Number of whorl of florets restricted upto four. The disc is conspicuously visible. Examples – ‘Potomac’, ‘Joar Helen’ and ‘surja’.

Class – 13. Semi-Double

Ray florets are long, elongated and straplike. Number of whorl of flores are more than five. Disc conspicuous. Examples – ‘Ronald’ and ‘Crimson Tide’

SMALL FLOWERED:

Class-1. Anemone

Disc florets are well developed and prominent. Ray florets may be flat, twisted and quilled. Examples – ‘Nimrod’, ‘Venus’, ‘Pink cushion’, ‘Violet cushion’, ‘Season’, ‘Ace’, ‘Perfect’, ‘Gaity’, ‘Dainty Maid’, ‘Mercury’, ‘Rose’, ‘Maise’, ‘Gem’, ‘Modella’, Herbinger’ and ‘Smita’.

Class-2. Button
Florets are short rayonate like and hemispherical. Florets radiate in all directions. Blooms are small and compact. 2-3 cm in diameter.Example : Liliput, Bull Finch and King Fisher.

Class- 3 Single Korean
Ray florets are strap-like. Bloom flat and disc well visible. Ray flores are arranged in five or less whorls. Examples ; Tune Full, Pat, Alpana, Dolore, Sharad bahar, Sharad Shobha, Sharada, Sharad Seema, Prabha, Sharad Singar, Sunset, Kirti, ragini, Luoy, Margery, Pilgrim, Pat, Fantasy and Vinaya.

Class – 4. Double Korean
Florets same as Class-3. Number of whorls of ray florets is more than five. Disc visible. Examples – Jyotsna, Khushrru, Flirt, Lalkila, Tara, Lilith, Priya, Purity, Criterion, Man Bhawan, Red gold, Fatima, Lalpari and Sonali.

Class – 5 Decorative
Florets like class-4. Here disc is not visible due to developed aray florets. Ray florets regular or irregularly reflexed. Examples – Megami, Sharad Mala, Jayanti, Sujata, Jubilee, Nilima, Sonali Tara, Puja, Jaya, Suneel, Ajoy, Illini Cascade, Pink Gin, Jawra, Ratna and Shabnam.

Class – 6. Pompon
Ray flores are short, broad and very systematically and uniformly arranged to give bloom a compact hemispherical shape. Width and breath almost equal. Ray florets may be incurved or reflexed. Disc normally covered or inconspicuously open. Examples – Horizon, Apsara, Nanako, Cotton Ball, Birbal Sahni, Purple Star and Maharaja.

Class – 7 Semi-quilled
The ray florets are tubular upto certain length of the floret from base and then open at the tip. Open tip portion may be flat, reflexed or incurved. Disc open. Example – jean, Alison and Garnet.

Class - 8. Quilled
Ray florets are elongated and tubular like a quill. The tips of flores may be open but not developed. Examples – Fraiar, Munchausen, Q-3, Donald, Rita, Snow Crystal, Space in 83 and Green Nightingle.

Class – 9. Stellate
Florets like class-3 but both the sides of ray florets are reflexed downwards. Florets may or may not be twisted. Disc flat with short florets. Examples- Laura, Heloise, Red Star, Harvest Home, Stella, Morning Star and Gordon Tailor

Class – 10. Cineraria
Blooms are flat Korean type with diameter not more than 3 cm. examples - Phyllis, Jessie, Kashturi, Bindya and Charmis.

CULTIVARS

There are larege number of chrysanthemum cultivars developed throughout the world and every year numerous varieties are being added in the existing one. The exact number will vary because every year new varieties are being developed throughout the world but they are not documented at one place. Above 500 vareities have been reported in India so far. The different AICRP centres reported chrysanthemum cultivars are as follows:

IIHR, Bangalore: Arka ravi, Arka Ganga, Arka Swarna,Chandrakant, Chandrika, Indira, Kirti, Niklima, Pankaj, Rakhee, Ravi Kiran, Red Gold, Yellow Gold.

IARI, New Delhi: Pusa Anmol, Pusa Centenary, Pusa Aditya, Pusa Chitraksha, Pusa Sona and Pusa Kesari.

NBRI, Luknow: Agnishikha, ajay, Alankar, Anamika, Appu, Apsara, Apurva, Apurva Singer, Aruna, Arun kumar, arun singer, Asha, Ashankit, Basant, basanti, Bindiya, Birbal Sahni, Colchi Bahar, Cosmonaut, Dhawal, Gairik, Gauri, gulal, Guldasta, haldighati,, Hemant Singar,, Hemanti, Himani, Himanshu, Jaya, Jayanthi, Jhalar, Jubilee, Jugnu, Jwala, Jyoti, Jyostna, Kansya, Kanak, Kapish, Kaumudi, Khumani, Kiran, Kumkum, Kunchita, kundan, Lal Kila, Lalima, Lalpani, Lilith, Lohita, Maghi, Manak, Manbhavan, May-day, Mayur, Meghdoot, Mini Queen, Mohini, Mother Teresa, Navneet, Navnet Yellow, Neelima, Niharika, Nirbhaya, Nirbhik, Nirmal, Pancho, Peet Singar, Phuhar, Pingal, Pitaka, Piambar, Priya, purnima,Prof. Harris, Puja, Ragini, , Rangoli, Ratna, Rohit, Shafali, Sharad Har, Sharada, Sharad Kranti,Sharad Kumar, Sharad Mala, Sharad Mukta, sharad sandhya, Sharad Shobha, Sharad Singar, Sheela, Shizuki, Shukla, Shveta, Shyamal, Sonali, Subarna, Suhag Singar, Sujata, Suneel, Sunayana, Suparna, Surekha Yellow, Surya, Sweta Singar, Tushar, Usha, Vandana, Vasantika, Vijay, White Charm, White Prolific, Yellow Prolific, Yellow Star.

PAU, Ludhiana: Baggi, Ratlam Selection, Punjab Gold, Gul-E- -Sahir, Santi, Yellow Delight, Anmol, Winter Quen, Garden Beauty, Autumn joy, Royal Purple, Kelvin Mandarin.

STANDARD CULTIVARS

White	Giant Indianapolis White, Improved Mefo, May Shoesmith, Beauty, Snow Ball, William Turner, Innocence, Gen Petain, Valiant, Green Goddess, Ajina White, Premier
Yellow	Bright Golden Anne, Bright Yellow May Shoesmith, Rivalry, Yellow Fred Shoesmith, Chandrama, Kikubiori, Mountaineer, Super Giant, J.S. Lloyd, Triumphant, Evening Star, Melody Len
Pink	Cassandra, Deep Champagne, Pink Champagne, Promenade, Regal Anne, Ajina Purple, Pink Cloud, Pink Turner
Red	Crimson Anne, Red Anne, Red Resilient, Working Scarlet, Alfred Wilson, Alfred Simpson, The Dragon
Bronze	Bronze Princess Anne, Resilient, Light Bronze Gay Anne, Purple Anne

PROPAGATION

Chrysanthemum is commercially propagated by vegetative means. The vegetative methods include multiplication through sucker, terminal cutting and micro-propagation. Among these methods, propagation through cuttings is the most common and popular method. The cuttings (5-7 cm length) are treated with 200-500 ppm of IBA and planted in plug tray in shadenet. A combination of cocopeat: perlite: vermiculite @3:1:1 are used a rooting media. The plnats are raedy for transplanting within 21 days.

SOIL

Chrysanthemum needs well prepared soil. Chrysanthemum thrive best in slightly acidic soils with pH ranging between 6.2 and 6.7. Chrysanthemum has a shallow but fibrous root system which is sensitive to water logging. Physical, chemical and biological status of soil is, therefore, an important factor affecting the growth of the plants.

CLIMATE

The chrysanthemumis basically a short day plant (SDP). It requires short day for flowering. Light and temperature are the main factors influencing thegrowth and flowering. For its vegetative growth it requires long day and temperature ranging from 20-28 °C and 15-20 °C for night. For bud initiation and flowering it requires short day and low temperature ranging from 10 °C to 28 °C. It requires the relative humidity of 65-75% for proper plantgrowth.It is planted during April-May (South Indian conditions), June-July(North India), February-March (Hills).

INTER-CULTURE OPERATIONS

PINCHING

Pinching is one of the most important operations in chrysanthemum culture. Pinching refers to the removal of the growing tips of the plant to induce the growth of vegetative laterals. It reduces the plant height, promotes axillary branching, delays flowering and helps in breaking rosetting. Pinching is performed both in suckers and in cuttings. It is normally done with thumb and forefinger. 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 is performed both in suckers and in cuttings. Pinching has the following advantages:

- it increase 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 is most easily controlled

DISBUDDING AND DE-SHOOTING

These operations are mostly performed for large flowering and decorative type chrysanthemums. Many of the standard type varieties are disbudded in which the largest terminal bud is reserved and all axillary buds are removed. When growers want to develop three blooms per plant or one bloom per plant these operations are most essential. Disbudding operation is an important factor in the maintenance of high-quality product.

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 lose vigour and will become weak.

STAKING OF PLANTS

Staking is necessary to keep plants erect and to maintain proper shape of plants and bloom. But all chrysanthemums do not require staking especially some compact cultivars. Stakes are prepared mostly from bamboos. Staking of plants is required for vertical support of the plants. Number of stake to be used for a plant depends upon the grower. Only one stake is used when a grower needs single bloom per plant. If a grower needs three blooms per plant he requires three stakes. In small flowered types, for profuse blooming 5-8 stakes are used. The stakes are inserted on the pot slightly slanting outwards so as to provide sufficient space for flower development at the top. When the bloom starts colour showing the surplus length of the stake is uniformly cut below the level of bud for uniform growth of bloom. Stakes are generally used to lead the stem and branches in desired direction.

MANURING AND FERTILIZATION:

The growth and development of stock or production plants largely depend on proper feeding right from the beginning. Addition of organic matter in the form of compost or rotten manure (20-25 t/ha) improves the soil structure and helps in the development of plant.Chrysanthemums are heavy feeders and have large requirements for both nitrogen and potassium. Inorganic fertilizers should be applied @ 125:120:25kgNPK/ha.Half of the Nitrogen and entire Phosphorous and Potassium should be applied as basal dose. Remaining Nitroge should be applied as top dressing 30 and 60 days after planting. The emphasis at the early stage is on nitrogen. Soil application of2 kg each of *Azospirillum* and *Phosphobacteria* per hectare at the time of planting is also beneficial. Foliar application of phosphorous and potassium during the growth period is also beneficial. As the buds appear, the proportion of potassium should be increased. Plants need phosphorous throughout the growing period and it is best applied as basal dressing for gradual availability to the plants. The rate of nitrogen application should be reduced as buds appear.Foliar spray of $ZnSO_4$ 0.25% + $MgSO_4$ 0.5% is also beneficial.

INSECT- PEST OF CHRYSANTHEMUM:

Aphids (*Macrosiphoniella sanborni*): Greenish-black nymphs and chocolate brown adults suck the cell sap from growing shoots and lower surface of leaves. Damage by aphid's results in loss of vigour, yellowing and premature leaf fall and stunted growth of attacked plants. Honey dew secreted by aphids favours development of sooty mould. The pest also acts as a vector of viral diseases.

Control : Spraying of Monocrotophos @0.05% or Phosphamidon @0.02% at 15-20 days interval controls aphid population effectively. Grubs and adults of Coccinellid beetles prey upon the aphids and effectively wipe out their population.

Thrips (*Frankliniella* sp.): Slender, white coloured nymphs and black adults feed on tender leaves causing silvering, mottling and distortion of leaves. Damaged flowers look discoloured, withered and dried due to scorching. Severe infestation adversely affects quality and quantity of flower production.

Control : Spraying with Monocrotophos (0.04%) twice or thrice at 15 days interval controls thrip population. Drenching the soil with good insecticide also helps in reducing the population.

Leaf Folder (*Hedylepta indicata*): It occasionally attains a status of serious pest on chrysanthemum. Pale-white coloured eggs a laid singly or in small groups on lower side of leaves. Green coloured larvae with brown head fold leaves together and feed on chlorophyll. The affected leaves get skeletonized and dry. The larvae also damage flowers.

Control: Cutting and burning infested plant parts reduces pest infestation. Two or three sprays of Methyl Parathion or Quinalphos @0.05% gives effective control of leaf folders.

Bud Borer (*Helicoverpa armigera*): Female adult deposits round, cream coloured eggs singly on bracts and petals of buds. Larvae feed on growing flowers resulting in considerable flower loss.

Control: Collection and destruction of damaged buds and flowers reduces further damage. Setting of light traps helps to control adult population by attracting them. Sprays of Endosulfan (0.07%) or Methyl Parathion (0.05%) taken up at the appearance of eggs on buds and tender foliage controls borer damage.

Hairy Caterpillar (*Spilosoma obliqua*): Female moth lays eggs in clusters on lower side of leaves. Black coloured matured larvae feed voraciously on leaves and buds and cause severe defoliation.

Control : Collection and destruction of egg masses and leaves infested with early larval instars of hairy caterpillar reduces pest build up. Deep ploughing in summer exposes pupae to predators.

Termites (*Microtermes obesi*): Termites mainly feed on roots. In case of severe infestations they spread to stem portion of the bark. Attack by the pest becomes severe under dry soil conditions. Damaged plants wilt, dry and finally die if infestation is very high.

Control: Deep ploughing destroys the termite colonies. Proper irrigation and avoiding dry soil conditions prevents pest build-up. Drenching the soil with Chlorpyriphos @0.05% or Endosulphan @0.1% before planting protects plants from termite attack.

Lesion Nematode (*Pratylenchus coffeae*): The nematode causes heavy rot damage, which subsequently leads to poor growth of chrysanthemum. The symptoms are in the form of stunting of plants with premature yellowing and drying of leaves, reduced flower size and dark lesions on the roots.

Control: Application of neem cake @ 1ton/ha or Carbofuran @ 2kg/ha reduces the nematode population.

Bud and Leaf Nematode (*Aphelenchoides ritzemabosi*): The nematode causes considerable damage to the foliage of chrysanthemum. Interveinal discolouration of leaves and their death is the characteristic symptom.

Control: Hot water treatment of suckers at 46°C for 5 minutes and spraying 0.02% Thionazin or 0.01% Methyl Parathion on aerial parts is recommended.

DISEASES

Although the list of diseases affecting Chrysanthemums or garden mums is long, they are relatively trouble-free given full sun, fertile well-drained soil, and adequate watering. Maximizing plant vigor by appropriate cultural practices is an important disease management strategy.

DISEASES OF THE FOLIAGE

Leaf Spots: Chrysanthemums are subject to several leaf spot fungi including *Septoria chrysanthemi, S. chrysanthemella, Alternaria species*, and *Cercospora chrysanthemi* . Symptoms first appear as yellow spots which turn brown to black. Spots often occur on lower leaves first and can coalesce into large necrotic areas and finally death of the entire leaf. Regularly clean up and destroy infected plant debris and hand pick symptomatic leaves from lightly infested plants. Avoid splashing water onto plant foliage and water early in the day to allow foliage to dry quickly. In severe cases, applications of fungicides with the active ingredients chlorothalonil, mancozeb, myclobutanil, propiconazole, or thiophanate methyl may be applied according to label instructions.

Powdery mildew (*Erysiphe cichoracearm*) as it name implies is characterized by a white to ash-gray powdery growth on leaves and occasionally stems. Foliage may become puckered or distorted; severely infected leaves will shrivel and die. The disease is most serious during hot, humid weather. Unlike most fungal diseases, free water is not required for Powdery mildew infection; high humidity encourages disease development. Powdery mildew can be avoided by proper plant spacing, good air circulation, low relative humidity, and adequate light levels. Apply preventive fungicides at the first sign of disease with the active ingredients copper, azoxystrobin, pyraclostrobin, triflumizole, myclobutanil, triadimefon, propiconazole, sulfur, potassium bicarbonate, or thiophanate methyl according to label instructions.

Gray mold(*Botrytis cinera*) may occur on petals, leaves, or as a stem canker as brown, water-soaked spots. Infected plant parts may be covered with gray to brown, powdery masses of spores. Senescing tissues are most susceptible. Gray mold is favored by extended periods of cloudy, humid, and wet weather. Practice good sanitation including removing senescing flowers and leaves. Avoid wetting flowers when watering and don't overcrowd the plants. Provide good air circulation and keep humidity low by a combination of heating and venting (See Fact Sheet on Reducing Humidity in the Greenhouse). Apply preventive fungicides as soon as disease is detected. Fungicides with the active ingredients chlorothalonil, dichloran, fludioxonil, trifloxystrobin, iprodione, mancozeb, copper sulfate pentahydrate, fenhexamid, azoxystrobin, and thiophanate methyl are registered for Botrytis control.

Rusts: Two species of Puccinia causes rust on chrysanthemums *P .chrysanthemi* and *P. horiana .P. chrysanthemi* is most common in late summer and is characterized by dirtybrown pustules and yellowish-green spots on upper surfaces of leaves. *P. chrysanthemi* causes minor damage in the field and is uncommon on greenhouse plants. Severe infestation may damage large areas of leaves and lead to defoliation and reduced flower production. Symptoms of rusts are white, pinkish or brownish pustules produced on leaf undersides with white, yellow, to pale-green lesions on upper leaf surfaces. Chrysanthemum white rust results in leaf distortion, discoloration, defoliation, and plant death. White rust is primarily a disease of greenhouse crops; when it occurs outside direct sunlight and low humidity kill the spores.

Bacterial leaf spot (*Pseudomonas cichorii*): Symptoms of bacterial leaf spot are tan to dark brown spots or blotches that are often bordered or ringed by yellowing tissue. Discoloration may be prominent along leaf veins or lesions may become angular as bacteria growth is limited by major veins. Leaf wilting and death often follow. Bacteria persist in or on infected plants, crop debris, infected seed, contaminated soil, and infested pots and tools. The management practices include planting pathogen-free seed and cultivars, resistant varieties, good sanitation, and avoiding overhead irrigation or handling plants when they are wet. Once plants become infected with bacteria, it is best to rogue infected plants and those near them before the disease spreads. Bactericides such as copper and antibiotics are of limited effectiveness and plants cannot be cured.

Bacterial blight (*Erwinia carotovora*): Symptoms of bacterial blight extend beyond plant leaves to include water-soaked lesions on stems, darkening and death of buds and stems, blackening of terminals, and wilt and collapse of upper portions of the plants. Infected cuttings may have brown to black decay at their base. Bacterial blight survives in crop debris and is favored by surface moisture, high temperatures, and high humidity. It is easily spread on infested tools, hands, or plants.

Using pasteurized growing media, pathogen-free cuttings, less humidity and increase air circulation, avoid wetting foliage, good sanitationpractice, and regularly inspect crop and dispose of infected plants.

Foliar nematodes (*Aphelenchoides ritzema-bosi*): The development of yellow to brown, angular spots on lower leaves and moving up the plant is a good indication of nematode infection. Nematodes are microscopic roundworms that live in the soil in infested plant material. Nematodes swim in a film of water on plants to spread to uninfected leaves. Lesions on the leaves eventually coalesce to cover the entire leaf which dies, withers, and falls. Remove infested plants and crop debris. Avoid wetting the foliage and overhead irrigation.

Viruses and other infectious agents: Chrysanthemums are susceptible to a large number of virus diseases including Chrysanthemum Mosaic Virus, Impatiens Necrotic Spot Virus, Tomato Aspermy Virus and Tomato Spotted Wilt Virus. Viroid diseases include Chrysanthemum chlorotic mottle viroid and Chrysanthemum Stunt viroid. Aster Yellows is a serious disease caused by organisms called phytoplasmas. Symptoms of virus (viroid) infected plants include stunting, spindly growth, and formation of dense rosettes. Flowers may be small, distorted or exhibit streaking and color break. Leaf symptoms are diverse and may appear as leaf yellowing, ring spots, lines, mottling, mosaics, vein clearing, distortion, crinkling, wilt and leaf drop. Aster Yellows results in chlorotic foliage, plant stunting, spindly, upright yellow shoots, few or no flowers, flower distortion and failure to color. Many of these diseases are spread by sucking insects such as aphids and leafhoppers. There is no cure for virus, viroid, or phytoplasma infected plants. Remove and destroy infected plants including weeds, that may be hosts. Control the insects that transmit these diseases beside washing of tools and equipment used in infested plants with an appropriate greenhouse disinfectant.

The number of viral diseases affecting chrysanthemum is at least 20. Their methods of transmission and control are as follows:

Virus	Symptoms	Transmission method	Control
Chrysanthemum stunt	Overall reduction in plant size, foliage pale in colour, flowers may open prematurely, red and bronze flowers often bleached. Leaf margins may fail to enlarge giving stiff and upright appearance.	During pinching	Use of cuttings from virus-free indexed stock
Tomato spotted wilt	Reduced growth, leaf may show ring and line pattern, plants may show one sided development with necrotic streaks in stem and leaves	Thrips, several weeds and other plants serve as source	Control of thrips and weeds
Tomato aspermy	Flower breaking and distortion, flowers may be small with warty florets.	Aphids	Control of aphids and use of cuttings from virus-free indexed stocks
Chrysanthemum flower distortion	Marked dwarfing and distortion of flowers, flowers may appear as unopened buds with short incurved distortion narrow florets.	Grafting, no insect vector known	Use of cuttings from virus-free stock
Chrysanthemum mosaic	Leaf symptoms mild or lacking, plant weak and small, flowers may show breakdown of florets.	Aphids	Control of aphids
Chrysanthemum rosette	Yellow mottling with mosaic pattern in some cultivars, enlarged veins wrinkled and rosette formation on terminal portion.	Grafting on insect vector known	Use of cutting from virus-free indexed plants

Vascular Wilts

Chrysanthemums are subject to two vascular wilt diseases caused by *Fusarium oxysporum f.sp.chrysanthemi*and *Verticillium dahliae*. Both pathogens persist in the soil for many years.

Fusarium Wilt: The first signs of this disease are yellowing of foliage, stunting, and wilting often along one side of plant. Plants may appear water stressed and foliage may brown and die. Stems show a reddish brown discoloration of the vascular system. Fusarium is spread in contaminated soil and infected cuttings and is favored by warm temperatures, high relative humidity, overwatering, and poor drainage. Use pathogen free cuttings or plants and pasteurized growing media. Also maintain a pH range of 6.5 to 7.0 and use nitrate nitrogen fertilization.

Verticillium Wilt: Symptoms of Verticillium wilt often appear only after blossom buds have formed; young vigorous plants may be symptomless. Foliage becomes yellow and wilted, sometimes only along leaf margins and on one side of the plant. Leaves begin to die from the base of the plant upward and often remain attached. Stems may exhibit dark streaks in the vascular system. This disease is favored when cool weather is followed by hot. Use of pasteurized growing media and pathogen-free cuttings control to some extent.

YIELD

The chrysanthemum takes 3-4 months to flower. The average yield of loose flower is 15-16 tonnes/hectare. For greenhouse chrysanthemum the yield is 150-250 flowers/m^2/year.

POST- HARVEST MANAGEMENT

HARVESTING TECHNOLOGY

The stage of harvest of flowers varies depending on their usage and market distance. Standards are harvested for distant market when only a few outer rows of florets start unfurling. But for local market flowers are harvested when the flower head has opened 50 % of its rays. Sprays are harvested when ray flowers show 50 % colour for distant market and for local market, when two rows of flowers have opened and others are showing colours.

Stems should be cut (with a knife, shears) at least 10 cm above the soil line to avoid taking woody plant tissue. Pinched spray chrysanthemums can be pulled from the soil and then cut to correct length. Leaves are removed from the lower third of the stems. Proper rehydration is vital for good vase life of chrysanthemums that have been stored or shipped long distances.

GRADING

Chrysanthemums are graded based on the stem length, flower appearance, number of flowers, stem straightness, colour and freshness of flowers. Standard chrysanthemums are graded into Blue, Red, Green and Yellow, whereas spray types are graded into Gold, Silver and Bronze based on the quality parameters. In Dutch market, spray chrysanthemums are graded into extra grade and shorter grade. The lower leaves are stripped off upto 15-20 cm and bundled in units of 5 stems and secured with a rubber band.

PACKAGING

Most of the Standard chrysanthemums 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. Standards and spider mums can be wrapped individually with thin wax paper to avoid bruising and entangling florets.

COLD STORAGE

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°C. Fully mature blooms can be stored dry (wrapped in polyethylene) for 3 to 4 weeks at 0°C. Storage at 0-1°C should not exceed 2 weeks. Yellowing of leaves can occur at 5°C in the dark but is less likely to occur at 1°C.

NURSERY RAISING AND PROPAGATION OF ORNAMENTAL CROPS

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INTRODUCTION

Floriculture sector is presently considered as key components of Indian agriculture. Its importance has increased in recent years due to increased consumer demand for quality cut and loose flowers. In era of commercial and high value agriculture, flower crops are front runners for betterment of small and marginal farmers in the India. But erratic rainfall pattern and extreme climatic variation in northern plains of India has created problems for efficient utilization of immense potential of flower crops. Therefore, utilization of new scientific innovation and intervention in floriculture sector is become imperative for sustainable development of Indian floriculture. Nursery is a place where plants are cultivated and grown to usable size. The nursery management gained a status of commercial venture where retailer nurseries sell planting materials to the general public, wholesale nurseries which sell only to other nurseries and to commercial landscape gardeners and private nurseries which supply the needs of institutions or private estates. Since most of the ornamental crops are multiplied and distributed from nurseries either public or private nursery for production of quality planting materials.

LOCATION AND LAYOUT OF NURSERY

The selection of appropriate site for establishing nursery is one of the important pre-requites for successful nursery business. Therefore, following points should be kept considered during selection of site:

i) Nursery should be raised in such place where there is no water stagnation and have gooddrainage system.
ii) Land for nursery should be well drained and located at on a high level.
iii) The soil for nursery should be sandy loam and normal in PH (around 6.5-7.0).
iv) The plot for nursery should be selected near to a water source.
v) Nursery plots should be chosen near the farm building, so that frequent supervision can be made easily.
vi) Nursery plots should be away from the shady places.
vii) Nursery plots should be selected at one side of the field to isolate the other fields for doing culturalpractices easily.
viii) Site should be safe from stray animals and excessive diseases and pest attacks.

Raising nursery from seeds and other planting materials is easy and convenient way for ensuring better germination and root development. The planting material of ornamental crops is multiplied under nursery conditions with proper care and management for raising healthy, vigorous and disease free seedlings. Besides, the ornamental shrubs and herbs are multiplied under nursery conditions for their faster growth and development.

NECESSITY OF NURSERY

Seedlings not only reduces the crop span but also increases the uniformity of the crop and thus, harvesting as compared to direct sown crops. Transplanting of seedlings also eliminates the need for thinning and provides good opportunities for virus-free vigorous and off-season nursery, if grown under protected conditions.

i) It is easy and convenient to manage seedlings under small area.
ii) Effective and timely plant protection measures are possible with minimal efforts.
iii) Nursery provide favourable climate to emerging plants for their better growth and development.
iv) Effective utilization of unfavourable period by preparing nursery under protected conditions.
v) Effective input utilization for crop production by reducing initial stage crop infestations and interferences.
vi) Nursery production help in maintaining effective plant stand in shortest possible time through gapfillings.

SOIL PREPARATION

Nursery bed preparation is an important step in crop management because it largely affects crop stand and its performance at field level. Therefore, soil should be worked to a fine tilth by repeated ploughing and spading. The previous year crop residues, which acts as source of pathogens and pests should be collected, removed and burnt. Well decomposed organic manure @ 40-50 kg/10m^2 should be mixed thoroughly in the soil.

SOIL TREATMENT

Soil treatment is an essential step in a successful nursery management because it is the base for seedlings stand, source of nutrition and pathogens. The damping-off caused by soil borne fungi like Pythium, Rhizoctonia, Phytophthora etc., is a common disease in the nursery beds. Besides, pests like cutworms, termite and mites are also damages young seedlings. There are various measures for soil treatment like soil solarization, chemical treatment, bio-control treatment etc. Soil solarization can be done with transparent polythene of 25-100 mm thickness during the hot and dry periods. For this soil should be moist before mulching because it increases latent heat and thermal sensitivity for resting soil borne pathogens, harmful pests and weeds which can be reduced to a sustainable level. Besides, the nursery beds and seeds can be treated with some fungicides like Bavistin @ 2g/litre before sowing. The insect-pests can be controlled by treating soil with Chlorpyriphos powder (20-25g/m^2) before sowing and or at the time of nursery preparation.

NURSERY BED PREPARATION

Before sowing seeds the beds should be leveled and pressed gently to make it firm. Nearly 15-20 cm raised beds of 45-50 cm width are always preferred for raising nursery. However, its length should be made according to the requirements or size of plots but should not exceed 5-6 m. In between beds, drains of about 30-45 cm width are prepared and connected to the main drain for removal of excess water during heavy rains. This space also facilitates easy movement during intercultural operations. The drains are flooded during dry period to modify microclimate of nursery beds in favour of seedlings. In recent years,soil less media, plug tray technique, and perforated poly trays are used to avoid possibilities of pathogen spread.

TOOL AND EQUIPMENTS

The tools and equipments vary depending upon the type of the nursery. For example in conventional type of nursery commonly used tools are Spade, khurpi, watering cane, fork, hoe, garden line,roller, basket, sirki, polythene sheet, sprayer, alkathene sheet,nose-cane, duster, sticks, tags etc. But in case of Hi-tech nursery, commonly used tools are Plug trays, perforated plastic trays, strip peat pots, nursery stand, sprinklers, protected structures, water pumping motor, media mixture, rakers, temperature control devices,humidity control devices, exhausters, media pressure, seed dibbler, etc.

INPUT MANAGEMENT IN NURSERY PRODUCTION

The rooting media and seed or planting materials are important inputs for nursery production. The rooting media should be having appropriate physical and chemical properties for better germination and root development. The media should be with constant volume and free from living organisms and firm enough to hold planting material properly. Commonly available rooting media are sand, coco peat, perlite, vermiculite, leaf mold, sphagnum moss and sawdust. Seeds are one of the least expensive but most important factors influencing yield potential. One of a farmer's most critical management decisions is the selection of seed source and variety. The cost of seed stocks usually is less than 5 to 10 percent of total production costs. Yet seed stocks can affect the yield potential of a crop more than any other input factor. Crop seeds contain all the genetic information to determine yield potential, adaptation to environmental conditions and resistance to insect-pests and disease.

NUTRIENT MANAGEMENT

Nursery growers should test soils/media each year during midsummer to fall to determine fertilizer/organic manure needs for nursery beds for the following year. Usually in nursery beds normal fertilizers like urea, Murate of Potash and DAP are applied. Timing of fertilization should be given in two spilt i.e. basal and top dressing (after 10 days) by broadcasting or foliar spray @ 0.5-2%. Immediate before transplanting, fertilization should be avoided as it encourages diversion of plant energy toward root development in nursery which has negative impact on seedlings during exposure for transplanting. Common source of nutrients in nursery is FYM, compost, vermicompost, leaf mold, cakes etc. Besides, primary nutrients like nitrogen and phosphorus are essentially applied through straight fertilizers as these play an important role in root and shoot development.

WEED MANAGEMENT

Weeds are plants unwanted at a place and time. Therepresence in nursery increases competition with seedlings fornutrient, water, light and CO_2 results in lanky seedlings. Besides,some weeds harbour pathogens and insects and alsoproduce allelopathic effect on crop plants. Therefore, weedcontrol is very essential requirement for successful nurseryproduction.

The followingmethods control weeds in either a nursery field or containercrop:

i) Select a weed-free field or media for nursery preparation.
ii) Control weeds in perimeter areas (i.e. fence rowsand windbreaks).
iii) To reduce weed seeds, properly store and compostmanure before applying to the soil.
iv) Minimize run-off from weedy fields to ponds.
v) Ensure weed-free material is planted.
vi) Cultivate fields when seedlings are small.

DISEASE AND PEST MANAGEMENT

Because of the variety of plants in the nursery, insect and disease control poses many challenges.In nursery beds usually fungal diseases like damping-off and foliar diseases like anthracnose, blight, leaf spot andmildews are serious problems. Bavistin @ 0.15% should be sprayed for fungal diseases and antibiotics like Streptocycline should be sprayed for bacterial diseases.Other measures are steam sterilization, soil solarization and hot water treatment. Integrated pestmanagement (IPM) combines chemical, cultural and biologicalcontrol techniques to address pest problems. Good sanitationand plant health reduce pest and disease problems. Some selective insect traps are available but yellow sticky traps can be used to identify pests. Insects should be controlled at vulnerable stages of their life cycle.

MODEL NURSERY LAYOUT

Nursery is the place where all kinds of plants like trees,shrubs, climbers, annuals etc. are grown and kept for transplanting in main field or for transporting orusing them as stock plants for budding, grafting and othermethod of propagation or for sale.The modern nurseries also serve as an area where gardentools, fertilizers are also kept for sale along with plant material.The nursery area is well prepared for effective utilization of inputs and to do things inproper manner. The following important components should be included during planning and preparing layout for nursery area.

FENCE

Prior to the establishment of a nursery, a good fence withbarbed wire must be erected all around the nursery to preventtresspass of animals and theft. The fence should be furtherstrengthened by planting a live hedge with thorny fruit plants(like Karonda, wild rose, jangli jalebi).

ROADS AND PATHS

A proper planning for roads and paths inside the nurserywill not only add beauty, but also make the nursery operationseasy and economical. This could be achieved by dividing the nursery into different blocks and various sections. Butat the same time, the land should not be wasted by unnecessarilylaying out of paths and roads. Each road/ path shouldlead the customer to a point of interest in the nursery area.

PROGENY BLOCK/MOTHER PLANT BLOCK

The nursery should have a well-maintained progenyblock or mother plant block/scion bank planted with varieties which are in good demand. The grafts/layers/ rooted cuttings/seedlings should be obtained preferably from the originalbreeder /research institute from where it is released or from areputed nursery. The success ofany nursery largely depends upon the initial selection of progenyplants or mother plants for further multiplication. A well managed progeny block or mother plantsblock will not only create confidence among the customers butalso reduces the cost of production and increases the successrate of grafting/ budding/layering because of availability offresh scion material throughout the season within the nurseryitself and there will not be any lag period between separationsof scion and graftage.

IRRIGATION SYSTEM

Horticultural nursery plants require abundant supplyof water for irrigation, since they are grown in polybags orpots with limited quantity of potting mixture. In areas with low water yields and frequentpower failures, a storage tank to hold sufficient quantity ofwater to irrigate the nursery plants is also very much essential.

OFFICE CUM STORES

An office-cum-stores is needed for effective managementof the nursery. The office building may be constructed in aplace which offers better supervision and also to receive customers. A store room of suitable size is neededfor storing polybags, tools and implements, packaging material,labels, pesticides, fertilizers etc.

SEED BEDS

In a nursery, this component is essential to raise the seedlingsand rootstocks. These are to be laid out near the watersource, since they require frequent watering and irrigation.Beds of 1meter width of any convenient length are to be made.A working area of 60cm between the beds is necessary. Thisfacilitates ease in sowing of seeds, weeding, watering, sprayingand lifting of seedlings. Irrigation channels are to be laidout conveniently.Alternatively, sprinkler irrigation system may be providedfor watering the beds, which offers uniform germinationand seedling growth.

NURSERY BEDS

Rising of seedlings / rootstocks in polybags requiresmore space compared to nursery beds but mortality is greatlyreduced along with uniformity. Nursery beds area should alsohave a provision to keep the grafted plants either in trenchesof 30cm deep and 1 m wide so as to accommodate 500 grafts /layers in each bed. Alternatively, the grafts/ layers can be arrangedon the ground in beds of 1 m wide with 60cm workingplace in between the beds. Such beds can be irrigated eitherwith a rose fitted to a flexible hosepipe or by overhead microsprinklers.

POTTING MIXTURE AND POTTING YARD

For better success of nursery plants, a good potting mixtureis necessary. The potting mixtures for different purposescan be prepared by mixing fertile red soil, well rotten FYM,leaf mold, oil cakes etc. in different proportions. The pottingmixture may be prepared well in advance by adding sufficientquantity of superphosphate for better decomposition and solubilization.The potting mixture may be kept near the pottingyard, where potting/pocketing is done.

STRUCTURES FOR NURSERY

I) SHADE HOUSES

Shade houses in nurseries in tropical and sub-tropical regionsoffer many advantages like raising of seedlings in bags directly,protecting the grafts from hot summer months, effective irrigationthrough upside down overhead micro-sprinklers. Theshade houses made with shade nets (50% or 75%) for regulation of shade are particularly very useful in arid regions wherethe humidity is very low during summer months.

II) GREEN HOUSES/POLYHOUSES

Grafting or budding of several ornamental species under polyhousesor low-cost greenhouses with natural ventilation will enhancethe percentage of graft/bud take besides faster growth of graftsdue to favourable micro-climatic conditions of polyhouse. Ingreenhouse construction, a wood or metal frame work is builtto which wood or metal sash bars are fixed to support panesof glass embedded in putty. In all polyhouses/ greenhousesmeans of providing air movement and air exchange is necessaryto aid in controlling temperature and humidity. It is best,if possible to have in the green house heating and self openingventilators and evaporative cooling systems.Plastic covered green houses tend to be much lighter than glasscovered ones with a build up of excessive high humidity.

III) HOTBEDS

The hot bed is often used for the same purpose as a greenhousebut in a smaller scale. Amateur operations and seedlings canbe started and leafy cuttings root early in the season in suchstructures. Heat is provided artificially below the propagatingmedium by electric heating cables, pot water, steam pipes orhot air blows. In the hot beds attentionmust be paid for shading and ventilation as well as temperatureand humidity control.

IV) LATHHOUSES

These structures are very useful in providing protection from thesun for container grown nursery stock in areas of high summertemperatures and high light intensity. Shade loving plants alsorequire lath house protection. Aluminium pre-fabricated lathhouses are available butmay be more costly than wood structures. Shade is provided byappropriate structures and use of shade nets of different densitiesallows various intensities of light in the lathhouses.

MISCELLANEOUS PROPAGATING STRUCTURES

I. MIST BEDS

These are valuable propagating units both in the green houseand outdoors and are useful mainly in rooting of leafy cuttings.

II. MIST CHAMBER

This is a structure used to propagate soft-wood cuttings, difficult to root plants and shrubs. Here the principle is to spraythe cuttings with a minimum quantity of water. This isachieved by providing the cuttings a series of intermittentsprayings rather than a continuous spray. The intermittentspraying can be done easily by means of a high pressure pumpand a time switch. The pump leads to a pipeline system insidethe propagating structure. The mist nozzles are fitted to thesepipelines and suitably spaced over the propagating material.

III. NURSERY BED

These are raised beds or boxes made of brick and mortar, providedwith drainage holes at the bottom. The dimensions ofthe boxes are 60 cm high, 120 cm broad and length as required preferably not exceeding 10 m. Roof structures for planting onboth sides and forming ridges at the centre are constructed onthe top of the nursery beds. These structures may be madepermanent with angle iron or may be made of wood. Moveablebamboo mats, palm leaf mats are placed over these structuresto protect the seedling from hot sun and heavy rains.

CONCLUSION

The nursery is the place for rearing and multiplying plants with minimal damage and maximum success. In present scenario, nursery is very much required and is the only approach for effective and efficient utilization of inputs at initial phase of crop plants. Hi-techinterventions like protected structures, micro-irrigation, plant growth regulators, soil-less media, automatic control devices, robotics etc. have made nursery industry a viable venture. Best management practices for nursery production address concerns about soil conservation, pesticide use and water conservation. But still it is facing a number of challenges in an effort to produce high-quality nursery stocks particularly in geographically inaccessible areas where timely input supply is a great challenge. However, proper planning and monitoring have solution for such problems.

Growing media properties and alternate media for ornamental plants production in nurseries

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A growing medium is a substance in which plants are grown. Selecting a good growing medium is fundamental to good nursery management because growing media is related to every other cultural practice like irrigation and fertilizer application.

FUNCTIONS OF GROWING MEDIA

Physical support: The growing medium must be porous enough to allow roots to grow well and provide physical support.Bulk density of the media is the responsible factor in influencing this.

Aeration: A good growing medium should provide adequate aeration at the root zone.

Water and nutrient holding capacity: Waterholding capacity of a medium is defined as the percentage of total pore space that remains filled with water after gravitational drainage. A good growing media must be able to supply adequate water and nutrients to growing plant.

PHYSICAL PROPERTIES OF GROWING MEDIA

Water Holding Capacity

Water-holding capacity of a medium is defined as the percentage of total pore space that remains filled with water after gravitational drainage. An ideal growing medium must contain high water holding capacity and at the same time enough macropores to allow excess water to drain out and prevent waterlogging.

Aeration

Larger macropores are responsible for gaseous exchange and supply the necessary oxygen to roots. A good growing medium should have high percentage of macropores.

Porosity

Total porosity of a growing medium is the sum of volume held by macropores and micropores. Medium which contains a higher proportion of larger particles result in more aeration and less water holding capacity than a medium containing fine sized particles, which will have less aeration and more water-holding capacity.

CHEMICAL PROPERTIES OF GROWING MEDIA

Fertility
Growing medium serves as the initial source of plant nutrition after plants emergence from seeds.

pH
pH of a growing medium indicates the level of its acidity or alkalinity. Slightly acidic to neutral pH favors growth of most plants although some species are tolerant to higher or lower pH levels. Growing medium pH influences plant growth by its effect on nutrient availability

Cation Exchange Capacity (CEC)
CEC refers to the ability of a growing medium to hold and exchange positively charged ions like ammonium, potassium, calcium etc. Higher the CEC of a medium better is its nutrient supplying capacity.

What happens when pH and EC are high or low?

Paramet er	Test value	Category	Common cause	Symptoms
pH	< 5. 5	Too low (acidic)	Minor nutrient toxicity	Bronze speckled leaves*
pH	> 6.5	Too high (tending to alkalinity)	Minor nutrient deficiency	Yellow new growth
EC	<1.5	Too low	Nitrogen deficiency	Overall yellow appearance
EC (sat. media extract)	> 3.5	Too high (Saline)	Salts burn	Leaf tip burn, root death

WHY SOILLESS GROWING MEDIA IS PREFERRED OVER SOIL

The advantages of soilless media over soil based growing media are as follows

Soil based media	**Soilless media**
Contain a variety of pests, such as pathogenic fungi, insects, nematodes, and weed seeds.	Soilless growing media are preferred in nurseries because they are generally pest free e.g. perlite, vermiculite

Manipulation of nutrient availability to plants is difficult because of inherent buffering capacity and cat ion exchange capacity of soil	Nutrient availability to plants can be better manipulated and regulated
Manipulation of air and water supplyis difficult because of inherent texture of soil	Better manipulation of air and water supply to crops
Removal of top soil raises ecological concern	Easily available

Media chemical analysis andinterpretations: test ratings

Parameter	Low	Optimal	High
1. Soluble salts, dS/m	< 1.5	2.0-3.0	> 3.5
2. pH	< 5.6	5.8-6.0	> 6.4
3. Ammonium-N, ppm	NA	10-20	>20
4. Nitrate-N,ppm	<50	100-200	> 250
5. Phosphorus,ppm	<3	6-9	> 12
6. Potassium,ppm	<50	100-200	> 250
7. Calcium,ppm	<100	150-250	> 300
8. Magnesium,ppm	< 30	40-80	> 100

Warncke andKrouskopf (1983)

MATERIALS BEING USED AS MEDIUM AND THEIR PROPERTIES

There are a number of materials which can be used either individually or in combinations with varioussubstrates to make soilless mixes. Growing media can be broadly classified into organic and inorganic materials. Here is the description of widely known materials that can be used as growing media.

VERMICULITE

- Vermiculite is the most commonly used media component
- Produced by heating the ground and sieved mica mineral to 700–1000°C.
- Vermiculite is sterile, light in weight
- Vermiculite is used to increase the water-holding capacity of a growing medium.
- It can hold 3–4 times its weight of water.

- pH ranges from neutral to slightly alkaline, 6.3 to 7.8
- Vermiculite contains nutrients such as K, Mg and Ca
- Particles are soft and easily compressed, so must be handled carefully.

PERLITE

- Perlite is a volcanic rock that is crushed and heated rapidly to a high temperature 1000°C
- White, light-weight aggregate with high pore space. Water-holding capacity is fairly low
- Perlite is added to media to improve drainage.
- Chemically inert with almost no CEC or nutrients and a neutral pH.
- Perlite may contain levels of fluoride that are injurious to fluoride-sensitive foliage plants- use of fluoride-containing superphosphate fertilizer should be avoided

ROCK WOOL

- Rock wool is made from basalt rock, steel mill slag or other minerals that are liquefied at high temperature (2700 ° F) and spun into fibers.
- Fibers are then made in to blocks or cubes as a finished product
- Has high porosity, air space and moderate water holding capacity
- Rock wool is slightly alkaline and has almost no cation exchange capacity or nutrients.

PUMICE

- Pumice is a natural product, a light silicate mineral of volcanic origin. Pumice can be used for many years; thus it produces relatively little substrate as waste.
- It has a neutral pH, contributes little to plant nutrition, but does not decrease the availability of fertilizer nutrients

POLYSTYRENE FOAM

- Polystyrene foam is a plastic product manufactured from resin beads which are subjected toheat and pressure.
- The polystyrene foam used in peat-like mixes is usually derived from scrapgenerated during the manufacturing of polystyrenebead-foam such as sheet insulation.

FLY ASH

- Fly ash is a residue of burning of coal and lignite to produce electricity. It is an amorphous mixture of ferroaluminosilicate minerals generated from combustion of coal at a temperature of 400- 1500 ^{0} C. The mineralogical, physical and chemical properties of fly ash depends on the nature of parent coal, conditions of combustion, type of emission control devices and storage and handling methods.
- Major matrix elements in fly ash are Si and Al together with significant percentage of K, Fe, Ca and Mg. Fly ash contains all naturally occurring elements and is

substantially rich in trace elements like lanthanum, terbium, mercury, cobalt, chromium.

ORGANIC GROWING MEDIA

PEAT

- Peat is the most widely used growing media and substrate component in horticulture
- Peat is formed as a result of the partial decomposition *Sphagnum* and other mosses, sedges
- Light weight, good air capacity, good water-holding capacity, high CEC, ease of storage, possibilities for reuse
- Important constraints are the limited availability and reduction in volume causing shrinkage in container culture.

Chemical properties of different types of peat

Characteristics	**Light peat**	**Dark peat**	**Black peat**
Total porosity (% vol.)	84–97	88–93	55–83
Water-holding capacity (% vol.)	52–82	74–88	65–75
Volume weight (g/cc)	0.06–0.12	0.14–0.20	0.32–0.40
Cation exchange capacity (meq/100 g)	100–150	120–170	80–150
Total nitrogen (% d.m.)	0.5–2.5	0.5–2.5	1.5–3.5
pH in water	3.0–4.0	3.0–5.0	5.5–7.3

COCOPEAT

- Cocopeat is obtained after the extraction of fiber from the coconut husk
- Coir pith has very high moisture retention capacity of 600- 800 per cent of dryweight
- It has good air capacity (11-53 %), low bulk density (0.18g/cc) and high CEC which varies from 20-30 meq/100 g
- It is more resistant to microbial breakdown and therefore may shrink less than peat
- Coir is easier to re-wet after drying than peat moss
- Has significant amounts of K and Ca
- The pH of coir ranges from 5.5 to 6.5

- The EC of coir ranges from 0.4 to 3.4 mmhos/cm.
- Coir has been the reported high chloride levels (typically 200 - 300 ppm). Leaching is essential and sub irrigation not good practice
- Coir may not be a preferred media component if non-leaching subirrigation is used.
- Because of the variability in the qualities of coir, it is important to purchase it from a reputable dealer with good quality-control practices

BARK

- Common media for nursery
- A fine dust of saw mills
- Presence in media improves aeration and reduce cost of media
- Before use it needs to be composted to remove phytotoxic compounds, avoid further nitrogen fixation by microbial decomposition and prevent loss of volume.
- Bark particles less than 10 mm are used as media
- Composted bark has low CEC, moderate pH and high Ca.

BAGASSE

- Bagasse is a waste by-product of the sugar industry. It may be shredded and/or composted to produce a material which can increase the aeration and drainage properties of container media.
- Because of its high sugar content, rapid microbial activity results after the incorporation of bagasse into a media.

SAWDUST

- The species of tree from which sawdust is derived largely determines its quality and value for use in a growing media. The C:Nratio(700:1 to 1300:1) of sawdust is much wide so that it is not readily decomposed. The high cellulose and lignin content along with insufficient N supplies immobilizes the nutrients.

RICE HULLS

- Rice hulls are a by-product of the rice milling industry. Although they are extremely light in weight, rice hulls are very effective at improving drainage.
- The particle size and resistance to decomposition of rice hulls and sawdust are very similar. However, N immobilization is not as serious of a problem in media amended with rice hulls.

COMPOST

- Compost is a key ingredient in most organic potting mixes, providing an organic source ofnutrients, reducing reliance on the finite global supplies of peat. In addition to using compost that meets organic standards, it is essential to use high quality compost that will result in good plant performance.

- Compost alone does not have the optimal water holding characteristics and soluble salt levels are often higher than optimal for potting mix.

PRESS MUD

- Press mud is a residue left over from sugarcane after extraction of juice. Its composition varies significantly depending on soil conditions, cane varieties, period of supply of cane and geographical variations
- . It consists of 80% water and contains 0.9%-1.5% sugar, organic matter, nitrogen, phosphorus, potassium, calcium, sulphur and coagulated colloids and other materials in varying amounts.

IRRIGATION WATER MANAGEMENT IN SOILLESS GROWING MEDIA

As a standard recommendation, it is advised to apply a constant volume of irrigation water at each irrigation and differ the number of irrigations as opposed to applying different volume of irrigation water keeping number of irrigations constant.

If a growing medium has high water holding capacity with suboptimal air capacity, then it should be irrigated less frequently with more volume of water. On the other hand,if medium has high air capacity with suboptimal water holding capacity then it should be Irrigated more frequently with lesser volume of water.

Fertilizer application in soilless media

- It is most important to apply the nutrients at peak growth period or critical growth stage

- Depending on the crop's total nutrient requirement, application of soluble fertilizers at each irrigation or at every other irrigation is generally accepted as best method to optimize plant growth

ADDITION OF AMENDMENTS TO GROWING MEDIUM

Lime: Lime or dolomitic limestone is added to growing medium to increase the pH if the growing plants require a pH higher than existing.

Starter fertilizer: Addition of a small starter dose of fertilizers will support the development of plants at initial stage when it is not possible to fertilize the plants externally.

Surfactants: also known as wetting agents which are added to increase the wettability of hydrophobic materials such as pine bark and peat moss.

Microbial inoculants: Beneficial microbial inoculants like mycorrhiza, pseudomonas, trichodermaetc can be added to the growing medium at recommended doses at the time of mixing.

PASTEURIZATION OF GROWING MEDIA

Sterilization of medium which renders it to be complete devoid of living organisms is not appropriate because many beneficial microorganisms that might present in growing medium can act as antagonistic to plant pathogens. Some commercial growing media will be available as pasteurized ones to avoid incidence of diseases, pests and weeds when they are used.Heat pasteurization is the most usual method of treating growing medium and it is mostly done with steam. Apart from this there are other methods like aerated steam, dry heat from flame, electric pasteurizers, microwave ovens and solar heat. A recommendation of heating the growing medium to 60 to 80 °C for at least 30 minutes is being given as standard.

The fundamental objective of preparation of growing media remains same although substrates and their combination may vary. Mixing of substrates should be such that, the resultant growing media should be porous, well drained,contain low soluble salts concentration, uniform with each permit to allow use of standardized fertilization and irrigation systems, pest and pathogens free, and stable interms of its chemical and biological characteristics when subjected to chemical treatments or sterilization.

ADVANCES IN CULTIVATION OF TUBEROSE FOR CUT AND LOOSE FLOWER PRODUCTION

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INTRODUCTION

Tuberose (*Polianthes tuberosa*) is an important commercial ornamental bulbous crop owing to its highly fragrant flowers. The crop is a native of Mexico and from here it spread to different parts of the world during the 16th century. Tuberose derives its generic name *'Polianthes'* from the Greek words '*Polios*' meaning white or shining and '*Anthos*' meaning semi perennial bulbous plant. It belongs to family Agavaceae which has about 12 species. Tuberose is commercially cultivated for cut and loose flower trade as well as for the extraction of its highly valued essential oils. It is exported from India to countries such as U.S., Germany, UK, Italy, the Netherlands, Japan, UAE and Saudi Arabia.

IMPORTANCE AND USES

The single petalled cultivars are used as loose flowers and for making floral decorations such as garlands, floral rangoli etc. They are also used for the extraction of essential oils, concrete and absolute. The concrete recovery in single petalled cultivars ranges from 0.08 to 0.135 %. These essential oils are used in high grade perfumes and highly in demand in the international market fetching a good price. Renowned perfume 'Poison' is manufactured using tuberose oil. The essential oil is also used in non-alcoholic beverages, ice-creams, candy and baked products.

Double petalled cultivars are used in floral decorations such as bouquets and for vase / bowl decoration. Tuberose is also highly suitable for gardening and landscaping purposes as it is highly suitable for growing in pots, beds and borders. In the food and beverage industry, fragrant flowers of Tuberose are added along with stimulants or sedatives to ppular beverages prepared from chocolate. The Tuberose plant holds significant medicinal value. Its bulbs are considered to be diuretic and emetic. The bulbs are rubbed with turmeric and butter and applied as a paste for removing red pimples of infants. Powdered form of dried bulbs is used as a remedy for Gonorrhea.

AREA AND PRODUCTION

Globally, tuberose is grown in countries such as France, Italy, South Africa, Taiwan, Kenya, Morocco, Egypt, China, U.S., Pakistan, Bangladesh and several other tropical and sub-tropical countries. In India, it is commercially cultivated in over 30,000 ha in more than 12 states.

The major tuberose growing states in India are as follows

	State	District
1.	Assam	Guwahati, Jorhat, Hatikhuli, Tinsukia and Dibrugarh
2.	West Bengal	Bagnan, Kolaghat, Midnapur, Panskura, Ranaghat, Krishnanagar
3.	Maharashtra	Pune, Nashik, Satara and Ahmednagar
4.	Gujarat	Navsari, Valsad, Surat and Baroda
5.	Haryana	Ambala, Gurgaon, Faridabad and Hissar
6.	Karnataka	Tumkur, Kolar, Belgaum, Mysore and Bengaluru rural
7.	Andhra Pradesh (inc Telanagana)	Guntur, Chitoor, Krishna, Khadappa and Ranga Reddy
8.	Tamil Nadu	Coimbatore, Madurai, Theni, Trichy and Dindigul
9.	Uttar Pradesh	Meerut, Ghaziabad, Muzzafarnagar, Saharanpur, Lucknow, Kanpur, Kannauj and Barabanki
10.	Uttarakhand	Udham Singh nagar, Haridwar and Dehradun
11.	Orissa	Cuttak, Puri and Benjam
12.	Rajasthan	Udaipur, Ajmer, Jaipur

CLIMATE

Tuberose is grown under wide environmental conditions ranging from tropical to sub tropical and even temperate climate. However, in general, the crop grows well in warm and humid climate. Hence, in India, commercial cultivation of the crop is confined to warm and humid areas.

A soil temperature of more than 20^0 C is suitable for obtaining maximum root growth. Temperature of 27^0 C is most suitable for planting. It should not be less than 24^0 C at the time of planting. The optimum temperature range for proper growth and development is from 20^0 C to 30^0 C. High (40^0 C) as well as low ($10\ ^0$ C) temperatures reduce the length of spike, weight and quality of flowers.

SOIL

Tuberose can be cultivated in a wide range of soils (light, sandy loam to a clay loam). Fertile, loamy and sandy soils having a pH in the range of 6.5 to 7.5 with good aeration and drainage are ideal for tuberose cultivation. Soils which are affected by salinity and alkaline condition could also be used with better agronomical practices.

The soil should have good water holding capacity for successful cultivation of the crop. At least 45 cm deep, well drained, friable soils, rich in organic matter and nutrients with plenty of moisture is preferable.

Proper field preparation is vital for obtaining a good yield. The land should be ploughed deep enough to a good tilth and it should be properly manured. The bulb production is severely affected and flower yield and quality is reduced if the soil is not thoroughly prepared and it contains soil clods or undecomposed organic matter. Enough quality of cow dung or FYM should be incorporated in the soil about a month earlier.

VARIETAL STATUS

Tuberose can be broadly divided into three categories based on the number of rows of tepals each flower possess. Single cultivars possess single row of petals. Semi-double cultivars have 2 to 3 rows of tepals. Double cultivars have more than 3 rows of tepals.

Besides these conventional types, variegated cultivars having variegated leaves with golden yellow streaks along the leaf margin viz. Rajat Rekha and Swarna Rekha have been released from NBRI Lucknow. Flowers of Rajat Rekha have silvery white streaks along the middle of blade. In Swarna Rekha (double) the leaf margin is streaked with golden yellow

Mexican Single, Sikkim Selection & Pearl Double are among the oldest varieties and the details of their introduction into India are not known. Mexican Single is a single flowered variety which produces maximum f lowers during the months of Cctober – December, which is considered as lean period for tuberose flowers yield. It is preferred by farmers and industries due to its higher flower yield.

During the past two decades, five cultivars of tuberose namely Shringar, Suvasini, Prajwal, Vaibhav and Arka Nirantara were released by IIHR Bangalore.

The flower bud of Shringar are attractive with slightly pinkish tinge. Its loose flowers are ideal for making garland while spikes can be used as cut flowers. The yield of loose flower is about 15,000 kg/ha/yr. Suvasini is a cross between single and double. This variety produces more flowers per spike and the spike are best suited for cut flowers. Prajwal bears single type flowers on tall stiff spike. It is a cross between ‘Shringar’ x ‘Mexican Single’. The flower buds are slightly pinkish in colour, while the flowers are white. The individual florets are large in size, compared to ‘Local Single’. It yields twenty per cent more loose flowers than ‘Shringar’. It is recommended both for loose flower and cut flower purpose. Cultivar Phule Rajani has been released from MPKV Rahuri for commercial cultivation.

Following are the commercial cultivars available in India:

Origin	Variety
NBRI, Lucknow	Rajat Rekha (single) & Swarn Rekha (double)
IIHR, Bengaluru	Arka Sugandhi, Arka Nirantara, Prajwal, Shringar, Suvasini, and Vaibhav
MPKV, Pune	Phule Rajani (single)
Local	Hyderabad, Calcutta, Kahikuchi, Saurashtra, Pune, Nilkottai (TN)
Introduced/wild	Mexican Single, Pearl Double, Sikkim Selection

PROPAGATION

Tuberose can be cultivated through the following three propagation methods

a) Seed or sexual propagation

Seed or sexual propagation is practiced in single petalled cultivars as they are fertile and undergo seed setting. For propagation through seeds, the seeds are sown in well prepared growing medium. A soil temperature of 26.6^0 C is considered to be optimum for germination. The seeds are sown in rows 10 cm apart and at a depth of 1.5 cm in heavy soil and 2.0 cm in light soil. The seed beds for raising seedlings should be thoroughly prepared by digging and sufficient quantity of FYM should be mixed prior to sowing. After the seeds attain good growth, they are transplanted in pots or in the ground.

b) Vegetative or asexual propagation

i) By bulbs

It is the most common method practiced commercially for tuberose multiplication. Care should be taken in the selection of suitable sized bulbs. Bulbs with a size of 2-3cm are ideal for propagation. Moreover, bulbs that are free from diseases and have an average diameter of 1.5 cm or above should always be preferred for planting.

ii) By division of bulbs

Propagation of tuberose can also be done through division of bulbs i.e. by using bulb segments. The success rate depends on size of bulbs and only segments of bulbs (2 cm or above in diameter) regenerate well. Bulbs are cut into two or three vertical sections, each containing bud and a part of the basal plate. Bulb segments are treated with fungicide & planted vertically in the rooting medium with their tips showing just above the surface. New bulblets along with roots develop from the basal plate which are then transferred to the ground to continue their growth. The multiplication of the crop gets enhanced through the use of bulb segments, however, detrimental effects are seen on the flowering.

c) Micro-propagation

Clonal propagation is carried out though tissue culture. The technique is utilized for rapid and large scale multiplication of the crop. Approximately 800 regenerated plants can be obtained from a single bulb. Furthermore, by using immature flower bud, petal segment, leaf base and bulb scale as explants, plantlets can be regenerated by transferring them in media containing various combinations of auxins and cytokinins. These micro propagated plants can then be further used for transformation and genetic engineering. • Tuberose plants can also be generated by using anthers with microspores at the uninucleate stage from single type varieties.

PLANTING OF BULBS

Bulbs 2-3 cm in size are generally used as plating material. The bulb size is directly correlated with the yield and quality of the produce. Prior to planting, the bulbs are given a fungicidal treatment by dipping them in a solution of Trizophos. This practice reduces the incidence of root knot nematode. The bulbs can be planted 4-5 weeks after uprooting. Storing the bulb for about 30 days helps to enhance the yield.

A Spacing of 30 cm x 20 cm (45-50000/acre); 30 cm x 30 cm (35-40000/acre) or 30 cm x 40 cm (30-35000/acre) (HDP/close spacing 20 cm x 20 cm) is generally adopted. The spacing Spacing varies from cultivar to cultivar, diameter of mother bulb, climatic condition, crop management and purpose of crop growing. The bulbs are planted at a depth of 4-8 cm in the soil depending on size of bulb, soil texture and growing region

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Staggered/sequential planting at 10-15 days interval can be undertaken to obtain regular flowering for longer duration.The ideal planting season for Tuberose is from March to September in the plains and from April to May in the hilly areas.

Tuberose once planted would produce flowers continuously. It is however recommened to take a second crop (ratoon) only. Third year ownwards the yield starts to decline.

IRRIGATION

The field should be irrigated immediately after planting to provide sufficient moisture for sprouting. Further irrigation should be avoided till bulbs have sprouted. The frequency of irrigation depends on soil type, stage of growth and prevailing weather conditions. In summer the field should be irrigated in weekly intervals or even earlier while in winter it should be irrigated at 10 day intervals. It is better to give few heavy irrigations than several light irrigations.

NUTRITIONAL REQUIREMENT

The optimum nutritional requirement depends on various factors such as climatic condition, soil type, cultivar planted, plant density etc.

Major Nutrients

Nitrogen is a much more important element than phosphorus or potassium and it influences vegetative growth and yield. Generally, 25 to 50 tonnes/ha FYM can be added to soil 2-3 weeks before planting. N, P2O5 & K2O @ 200; 150-200 & 150 - 200 kg/ha (half of N as basal, remaining in two-three splits at 30 days interval)

Micro-nutrients

Foliar spray of ZnSO4 (0.5%) + FeSO4 (0.2%)+ Boric acid (0.1%) improves growth and flowering.

WEED MANAGEMENT

Heavy manuring and irrigation requirements of the crop create conducive condition for growth and development of various species of weeds. These weeds, if not timely removed, markedly decrease crop productivity. Weed removal is usually done through either physical or chemical methods. Physical method involved the manual removal of weeds through hand weeding. Chemical methods include pre-emergence application of Atrazine at 3 kg/ha or Pendimethalin (1.25-1.5 lit/ha) and post-emergence application of Paraquat (Gramoxone) at 3 lt/ ha

HARVESTING

Tuberose comes in first flowering after 3-4 months after planting. For cut flower use, the whole spike is clipped (when few flowers open) with a sharp secateur leaving 4-6 cm basal portion of scape on the flowering plant. For loose flower usage and extraction of concrete / absolute only individual florets are picked from the flowering spike in the early morning hours before 8 a.m. when they begin to open.

LIFTING, CURING AND STORAGE OF BULBS

Tuberose bulbs need a minimum period of 7-8 months (40-50 days after flowering) for proper maturation. Irrigation is withheld a few days prior to uprooting to facilitate digging.

Entire clumps are dug with spade / pickaxe without damaging bulbs and bulblets. Leaves of the clump are clipped, adhered soil is cleaned and bulbs/bulblets are separated from the clump.

Cleaned bulbs are then graded as per size (mature > 1.5 cm & immature < 1.5 cm diameter). Storage of bulbs for 4-6 weeks (at ambient temp) is necessary before they are taken out for planting. Mother bulb measuring 1.5-2.0 cm diameter produces a clump weighting about 200-250 g having 6-8 daughter bulbs (>1.5 cm) and 10 -12 bulblets (<1.5 cm).

YIELD

Flower production varies with cultivar or variety and depends upon bulb size at planting time, density of planting, cultural practices adopted and climatic condition prevailing in the area. Flowers are ready for harvest in about 3 to 31/2 months after planting.

One hectare of tuberose plantation yields 4-7 lakhs of spikes per year for cut flower purpose. In case of single varieties, 14-15 tonnes /ha of loose flowers may be harvested.
20-25 tonnes/ ha of bulbs and bulblets may be harvested at the end of 3rd year.

POST HARVEST MANAGEMENT

a) Loose Flowers

Loose flowers are transported in gunny/polythene bags (lined with newspaper), bamboo baskets, plastic crates to the market (covered with muslin cloth or with wet gunny bags). About 10-15 kg fresh flowers are packed in each basket

b) Cut Flowers

Flower spikes are graded as per spike length, rachis length and quality of flower and then bunched in round bundles. Each bundle having 50-100 cut spikes. Stem portion is wrapped in wet newsprint sheets and the bundles are packed in card board boxes for transportation.

PACKAGING AND TRANSPORT

For cut flower purpose, long spikes are preferred and are sold in round bundles or bunch. Each bundle /bunch contains 25, 50 or 100 spikes. To avoid damage of the flowers and buds, the whole bundle should be wrapped in soft, white tissue paper or paper/polythene sheet.

PEST MANAGEMENT

a) Bud Borers (*Helicoverpa armigera*)

Bud borers cause damage to the florets by making holes in the flower buds. Collection and destruction of damaged buds helps to reduce the damage. Setting up of light traps also helps to control population by attracting them.

Spraying of monocrotophos (0.2%) or Thiodan (0.5-0.8%) or Methyl Parathion (0.05%) at appearance of eggs on buds and tender foliage helps to control borer damage. Spray of Neem oil (1%) also gives considerable protection by repelling various stages of pest.

b) Aphids (Aphis gossypii)

Aphids feed by sucking the sap on the flower buds and growing points. Spray of Malathion or Dimethoate (0.1%) at an interval of 15 days is effective in controlling Aphid population.

c) Thrips (Taeniothrips simplex)

Thrips damage the whole plant by sucking sap from leaves, flower stalks and flowers. Thrips can be controlled by spray of Dimethoate or Metasystox (1.75 to 2.0 ml/litre) or malathion (0.1%).

DISEASE MANAGEMENT

Basal/Foot Rot and Tuber Rot	**Soil drenching with Formalin (0.2%) or Zineb (0.3%) and Mercuric chloride (0.1%) OR** **Foliar application of Thiram (0.2%), Bavistin (0.5%), Brassicol (0.1%) or Zineb (0.3%), three times at 20 days interval.**
Blossom Blight	**Foliar spray of Benomyl (0.2%) or Thiophanate methyl (0.2%)**
Flower Bud Rot	**Remove diseased plant and use of Spreptocycline (0.01%)**
***Alternaria* Leaf spot**	**Spray of Mancozeb (0.2%) or Iprodione (0.2%) at 10 days interval**

SUCCESS STORY: MPKV CENTRE

Several farmers from Pune region, under the guidance of AICRP on Floriculture – Pune (MPKV) Centre took up the cultivation of Phule Rajani. Earlier, Pune Local Single was commonly cultivated in the region. The famers obtained a net profit of 5.13 lakh / ha by cultivating Phule Rajani, which was several times higher than that obtained from Pune Local Single (0.81 lakh / ha). The yield of Phule Rajani was also almost double that of Pune Local Single.

SUCCESS STORY : BCKV KALYANI CENTRE

This is a success story of the Tuberose variety – Prajwal at Naida District, West Bengal. The previously cultivated variety, Calcutta Single was highly susceptible to foliar nematode *Aphelenchoides basseyii*. The farmers namely Sri Umesh Biswas, Sri Joydev Biswas, Sri Shymal Biswas, Sk. Kutubuddin of Dhantala area of Ranaghat – II block of Nadia district began cultivation of Prajwal and also took the responsibility of multiplying it for further dissemination under the guidance of AICRP Flori- Kalyani centre. Presently they are supplying the bulbs to the neighbouring district. They obtained a net profit of Rs. 2,41,250 from Prajwal which was several times more than the traditional single variety (Rs.45,050) per bigha (0.133 ha) in two years.

FURTHER READING

i) Floriculture in India (Mukhopadhyay and Banker)
ii) Commercial Flowers (Bose et al)
iii) Production Manual on Tuberose (Techncial Bulletin from ICAR – DFR)
iv) Internet
   a) http://www.ccari.res.in/Technical%20Bulletin%20No.%2050.pdf
   b) http://vikaspedia.in/agriculture/crop-production/package-of-practices/flowers/tuberose
   c) https://www.agrifarming.in/tuberose-cultivation-beginners-guide/

POTENTIAL OF ORNAMENTAL PLANTS IN MITIGATING INDOOR AIR POLLUTION

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INTRODUCTION

Poor air quality is associated with health problems throughout the world due to rapid urbanization and industrialization.Urban air pollution is a matter of global health concern. Recent incidence of toxic haze which is hovering on metro cities is of great concern. It is caused by many factors which are complex and will take a long way to find proper solution.Little relief is possible if we rely on ornamental plants which can mitigate at least indoor air pollution.Indoor air is considered more polluted than outdoor environment.People spend major portion of time indoors in office, house, schools, colleges, shops. So, air quality of indoor environment is very critical for human health.As homes become more hi-tech, indoor air pollutants are easily trapped.As outdoor air enters, it mixes with pollutants derived from indoor sources such as Volatile Organic Compounds (VOC's). Volatile Organic Compounds are released from synthetic (petroleum-derived) furnishings, finishes, solvents, polished furniture, insulations, curtains, carpets, copiers and printers, and other painted household articles.Indoor air pollution is one of the important ecological threats to human health, leading to symptoms of "sick building syndrome".

TOXIC CHEMICALS FOUND IN HOME AND WORKING ENVIRONMENTS.

Toxic chemicals orVolatile Organic Compounds found in home and working environmentsareBenzene, Trichloroethylene,Formaldehyde, Xylene, Carbon monoxide, Ammonia *etc*.

BENZENE

It is a solvent present in inks, oils, paints, plastics and rubber. It is also used to make detergents and pharmaceuticals. Short-term exposure to benzene can result in irritation to eyes and skin, drowsiness and headaches.

TRICHLOROETHYLENE

It is used in the dry-cleaning industry, in printing inks, paints and adhesives. Short-term exposure to Trichloroethylenecan result in dizziness and nausea.

FORMALDEHYDE

It is found in all indoor environments, including foam insulations, plywood panelling, synthetic fabrics, paper bags, facial tissues, napkins and household cleaning agents.Short-term exposure to formaldehyde can result in irritation to nose, mouth and throat. More severe cases can include swelling of the larynx.

XYLENE

It is found in printing, leather and paint industries, tobacco smoke and vehicle exhausts. Short-term exposure to Xylene can result in irritation to mouth and throat, headaches, dizziness and heart problems.

AMMONIA
It is found in window cleaners, floor waxes, salts and fertilisers. Short-term exposure to ammonia can result in irritation to eyes and throat.

HARMFUL EFFECTS OF INDOOR AIR POLLUTION
All these toxic chemicals or Volatile Organic Compounds pollute the indoor atmosphere without any visual warning. Neglecting the indoor air pollution results in frequent illness,allergies,asthma, bronchialinfection, sorethroat, sinus, headache, cancer and many other ailments. Even at slight levels, the mixture of VOC's can cause these ailments resulting in 'sick-building-syndrome' or 'building-related illness'. Moreover, indoor environments, in general have raised CO_2 levels from human respiration, which can add substantially to headaches, stuffiness, drowsiness or loss of concentration.

NASA CLEAN AIR STUDY
NASA conducted Clean Air Study to demonstrate the effectiveness of ornamental plants to purify air. In the NASA study, the researchers tested the air filtering qualities of several indoor plants against toxic chemicals found in home and working environments. According to NASA, greening of work places with indoor plants can soak up these pollutants and make our interiors refreshing.Each plant was subjected to each chemical while placed in a sealed chamber.Researchers monitored the level of chemical in the chamber over the course of 24 hours, total plant leaf surface area and total amount of each chemical removed per plant. House plants that need little light were found to show the potential for removing trace pollutants from indoor air.Its researchers suggest that efficient air cleaning is accomplished with at least 1plant/100 sq. ft. of home/office space.

BENEFITS OF INDOOR PLANTS
It is proven that indoor plants reduce indoor air pollution, reduce workplace illness, reduce sick-leave absences, reduce stress and negativity, do not create unhealthy mould problems,raise performance andproductivity, improve job satisfaction, enhance business image with potential clients, improve school performance and patient well-beingand contribute to meeting at least 75% of Indoor Environmental Quality (IEQ) criteria. Indoor plants reduce all types of urban air pollution(90% of which comes from fossil fuel combustion) like Nitrogen and Sulphuroxides, Carbon dioxide (CO_2),Carbon monoxide (CO), Air toxics (volatile organic compounds), Fine particulate matter,Ozone etc.

RECOMMENDED ORNAMENTAL PLANT SPECIES FOR MITIGATING INDOOR AIR-POLLUTION

- Peace-Lily (*Spathiphyllum*)
- Pot mum (*Chrysanthemum morifolium*)
- Golden Pothos(*Epipremnumaureum*)
- *Dracaena reflexa*
- Snake Plant (*Sansevieriatrifasciata*)
- Lady Palm (*Rhaphis excelsa*)
- Flamingo Lily (*Anthurium andraeanum*)
- English Ivy (*Hedera Helix*)
- Barberton Daisy (*Gerbera jamesonii*)
- Weeping Fig (*Ficusbenjamina*)

- Boston Fern (*Nephrolepisexaltata'Bostoniensis'*)
- *Dracaena marginata*
- Bamboo Palm (*Chamaedoreaseifrizii*)
- Spider Plant (*Chlorophytumcomosum*)

PEACE-LILY (*SPATHIPHYLLUM*)
NASA's analysis of indoor houseplants revealed that the Peace Lily was the most efficient indoor plant inremoving airborne VOC's including Formaldehyde, Trichloroethylene and Benzene. They require very little light or water.*Spathiphyllum* should never be put in direct sun light, as the rays of sun may lead to leaf burn. It can be planted in a dark corner, give it water once a week and it will help purify the air around that general area.*Spathiphyllum* produces a showy white inflorescence, consisting of a hood-shaped spathe surrounding the spadix, which adds to their ornamental value.

***CHRYSANTHEMUM MORIFOLIUM*(POT MUM)**
It loves direct sunlight and a medium amount of water.Their blooms not only help brighten the room, they also help cleanse the air of many chemicals that are common in homes like Formaldehyde, Xylene, Ammonia,Benzene, Toluene andTrichloroethylene.

***EPIPREMNUMAUREUM*(DEVIL'S IVY / GOLDEN POTHOS)**
It is best to keep*Epipremnumaureum*near a window, without direct sunlight shining down on it. It is quite efficient at cleansing the air of pollutants, such as Benzene, Trichloroethylene, Xylene and Formaldehyde.It is a climbing vine which can be trained up a stake or totem. It grows in indirect sunlight; warm temperatures of23° to 28°C and moderate humidity. It grows in standard potting mix with extra organic matter. Allow the plant to dry between watering. It can be propagated from stem cuttings.

***DRACAENA REFLEXA* (PLEOMELE / DRACAENA)**
According to NASA, *Dracaena reflexa* is one of the best houseplants for absorbing airborne toxins, including Formaldehyde, Nitrogenoxide, Benzene, Xylene and Trichloroethylene.

***SANSEVIERIATRIFASCIATA* (SNAKE PLANT / MOTHER-IN-LAW'S TONGUE)**
According to NASA, it is one of the best houseplants for absorbing airborne toxins, including Formaldehyde, Nitrogen oxide, Benzene, Xylene andTrichloroethylene. It can endure low amounts of light at long durations. It withstands drought, poor light, low humidity and temperature fluctuation. It grows in diffused sunlight or moderate daylight; moderate warmth of18° to 23°Candlow to moderate humidity. It can be potted in standard soil mixture.Allow the plant to dry well before watering. *Sansevieriatrifasciata* can be propagated by division or horizontal leaf sections of 10 - 12 cm inserted one-third their length in rooting medium.

***RHAPISEXCELSA* (LADY PALM)**
Rhapisexcelsa is a perfect fan palm to have in a dark corner of home. They tolerate low light levels, high amounts of water and wide range of temperatures. It can thrive in both indoor and outdoor environments.NASA Clean Air Study identified it as one of the best houseplants in cleansing the air of Formaldehyde, Ammonia,Xylene and Toluene.

***ANTHURIUM ANDRAEANUM*(FLAMINGO LILY)**

According to the NASA Clean Air Study, Flamingo Lily was incredibly effective at removing airborne Formaldehyde, Ammonia, Tolueneand, Xylene in home or office.It prefers high-humidity environments.

***HEDERA HELIX* (ENGLISH IVY)**

According to Clean Air Study, English Ivy is effective at cleansing Benzene, Formaldehyde,Xylene and Toluene from the air. *Hedera helix* also helps reduce mould in homes. They are sturdy and adaptable house plants which can be trained up a trellis or stake, or pinched back continually to develop into tough bushy plants. They prefer moderate daylight; fairly cool temperatures of 15° to 23°C and moderate humidity. They grow in well-drained standard potting soil. They are propagated easily from stem cuttings.

***GERBERA JAMESONII*(BARBERTON DAISY)**

NASA's Clean Air Study found that *Gerbera jamesonii*is effective at cleansing the air of Formaldehyde, Benzene and Trichloroethylene. It has to be kept it in an area that has plenty of natural light.

FICUS BENJAMINA (WEEPING FIG)

According to NASA's Clean Air Study, *Ficus benjamina* was effective at cleansing airborne Formaldehyde,Xylene and Toluene.This low-maintenance, evergreen plant grows well both inside and out. Place *Ficusbenjamina* in an area that has plenty of bright indirect natural light. It is a very versatile plant as far as light goes. In the full sun it will have a thick canopy of leaves. But, in the dense forest it will grow very open with fewer leaves and thin weeping branches.

***AGLAONEMA MODESTUM*(CHINESE EVERGREEN)**

This tropical foliage plant is one of the most durable house plants. It tolerates poor light, dry air, air-conditioning and drought.*Aglaonema modestum*grows in moderate daylight (1,600 lux); warm temperatures of 20° to 25° Candlow to moderate humidity. Let soil dry between watering. It needs little moisture. It can be propagated by division, stem cuttings rooted, or stem sections.

OTHER POPULAR AIR FILTERING INDOOR PLANTS

***ASPIDISTRA ELATIOR*(CAST-IRON PLANT)**

As the name implies, these are hardy house plants enduring heat, dust, poor light and lack of moisture. They grow in low to moderate daylight, they dislike sunlight. It prefers moderate temperatures of 18° to 20°C and low to moderate humidity. It can be potted in standard potting mix. It can be propagated by division.

***CHAMAEDOREAELEGANS*(PARLOURPALM)**

Palms make elegant tub plants for large rooms, offices and patios. Most palm varieties are well adapted to indoor cultivation. They will stand direct sun, but prefer indirect light; moderate temperatures of 20° to 30°C and moderate to high humidity. Pot firmly in organic soil and keep the soil evenly moist. Always keep the leaves clean. They can remain in the same pot for several years. They are propagated from seed / division.

***MONSTERADELICIOSA*(SPLIT-LEAF PHILODENDRON)**
They are hardy, easy-to-grow house plants, enduring low light, a wide range of temperatures, dust and low humidity. They grow in diffused sunlight or daylight; warm temperatures of 23° to 28°Cand moderate humidity. They are potted in standard soil mix; extra organic matter is desirable. They are propagated from stem cuttings; stem sections and air-layering. *Monstera* produces aerial roots.

***SCHEFFLERAACTINOPHYLLA*(UMBRELLA TREE)**
They are hardy rapidly growing house plants which grow well in offices. They grow in direct sunlight or bright indirect light; warm temperatures of 20° to 30°C and low to medium humidity. It can be potted in standard potting soil; allow the plant to dry between watering. They are propagated from stem cuttings.

***DIEFFENBACHIA AMOENA*(DUMBCANE)**
*Dieffenbachia amoena*tolerate poor light if well established. They grow in indirect sunlight; warn temperatures of 20° to 26°C andlow to medium humidity. It can be potted in standard potting mix; let dry between watering. They arepropagated by laying cane sections in rooting medium.

***DRACAENA FRAGRANS*(CORN PLANT)**
Dracaenas tolerate low light and have attractive variegated foliage. They grow in moderate daylight; warm temperatures of 20° to 26°c and low to medium humidity. It can bepotted in standard soil mix; keep the soil evenly moist. They arepropagated from stem cuttings.

***FICUSELASTICA*(RUBBER PLANT)**
*Ficuselastica*prefer diffused daylight; warmth of 20° to 26°C and medium to high humidity. Always keep the leaves clean. They are propagated from leaf or stem cutting or by air-layering.

***NEPHROLEPSISEXALTATA*(BOSTON FERN)**
They are very attractive evergreen fern. Erect, narrow, sword-shaped bright green fronds arise from creeping surface roots in wonderful clusters. They look great for hanging baskets. They prefer partial to full shade. They are fast-growing. It grows up to 3 to 4 feet high and spread indefinite.

***PHILODENDRON SELLOUM*(SPLIT LEAF PHILODENDRON)**
*Philodendronselloum*is used frequently as part of the interior landscape of an office or lobby. In this environment the plant is considerably smaller than in nature.

***SAINTPAULIASPECIES*(AFRICAN VIOLET)**
They are the most popular of flowering house plants**.** African violet is easy to grow, and flowers year-round. *Saintpaulia*grow in diffused sunlight in summer, full sunlight in winter.Hot sun causes leaf scorch. They prefer moderate temperatures of 18° to 23°C and high humidity. They are ppropagated easily from leaf petiole cuttings; seed, and division of multiple crowns.

***ALOE BARBADENSIS*(ALOE VERA)**
*Aloe barbadensis*requireswell-drained soil and sunny position. It grows very well in a sunny windowsill.

***CRASSULAARGENTEA*(JADE PLANT)**

Jades are best grown in very bright sunlight with low humidity. If the plant is accustomed to dimmer light,move it into the sun in stages. *Crassulaargentea*are best grown between 12°C at night and 26°Cduring day.They should be repotted every two to three years. Optimum soil pH is 6.5.

***SCHLUMBERGERASPP*(CHRISTMAS CACTUS)**

These succulents make good basket plants. They produce brilliant flowers in winter. They grow in filtered sunlight. They should be potted in rich organic soil. They are propagated from pieces of branch, two or three inches (5 to 8 cm) long.

PEPEROMIA

They are low-growing house plants. They grow in bright, diffused sunlight; warm temperatures of 23° to 28°C and moderate humidity. They should be potted in standard potting soil.Allowthe plant to dry between watering as stems are prone to rot. They are propagated easily from stem and leaf petiole cuttings.

PHILODENDRON

It is a common house plant because of its ability to tolerate drought, dust, dim light and dry air. They can be climbers or non-climbers. They prefer to grow in indirect sunlight, warm temperatures of 20° to 26°C and moderate to high humidity. Always keep the leaves clean. They are propagated from cane sections or stem cuttings.

SELECTING INDOOR PLANTS

Always start the indoor gardening with pest and disease-free plants. Do not bring a plant into your indoor if it shows signs of insects or diseases. The plants selected for indoor gardening should be healthy-looking from top to bottom.Always match the plant to indoor growing conditions.Know the environmental conditions prevailing at your homes (especially where the plant(s) are going to be placed) and find a plant that will best grow under these conditions.

ACCLIMATIZATION

Process of acclimation reduces the shock an ornamental plant suffers when they are moved to area with significantly different environmental conditions.A homeowner should acclimatize the ornamental plants when placing them outdoor bygradually increasing the light intensities and reversing the process when placing or bringing them back indoors.For newly purchased indoor ornamental plants, acclimatize them by initially locating them in a high light area of home and gradually moving them to their permanent darker location over a period of four to eight weeks.

ENVIRONMENTAL FACTORS

The environmental factors which affect the growth of indoor plants are Light, Temperature, Humidity, Ventilation, Water and Fertilization. Any one of these factors in incorrect proportions will prevent proper plant growth indoors.

LIGHT

It is the most essential factor for indoor plant growth.The growth of plants and the length of time they remain active depend on the amount of light they receive.Light is the ultimate source of energy requirement for growth of plants in indoor. Light influences synthesis of

chlorophyll and anthocyanins, opening of stomata, rate of plant growth, leaf size, flower and seed production, maintenance of leaf temperature and determination of plant morphology.
Three aspects of light to consider areIntensity, Duration and Quality.The intensity of light controls the length of internode and variegation of leaves.

CLASSIFICATION OF PLANTSSUITABLE FOR INDOOR GARDENING BASED ON THEIR REQUIREMENT OF LIGHT.

Plants with low light intensity requirement (0.5-0.8 Klx / 500 – 800 lux)

- *Aspidistra*
- *Aglaonema*
- *Fatshedera*
- *Fittonia*
- *Maranta*
- *Nephrolepis*
- *Sansevieria*

Plants with medium light intensity requirement (0.8-1.6 Klx / 800 – 1600 lux)

- *Asparagus*
- *Anthurium andreanum*
- *Adiantum*
- *Calathea*
- *Chlorophytum*
- *Draceana*
- *Dieffenbachia*
- *Ficuselastica*
- *Monstera*
- *Pilea*
- *Peperomia*
- *Sansevieria*
- *Scindapsus*

Plants with high light intensity requirement (1.6– 3.2 Klx / 1600 – 3200 lux)

- *Ananas*
- *Bilbergia*
- *Cryptanthes*
- *Coleus*
- *Codiaeum*
- *Hoya carnosa*
- *Hedera*
- *Pedilanthes*
- *Yucca*

INDOOR LIGHT INTENSITY

Indoor light intensity variesaccording to the location/ distance from source, time of the day, latitude and time of year.Using the light readings, home can be divided into four areas, which have the following light levels for 8 hours per day:

1. Low-light areas : 25 ft-c–75 ft-c (270- 800 lux)
2. Medium-light areas: 75 ft-c–200 ft-c (800- 2000 lux)
3. High-light areas:>200 ft-c but not direct sunlight (> 2000 lux)
4. Sunny light areas: at least 4 hours of direct sunlight

LIGHT CONDITIONS

A southern exposure typically provides the greatest light intensity, than western, eastern and northern. Symptoms of insufficient light intensity includeweak growth, long spindly stems, poor color in older leaves and leaf loss or failure to flower.

PHOTOPERIODIC RESPONSE (DURATION)

Duration refers to the length of light exposure. A daily exposure to light, preferably 8-16 hours, is needed for plant processes.Symptoms of insufficient duration of light are small leaves, spindly stems and older leaf drop.

Short-day plants - Poinsettia, Kalanchoe and Christmas cactus.

Long-day plants - Cineraria.

Day-neutral plants - African violet.

TEMPERATURE

Temperature affects productivity and plant growth and manipulates flowering and plant height. In generalfoliage plants requires a temperature of 21-26°C during day and 15-20°C during night whereas flowering plants requires a temperature of 21-26°C during day and 12-16°C during night.Most indoor plants tolerate normal temperature fluctuations. Lower night temperature induces physiological recovery from moisture loss, intensifies flower color and prolongs flower life. Excessively low or high temperatures may cause plant failures, stop growth, or cause spindly growth and foliage damage or drop.A cool temperature at night is actually more desirable for plant growth.

Two critical stimuli that induce flowering are day length and temperature.Short-day plants initiate flowers only when the day length is less than a species-specific critical number of hours.Long-day plants initiate flowers only when they day length exceeds a species-specific critical number of hours.Day-neutral plants initiate flowers independent of day length.

TEMPERATURE/DAY LENGTH

- Cool temperature/short-day – Christmas cacti, gardenia, kalanchoe, cattleya orchid
- Cool temperature/long-day – tuberous begonia, cineraria,
- Cool temperature/day-neutral – geranium, tulips, amaryllis, wax begonia,
- Warm temperature/short-day - poinsettia, mum, bougainvillea.
- Warm temperature/day-neutral – African violet, Spathiphyllum,impatiens, anthurium, phalaenopsis.

HUMIDITY
It is the percent of the moisture saturation of air.Most indoor plants grow best with relative humidity of over 50%. Humidity can be increased by using Humidifiers, Humidity trays orMisting.

CONTAINERS
A good indoor plant container should be large enough to provide room for soil and roots, should have sufficient head room for proper watering, should provide bottom drainage and should be attractive without competing with the plants it holds. Clay and ceramic, plastic and fiberglass, wood, aluminium, copper, brass or any other material can be used as containers.Porous clay pots with drainage holes are widely used by commercial indoor plant growers and are frequently left with the plant when it is purchased. Ornamental containers are nothing but an outer shell to cover a plain pot.Clay pots absorb and loose moisture through their walls. Although easily broken, clay pots provide excellent aeration for plant roots. Ceramic pots are usually glazed on the outside and sometimes on the inside.They are frequently designed without drainage. They are best used when a pot with drainage is used for the plant and placed in the ceramic pot for decoration. Plastic and fiberglass containers are usually quite light, easy to handle, relatively inexpensive and quite attractive in shape and color.Plastic pots are easy to sterilize or clean for reuse, and because they are not porous, they need less frequent watering. Drainage is most important part of any pot to be used for indoor plants. Fill the bottom of your pots with gravel or stones to help with drainage.

GROWING MEDIA FOR INDOOR PLANTS
The growing media used for indoor plants should meet the requirements likegood quality,highwater holding capacity,high nutrient holding capacity,good porosity for root aeration and drainage and neutral pH. Common media combinations used areCocopeat, Perlite, Sphagnum moss, Vermiculite, Vermicompost,Shredded bark and Leaf molds.

REPOTTING
Actively growing indoor plants need repotting from time to time-very rarely with some slower growing plants and more frequently with others. Foliage plants require repotting when their roots have filled the pot and are growing out the bottom.When repotting becomes necessary, it should be done without delay. Potting media should be moistened before repotting begins. To remove most plants from their pots, hold your hand over the soil, with the plant between the index and middle fingers and knock the lip of the container against a solid object. Pot selected for repotting should be no more than 2 inches larger in diameter than the pot the plant is currently growing in. After placing the plant in the new pot, fill void space with more media and water to settle.

WATERING
Overand underwatering account for a large percentage of plant losses. Indoor plant roots are usually in the bottom two-thirds of the pot, so don’t water until the bottom two-thirds starts to dry out slightly.Best way to know this is physically monitor soil moisture content with finger. Water the pot until water runs out of the bottom.This serves two purposes. It washes out excess fertilizer residues (salts).It guarantees that the bottom two-thirds of pot receives sufficient water.

FERTILIZING

Fertilizingincreases the growth of stunted pants, provides darker green color, increases flowering and increases insect and disease resistance.Some plants can be fertilized every two weeks, while others will go well for several months without needing any supplement.As a general rule, use a recommended fertilizer every two week.Fertilizer should not be put on the soil without being mixed with water.Nitrogen is responsible for green and lush growth. Phosphorous is responsible for strong roots and flowering. Potassium is responsible for bright colours, strong stems and disease resistance.

PINCHING

To keep a plant, compact but bushy, frequent pinching is required. This involves the removal of 1 inch or less of new stem and leaf growth. Pinching back to just above a node, makes the plant more attractive and stimulates new growth.

PRUNING

Pruning includes removing more than terminal shoot tips.Sometimes an entire branch or section of a plant should be removed for the sake of appearance or plant health.

DISBUDDING

Certain flower buds are removed to obtain larger blooms from a few choice buds or to prevent flowering in a very young plant or recently rooted cutting that should not bear physical drain of flowering early.

TRAINING ON TRELLISES

Indoor plants like Ivies,Philodendron and Syngoniumare grown in a formal pattern on trellises.

CLEANING

Cleaning is important to keep the plant clean and neat. It improves them aesthetically and helps reduce the incidence of insects and diseases.

CONCLUSION

Filtration systems and air purifiers do not lessen intensities of indoor air pollutants; in fact, worsens the problem.More benign addition to air filtration isthe use of different indoor ornamentals plants. Indoor ornamental plants can remove toxicants and volatile organic compounds from air. If the building construction is not designed to maintain indoor–outdoor air exchange, consequence is amplified concentrations of indoor air pollutants.Considering the present scenario, there is a pressing need to promote indoor gardening. Hence, we shouldselect a proper strategy including ornamental plants for mitigating indoor air pollution. Steps should be initiated to explore the possibility of using of various species of indoor ornamental plants for controlling indoor air pollutants and thereby improve Indoor Air Quality and Indoor Environmental Quality.

ADVANCES IN CULTIVATION OF JASMINE FOR LOOSE FLOWER PRODUCTION

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INTRODUCTION

Taxonomic name *Jasminum* is a genus of shrubs and vines belonging to the family Oleaceae.The genus *Jasminum* containsmore than 200 species native to tropical and warm temperate regions of the Eurasia, Australasia and Oceania.Jasmines are widely cultivated for the characteristic fragrance of their flowers. It belongs to the Kingdom: Plantae, Order: Lamiales, Family: Oleaceae, Tribe: Jasmineae and Genus:*Jasminum*L. There are trailing, climbing, and erect growing species and cultivars in the genus *Jasminum*. Some selected species include*Jasminum humile* L. – Italian jasmine, Italian yellow jasmine; *Jasminum adenophyllum* Wall. – bluegrape jasmine, pinwheel jasmine, princess jasmine; *Jasminum mesnyi* Hance – Japanese jasmine, primrose jasmine, yellow jasmine; *Jasminum angustifolium* (L.) Willd.;*Jasminum auriculatum* Vahl – Indian jasmine, needle-flower jasmine and *Jasminum sambac* (L.) Aiton – Arabian jasmine, Sambac jasmine. Jasmines constitute a group of fragrant flowers which are commercially grown in many parts of the country as dry land crop and leading states in jasmine production are Tamil Nadu and Karnataka. Jasmine contributes substantially to the national economy and it is estimated that annually more than 20 crores worth of jasmine flowers are produced and sold in India and are also exported to neighbouring countries.

IMPORTANT SPECIES OF *JASMINUM*

Four important species of *Jasminum* widely cultivated in India are *Jasminum sambac*, *Jasminum grandiflorum*, *Jasminum auriculatum* and *Jasminum multiflorum.*They prefer mild tropical climate.

DISTRIBUTION OF SOME IMPORTANT JASMINE SPECIES

J. auriculatum	India
J. grandiflorum	Subtropical Himalayan Region
J. favreri	Myanmar
J. humile	Tropical Asia
J. flexile	India
J. multiflorum	India, China, Myanmar, Malaysia, U.S.A
J. officinale	Iran, India, China

USES OF JASMINE

Jasmine flowers are preferred for making special type of flower strings called veni, garlands, floral decorations, religious offering, extraction of essential oil which is used in preparing high grade perfumes, perfumed hair oils and attars, soap and cosmetic industry, colognes and flavouring the beverages etc. Jasmine is enjoyed in the garden, as a house plant. The flowers are worn by women in their hair in south India. The flowers of Arabian jasmine (*J. Sambac*) are reported to be used in China for flavouring tea. They also have medicinal uses which has growing demand in India as well as in many developed countries.

SOIL AND CLIMATE

Jasmine can be planted on a wide range of soils. Well-drained sandy loams and red loams under tropical conditions are suitable for its cultivation. In clayey soils, there is increased vegetative growth and reduced flowering.

LAND PREPARATION AND PLANTING

Land with proper drainage, irrigation facilities and sunny location are essential. 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.

PROPAGATION

Jasmines can be propagated by cuttings, layering, sucker, grafting, budding and tissueculture. Layering and cutting are the main propagation methods. Commercially *Jasminum auriculatum*is propagated bySemi hard wood cuttings,*Jasminum grandiflorum* byTerminal cuttings and*Jasminum sambac* byTerminal and semi hardwood cuttings. Better rooting of cuttings can be obtained by planting in coarse sand and also by using any of the rooting hormones like IBA (1000 ppm), IAA (1000 ppm) and NAA (1000 ppm) for terminal cuttings. 2500 ppm of rooting hormones are used for semi hard wood cuttings.

Simple and compound layering methods are followed during June-July to October-November. Layers will be ready for planting within 90-120 days.

PRUNING

NEED FOR PRUNING

In jasmine, flowering habit is terminal and axillary. So, increasing the number of shoots would increase the yield, for which pruning is essential. Pruning influences growth, flower bud initiation, differentiation and ultimately the flower production.Pruningis done to get the desired crop. Normally, irrigation is withheld prior to pr uning and plantsare pruned by removing all past season shoots including dead and diseased br anches. It is advisable to prune the plants during the last week of November to get increased y ield and quality flowers. Pruning is done at a height of 45-50 cm from the ground level.

ADVANCES IN CULTIVATION OF *JASMINUM SAMBAC*

Jasminum sambac is commonly known as Gundumalli / Malligai / Arabian jasmine /Tuscan jasmine / Mogra.

VARIETIES

- Gundumalli
- Motia
- Virupakshi
- Sujimalli
- Madanabanam
- Ramabanam
- Khoya
- Single Mogra

- Double Mogra
- Iruvatchi
- Ramanathapuram gundumalli
- Kasthurimalli
- Oosimalli etc.

SALIENT FEATURES OF SOME*JASMINUM SAMBAC* VARIETIES

RAMANATHAPURAM GUNDUMALLI

- Round flowers with good fragrance
- Yield : 7 to 8 t/ha.

KHOYA:

- Flowers familiar to *J.sambac*,
- But bolder buds with less fragrance.

LAND PREPARATION AND PLANTING

After ploughing the land, pits of about 30 x 30 x 30 cm size are taken and filled with topsoil and 20 kg well-rotten Farm yard manure per pit. Layers or rooted cuttings of *Jasminum sambac*are planted in pits with a spacing of 1.25 m X 1.25 m during June to November.

IRRIGATION

Irrigation should be given immediately after planting followed by weekly irrigation depending upon the weather conditions.

MANURING

FYM 10 kg and NPK at 60:120:120 g per plant is applied twice once after pruning and again during June - July.

PRUNING

*Jasminum sambac*bushes are pruned to 50 cm height from the ground level during last week of November.

WEED CONTROL

Manual weeding is effective but expensive. Use of weedicides like paraquat is also practised. Mulching also reduces weed population.

IRRIGATION

Constant and adequate water supply during peak flowering season is essential for high yield of flowers. After flowering is over, the water supply can be cut off. During summer, irrigate twice a week.

SEASON OF FLOWERING AND HARVEST

Flowering commences in March - April. Fully developed unopened flower buds should be picked in the morning hours.

YIELD

About 5t / ha can be obtained.

ADVANCES IN CULTIVATION OF *JASMINUM AURICULATUM*

Jasminum auriculatum is commonly known as *Mullai / Jui*

VARIETIES

- Co-1
- Co-2
- Long Point
- Long Round
- Medium Point
- Short Point
- Short Round
- Parimullai etc

SALIENT FEATURES OF SOME *JASMINUM AURICULATUM VARIETIES*

PARIMULLAI:

- Selection from a local type.
- Medium round bud.
- Resistant to gall mite.
- Yield : 8 t/ha
- Flowering duration-9 months/year.

Co-1:

- Selection from a Long Round type
- Flowers have long corolla tube
- Easy for harvesting and marketing
- Yield 8.8 t/ha.

Co-2:

- Induced mutant from a Long point type.
- Longer corolla tube
- Flowerbuds are bolder
- Fieldtolerant to phyllody
- Yield - 11.1 t/ha.

PROPAGATION AND PLANTING

Layers or rooted cuttings of *Jasminum auriculatum*are planted in 30 cm x 30 cm x 30 cm pits dug at 1.8 m x 1.8 m spacing during June to November.

MANURING

FYM 10 kg/ha is applied with 120:240:120 g NPK/plant in six split doses at bimonthly intervals. The first dose is given immediately after pruning.

PRUNING

The bushes are pruned to 45 cm height from ground level during the last week of January.

SEASON OF FLOWERING AND HARVEST

Flowering extends from May to November. Fully developed unopened flower buds should be picked in the morning hours.

YIELD
About 5,000 kg of flower buds/ha can be obtained.

ADVANCES IN CULTIVATION OF *JASMINUM GRANDIFLORUM*
Jasminum grandiflorum is commonly known as Jathimalli (or) Pitchi (or) Spanish jasmine (or) Jayi.

VARIETIES
- Co-1
- Co-2
- Thimmapuram
- Lucknow etc

SALIENT FEATURES OF SOME *JASMINUM GRANDIFLORUM*VARIETIES

Co-1:
- Clonal selection from germplasm.
- Suitable for both loose flower production and oil extraction.
- Pink streaks are found on external surface of petal.
- Average yield 10 t/ha.
- Concrete recovery is 0.29 per cent.

Co-2:
- Induced mutant from CO1 Pitchi.
- Bolder pink buds with long corolla tube
- Yield - 11.68 t/ha.

PROPAGATION AND PLANTING
Layers or rooted cuttings are planted at 2.0 m x 1.5 m spacing in 30 cm x 30 cm x 30 cm pits during June - November.

MANURING
FYM or compost 10 kg, NPK at 60, 120 and 120 g per plant is applied in 2 split doses in December after pruning and again in June - July.

PRUNING
Pruning is done during the last week of December to 45 cm height from ground level.

SEASON OF FLOWERING AND HARVEST
The season starts from May to October. Fully developed unopened flower buds are picked in the morning for fresh flower trade. For oil extraction opened flowers are to be picked before 10 a.m.

YIELD
The flower yield is 6 t/ha of flower buds

ADVANCES IN CULTIVATION OF*JASMINUM PUBESCENS. SYN. JASMINUM MULTIFLORUM*

*Jasminum multiflorum*is commonly known as Kakada / Kunda

PROPAGATION AND PLANTING

Rooted cuttings are planted at 1.2 m x 1.2 m spacingin 30 cm x 30 cm x 30 cm pitsduring June - November.

MANURING

FYM or compost 10 kg, NPK at 60, 120 and 120 g per plant is applied in 2 split doses inDecember after pruning and again in June - July.

PRUNING

Pruning is done during the January to 45 cm height from ground level.

SEASON OF FLOWERING AND HARVEST

The season starts from November to December.Fully developed unopened flower buds are picked in the morning for fresh flower trade.

YIELD

The flower yield is 3-4 t/ha of flower buds

PLANT PROTECTION IN JASMINE

PESTS

BUD WORM (*HENDECASIS DUPLIFASCIALLIS*):

Infested flowers turn pale red in colour and fall off from the plant. Collect and destroy infested flowers along with larvae at least once in a week. Set up light trap to attract and kill the adult moths. Spray Monocrotophos 2ml/l for the control of the pest.

GALLERY WORM(*ELASMOPALPUS JASMINOPHAGUS):*

Caterpillar web together the terminal leaves, shoots and flower heads and feed on them. Faecal matter can be seen attached to the silken web. Management is same as given for jasmine bud worm

LEAF WEBWORM (*NAUSINOE GEOMETRALIS):*

Spray dimethoate 30 EC 500 ml in 500 – 750 L of water/ha for the control of the pest.

BLOSSOM MIDGE

Spray Monocrotophos 2 ml/lit or Quinalphos 2 ml/lit to control it.

RED SPIDER MITE (*STENEOTARSONEMUS PALLIDUS*):

Spray Wettable Sulphur 50 WP @ 2 g/lit or Dicofol 2.5 ml/lit to control the mite infestation.

JASMINE ERIOPHYID MITE (*ACERIA JASMINI)*

Spray dicofol 18.5 EC 3ml/l or wettable sulphur 50WP 5g/lit.

LEAF EATING CATERPILLAR
Leaf eating caterpillar can be controlled by spraying Quinalphos 2 ml/lit.

WHITE ANTS
To control, dust Lindane to the pits before planting @ 5 g/pit

DISEASES

LEAF BLIGHT
It is caused by a fungi*viz., Cercospora jasminicola.* Circular to irregular reddish-brown spots appear on the upper surface of leaves. Spray of Bavistin (0.1%), Mancozeb 0.25% are equally effective.

ALTERNARIA LEAF SPOT AND BLIGHT:
It is caused by *Alternaria jasmini* or *A. alternata.* Collect and remove fallen leaves. Spray with Copper oxychloride or Mancozeb at 2 g/lit

YELLOWING OF LEAVES
It is caused by 3 factors viz., iron deficiency, nematode infection and root rot disease.

IRON DEFICIENCY
It can be rectified by spraying Ferrous sulphate 5 g/lit at monthly intervals until the chlorotic symptoms disappear.

NEMATODE
Initially test the soil for nematode infection. Apply 10 g of Temik granules near root zone and then irrigate the field.

ROOT ROT
Drench the soil around the plant with Copper oxychloride at 2.5 g/lit.

LEAF SPOT
Spraying of Mancozeb at 2 g/lit. from the onset of monsoon at monthly intervals will control the disease occurrence.

POST-HARVEST TECHNOLOGY FOR JASMINE

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
Harvested flowers should be given cold treatment before packing. Packing should be functional, economical and attractive besides being acceptable in markets. Corrugated cardboard boxes are good for distant market. Wholesalers pack flowers in bamboo baskets. They are packed so as to maintain some moisture and air circulation in the baskets. Water is sprinkled on the newspapers covering the inside of the basket. The top is covered with paper again and closed with a bamboo basket cover or gunny sack which is stitched at the edges.

MARKETING, DISTRIBUTION AND TRANSPORTATION

Transporting of jasmine flower is done through trucks, ships (Refrigerated) etc. Before long distance transportation it is better to keep flowers in bamboo basket which should be covered under moist muslin cloth. Proper care should be taken so that flowers are not handled badly or damaged during transportation.

EXPORT PACKAGING TECHNOLOGY FOR JASMINE (SOURCE: TNAU, COIMBATORE)

Major mode of transport of Jasmine flowers for export is by air. Jasmine flowers reach the Dubai and Singapore markets within 24 hours after harvesting, while it takes around 36 – 48 hours to reach the New York market. High levels of post-harvest losses (35 to 40%) was reported during transit. Since jasmine flowers are very delicate, they show signs of wilting with an abrupt loss of fragrance within 24 -36 hours after harvesting. One of the major problems faced by the exporters is lack of a proper packaging technology for export. Whenever there is delay in sending the flowers due to flight cancellations, the exporters face heavy losses, because the jasmine flowers cannot be preserved beyond a day. Since the jasmine flowers retain their freshness only for a day in ordinary packaging, any packaging technology that would extend the post-harvest life of flowers for even few hours would definitely benefit the exporters.

An export packaging technology has been standardized for jasmine flowers by TNAU under the ICAR-NAIP sponsored project 'Value Chain on Flowers for Domestic and Export Markets', in collaboration with a successful flower exporter, M/S. Vanguard Exports.

EXPORT PACKAGING TECHNOLOGY FOR JASMINE FOR DUBAI MARKET

The jasmine flowers were collected from the auction centers and then loose flowers are made into strings with different shape and size based on the requirement of the buyer and these jasmine strings are treated with floral preservatives (Boric acid @ 4%) to preserve the freshness of the flower and improve the shelf life of jasmine strings. The treated jasmine strings are packed in ventilated corrugated fibre board (CFB) boxes with butter paper lining and the ventilation is made by making holes in the corrugated fiber boxes. After proper packaging the boxes are airlifted to respective destination.

EXPORT PACKAGING TECHNOLOGYFOR JASMINE FOR USA MARKET:

Jasmine flowers were collected from auction centers and loose flowers are made into strings and related products. Stringed flowers of jasmine are treated with 4% boric acid and packed in aluminum foil lined light weight cardboard boxes.These boxes in turn are packaged in large thermocole boxes with intermittent ice gel packs to maintain the temperature and humidity inside the box. These thermocole boxes are transported in refrigerated vans to airport and then it is dispatched to the respective destination.

IMPACT OF THE ADVANCED PACKAGING TECHNOLOGY

- Shelf life of jasmine flowers increased to 72 hours against 36 hours in normal packaging system.
- Post-harvest losses in jasmine were reduced from 40% to 10%
- The export volume increased to 1000 kg/ day from 500 kg/day

EXTRACTION OF JASMINE CONCRETE

Jasmine concrete obtained from *Jasminum grandiflorum* is a wax like substance containing the natural flower perfume together with some plant waxes, albumin and colouring matter.

Solvent extraction method is practiced in which the principle is that the odoriferous substances of the flower are allowed to be absorbed by a highly volatile solvent and then the solvent is evaporated leaving the odoriferous principles.

STEP I –

- Solvent treatment: Flowers are soaked in Food Grade Hexane.
- Mixing Hexane 2 litres / kg of flowers for 30 minutes.
- Rotate the container slowly for 20 minutes in the rotary type of extractor.
- Perfume substance along with wax and pigments dissolved in Hexane

STEP II –

- Evaporation: Perfume laden solvent is led into the evaporator
- Evaporation at a constant temperature of $75^{o}C$.
- Vapour of the solvent condensed into liquid for recycling
- 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

1 tonne flowers yield 1.5 – 2 kg absolute

SEED PRODUCTION OF ANNUAL FLOWERS

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INTRODUCTION

In commercial floriculture, flower seed productionis considered as a profitable enterprise and is having immense potential for entrepreneurship development. Flowers are being grown due to their aesthetic value since long and of late their seed production at commercial level has gained momentum. The seasonal flowers are indispensible as their use in beautification of gardens and large quantity of annual flower's seed is required globally. As seed pods of most of the annuals are picked manually, this adds to the cost of production in developed countries. Since labour is comparatively cheaper in India, thus foreign seed companies have been opting contractual seed production in Punjab, Haryana, Andhra Pradesh, Uttar Pradesh, Maharashtra and Karnataka for the last two decades.

The sub-tropical climatic conditions of India are highly favourable for seed production of flowering annuals. Flowering annuals are usually grown for landscaping and commercially for seed production under Northern Indian climatic conditions. These annuals are grown as *rabi*season crop under north - western plains of India which flowers in March -April and set seed in April-May. The estimated export of flower seed from the Punjab state to U.S.A, Holland, Germany, U.K. is more than Rs. 6-7 crores per annum from an area of around 2000 acres.

PRODUCTION TECHNOLOGY

The production technology in terms of method of seed sowing, transplanting, pollination behaviour, seed collection of flowering annuals is being discussed as under:

PLANTING TIME AND PLANTING METHOD

i. Early planting: Seeds are sown in nursery bed in the first week of October and transplanting of seedlings is carried out from last week of October to first week of November, for example delphinium, helichrysum, ice plant, nemesia, pansy, petunia, poppy, stock and sweet alyssum etc. The seeds of flowers like linum, nasturtium, poppy and sweet peas and are directly sown during this time.

ii. Mid planting: Seeds are sown in nursery bed in the second week of October and transplanting is done from second to third week of November, such as Coreopsis lanceolata, gazania, phlox, sweet sultan, sweet william and verbena.

iii. Late planting: The nursery is sown in second to third week of October and seedlings are transplanted in first fortnight of December like Coreopsis tinctoria, Gaillardia aristata, Gaillardia pulchella and Monarda citriodora are sown during this period.

DIRECT SEED SOWING

In direct sowing, bold seeded crops like calendula, dimorphotheca, linum, nasturtium and sweet peas are sown directly in the field. The seed of flowers having small seeds like alyssum, Escholtzia californica, ice plant and Papaver sps., is mixed with sand or other bulky material and then sown in the field at required distance.

NURSERY TRANSPLANTING

The annuals such as coreopsis, gaillardia, gamolepis, gazania, helichrysum, nemesia, pansy, petunia, sweet sultan, sweet William and verbena, etc. are transplanted at four leaf stage. The transplanting is generally carried out from October to November for bedding purpose, however for seed production appropriate time of planting is crucial as it affects the seed yield. It has been observed that species such as delphinium, helichrysum, ice plant, nemesia, pansy, petunia, poppy, stock and sweet alyssum produce higher seed yield when transplanted during last week of October to first week of November as compared to late planting.

POLLINATION BEHAVIOUR

For successful seed production, the pollination behaviour of the species is important. On this basis, the flowers are classified as self pollinated (balsam, clianthus, lupin, and sweet peas), often cross pollinated (antirrhinum, aster, linaria, linum, salvia) and cross pollinated (calendula, Coreopsis lanceolata, Coreopsis tinctoria, corn flower, delphinium, gaillardia, helichrysum, sweet alyssum, verbena). The self pollinated crops do not require any isolation distance, often cross pollinated crops have 5-10% chance of seed set due to cross pollination hence requires at least 100 meter isolation distance. In case of cross pollinated crops the flower anthers and stigmas are exposed for out crossing through insects, air, etc which require 500 meter to 1000 meter isolation distance for maintaining the seed purity of a crop species.

SPECIAL FEATURES AND CHALLENGES OF THE FLOWER SEED INDUSTRY

The flower seed trade developed from small-scale sales of selected varieties by speciality nurseries two centuries ago to a highly technical, vibrant segment of the seed industry today. There are a number of unique characters that set the flower seed trade apart from its crop and vegetable seed counterparts:

PRODUCT RANGE

There are hundreds of species commonly used as flowers, compared with only a few major food staples and tens of vegetables. Existing flower seeds come from a broad botanical taxonomic base, and new crops are being introduced every year. Most of the popular flowers are annuals, but there are also many biennials and perennials. They are commonly used as bedding plants, pot plants and cut flowers. Some flowers are edible and are often used in regional gourmet cuisines or as garnishes in salads. This very broad product range demands a very broad knowledge base for those involved in the industry.

CONTINUED QUEST FOR NEW PRODUCTS

New flowers are selected mainly for their ornamental value rather than crop yield, which is the primary selection factor in food crops. Being a qualitative trait, ornamental value is largely subjective and depends greatly on cultural changes in society. Novelty captures the attention of the consumers and there is a continual need for a different look, a newer colour. Flower breeders have to keep abreast of significant cultural changes in society and the successful ones are trendsetters, much like designers in the fashion industries. Identifying exotic plant materials from foreign countries and adapting them to local seed companies must ensure that seeds of the desirable varieties are available at the required time. They also need to develop cultural guidelines for optimal crop performance and provide information on how to induce flowering at the desired period. This information is particularly key to the successful introduction of new crops.

HIGH SEED GERMINATION REQUIREMENT

For the flower seed industry, the single most important development in greenhouse production is the emergence of 'plug' growers. These are growers who specialize in the production of young plants that are then sold to 'finishers' who bring the young plants to flower for the market. Standardized sized trays containing different numbers of individual cells ('plugs'), each planted with one seed, are used for young plant production. The plug growers sell these trays to finishers with a guaranteed minimum plant count. The finishers then transplant the young plants into larger containers by hand or, more commonly, by computer driven automatic transplanting machines.To optimize production efficiency, growers demand that each seed must germinate and produce a seedling, otherwise valuable greenhouse space and nutrients are wasted. Transplanting labour is a major cost in production.Fortunately, these increased prices also allow the industry to practise seed enhancement technologies not commonly encountered in other crops. For example, many flower seeds are routinely primed for improved performance or pelleted to either permit greater ease of handling or increase precision planting using mechanical seeders. Each of these techniques must be researched for optimum performance according to crop, which requires specific equipment, expertise and knowledge.

SEED PRODUCTION OF IMPORTANT WINTER ANNUALS

Antirrhinum majus: This is winter season annual bearing yellow, red, pink, magenta, scarlet, cream and white flowers in March April. For seed production tall (4-5feet) as well as medium (2-3 feet) varieties are preferred. The mature branches are harvest from April to mid May, but at the time pod formation the crap is attacked heliothis. So regular spray schedule Nuvacron @2.5mle at 10 day inter should be followed to obtain higher seed yield. The seed yield ranges between 100 kg/acre

***Bellis perennis*:** This is a dwarf and beautiful flower grown mainly for landscaping purpose. But now-a-days semi double and single forms are being grown for seed production. The seedlings should be transplanted in the first week of November at 30*30 cm for obtaining higher yield. Plants growing vegetative till January and produce flowers from February till mid April. The seed setting starts after 6-7 days of flower opening, and seeds are enclosed in small pods which are picked along with short stalk whey they turn their colour to light greenish brown. These pods are then kept in a shady place for 3-4 days for seed shattering which is then cleaned by sieving and winnowing. The yield of single varieties is around 50 kg/acre and 20-25 kg/acre in semi double varieties.

Calendula officinalis:It is orange and yellow colored winter season flower generally grown for landscaping and these days for seed production also. The plants have along blooming period from December till April with peak in March. The seeds are arranged in central disc, which are manually collected during March-April at one-week interval. The seed yield of open pollinated varieties is around 160-170 kg/acre.

Chrysanthemum multicaul: This is yellow coloured dwarf annual with profuse flowering, hence suitable for landscaping as well apart from seed production. The seedlings are transplanted in first week of November at a spacing of 30x30 cm. The plants come in bloom earlier in second week of January. The seed is picked manually after one week and the seed yield is around 40-45 kg/acre

Coreopsis lanceolata: This is one of the important flower grown for seed production. This is a tall annual transplanted by mid November for obtaining higher seed yield. The plants come in bloom during end April and remain in bloom till end May. For seed picking the seed pods are collected manually in May and by end May the seed is collected from the field with broom and is cleaned by winnowing and sieving. The yield of this crop is between 225-250 kg/acre.

Coreopsis tinctoria: This is again a tall flowering annual with long crop duration. The plants attain a height of 1.5 meter at flowering. The flowers are in bunches bome on the top of branches. The flowering is at peak in April to May. For seed picking the flowering branches are harvested with sickle when the flower petals start drying and fading in June. The yield of clean seed is around 250-275 kg/acre.

Delphinium ajacus: It is cream, mauve, purple and dark pink coloured winter annul grown for cut flower or as background in herbaceous border. For seed production the seeds are directly sown in well prepared raised (15-20 cm) beds at 30x30 cm. The flowers are arranged vertically on long stems, which later on produce small legumes enclosing seeds. The crop is in full after mid March till mid April. Flowering branches are harvested manually when the pods show signs of drying and slight splitting. The yield of crop varies 30-40 kg/acre depending on the health of crop and prevailing temperature.

Dianthus barbatus: This is erect stature plant with clusters of pink to maroon colored flower, which are also suitable for flower arrangement. For seed production transplanting is done in the first fortnight of November and flowering commences in March. The yield of clean seed is around 120-130 kg/acre when planted. The seed is cleaned by winnowing and sieving.

Dimorphotheca aurantiaca: Dimorphotheca is an erect plant, medium in height and bears white flowers with purple centre that is generally preferred for landscaping. The flowering commences from March to April and the seed picking starts in April. The seed is bold which is easily cleaned and yield is around 120-125 kg/acre.

Gamolepis elegans: This is yellow coloured dwarf annual mainly grown for edging and bedding effect in landscaping. The flowering is at peak after mid March but flowering span is very short up to 15-20 days only. The flowering branches are harvested with sickle in a single lot after the seed -pods turn brown and thereafter reshuffled in shady place for seed collection. Early planting by first week of November results in higher seed yield. The seed yield is between 120-130 kg/ acre.

Gazania splendens: TheOptimum time of transplanting for a seed crop is up to rnid November as delay in transplanting decrease the seed yield. The plants produce flowers from end February to mid May. The seed collection starts in April which is done manually during the first three-four pickings, later on after peak flowering the seed is collected with broom and is cleaned by winnowing and manual picking of inert matter (flower stalks). The yield of clean seed is around 250 kg/acre.

Helichrysum bracteatum: The seedlings are transplanted by mid November, the tall and dwarf varieties are available in this crop. This flower has a longer flowering duration from March till mid May. Helichrysum belongs to the family of sunflower but flower size is comparatively small and petals are papery and shining. Seeds are enclosed in central disc and collected on maturity when flower colour fades and get dry in April-May. The yield of this crop ranges between 6/80-90 kg/acre

Iberis amara**:** This is a winter season annual bearing white flowers and is commonly used for landscaping. The plants came in bloom after three months of planting in March with flowering duration of 40-50 days. For seed collection the whole plant mature uniformly so single harvesting is followed when the pods turn brown and the plants are dried up. The seed yield under flat and raised bed was recorded between 125 kg/acre, therefore it can be transplanted in flat in sandy. Loam soils and in raised beds in clay-textured soils.

Mesembryanthemum criniflorum: This is a dwarf plant bears pink, magenta, purple, white, cream and peach flowers in March. The plant grows vegetative till January and attains full spread by that time; Raised bed planting of this crop resulted in higher seed yield i.e, 150 kg/acre due to wider plant spread and more branches as compared with flat planting where flood irrigation results in poor growth and high mortality due to water stagnation. The seed yield in this crop depends on plant population in the field and prevailing temperature during flowering and seed collection

Petunia hybrida: Petunia is one of the commonly grown flowers. The right time for transplanting is from end October to first week of November. This crop comes in bloom during March and has long flowering duration till June depending on the species. The seedpods are hand picked when they turn brown in colour. The pods are reshuffled everyday for seed shattering and seed is then cleaned by sieving. The yield is around 70-80 kg/acre depending on the varieties.

Tropaeolum majus: This is a winter season annual bearing yellow, orange to scarlet coloured flowers. This is highly preferred for seed production because of bold size of seed and easy seed collection and cleaning. The seeds are directly sown in beds at 30x 30cm by mid November and plants come in blooni after mid March. The flowering is at peak from end March to mid April. The seed after ripening fall below the plants, which are collected with broom before irrigating the field. The yield of clean seed is around 250 kg\acre.

Verbena hybrida: This is a beautiful annual bearing pink, red, maroon, magenta, white, cream and peach coloured flowers in March to mid May. Transplanting in early November results in vigorous plants and higher seed yield. Raised bed planting of verbena recorded a significant variation in branch production and seed yield as compared with the planting in flat beds. The flowers are in bunches and for seed picking the flowering branches are harvested with sickle and seed is extracted after 4-5 days. The seed yield varies between 100-115kg/acre from a good crop.

Viola coernuta: It is an open pollinated species and transplanted by end November. Flowering is at peak in March and seed pods get mature by end March when their colour turns yellowish green but before splitting of pods. The flower and pod size is small, hence adds to the cost of production. Therefore seed collection at right stage is absolutely necessary for getting good returns. The average seed yield is 70-80 kg/acre

SEED COLLECTION AND CLEANING

Method of seed collection varies from crop to crop depending on the flowering behaviour as well as the maturity of crop. The mature pods with pale yellow to brown colour are picked individually or harvested in mass accordingly. In longer duration crops like coreopsis, gaillardia, helichrysum the pods are picked in initial 3-4 pickings followed by mass collection during end of April to mid May. Over-ripening may result in lower seed yield and immature pod collection will degrade the quality and therefore stacked lot must be reshuffled daily or alternate day, otherwise that will result in decay. The pods of calendula, *Coreopsis lanceolata*,gaillardia,helichrysum, pansy,petunia and poppy should be kept under shady and well-ventilated place and reshuffled every day. The seed shattered from the pods is then cleaned by sieving and winnowing. Similarly the flowering branches of alyssum, antirrhinum,gamolepis and marigold should be picked up at regular interval and dried in shade. However in crops like, candytuft, *Coreopsis tinctoria*,ice plant, nasturtium, and phlox only single harvesting with sickle is done when flowers start fading and petals droop down. The seed then collected is winnowed and sieved with different sieves according to the size of seed and inert matter.

SEED PRIMING, PELLETING AND COATING

With the mechanisation of young plant (plug) production, the importance of easy sowing and predictable, synchronized seedling emergence has grown. Unfortunately, seed do not always perform in ways that enable successful young plant production under automated conditions. The shape of seeds can be such that sowing is not easy, fungi can attack the germinating seed or emerging seedlings or germination can be too slow, irregular or too low. For ease in sowing and synchronized seedling emergence for plug production, following treatments/methods have been developed.

1. Priming – to improve speed and uniformity of germination.
2. Pre-germination –to obtain close to 100% usable plants.
3. Pelleting – to improve germinability of seeds.
4. Coating- to fight fungi during and shortly after germination.

CONCLUSION

The returns from seed crop of flowering annuals vary from crop to crop. The net profit comes out to be between 20,000/ to 30,000/-per acre depending on the crop species, seed yield and crop handling operations. Since the seed production has been undertaken by the growers entirely on contractual basis, the rates vary on yearly basis of the companies outsourcing this activity.

Protected Cultivation of Rose

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Approximately eight billion rose stems, 80 million potted rose plants and 220 million garden rose plants are sold annually world over.About 31% of all cut flowers traded at theEuropean auctions were cut-roses with a total value of about858 million EUR (Heinrichs, 2008). In India, 4330 hectare area, producing 874 million stems valued at Rs.44.00 crores, is under rose cultivation in the states of Delhi, Tamil Nadu, Karnataka, Maharashtra and West Bengal (www.nabard.org).

POLY HOUSE VARIETIES

Long stemmed varieties : Aalsmeer Gold, Bianca, Black Magic, Dallas, First Red, Grand Gala, Grand Prix, Jacaranda, Konfetti, Noblesse, Ravel, Red Velvet, Skyline, Tineke, Virginia, Vivaldi

Medium stemmed varieties: Europa, Flirt, Frisco, Golden Times, Kardinal, Kiss, Lambada, Ohio, Prophyta, Souvenir, Tina, Vanilla.

PROPAGATION

Rose can be propagated by seed and vegetative methods like cutting, layering grafting and budding. Seed propagation is followed for breeding new varieties.

BUDDING

Roses are commercially propagated by T budding or shield budding. The ideal time for budding in North India is from January to March. In case of areas with mild climate, it can be done throughout the year.

STENTING

Stenting is a quick method of propagation of roses based on grafting a selected cultivar on an unrooted cutting of a root stock resulting in a complete plant in 3-4 weeks. The stented plant is called a stentling. The technique used is whip grafting. A piece of stem with a five leaflet leaf and a single dominant axillary bud is used as a scion. A piece of stem consisting of a single internode without buds or leaves is used as root stock. Scion and stock are held together with the helpof a peg. The basal end of a rootstock is dipped in talc with IBA at 0.4%. The rooting medium is a mixture of peat and perlite in 1:1 ratio. The relative humidity is maintained at 100% with intermittent misting. The ideal temperature is 25^0C.

ROOT STOCKS

For budding and grafting the rootstocks are very important. Climate, compatibility, soil, pests and diseases and utility play an important role in the selection of root stocks.*Rosa indica var. ororata* is recommended for Northern plains. This can with stand dry, wet conditions and salinity. This is also tolerant to powdery mildew and insect pests.*Rosa bourboniana* is widely used in North India for producing standard roses as it throws vigorous and strong shoots. It has not gained prominence because of susceptibility to powdery mildew.*Rosa multiflora*is widely used as root stock in South and Eastern India and hills. It is resistant to nematodes.*Rosa canina* is commonly used as root stock in Europe. This is propagated by seed and is resistant to drought and alkaline conditions. *R. manetti*, Dr. Huey, *R. laxa* and

Natal briar are also used as roots tocks in other countries. Natal Briar is gaining prominence as a rootstock for green house roses.

CLIMATE

Rose production is favoured by an extended growing season with a majority of sunny days. Roses in gardens should have sunshine for a minimum of six hours and prefer morning sunlight. Temperature has a significant effect on quality aspects such as stem length, bud and leaf size and stem diameter. The ideal temperature for rose cultivation is 15-27^{0}C. Best commercial quality is obtained when the night temperature is round 16^{0}C. Optimal rose production occurs at a light of 12-15 mol/m^2/day. The ideal relative humidity is 60-65%.

SOIL

Roses prefer well drained soil with a pH near 7. Roses are also tolerant to pH below 7 as long as it is not below 5.5. Roses are not salt tolerant, so EC values should be less than 2.0dsm^{-1}. Soils of sandy loam are preferred for their rapid infiltration rates. Roses cannot stand water logging and are susceptible to leaf fall under such conditions.

PLANTING

In polyhouses, rose is planted on raised beds having one metre width, 30 cm height and length as per the structure. Roses are planted in double lines at 30 x 15-20 cm. The soil may be sterilized with formaldehyde and thoroughly mixed with FYM , phosphatic and potassic fertilizers. Farm yard manure at the rate of 100 t/ha should be thoroughly incorporated in the soil.

IRRIGATION

Drought stress leads to defoliation and sun burn of canes and may contribute to spider mite. However overwatering or poorly drained soils may lead to root disease or nutritional problems.Generally, a rose plant requires water at 8-10 l/m^2 a day.

BENDING

Bending originated in Japan which allows harvesters to cut longer stems by cutting back to the knuckle rather than a 5 leaflet leaf. All weak shoots are bent down to fill any area void of foliage and thus attain a desirable leaf area index to optimize photosynthetic potential and facilitate the transport of sugar to the developing shoots. The shoots which arise on dormant buds following knuckle cuts are generally more vigorous and produce high quality and superior grade flowers. This vigour may be attributed to the fact that cane diameter is larger at knuckle and since weak shoots are bent, all remaining shoots are exposed to better light and less competition. Two practical benefits of the arching technique is that the annual cut back is eliminated and roses are grown at working level height. Bending is necessary for keeping enough leaves on the plant which are required for production of carbohydrates.

NUTRITION

A fertilizer dose of 520 kg N, 868 kg P_2O_5 and 694 kg K_2O/ha/year was recommended for high density planting (30x30 cm) of Super Star under open field conditions (Bhattacharjee and Damke, 1994). Potassium application rates affected the number and quality of flowering stems and reduced diseases. Potassium rates closer to 50 g/m2/year are recommended to obtain maximum quantity of commercial stems regardless of the cultivar (Barbosa et al., 2007). Heavy dose of organic manure like FYM at the rate of 50-100 t/ha is recommended in rose. Bhattacharjee (1994) observed that the soil application of sulphur at 10 kg/ha, magnesium sulphate at 50 kg/ha and calcium sulphate at 50kg/ha significantly improved flower yield and quality in cv. Raktagandha

WEEDING

Rajamani *et al.* (1992) recorded better control of monocot weeds with glyphosate 1.0 kg a.i/ha and dicot weeds with oxyfluorfen 0.5 kg a.i/ha.

HARVESTING

Roses should be harvested at the tight bud stage when one or two petals begin to unfold. The stage of harvest depends on the variety, distance to market place, climate and consumer preference. Roses cut too early may develop bent neck. Flowers should be cut in the morning or evening. They should be cut leaving two 5 leaflet leaves on the stem.

After cutting, they are immediately placed in a hydrating solution to maintain turgidity. After they are cut, they are cooled or graded. Roses are stored at 2-3^{0}C with a relative humidity of 90-95%. The flowers should be transported to cool rooms. Precooling removes the field heat and improves the post harvest life. The hydrating solution may be acidified with citric acid 300 ppm to improve the uptake of solution. The vase life can be improved by using floral preservatives in vase solution. Aluminum sulphate and citric acid @ 300 ppm improve the vase life. The flowers can be wet stored at 2-3^{0}C. After cooling the flowers are shifted to grading room. All the inferior stems and those infested with pests and diseases are removed. The flowers are sorted to different grades manually or automatic graders. Long stemmed varieties are graded from 40 cm onwards with a difference of 10 cm. The short stemmed varieties are graded from 40-65 cm with a difference of 5 cm.

PACKING AND TRANSPORT

The graded stems are made into bundles of 20 each. The buds are wrapped with corrugated paper. The leaves are removed from lower 5 cm portion of the stems. The bunches are packed in fiberboard boxes. The stems should be tightly packed to avoid movement during transport.

COMMERCIAL GERBERA CULTIVATION

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INTRODUCTION

Gerbera (*Gerbera jamesonii*) is an important commercial flower crop grown throughout the world in a wide range of climatic conditions. It is ideal for beds, borders, pots and rock gardens. The flowers come in a wide range of colors and lend themselves beautifully to different floral arrangements. The cut blooms when placed in water remain fresh for a reasonable amount of time.

Gerbera belongs to the family Asteraceae**.** Plants are stem less and tender perennial herbs, leaves radical, petiolate, lanceolate, deeply lobed, sometimes leathery, narrow at the base and wider at the top and are arranged in a rosette pattern.

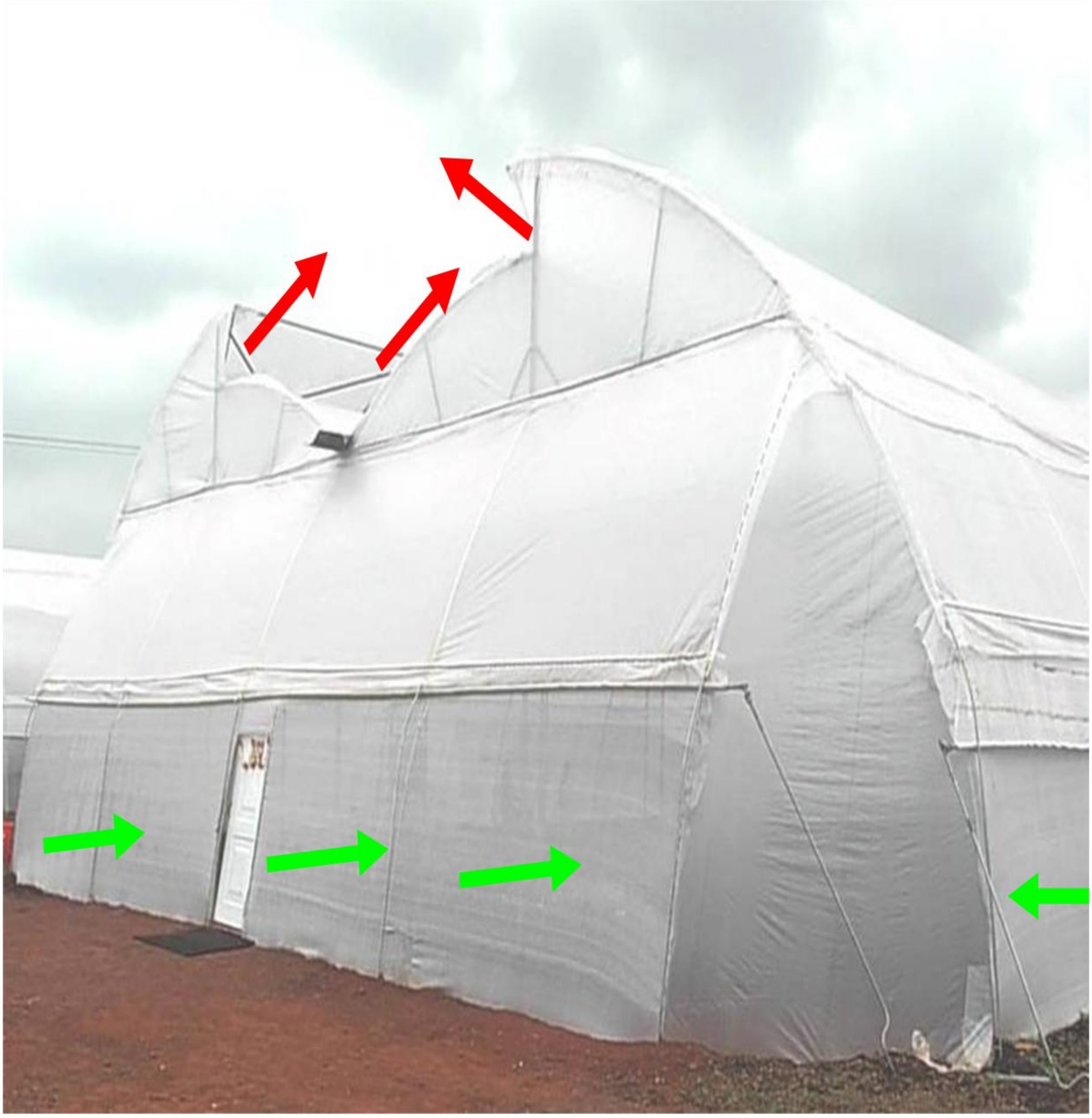
The daisy-like flowers grow in a wide range of colours including yellow, orange, cream-white, pink, brick red, scarlet, maroon, terracotta and various other intermediate shades. The double cultivars sometimes have bicolour flowers, which are very attractive. The flower stalks are long, thin and leafless.

GREEN HOUSE FOR COMMERCIAL CULTIVATION:

Though Gerbera can adapt to a wide range of climatic conditions open cultivation is not possible for commercial production of quality cut flowers as it is very sensitive to high humidity. In India it is cultivated in naturally ventilated green houses.

SITE SELECTION

A land selected for green house erection should be leveled, it should not have wind breaks or multi storied structures present up to 30 meters and no high tension electricity wire up to 5 meters. The availability of good quality of water, electricity and good connectivity are the other important criteria for site selection.



GREEN HOUSE SPECIFICATION

As the crop is sensitive to high humidity, the green house structure should be erected in such a way that it will avoid building up high humidity inside the poly house and provide good ventilation. Hence, the height of the green house is kept 6 to 6.5 m. There should be a sufficient space on top and sides of the green house for air movement. Length of the green house is kept along the north-south direction to facilitate quick passing of air entering either from east or west. The distance between two adjoining poly houses should be minimum 4 m.

To avoid the shading effect of gutter on the plants, gutter direction should be north – south. The vent opening along the wind direction restricts the entry of latter through it.

To protect the plants from the rains, without affecting the air circulation**,** side curtains should be kept open in slanting position.A UV stabilized polythene film of 200 microns thickness is used for the gerbera poly house. To control light intensity and solar radiation, white shade net is used as a screen. The shading per centage may vary as per the locations receiving different light intensities.

Gerbera can tolerate minimum of $12^{O}C$ and the maximum of 35 ^{O}C temperatures. The optimum night and day temperature range for high production of best quality flowers is 12 to $18^{O}C$ and $20\text{-}27^{0}C$, respectively. The bud initiation stops if the temperature drops below $12^{O}C$. High temperatures above $35^{0}C$ causes bud abortion.

The plant should receive light intensity in the range of 35,000 to 40,000 lux. If the plants are exposed to conditions of high light intensity and more temperature inside the poly house it affects the nutrient uptake by the plants causing scorching of leaves, production of short stemmed flowers with faded colour whereas the insufficient light causes low photosynthetic activity and production of flowers with lanky, limply stems.

The optimum humidity inside the greenhouse should be 70 to 80 %. Very high humidity results into reduced rate of evaporative-transpiration creating high root pressure which may cause flower stalk breaking in some varieties. If the humidity is less desiccation of plant tissue may occur. It also causes neck bending and flowers with weak and hollow stems.
The climatic conditions inside the poly house can be corrected adjusting the green house operations.

The side curtains should be kept open throughout the day, early in the morning till the evening during summer and rainy seasons to facilitate maximum air circulation. When the weather is cloudy the top net is opened but in summer it is closed in the noon hours to cut off the excess light.

In cold weather conditions, side curtains are opened very late in the day and the top net also should be kept closed at night to increase temperature inside the poly house. White wash is applied to east, west and north sides of the green house to protect plants from bright light intensity during summer season.

The polythene at the top of the greenhouse should be cleaned with water every month. This is very important during the period of low light intensity.

SOIL

To be successful in Gerbera growing, soil analysis is a pre requisite. Soil pH should be in between 5.5 to 6.5 or it should be maintained at this level to get maximum efficiency in absorption of nutrients. The salinity level of soil should not be more than 1 mS cm^{-1}. The soil should be preferably red lateritic, highly porous and well drained to have better root growth and better penetration of roots. The roots of Gerbera go as deep as 50 to 70 cm. The optimum nutritional values of the soil for gerbera cultivation are as below.

Parameters	Values
pH	5.5-6.5
EC (mS cm^{-1})	< 1
Organic carbon (%)	0.75-0.90
$CaCO_3$ (%)	< 5
N (ppm)	175-200
P (ppm)	50-100
K (ppm)	250-500
Ca (ppm)	500-1500
Mg (ppm)	150-300
Na (ppm)	< 175
SO_4 (ppm)	10-50
Fe (ppm)	5-10
Mn (ppm)	5-10
Zn (ppm)	2-5
Cu (ppm)	1-5
B (ppm)	0.5-1.0
Mo (ppm)	0.5-1.0

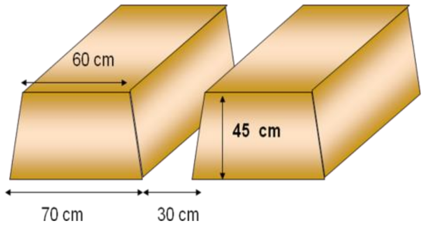
BED COMPOSITION AND PREPARATION

Gerbera cannot withstand water logging hence, raised beds are prepared to have better drainage. The bed media composition should be adequate in organic matter, highly porous, well drained and provide proper aeration to the root system. The proportion of media components is 55-60% soil, 10-15% sand and 30% well decomposed farm yard manure. Rice husk (@ 2.5-4 kg per sq. m) is also added to improve the drainage. If the original soil of the area is black cotton then gravels or murum (6" layer) can be added at the bottom for better drainage.

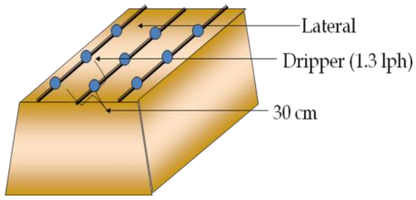
Different stages of bed preparation

All the media components are mixed thoroughly and the beds are made 30 cm apart with the height of 45 cm. Adopting more bed width may accommodate more number of plants per unit area. However, that may cause water stagnation at the centre of the bed. Hence, considering the economics as well as the crop health it should be 70 cm at the base and 60 cm at the top. The bed length can be adjusted as per the available space and the irrigation system. In general it should be less than 30 m to facilitate equal distribution of water.

At the time of bed preparation neem cake @ 1 kg per sq. m is added as prevention against nematode.



Bed Dimension



Drip irrigation lay out

GENERAL DISINFECTION OF BEDS

Before planting, disinfection of soil is absolutely necessary. In particular, the fungi *Phytophthora* and *Fusarium* are a menace to Gerbera. Various methods of sterilization are used out of which steam sterilization is not feasible for Indian conditions. Solar sterilization is the cheapest method of soil disinfection in which the soil is covered with plastic for 6 to 8 weeks in order to heat it up by the sunrays which kill most of the soil micro flora.

The chemical agents used for soil sterilization include methyl bromide @ 25 – 30 g per sq. m), Basamid (Dazomet) @ 30 – 40 g per sq. m. Formalin @ 7.5 to 10 litres per 100 sq. m is commonly used for the same. But the process is lengthy. However, the most easy, safe, fast, economical and very effective soil disinfectant is an oxidizing agent, hydrogen peroxide with silver of 50% strength (@ 7ml l^{-1} of water). The process is followed after bed preparation. In this method of soil sterilization, the beds are irrigated till field capacity level with water having neutral pH and EC less than 0.5 mS cm^{-1}. This is followed by sprinkling hydrogen peroxide with silver solution about 5 litres per sq. m. Plantation can be carried out 4 to 6 hours after the treatment.

BASAL FERTILIZER DOSE (AFTER BED PREPARATION)

The phosphorous and magnesium status of soil media at the time of planting is very important for better root growth and early establishment of plants. A basal fertilizer dose comprising 25 kg Single Super Phosphate, 5 kg Magnesium Sulphate per 100 sq. m. bed area is added in the upper 6” soil layer. The dose is recommended for a soil with medium phosphorous and magnesium levels. The dose should be adjusted as per the soil nutrient status of the particular area. After basal dose application, beds are irrigated to bring them to the field capacity level. Soil EC and pH should be checked before planting.

PLANTING:

Tissue cultured plants are preferred for planting. While planting Gerbera plants, the crown of the plant should be 1 to 2cm above soillevel. As the root system establishes; the plants are pulled down. Therefore, the crown must be above the ground level at planting and also throughout the life cycle.

Plant the saplings without disturbing the root ball. Generally, two rows should **Tissue cultured plant** beplanted on one bed at 37.5 cm distance between two rows and 30 cm distance between the plants in one row. The plant density is 6 per gross sq. m and 9 per net sq. m.

After plantation, humidity should be maintained at 80 to 90 per centfor 4 to 6 weeks to avoid desiccation of plants.

The soil surrounding the plant should be raked fortnightly for better aeration.



Gerbera planting **Three laterals per bed**

IRRIGATION

For Gerbera, water pH should be 6.5-7.0 with EC < 0.7 mS cm^{-1}, TDS <450 ppm and hardness <200 ppm. To lower the pH of water, acids can be added in the water tank.

Immediately after planting, plants are watered with overhead irrigation for three weeks without any fertilizers, so as to avoid increase in soil EC; to enable uniform root development. Thereafter, gradually shift to drip irrigation. Drip irrigation is mainly for correct doses of fertilizers.

As shown in the figure three laterals are laid, two on the sides and one at the centre of the bed between two rows of plants so as to irrigate the plant as well as to the moisture level maintained at the bed edges and sides wet. Irrigation to bed edges is equally important to minimize the evaporation losses and to maintain micro climate. This is very important in the summer season. If required, showers are ued for this purpose.

The water requirement of Gerbera plant is approximately 300 to 700 ml per plant per day depending upon the season. The plants should be irrigated before 12 noon. As a thumb rule, the soil should be moderately moist, however never having excessive water.

Always fresh water is used for irrigation *i.e.*the water should not be stored for more than 4 to 5 days.

In hot summer, foggers can be used to maintain the humidity inside the green house.

The water quality standards for gerbera-

Particulars	Values
pH	

EC (mS cm^{-1})	< 0.70
Alkalinity as $CaCO_3$ (ppm)	60-80
Sodium absorption ratio	< 10
Residual sodium carbonate	< 1.25
NO_3 (ppm)	< 5
H_2PO_4 (ppm)	< 5
K (ppm)	< 5
Ca (ppm)	40-120
Mg (ppm)	6-25
Na (ppm)	< 80
Cl (ppm)	< 80
SO_4 (ppm)	24-240
B (ppm)	< 0.5
F (ppm)	< 1
Fe (ppm)	< 5
Mn (ppm)	< 2
Zn (ppm)	< 5
Cu (ppm)	< 0.2
Mo (ppm)	< 0.02
HCO_3 (ppm)	< 90

FERTIGATION

Analysis of leaf blade considered more reliable for the determination of nutrient status. Good flower yield in gerbera is recorded when the leaves contained 2.7-3.13% N, 0.19-0.35%, P, 3.06-3.64% K, 1.66-2.18% Ca and 0.3-0.48% Mg. There are many recommendations on fertilizer application in Gerbera. Generally, fertigation should be started after three weeks of planting with N:P:K @ 1:1:1 (*e.g.*19:19:19) @ 0.4 g per plant every alternate day with EC 1.5 mS cm^{-1} for first three months during the vegetative phase to have better foliage. Once flowering commences the ratio should be changed to N:P:K 2:1:4 (*e.g.* N:P:K 15:8:35) @ 0.4 g per plant every alternate day with EC 1.5 mS cm^{-1} for higher production of the best quality flowers. Calcium nitrate is applied once or twice a week with the same EC. Magnesium and micro- nutrients are applied as per the need. Micronutrients (*e.g.* Fertilon

Combi II, Microsole B, Rexolin, Sequel and Mahabrexil are given @ 40 gm per 1000 lit of water daily or weekly based on the deficiency symptoms.

Selection of a fertilizer grade is very important. Fertilizers like ammonium sulphate, potassium sulphate, magnesium sulphate, mono ammonium phosphate and urea phosphates are recommended for the alkaline soils where as potassium nitrate, magnesium nitrate and mono potassium phosphate should be used to fulfill the demand of Gerbera crop grown in acidic soils.

Sufficient organic manures with EC less than 2 mS cm^{-1} should be added to the beds at every 3 months interval to maintain proper C-N ratio.

CROP CANOPY MANAGEMENT

Disbudding- Usually, 30-40 days after planting the flower buds appear in the leaf axils which are removed so as to achieve better vegetative growth of the plant. When the plant bears 16-17 functional leaves the flowers can be retained on the plant.

Leaf pruning- Ideally, 25-30 leaves per plant are sufficient to harvest the desired quantity of light and perform the photosynthetic activity. If, the number of leaves goes beyond 40 it may cause competition for resources, more chances of pest and disease incidence hence, some of the leaves are removed.

HARVESTING AND PACKING-

Gerbera is a 30 to 36 months crop. The first flowers are produced 7 to 8 weeks after plantation when plants are with 14 to 16 leaves. The average yield is 240 flowers per m^2 (6 plants per sq. m).

The flowers are plucked when 2 to 3 whorls of stamens have entirely been developed; or the outer 2 rows of the disc florets are open. A flower with 45-55 cm stalk length, 10-12 cm diameter is considered to be of a good quality.

Plucking of flowers is done in the morning or late in the evening or during the day when temperature is low. After cutting the heel of the stem by giving an angular cut they are immediately put in 2 to 3 cm water for four hours at 14 to $15^{O}C$.

A commercial bleach/Sodium Hypochlorite @ 7 to 10 ml or Citric acid + Ascorbic acid @ 5ml each in a litre of water should be used as the preservatives. A Gerbera cut flower has a minimum vase life of 8 to 10 days.

This is followed by sleeving the individual flower with poly thin bag of size 4.5" X 4.5" to protect the flower during handling and transportation. Bundles of 10 flowers each are packed in a box of dimensions 98 cm x 40 cm x 12 cm. Generally 250 to 300 flowers are packed per box. Flowers are precooled at 8 to 10^{0} C and transported through refrigerated van at 12 to14^{0} C for distant markets whereas for local markets flower are sent immediately after harvest .

Sleeving and bunch making of Gerbera flower, Kolhapur, Maharashtra

POT CULTIVATION OF GERBERA

Like many other resources,the soil also has become a scarce commodity due to rapid and extensive urbanization and industrialization. This constraint of agriculturally usable soil, is fast leading to the revolution of Hydroponics wherein the substrate used for cultivation, comprises of anything else other than soil, *viz.*, water, cocopeat, perlite, gravel, rock wool. Usually earthen pots of 5 litre capacity are used for planting as they remain cool. Twenty eight thousand plants can be accommodated in one acre.

Irrigation and fertigation are the decisive factors in soil-less cultivation of Gerbera as the media used has no buffering capacity. Daily 5 fertigation cycles should be set starting early in the morning and last cycle is given in the late afternoon. The plant should get 70 to 80 ml fertigation solution through each cycle. The EC of fertigation solution is 1.5 mS cm^{-1} and pH 5.8.

Flushing cocopeat in pots should be done once in a month to avoid building of EC in media. About 30% of leachate should be drained out daily.

FERTIGATION STANDARDS FOR POT GERBERA

Major elements		Minor elements	
Element	Milimoles per litre	Element	Micromoles per litre
NH_4	< 1.5	Fe	35
K	5.5	Mn	5
Ca	3	Cu	0.75
Mg	1	Zn	4
NO_3	11.25	B	30
P	1.25	Mo	0.5

SO_4	1.25

The table below gives us the comparison in a nut shell between soil and pot cultivation.

Pot Cultivation	**Soil Cultivation**
Buffering of cocopeat is a must. Buffered cocopeat, is cocopeat that has been treated with Calcium Nitrate. Buffering cocopeat ensures that the sodium and potassium ions inherent to the cocopeat complex are washed away.	Buffering is not required in soil.
The menace of soil borne diseases is eliminated. Nevertheless, sterilized cocopeat is available and use of sterilized cocopeat is recommended.	Risk of soil borne diseases is more; hence, soil sterilization is mandatory.
Since the substrate contains no inherent nutrients, daily fertigation, at least 4 to 5 times is essential.	Since, soil itself acts as a mineral nutrient reservoir to some extent, skipping of fertigation for a day or 2, wouldn't pose serious threat to the plants, *per se.*
Nutrients can be supplied to the plants, precisely as per the crop requirement, and the uptake can be monitored.	Exact fertigation as per crop requirement is not possible.
Daily monitoring of fertigation EC and pH is mandatory.	Daily monitoring is not a must. Monitoring once a month is sufficient.
The spread of pests and diseases can be greatly reduced.	Limitations in avoiding the spread of diseases and pests.
Initial cost of investment is on the higher side, as it involves benches, pots, EC/pH meter etc.	Initial cost incurred is less compared to pot cultivation.
As the number of plants that can be accommodated is more per unit area, the production is on the higher side when compared to soil cultivation. The precise control on fertigation and watering, has a positive effect on the quality as well as the quantity of the flowers.	The plant population being less, the production is on the lesser side.

Giving emphasis on the above mentioned aspects and meticulously following the management practices, pot cultivation of gerbera, offers good possibilities and can be a significant improvement, compared to soil cultivation.

Newly planted Gerbera in earthen pots with coco peat as a growing media

Soilless Cultivation of Gerbera at Hi-Tech Floriculture Project Agriculture College Pune

A successful Pot Gerbera Project at Kolhapur, Maharashtra

DISEASES AND PESTS

Aphids: Aphids (*Aphis gossypii*) suck the cell sap from young leaves and buds that causes distortion of leaves, excrete some substance on which fungus develops. Spray the plant with Malathion 2 ml or Diamethoate 2 ml to control the disease.

Greenhouse Whitefly- *Trialeurodes vaporariarum, Bemisia tabaci are reported to be causing damage to the green house crops.* It occurs when climate is hot and dry. Feeds on the lower side of leaves, excrete large quantity of honey dew which leads to development of black sooty moulds on the leaves. Methomyl 1.5 g or Malathion 2 ml or Diamethoate 2 ml or Imidacloprid 0.5 ml orAcetamiprid 0.4 g or Difenthiuron 1.25g per litre can be used to control this pest.

White fly and sooty mold after white fly attack **Leaf miner**

Leaf Miner (*Liriomyza trifolii*)-White coloured specks on leaves caused by flies. White serpentine tunnels in leaves caused by larvae, which stays in soil. Use Chlorpyriphos 1ml or Dichlorovos 1 ml or Acephate 1.5 g or Acetamiprid 0.4 g to control leaf miner in Gerbera.

Red Mites- Suck the sap from lower sides of the leaves causing development of brown spots on lower surface of leaves resulting in marginal drying of leaves. Webbing on the flower petals can be seen. The pest can be controlled with pure water spray or wetable sulphur 1.5 g or Dicofol 1.5 ml orabamectin 0.4 ml, fenazaquin 1 ml or propergite 1 ml per litre of water. Some organic, plant extracts commercially available also give good control of the pest.

Red mite infested leaf **Web formed by red mites on flowers**

Cyclamine mites (*Phytonemus pallidus*)-Older leaves are curled up. Younger ones being deformed and leathery, deformed flowers or petals are missing, inward curling and discolouration of petals. This pest can be controlled by spraying wetable sulphur1.5 gm or karathane 0.4 ml or Abamectin 0.4 ml or Derisom 2ml per litre of water


Cyclamaine mites infestation

Thrips- *Frankliniella occidentalis* causes white specks or stripes on ray florets; flower heads may be deformed. Silvery, grayish spots on the leaves and brown spots on leaf petioles/midvein are observed. Chemicals used for management of thrips are fipronil 5ml or imidacloprid 0.5ml or dichlorvos 1.5 ml + Monocrotophos 2ml or Dimethoate 2ml or Abamectin 0.4 ml or calnova 0.5 ml + calpaste 2gm per lit of water.





Thrips **Caterpillars on leaves and flowers**

Caterpillar- *Heliothis* and *Spodoptera* both the speciesfeed on leaves voraciously making holes in the leaf lamina sometimes leaving only veins on the leaves. Larvae attack flower buds as a result deformed flowers are produced. The pest can be controlled biologically by spraying HNPV (Heliokill) 1 ml or Metarhisium 4 gm per l litre of water in the evening. The chemicals like emamectin benzoate 0.2 ml or methomil 1.5 gm or deltamethrin 0.5 ml or indoxacarb 0.5 ml or Thiodicarb 0.4 gm per lit of water in the spray form or soil application of phorate @ 2 gm per plant are used to control the pest.

Root knot Nematode *(Meloidogyne incognita)*-Yellowing of leaves, stunted growth of the plant with reduced leaves size, knots on roots. Water logged condition in the green house and muddy water during rainy season are favourable conditions for nematode growth. Soil application of neem cake 30 to 50 gm per plant or carbofuron granules 10 gm per sq. m, drenching with methyl parathion 2 ml or benomyl 3 gm or hydrogen peroxide with Silver 3 ml or nematogaurd *(Pacealomyces)* 5 gm can be done to contro, the nematode.


Root knot nematode

DISEASES

Crown Rot: The causal organism is*Phytophthora cryptogea* results in wilting disease of Gerbera, crown of the plant becomes black. For the control apply , Aliette (Fosetyl Alluminium) (SP) 1 gm per lit of water as a spray or Topsin –M (Thiophanate - Methyl) (D)2 gm or Blitox (Copper oxychloride) (D) 1.5gm or Kocide (Copper oxychloride) (D) 2 gm per lit water drench 50 – 100 ml per plant

Crown rot

Root rot:

The disease is caused by *Pythium sp*. Initially dropping of younger leaves, finally wilting of the plant occurs. Root skin is easily removed. Aliette (Fosetyl Alluminium) (SP) 1 gm per lit water spray or Topsin –M (Thiophanate - Methyl) (D)2 gm or Benlate (Benomyl) (D) 3 gm or Bavistin (Carbendazim) (D) 2 gm or Captaf (Captan) (D) 2 gm per lit water drench 50 – 100 ml per plant give good control .

Fungal complex:

Plant becomes weak and stunted, with poor quality stems. This is a combine infection of *Cylindrocarpon destructans*, *Fusarium solani* and *Fusarium oxysporum*. If leaf-stem is cut, you can see the vessels are black. It causes blocking of the crown portion with brown discolouration. For the control drench the plants with Topsin –M (Thiophanate - Methyl) (D)2 gm or Bavistin (D) 2 gm or Hydrogen peroxide with Silver (D) 3 ml or Benlate (D) 1.5 gm or Streptocyclin + COH 0.2 gm + 1.5 gm per lit of water 50 -100 ml per plant or control sucking pests (Vectors) totally .

***Alternaria* leaf spot:**
Develops when moisture persist on leaf surface for longer duration. Black circular spots appear on leaves. For the control spray Dithane M-45 (Mancozeb) (SP) 1.5 gm per lit of water .



Alternaria leaf spot **Powdery mildew**

Powdery mildew:
White powdery fungal growth observed on the leaf lamina. In case of severe attack leaves start curling. For the control spraying of Wettable Sulphur (SP) 1.5 gm or Karathane (Dinocap) (SP) 0.4 ml or Quintol (Iprodion+ Carbendazim) (SP) 0.5 gm or Index (Myclobutanil) (SP) 0.5 gm or Rubigan (Fenremol) (SP) 1 ml or Hydrogen peroxide (SP) 2 ml per lit of water can be used .

Botrytis: Occurs especially when the atmospheric humidity is more than 92 per cent for two hours in the morning; gray spots develop on the flower petals, rot in the heart of flower may take place. Drenching with Iprodion+Carbendazim 0.5 gm per litre of water or spraying Mancozeb 1.5 gm Myclobutanil 0.5 per lit of water spray give good control of this disease.


Botrytis

Bacterial blight: Yellowish oily spots appear on the leaves that turn brown later. Brown discolouration is observed along the mid vein. Subsequently the flower bud wilts and the spots extend to the flower stems. Spraying with Streptocyclin 0.2 ml or Kasugamycin 1.25 ml or ethoxy methyl mercury chloride 0.2 g per lit water or drenching with Copper oxychloride 1.5 gm or Copper hydroxide 2 gm per litre water are used to control the disease.
Drenching is always done in the morning before irrigation whereas spraying in the evening hours for better results.
Pesticides containingTriazophos**,** Propiconazole, Penconazole, Hexaconazole, Deltamethrin + Trizophos (Spark), Profenophos, Metalaxyl + Mancozeb (Rodomil) should not be applied in Gerbera.

CARE TO BE TAKEN WHILE SPRAYING OF PESTICIDES, FUNGICIDES AND FERTILIZERS FOR BETTER RESULTS

The pH of the spray solution should be maintained between 6 and 6.5 by acidification 12 hrs before spray. The solution mixture should be immediately used after preparation before 12 Hrs. A spray adjuvant is added to the spray solution to enhance the efficacy of the spray. To avoid the plant damage like scorching, maintenance of suitable conditions inside the green house is very important.

NUTRIENT DISORDERS

Nitrogen-The deficiency of nitrogen causes general yellowing starting from older leaves then gradually moving upward as the element is translocated out of older leaves to the new growth under deficiency.

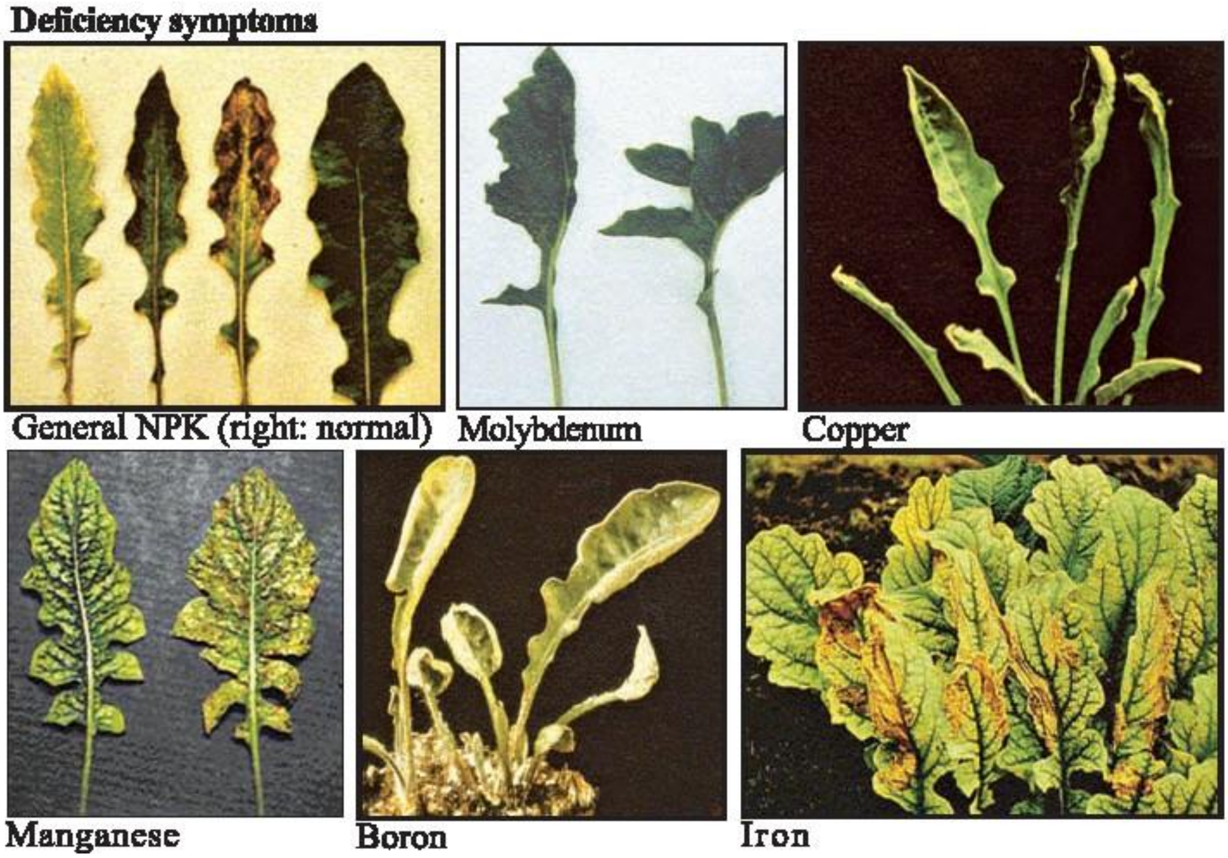
Phosphorous- The deficient plant shows brownish, purplish discoloration along the vein on lower leaf surface of older leaves.

Potassium- Its deficiency causes marginal necrosis of older leaves.

Calcium- Extreme yellowing of young, newly emerged leaves, week flower stems.

Magnesium- Interveinal chlorosis of young leaves, leaves become thick and crispy.

Sulphur- General yellowing of younger leaves starting from centre of the leaf extending towards margin.



Iron- Interveinal chlorosis of young leaves. In severe cases leaf colour turns to yellowish white.
Zinc- Chlorosis, half side of the leaf blade fails to expand and develop while the other half portion is normal, thus, resembling a 'C' shape.
Manganese- Leaves turn yellowish, starting with younger ones; the veins remain green, heavy chlorosis.
Copper- Newly emerged leaves fail to open, leaf blade cannot expand, distorted leaves chlorosis, poor flower growth.
Molybdenum- The deficiency of this element causes chlorosis on the edges of leaves.
Boron- Bases of younger leaves turn black, small distorted leaves abnormal flower buds, uneven opening of flowers are the symptoms of boron deficiency.

Toxicity-

Boron **Iron** **Fluoride**

Boron- Toxicity symptoms appear as chlorotic patches on leaves, necrosis of leaves.
Iron- The leaves become necrotic due to iron toxicity.
Fluoride- Deformed and twisted leaves are the symptoms of the toxicity of fluoride.

PHYSIOLOGICAL DISORDERS

Various physiological disorders are observed in gerbera which are resultant of unfavourable climatic conditions, climatic fluctuations and nutritional deficiencies and imbalance.
Double stemmed flowers, double faced flowers,flower heads with calyx like growth at the centre- A physiological disorder caused by imbalance of nutrients; usually observed when the plant shifts from vegetative to the generative phase.
Neck bending- Loss of turgidity and deficiency of calcium are responsible for the neck bending.

Non-uniform flower blooming- It may occur due to any physical injury to flower stem or pest attack or due to phyto-toxicity.

Pre-harvest stem break- is a result of high root pressure and high atmospheric humidity.

Short stem length- High salinity level, moisture stress and low soil temperature are the causes of short stemmed flowers.

Premature wilting of flowers- is due to cloudy weather followed by bright sun or carbohydrate depletion.

Calyx-like growth and petals at the centre of the flower head

Double faced flowers **Oval heart flower**

Neck bending flower **Double stemmed**

COMMERCIAL CARNATION CULTIVATION

Sachin Chavan

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Carnation is a half hardy perennial with branching stems and tumid joints. Leaf blades are simple, entire and usually narrow. Each stems form a terminal flower and hence inflorescence is generally a terminal cyme. The flowering shoots of carnation are marketed in two forms, standard form and spray or miniature form. Perpetual flowering and green house carnations are of modern origin.

Botanical Name: Dianthus caryophyllus
Family: Caryophyllacae
Native: Southern-Europe
Temperature: Night 14ºC-16ºC,
Day-17ºC-22ºC
Crop-duration:-2-3years.

TYPES OF CARNATION

1. **Standard type:** In Standard type, flowering buds formed on short lateral shoots arising from the axis of the upper leaves are removed to leave one large, terminal flower on a long leafy stem. It has one large flower on an individual stem.
2. **Spray type:** In spray type, terminal flower bud is removed at an early stage to encourage more even development of the lateral flowers, which then produce a multiple flowered stem.

VARIETIES OF CARNATION

Colour	Varieties of Standard Type Carnation
Red	Aicardi, Barbarot, Balance, Corba, Domingo Gaudina, Hilwarda, Kooij, Santamaria, Selecta, Turbo
Pink	Charmant Pink Dona, Famosa Pink Dover, Pink Shiva, Pink America, Pink Monterama
White	Angelica, Baltico,Hydra White Liberty, Madame Coletta, Viking
Yellow	Diana, Hermes, Salmanca ,Tobago,Yellow solar
Cream	Kamar, Sablia, Sagres, Shanteng
Cerine	Cherry Solar, Dona, Maxi, Rubes co, Shiva
Orange	Malaga, Nabita, Nova Scollia, Olymbia, Solar
Green	Green Elegance, Lady green ,Lenny,Nokia,Pradorova
Lidae	Farida , Remo
Fancy	Alibaba, Garuda, Rindez Sonya
	Varieties of Spray Type Carnation
Red	Etna , Karma, Rony,
Pink	Anne lies, Barbara, Silvery pink
Yellow	Alicetta, Lior ,Odeon
White	Excel, Royalette, Tibet
Others	Exquisite, Kissi , Scarlet Elegance
Micro	Carnation : Eolo, Pink Eolo, Wiko
Mini	Spray Carnation : Lima, Onia, Roland

SOIL FOR CARNATION CROP

Red sandy loam soil with good drainage is best for the cultivation of carnation, land polyhead up to 80 – 100 cm deep. Optimum soil pH is 6.5 addition of calcium carbonate or dolomite, lime stone corrects acid condition and also supplies calcium and magnesium for plant nutrition. Addition of sulphur or acid forming fertilizers will reduce the soil pH if it is on the higher side. EC of 1.2 at the start and 1.5 at the generative period is ideal.

SOIL STERILIZATION

Formaldehyde:

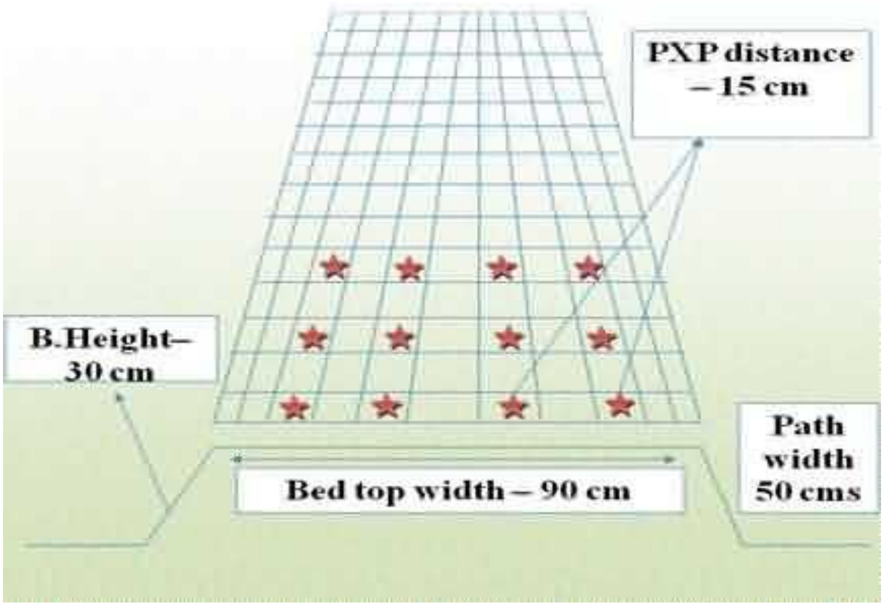
- Mix with water in 1:10 proportion and drench the beds
- Cover the beds with polythene for 7 days
- Stir the soil to evaporate the chemical
- Leach the soil with water to remove the chemical
- Planting has to be done after 2 weeks

Dazomet (Also known as Basamid granules):

- Micro granular soil fumigant contains 98% Dazomet
- When mixed with soil, releases biologically active gases like methyl isocyanate, which penetrates between soil particles
- It leaves no harmful residues Dosage 40 gm/ sq.mt.

APPLICATION OF MANURES IN CARNATION CROP:

Well decomposed cattle manure - 25 kg/ sq. mt. , Leaf mould - 25 kg/ sq. mt. , Neem cake - 500 gm/ sq. mt., Bone meal - 200 gm/ sq. mt.,



- Bed preparation for carnation crop is to be done after soil sterilization and proper washing out with water, when the field capacity of soil is reached.
- The beds should be prepared in the direction of gutters of the green houses.
- Leave sufficient space for main pathway, which is required for various operations.
- The green house columns generally should be on the beds.
- After preparation of beds avoid walking on the beds, which may damage the soil and bed structure.
- The paths in between two beds should be sufficiently wide to carry out all cultural operations, efficiently.

- In case of crops, where in support structures are required, the support structures are to be erected before final preparation of beds.
- After fumigation, the raised beds of given dimensions are prepared, like **bed top width** – 90 cm, **bottom width** – 100 cm, **path width**– 50 cm and **height of bed** – 30 cm.

BASAL FERTILIZERS APPLICATION IN CARNATION:

- Super phosphate – 200 gm/sq.mt.
- Muriate of potash – 150 gm/sq.mt.
- Magnesium sulphate – 50 gm/sq.mt.
- Borax – 2 gm/sq.mt.

Thoroughly mix with the soil and water plant after 2 weeks

PLANT SPACING AND PLANT DENSITY:

15 x 15 cm, 20 plants/ sq.mt [10000 plants/ 500 sq.mt.] usually **32 plants/ net m2** [per m2 of bed] and about **20 plants per gross m2** [per m2 of greenhouse] are planted. This should be followed very strictly. Because more plants/ sq.m will just give a higher in the first flush, after wards this advantage disappears and more problems with disease will occur.

Before planting, **place 7.5 x 7.5 cm supporting net on the beds.** Plant the rooted cuttings as shallow as possible. Do not press the soil, because it may cause fusarium rot disease, which leads to the mortality of plants. Immediately after planting, drench with 1 g carbendazim or captan per lit of water. Continuous spraying of water should be given to maintain the soil wetness (i.e. minimum 10 days) to enhance the rooting of plants.

FERTIGATION (500 SQ.MT. AREA)

Quantity of water 1000 lit for 500 sq.m

S.No.	**Name of fertilizers**	Quantity (gm)
A – Tank		
1	Calcium Nitrate	600
2	Potassium nitrate	250
3	FE EDTA (Three weeks after planting)	15
B – Tank (Tuesday, Thursday, Saturday)		
4.	Mono ammonium phosphate 12:61:0	150 g
5.	Sulphate of potash 0 : 0 : 50	600 g
6.	Magnesuim sulphate	500 g
7.	Manganese sulphate	5 g
8.	Zinc sulphate	3 g
9.	Copper (copper sulphate)	3 g
10.	Molybdenum (Sodium molybdate)	1 g
11.	Boron (Borax)	5 g

(Sunday plain irrigation water)

IRRIGATION IN CARNATION CROP

Over watering and poor drainage cause root death and stunted growth. Water logging would cause deprival of oxygen to plants. The growing medium should be evenly moist.

CROP SUPPORT (NETTING)

To ensure straight stems, the carnation crop needs to be supported with 4 (or) 5 layers of support material. Good support material is metal wire with a mesh width of 7.5 x 7.5 cm to 15 x 15 cm minimum at every 3 mts, The wires should be supported with poles. The poles at the beginning and the end of each bed should be strong enough and be in cast concrete.
For an optimal support of the crop, an increasingly width of meshes may be used. (e.g.) Bottom net of 7.5 x 7.5 cm, 2nd net of 12.5 x 12.5 cm, Upper nets of 15 x 15 cm

PINCHING OF CARNATION

Pinching is an important operation in the successful **production of quality carnation.** There are generally two types of pinching used.
(i) Single pinch: This method facilitates more rapid flowering but all stems flower at same time. After the establishment of plants, about 3 – 4 weeks after planting, the apex shoot is pinched leaving on the 5th – 6th pair of leaf or leaving 5 – 6 lateral shoots to develop.
(ii) Pinch and half method: After initial pinch, one half of the breaks from the first pinch are pinched a second time about three to five weeks after first pinch.

This method result in lower yields in first flush compared to single pinch method, it will result in more even and stable production over time follows pinching with spray of fungicides.

DISBUDDING IN CARNATION

The practice of removing undesirable immature flower buds other than central terminal bud is called disbudding. But in case of spray carnations only the central terminal bud is removed to encourage lateral flower buds to develop care must be taken to avoid any injury to the main stem.

DE SHOOTING IN CARNATION

It is found to influence flowering in carnation. Removal of all secondary shoots from 5 weeks after planting and on alternate days till flowering does not affect the stem lengths but stem size and flower size is increased by 10 to 15 %.

PESTS OF CARNATION

Red Spider Mites:

Symptoms:

- These have the ability to produce fine silk webbing, spider mites are very tiny and very small and are difficult to identify.
- They suck sap from the leaves which results in tiny yellow (or) white speckles. Once the foliage of a plant becomes bronze it often drops prematurely. Heavily infested plant may be discoloured stunted.
- Favourable condition
- High temperature and low relative humidity
- More populated crop (dense crop)

Control measures

- Apply Thiovat (Wettable sulphur) @ 2.0 gm/lit of water ,
- Metasystox (Oxy-demeton-methyl) @ 1.0 ml/lit or
- Vertimec (Abamectin) @ 0.4 ml/lit of water.
- Oberon (spiromesifen) @ 0.5 ml/lit of water
- Magistar (fenazaquin)@0.5 ml/lit of water

Aphids of Carnation:

Symptoms:

- These are the sucking insects. Feeding usually occurs on buds and undersides of leaves. Feeding on young leaves results in distorted leaves as they continue to grow. Older leaves may display patches of chlorotic spots. Nymphs and adults suck the sap from the leaves, stems and flower buds in colonies. Aphids excrete honey dew, which results in black fungus development on plants.
- Favourable conditions:
- Cloudy weather favours rapid build-up of aphids population
- Low temperature favours development of young aphids

Control : Apply Asatap (Acephate) @ 0.5 – 1.0 gm/lit of H_2O

Thrips of Carnation

Symptoms:

- Both the nymphs and adults suck the sap from leaves and flower. They excrete brown droplets, which afterwards true black. Leaves may fade and shrivel in case of heavy infestation and foliage becomes silvery.
- Favourable condition
- Mainly temperature affects the thrips population

Control

- Spray Asatap (Acephate) @ 1.0 gm/1 lit of water, Decis (Deltamethrin) @ 0.5 ml/lit of (or) Exodust @ 1.0 gm/lit.

Caterpillars in Carnation Crop:

Symptoms:

- Caterpillars feed on the leaves. Sometimes they may bore into the buds plant growth is affected adversely
- Favourable condition
- Affected by caterpillars, Infected bud
- Warmer climate in polyhouse
- Fluctuation of relative humidity in the polyhouse
- Fluctuation of temperature in the polyhouse

Control:

- Spray Monocrotophos (Monocil) @ 1.0 ml/lit (or) Polytrin (Cypermethrin) @ 0.5 ml/lit

Nematodes problem in Carnation cultivation:

Symptoms

- Root knot nematode is a serious pest. Infected plants usually appear stunted and tend to wilt on warmer days.
- When such plants are dug, the root galls are generally conspicuous and easily identified.

Control: Apply Thionet (Phorate) @ 6.0 gm/sq.mt/Basamid(Dasomet) @ 6.0 gm/sq.mt.

DISEASES OF CARNATION CROP

Powdery mildew:

- On the top of the leaves white, powdery fungal growth develops consisting of hyphal threads and spore carriers. The fungus is also observed on the underside of leaves. Malformation of young leaves takes place due to infection of powdery mildew. Brown spots develop on full grown leaves.

Control:

- Spray Roko (Thiophinate methyl) @ 2.0 gm/lit or Bayer (Biternol) @ 2.0 gm/lit

Black spot (*Alternariadianthi*):

The disease is characterized by appearance of round purplish spots on the leaves, enlarging slowly with brownish black centre having sporulation. The leaf tissues surrounding this spot turn yellow, severe infection leads to premature death of the leaves.

Control:

SprayChlorothalonil @ 1.5 gm/lit

Botrytis in carnation crop:

Symptoms:

The fungus is usually identified by the development of fuzzy, grayish spore over the surface of the rotted tissues. The fungus causes a brown rotting and blighting of affected tissues. Blooms are worst affected resulting in poor quality.

Control:

- Spray Carbendazim / Capton @ 2 g / litre of water.

Phytophthora [Foot rot] of Carnation crop:

Symptoms:

Withering and yellowing of foliage, leaf death external browning of stems and internal browning at nods appear. Stem and root rot may take place. Lower leaves become purple and dry shortening and blackening of stems take place and rotting of stems can be observed. **Control:**ApplyAlleite @ 1.5 gm/lit of H_2O (as Kavach (Chlorothalonil) @ 1.5 gm/lit of H_2O.

Pythium [Root rot] of Carnation crop:

Symptoms:

Its infection results in stunted growth and ultimately drying of entire plant.

Control:

- Spray Bavistin (Carbendazim) 2.0 gm/lit or Alleite @ 1.5 gm/lit or as Kavach(Chlorothalonil) @ 1.5 gm/lit of H_2O.

Fusarium (Stem rot and wilt):

Symptoms:

- Infection takes place through wound. The lower leaves start becoming yellow followed by withering of leaf bases and yellowing of mid ribs and eventually the branch wilts. Brown discoloration and shredding of vascular bundles.

Control:

- Spray Alleite @ 1.5 gm / lit or Kavach (Chlorothalonil) @ 1.5 gm / lit of H_2O.

PHYSIOLOGICAL DISORDERS IN CARNATION CROP

Calyx Spliting :

It is a major problem in carnation. This is due to fluctuation in temp. (< 10º C), moisture situation, low N, high ammonical N, boron deficiency and varietal character.

Control:

- This may be rectified by uniform watering, Higher nitrate to ammonical N ratio fertilizer applications, spraying of borax. Use small rubber band on bud when it show opening.

Sleepiness:

Carnation petals cup upwards and do not open. This is due to ethylene gas emitted by fruits and vegetables. This is controlled by not mixing the flowers with vegetables and fruits during storage and transit.

Weak Stem:

Common during winter months due to reduced light & Excess Nitrogen

Boron Deficiency:

Symptoms:

Malformed flower buds, short stems and excessive branching.

Control:

- To rectify the apply boron through drip irrigation @ 30 gm borax / 10 sq.mt. once in a year

HARVESTING OF CARNATION CROP

- Harvesting of carnation starts from the end of the fifth month in some varieties and starting of the sixth month in other varieties.
- The flowers should be harvested early in the morning or late in the afternoon.
- The flower must be placed in buckets with clean water or 1ml of sodium hypochlorite (15% a.i.) in 10 litter of water.

Carnation is harvested in **three stages of harvests**, namely

Tight bud stage:- Advised for long distance market but in this flowers may not open sometimes

Paint brush stage: - Standard carnations should be harvested when the outer petal unfold nearly perpendicular to the stem. Spray types are harvested when two flowers are open and the bud shows colour,

Semi open stage: - Ideal for short distance marketing.

GRADING OF CARNATION CUT FLOWER

grade	**Stem Length (cm)**
III	40-50
II	50-60
I	60-70

PULSING OF CARNATION

Commercially used Floral Preservatives

Chrysal, **AVB**, **Florissant 100** and **Forever.**

Doses: @ 2ml of Chrysal / Florissant 100 in 10 L water.

PACKAGING OF CARNATION

Wrapping the cut carnation flower in corrugatedsheet, putting rubber band and packing in fibre board boxes, wrapping the cut carnation putting rubber band on cut carnation

PACKAGING SIZES

Flowers are packed in bunches and sleeved in plastic sheets or newspaper as desired by customer. The sleeved bunches are packed in cardboard boxes having 122 cm L x 50 cm W x 30 cm H that are brought into the cold store and cooled down

POST-HARVEST HANDLING

Storage - The cut ends of the flower stems are dipped for 10 minutes in 1000 ppm STS and thereafter pulsed at 10 to 20º C temperature for one hours in 5% sucrose + 150 ppm HQC (Hydroxy Quinine citrate). Cut carnation at paint brush stage, can be stored under refrigerated for 3 weeks at 4± 1ºC, both under wet and dry storage condition at Ludhiana. **Vase life -** 14 to 21 days preservative solutions are 4% sucrose + 30 ppm AgNo3, 4% sucrose + 300 ppm 8 HQC.

YIELD OF CARNATION CROP

Standard type: 200 Flowers per square meter

Spray type: 250 Flowers per square meter

WEED MANAGEMENT IN ORNAMENTAL CROPS

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Floricultural crops are important among horticultural crops in India. thesehorticultural crops generate foreign exchange, create employment (Njoroge 1999). Most of these crops are slow growing and have poor canopy developmentduring the early stages. This habit makes them susceptible to competition from weeds, whichadversely affect yield and quality of these crops.Product quality is a major aspect of horticultural industry. Generally, farmers do not understand the negative implications of weeds in term of yield lossesand the cost of its control. Weedcontrol has been observed as one of the mostimportant practice in crop production because goodweed control will ensure maximum yield and highquality of farm produce (Njoroge 1999). Since most horticultural crops are very slow in growth, especiallyin the early stages of their establishment, it becomesimperative to begin weed control early enough in orderto ensure high yield and quality.

Developing a weed management program involves site assessment, determining the type of ornamental planting, consideration of weed management options for the ornamental species selected, preparation of the site prior to planting and finally installation of the planting and implementation of the weed management plan.

SITE ASSESSMENT

An assessment of cultural factors to determine the suitability of species for the site is an excellent time to begin the development of a weed management program. Landscapers should take soil samples to determine pH and nutrient analysis, note drainage and shading patterns and identify potential long-term maintenance problems such as heavy traffic areas. Landscapers should also note the presence of weed species on the site with particular attention to perennial weeds such as yellow nutsedge, mugwort, Canada thistle, bindweed, bamboo and Japanese knotweed. These weeds are difficult, if not impossible to control after the site is planted. Inspect surrounding areas (especially in the turf) for weeds that may encroach such as ground ivy, wild violet, bermudagrass and quackgrass.

DETERMINE THE TYPE OF PLANTING

The ornamental species selected for the site will to a large extent, dictate the weed management options available after the site is established.

WOODY TREE AND SHRUB BEDS

A planting of woody tree and shrub beds allows the maximum amount of weed management options. Since these plantings are open and easy to work around, removal of weeds manually is less laborious and least injurious to the planting. Spot treatments with non-selective herbicides such as Roundup without injury to the planting is also a possibility. Annual weeds may be controlled with the use of landscape fabrics and mulches. The widest range of preemergence and postemergence herbicides are available for use in woody tree and shrub bed plantings.

WOODY GROUND COVER BEDS

As woody ground cover beds spread, most weeds should eventually be shaded out and excluded from the planting; however, weed control within the first few years of establishment may be necessary. Spot treatments with non-selective herbicides without injury to desired plants may be difficult, so every effort should be made to control perennial weeds prior to planting. If ground covers are expected to root and spread, landscape fabrics are not an option. Mulches may be utilized to suppress annual weeds and a wide range of preemergence and postemergence herbicides may be safely used.

HERBACEOUS PERENNIAL BEDS

Closed plantings of herbaceous perennials may eventually shade out annual weeds but weed control at establishment is necessary. It is very important to control perennial weeds prior to planting because it may be difficult to make spot treatments with non-selective herbicides. Landscape fabrics may be used in clump-type plantings but are not an option around spreading species. Mulches may be used and a limited number of preemergence herbicides are available. Perennial grasses may be controlled in most herbaceous perennials with postemergence herbicides such as Fusilade II.

ANNUAL FLOWER BEDS

Planning a weed management program for annual flowers is similar to herbaceous perennial beds except that fewer preemergence herbicides are available and the use of landscape fabrics is not economical because of the short–term nature of the planting. Perennial weeds can be suppressed between plantings with non-selective herbicides.

MIXED PLANTINGS OF WOODY AND HERBACEOUS PLANTS

Development of a weed management program is more complex because few herbicides are safe on a wide range of ornamental species; however, different areas of the bed could receive different herbicide treatments. It is very important to control perennial weeds prior to planting since it may be difficult to make spot treatments with non-selective herbicides. Landscape fabrics may or may not be useful depending on the nature of the planting.

ORNAMENTAL SPECIES SELECTION AND WEED MANAGEMENT OPTIONS

Ornamental species selection is generally determined by the landscape design, their suitability for the site and desired aesthetics; however, the landscaper should select species that are compatible with weed management options available. Selection of weed management options will depend upon weed species present, ornamental species selection, planting design, economics, and personal choice.

WEED COMPETITION

Weeds compete with crops for water, nutrients, space, light and oxygen resulting into a delay in maturity and low yield. Generally, these losses occur as a result of reduced yield, quality, harbouring of pests or diseases, allelopathic effects on crops etc. The extent of yield losses depends on the type of weed flora, their intensity and duration of weed competition and soil and climatic factors. Some weeds exertallelopathiceffects on some crops. For an example, *Centrosemaspp.* has allelopathic effect on banana and plantain. Thus, to get maximum returns frominputs applied to these horticultural crops, there is agreat need of proper weed control measures in thesecrops. Most of these weeds are not host specificbecause they infest both vegetables and flowers. It istherefore, very difficult to draw a clear-cut boundarybetween vegetable or flower weeds. Weed control is especially important early in the season when weed competition can substantially reduce vigour, uniformity and overall yield. The period from emergence to four weeks has been found to be critical in the competition of weeds in many row crops including vegetables and flowers.

WEED FLORA

Weeds in vegetable and flower fields are in different sizes, forms and behaviours. They belong to many families varying in physiology, morphology and habits of growth. The first step in weed managementis to identify the weeds and understand their life-cycles. Weeds can be categorised by their life-cycles and management strategies developed accordingly (Nwafor et al.2010). Annual weeds complete their life-cycles in one year and reproduce solely by seeds. Annuals are divided into summer and winter groups depending on when they grow. The perennial weeds live for more than two years and can reproduce by seed or vegetative structures such asstolons, rhizomes, tubers, bulbs and roots (Njoroge 1999). Because perennial weeds are difficult to manage in vegetables, it is better not to use a field with severe perennial weed problems. A detailed list of annual and perennial weeds infesting different vegetable and flower crops during different growing seasons are presented (Tables 1and 2). With a sound knowledge of weed phenology and environmental factors at the local level, it is possible to predict when and where certain weeds will raise problems. Major problems in vegetables and flower are cause by broad-leaf weeds because grass weeds are much better managed in rotation or they can be successfully eliminated with the use of selective foliar-applied herbicides. The choice of control method depends on environmental concerns, marketing opportunities, desired management intensity, labour availability, weed pressure, and the crop.

Table 1. Commonly infested annual weeds of vegetable and flower crops in India

Weed	Gassy	Broad - leaf	Weed	Grassy	Broad-leaf
Summer annuals					
Setariaverticillata	X		*Trianthemaportulacastrum*		X
Dactylocteniumaegyptium	X		*Amaranthus viridis*		X
Eleucineindica	X		*Digera arvensis*		X
Digitariasanguinalis	X		*Phyllanthus nirur*		X
Echinochloacolona	X		*Portulaca oleracea*		X
Euphorbia microphylla		X	*Setariaverticillat*		X
Commelinabenghalensis	X		*Cannabis sativa*		X
Winter annuals					
Phalaris minor	X		*Avenaludoviciana*	X	
Loliumtemulentum	X		*Polypogenmonspeliensis*	X	
Poaannua	X		*Sonchus arvensis*		X
Euphorbia simplex		X	*Rumexdentatus*		X
Melilotus alba		X	*Chenopodium album*		X
Stellaria media		X	*Coronopusdidymu*		X
Malva parviflora		X			

Table 2. Commonly infested perennial weeds of vegetables and flower crops in India

Weed	Gassy	Broad -leaf	Sedges
Summer perennials			
Sorghum halepense	X		
Cynodondactylon	X		
Cyperusrotundus			X
Parthenium hysterophorus		X	
Winter perennials			
Convolvulus arvensis		X	
Cuscutareflexa		X	
Cuscutachinensis		X	
Orobancheaegyptiaca		X	
Cirsium arvens		X	

METHODS OF WEED CONTROL

Weed control in ornamental especially importantearly in the season when weed competition cansubstantially reduce vigour, uniformity and overallyield. Themethods used for controlling weeds have beendivided into two broad categories, non-chemical andchemical. Many non-chemical weed managementmethods are common sense farming practices. These practices are of increasing importance due to consumers' concerns about pesticide residues, potential environmental contamination from pesticides, and unavailability of many older herbicides (Masiunas 2000).

NON-CHEMICAL METHODS

Weed management should start with non-chemical strategies. The aim should be to manage theweed population below a level that reduces economicreturn. In some instances, the cost of controllingweeds may be more than the economic return obtained from any yield increase. This situationoccurs when a few weeds are present or the weedsgerminate late in the season. In those instances, thebest strategy may be to do nothing. In othersituations, weed populations and other considerationsmay requirecombining herbicides with non-chemicalapproaches.

PREVENTIVE METHODS

These methods are closelyconnected with crop rotations and necessary when nodirect measures of weed control can be taken foreconomic reasons. They are based on a reduction inthe soil seed and propagule bank and the earlyawareness of the infestations. It is necessary to avoidthe invasion of new species through the use of cleanplanting material and to prevent seed dispersal on theirrigation water, implements and machines. A writtenrecord of the history of weed infestation in the field isvery useful. Another aspect is to impede perennialweed dispersal (or parasitic weeds) through the use oftreatments and tillage and the use of drainage tillage toprevent propagation of some species (*Phragmites spp., Equisetumspp.,Juncusspp.*) that need highmoisture levels. It is also necessary to scout the fieldedges to prevent invasions, acting only when necessary, and bearing in mind the usefulness of the edges and borders to control erosion and hosting usefulfauna.

CULTURAL METHODS

One should aim to establish a vigorous crop that competes effectively with weeds. This approach starts with land selection. A general rule is not to plant flowerson land with a history of heavy weed infestation, especially of perennial weeds.

STALE SEEDBED

Stale ('false') seedbeds aresometimes used for flowers when other selective weed control practices are limited or unavailable. Success depends on controlling the first flush of emerged weeds before crop emergence, and on minimal disturbance, which reduces subsequent weed flushes. It consists of preparation of a seedbed 2-3 weeks before planting to achieve maximum weed-seed germination near the soil surface. These seedlings are killed by light cultivation or by applying non-residual herbicides glyphosate and paraquat just before or after planting, but before crop emergence. The crop is planted with minimum soil disturbance to a void exposing new weed seed to favour able germination conditions.The pre-germination should occur as close as possible to the date of planting to ensure that changes in weather conditions do not have an opportunity to change the spectrum of weeds (cool vs. warm season) in the field.

CROP ROTATION

Crop rotation is a key control method to reduce weed problems in flower and vegetables. It was considered for a long time to be a basic practice for obtaining healthy crops and good yields. This concept was mistakenly eliminated with the use of more agrochemicals. At present, however, crop rotation is gaining interest and is of value in the context of integrated crop management. Weeds tend to thrive with crops of similar growth requirements. Cultural practices designed to contribute to the crop may also benefit the growth and development of weeds. Monoculture results in a build-up of weed species that are adapted to the growing conditions of the crop. When diverse crops are used in a rotation, weed germination and growth cycles are disrupted by variations in cultural practices associated with each crop (tillage, planting dates, crop competition, and weed control methods). It is best to alternate legumes with grasses, row crops with close planted crops and heavy feeders with light feeders.

COVER CROPS

Rapid development and dense ground covering by the crop will suppress weeds. The inclusion of cover crops such as *clovers, oilseed radish, summer greengram, summer black gram, sunhemp, Sesbania or forages* in the cropping system can suppress weed growth. Highly competitive crops may be grown as short duration 'smother' crops within the rotation. Additionally, cover crop residues on the soil surface will suppress weeds by shading and cooling the soil. When choosing a cover crop, consideration should always be given to how the cover crop will affect the succeeding crop. In addition, decomposing cover crop residues may release allelo chemicals that inhibit the germination and development of weed seeds. The cover-crop systems tend to control small seeded annual broadleaf weeds the best.

PLANTING PATTERNS

Crop population, spatial arrangement, and the choice of cultivar (variety) can affect weed growth.Narrow row spacing and proper plant density assure that the crop rapidly closes the canopy. A closed canopy shades out late emerging weeds and prevents germination of weed seeds requiring light. Similarly, fast-growing cultivars can have a competitive edge over the weeds. Weeds seldom pose a problem once the canopy closure occurs.

PLANTING TIME

The crop planted at the right timeshowed more competitiveness towards weeds thanlate planted crop. Crops may be divided into warm-and cool-season plants, depending on the optimaltemperature for their growth. The planting dateeffects the time of emergence and early seedlingvigour of the crop, which are important indeter mining crop competitiveness.

Cool-seasoncrops germinate at cooler soil temperatures and thuscompete better against early emerging weeds than dowarm-season crops. The crop should be planted at atime when the temperatures are favourable for cropgrowth.

MULCHING

Mulching or covering the soil surface canprevent weed seed germination by blocking lighttransmission preventing seed germination.Mulchesmay be classified as either natural or organic (straw, bark, compost) or synthetic (plastic). As naturalmulches are difficult to apply over large areas, theyare best for small, specialized areas. Natural mulchesshould be spread evenly at least 1.5 inches thick overthe soil to prevent light penetration; weeds can easilymanage to reach the surface if the layer is not thickenough. Allelopathic chemicals in natural mulch alsocan physically suppress seedling emergence. Somemanual weeding may be required along with the practice of mulching (Nogueroles and Zaragoza1999).Natural mulch materials must be free of weed seedsand other pest organisms and be heavy enough thatthey are not easily displaced by wind or water. Amajor advantage of natural mulches istheirbiodegradability addingorganic matter to the soil.The use of plastic mulching is very popular inmany vegetable-growing areas. Plastic mulches havebeen developed that filter out photosyntheticallyactive radiation, but let through infrared light to warmthe soil. These infrared transmitting mulches havebeen shown to be effective at controlling weeds.Synthetic mulches control weeds within the row,conserve moisture, increase soil temperature, and areeasy to apply. Black plastic mulches are the mostcommon and are particularly effective in improvingearly season growth of warm-season crops such as tomatoes, muskmelons, watermelons, and peppers.Better early season growth of these crops improvestheir competitive ability against weeds. Plasticmulches used in combination with trickle irrigationalso improve water use efficiency. The biggestdisadvantage of plastic mulch is disposal, as manylandfills do not accept it. Photodegradable plastic mulches have been developed, but their season long persistence is a problem. Also, photodegradable mulches just degrade into smaller pieces of plastic that still contaminate the environment. Biodegradable plastic mulches are not yet widely available. Mulching generally prevents the germination of light sensitive weeds like *Ageratum conyzoides, Portulacaoleraceaeetc*. Some perennial weeds are not controlled (e.g.*Cyperus spp*., *Convolvulus arvensis*) by this process and for them inter-row cultivation or herbicidal treatments are necessary.

SOLARISATION

In this process, moist soil is covered with a clear, thin transparent plastic sheet, to trap the soil radiation for 30-45 days. Solarization works when the heat created under the plastic film becomes intense enough to kill weed seeds. The maximal soil temperature reaches nearly 60°C under polyethylene covered plots. The factors involved in solarization are soil temperature, moisture and probably gases due to which solarization reduces the germination, establishment and biomass of heat sensitive weed species. Results are often variable, depending on weather conditions. In Northern India, high soil temperature (50-60°C) can develop in soil covered with transparent polyethylene sheets in May-June (Kumar et al.1993). Cold (high latitude) or cloudy places are usually not suitable for implementing solarization. Some species can tolerate solarization(e.g.deep-rooted perennials, viz.*Sorghum halepense, Cyperusrotundus*, and also some big weed seeds such as legumes). After solarisation, the use of deep or mouldboard tillage must be avoided and the sowing should be done with minimal soil disturbance. This system is more suitable for small areas of vegetables, but is widely used under plastic greenhouseconditions.

MECHANICAL METHOD

Mechanical removal of weeds is both time consuming and labour-intensive but is one of the most effective methods. Mechanical weed management starts with seedbed preparation. Moldboard plowing is usually the first step in mechanically managing weeds. It is particularly useful in controlling emerged annual weeds. An important second step is often rotary hoeing for mechanically managing weeds in large- seeded vegetable crops (sweet corn, snap beans and peas). Rotary hoeing needs to be done after the weeds germinate but before they emerge; it controls only small-seeded weeds. Once the crops have emerged or transplants are established, a row cultivator may be used to manage emerged weeds. Adjust the cultivator sweeps or teeth to dislodge or cover as many weed seedlings as possible. Seedling weeds can be killed by cultivating 1-2 inches deep. The best weed control is obtained with a row cultivator in relatively dry soils by throwing soil into the crop row to cover small weed seedlings. Avoid crop injury from poor cultivation, which reduces crop yields. Relying entirely on mechanical practices to manage weeds isdifficult on large acreages. Also, several weeds especially perennials, are extremely difficult to manage unless herbicides are combined with non- chemical approaches. The tillage operations for seed bed preparation should be planned keeping in view with the type of weeds present in the field. When annual weeds are predominant (crucifers, solanaceous, grass weeds) the objectives are unearthing and fragmentation. This must be achieved through shallow cultivation. If weeds have no dormant seeds (*Bromus spp.),* deep ploughing to bury the seeds will be advisable. If the seeds produced are dormant, this is not a good practice, because they will be viable again when they return to the soil surface after further cultivation. When perennial weeds are present, adequate tools will dependon the types of rooting. Pivot roots (*Rumex spp.)* or bourgeon roots (Cirsium spp.)require fragmentation and this can be achieved byusing a cultivator. Fragile rhizomes (*Sorghumhalepense*) require dragging and exposure at the soil surface for their depletion, but flexiblerhizomes (*Cynodon dactylon*) require dragging andremoval from the field. This can be done with acultivator or harrow. Tubers (*Cyperus rotundus*)orbulbs (*Oxalisspp*.) require cutting when rhizomesare present and need to be dugup for exposure toadverse conditions (frost or drought). This can bedone with the mouldboard or disk ploughing. Chiselploughing is useful for draining wet fields andreducing the infestation of deep-rooted hygrophilousperennials (Phragmites, Equisetum, Juncus).This iswhy reliable weed information is always necessary.

CHEMICAL METHOD

Herbicides offer a great scope for minimizing the cost of weed control irrespective of the situationand offer a good weed control alternative to cultural or mechanical methods in horticultural crops.Chemical control, however, is relatively poorly developed in vegetable and ornamental crops as they tend to be grownin relatively smallareas, hence making use of herbicides expensive and uneconomical. With thismethod, less labour is required; this allows the transfer of labour to other activities. Usage of pre-emergence herbicides assumes greater importance in view of their effectiveness from the initial stages of crop growth, which is the most critical period of weed competition (Bhutani et al.1978). The weeds emerging later also compete with the crop and reduce its productivity and need for post- emergence herbicides or other non-chemical approaches described above. However, the herbicides alone could not provide long term control of a wide range of weed flora present in a field. This necessitates the use of an integrated approach for long term control of weeds in vegetable and ornamental crops. Several herbicides are often labelled for a crop. Scouting in your area to determine which weeds ae present can allow you to select the herbicide that can give you the best control. Potential environmental hazards must be considered when selecting a herbicide. Herbicide labels contain information on these hazards. The details of herbicides commonly used for weed control in flower corps are listed (Table 3). If a user is not familiar with the use of herbicides, it requires preliminary tests to verify its effectiveness in local conditions and selectivity to available crop cultivars.

GOOD PRACTICES DURING THE USE OF HERBICIDES

•A summary of a 'decalogue' of good practices in the use of herbicides in extensive vegetable crops
(Zaragoza 2001) is provided below:

• Periodically inspect the fields and assess the weed of importance. Identify correctly the major
weeds.
• The weed and crop stage of growth must be takeninto account.
• Careful selection of the product and dosage, bearing in mind points one and two.
• Read the product label and follow the recommendations.
• Avoid adverse conditions at the time off application: wind, temperatures, rainfall. Do not delay
treatment.
• Quality of the spraying is obtained by the correct calculation of dosage (surface to be treated must be
well measured) and by the spraying equipment, which must be calibrated and in good condition
(especiallynozzles).
• Band or patch application to save herbicide and reduce residues.
• Keep to the environmental norms: avoid spills, drift, respect the edges, water ways, and sensitive
areas. Rinse all empty cans or containers thrice and do not re-use them.
• To avoid propagation of resistant species, the same herbicide or herbicides with the same mode of
action must not be used repeatedly.

Table 3. List of herbicides for use in flower crops

Crop	**Herbicide**	**Dose kg/ha**	**Time of application**
Gladliolus	Oxyfluorfen	0.25	PRE
	Alachlor	1.00	PRE
	Atrazine	1-2	PRE
	Pendimethalin	0.75 -1.00	PRE
	Metribuzin	0.5	PRE
	Butachlor	1.5	PRE
	Pendimethalin + Metribuzin	0.75 +0.30	PRE
	Oxyfluorfen	0.5	PPI
	Glyphosate	1.0	POST- directed
Gerbera	Pendimethalin	1.0	PRE
	Alachlor	1.5	PRE
Rose	Diuron	2.0 -2.50	PRE
	Glyphosate	0.5	POST- directed
	Oxyfluorfen	1.0	PRE

	Atrazine	1.0 -2.0	PRE
	Metribuzin	0.75 - 1.50	PRE
China aster	Oxyfluorfen	0.1	PRE
	Metolachlor	1.0	PRE
Marigold	Trifluralin	1.0	PPI
Tuberose	Metolachlor	2.0	PRE
	Pendimethalin	1.25	PRE
Winter annuals (Helichrysum - bracteatum, Coreopsis lanceolata Chrysanthemum carinatum)	Pendimethalin	0.50	PRE

PPI- Pre plant incorporation, PRE - Pre- emergece, POST - Post - emergence

List of pre-emergence herbicides labelled for use in landscape planting beds.

Common Name (active ingredient)	Example Trade Name and Formulation	Can be applied to turfgrass?	Remark
Dithiopyr	Dimension® 2EW	Yes	Over 440 ornamentals safe for over-the-top applications. Can be tank-mixed with Gallery for increased weed control.
Oryzalin	Surflan® 4AS	Yes	Good control of annual grasses.
Pendimethalin	Pendulum® 2G , Pendulum® 3.3EC, 3.8 AC	Yes	Safe for use on many annual and perennial bedding plants.
Prodiamine	Barricade® 4FL, 65 WG	Yes	Can be applied over-the-top of hundreds of ornamental species
Trifluralin	Treflan 5G	No	One of the safer herbicides for use in bedding plants but may not last as long as some other herbicides.
flumioxazin	Broadstar™ 0.25G	No	Long-lasting weed control. Do not apply to wet foliage or new flushes of growth.
Oxadiazon	Ronstar® 2G	Yes	Many newly transplanted ornamentals can be treated safely.
s-metolachlor	Pennant Magnum® 7.6 EC	Yes	Yellow nutsedge control. Safe on hundreds of ornamentals.
benefin + oryzalin	XL 2G	Yes	Can be applied to many established annual bedding plants.
pendimethalin + dimethenamid-p	FreeHand® 1.75G	Yes	Safe for use on many trees, shrubs, and bedding plants.
trifluralin + isoxaben	Snapshot® 2.5TG	No	Over 600 landscape plants on the label.
oxyfluorfen + oryzalin	Rout® 3G	No	Over 120 plants on label. Water in as soon as possible after application.

oxyfluorfen + pendimethalin	OH2® 3G	No	Safe on many woodies but do not use on bedding plants
oxyfluofen + trifluralin	Granular Herbicide 75 5G	No	One of the few herbicides with plumbago on label.

List of post-emergence herbicides labelled for use in landscape planting beds.

Common Name (active ingredient)	**Example Trade Name and Formulation**	**Application method**	**Remark**
Clethodim	Envoy Plus	Over-the-top	Controls grass weeds. Safe on many ornamentals.
fenoxaprop-ethyl	Acclaim® Extra	Over-the-top	Controls grass weeds. Safe on many ornamentals.
fluazifop-butyl	Fusilade® II, Ornamec®	Over-the-top	Controls grass weeds. Safe on many ornamentals.
Sethoxydim	Segment	Over-the-top	Controls grass weeds. Safe on many ornamentals
Imazaquin	Image®	Over-the-top	Pre- and postemergence control. Do not apply in areas where bedding plants will be planted.
Halosulfuron	SedgeHammer®	Directed	Good control of sedge species. Ornamentals should be planted for 3 months prior to application. Wait 4 weeks to plant in treated areas.
Sulfosulfuron	Certainty®	Over-the-top	Controls some broadleaf, grass, and sedges. If applying pre-plant, wait 14 days before planting ornamentals.

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CUT FOLIAGE FOR INDUSTRY

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The plants having exquisite and magnificent foliage find uses in various floral decorations like bouquets, wreaths, interior decoration and floral designs in both fresh and dried means. These plants having decorative foliage are also known as cut greens, cut foliage or florist greens. Various plants are used world over as foliage plants based on climate, utility and availability. Most of the tropical plants are famous for their cut foliage because of their faster growth, regenerability and decorative foliage. The foliage from tropical parts are being exported to different countries.

The cut foliage is used in various ways

- As fillers in floral arrangements.
- Highly decorative foliage are singularly used in arrangements.
- They are also used for softening floral arrangements.
- They complement and add the contrast to floral arrangements.

Although the foliage from many plants can be used as cut foliage, the following factors make a plant successful in cut foliage Industry

- Higher vase and shelf life
- Faster growth
- Higher productivity
- Faster regeneration after cutting
- Decorative and attractive foliage
- Hardy and resistant to pests and diseases
- Free from thorns and unpleasant odour and latex.

MOST IMPORTANT CUT GREENS IN THE GLOBAL FLORIST TRADE:

Asparagus, Ferns (*Rumohra*, *Nephrolepis* and *Polypodium*), *Eucalyptus,* Coniferous plants (*Podocarpous*, *Cupressus*, *Cypress* and *Thuja*)**,** Chamaedorea, Huckleberry (*Vaccinium* species), Salal (*Gaultheria* species) and*Pittosporum tobira*

MINOR CUT GREENS IN THE GLOBAL FLORIST TRADE:

Adenanthos, Adiantum, Agave, Alpinia, Alocasia, Amomum, Anigozanthus, Anthurium, Araucaria, Arbutus, Arundina, Arachniodes, Aspidistra, Aucuba, Azara, Banksias, Berzelia, Blechnum, Buxus, Calathea, Callistemon, Calocedrus, Camellia, Chamaecyparis, Chamaedorea, Cineraria, Cocculus, Codiaeum, Coprosma, Cordyline, Cotinus, Croton, Cryptomeria, Cupressus, Cyathea, Cycas, Cyrtomium, Dizygotheca, Davallia, Dodonaea, Dracaena, Elaegnus, Euonymus, Excoecaria, Fagus, Ficus retusa, Genista, Grevillea, Gynura, Hedera, Heliconia, Hosta, Laurus, Leucadendron, Leucospermum, Lophomyrtus, Livistonia Lycopodium, Magnolia, Maranta, Melaleuca, Meryta,Monstera Murraya exotica, Myrcine, Myrtus, Nandina, Nephrolepis Nothofagus, Oreopanix, Palms, Pandanus, Paxistima, Pleomele, Philodendron, Phoenix, Phormium, Phylica, Pittosporum, Polypodium, Polyscias, Pseudotsuga, Pteris,Rhapis, Rosmarinus, Ruscus, Rumohra, Russelia, Salix, Sarcococca, Schefflera, Syngonium, Weinmannia, Yucca, Zamia

CULTURAL PRACTICES

SOIL

Well drained soils rich in organic matter are preferable. The soil pH should be between 6 to 7 and extremes should be avoided.

CLIMATE

The temperature and light intensity suitable for the species should be there. Shade should be provided for successful cut foliage production under tropical conditions according to the requirement of species. Shade nets not only protect plants from high light intensities but also improve vegetative growth, yield, vase life and quality of cut foliage. Different shade levels modify microclimate, PAR, transmittance and canopy temperature and improve leaf area, fresh weight and harvest Index. Overall 50% shade level was found optimal in majority of conditions. Low temperature and drought are limiting factors for productivity of tropical foliage species. They should also be protected from frost.

Suggested Light levels for various foliage plants (Conover and Poole, 1990)

Light (Foot candles)	Plant species
1000-2000	*Anthurium, Calathea*
1000-2500	*Agalaonema, Chlorophytum, Fittonia*
1000-3500	*Maranta*
1500-2500	*Cissus, Dieffenbachia, Hedera, Pilea, Spathiphyllum*
1500-3000	*Chamaedorea, Epipremnum, Hoya, Nephrolepis exaltata, Peperomia, Philodendron scandens, Schefflera arboricola, Syngonium*
1500-3500	*Cordyline terminalis, Dracaena, Philodendron*
1500- 4500	*Polyscias*
1500-6000	*Sanseveria*
2000-3000	*Bromeliads*
2000-4000	*Dizygotheca, Dracaena fragrans, Monstera deliciosa*
2000-6000	*Ficus lyrata*
2500-4500	*Asparagus*
3000-6000	*Dracaena marginata, Pittosporum*
3000-8000	*Codiaeum variegatum*
4000-6000	*Chrysalidocarpus lutescens, Ficus benjamina*
4000-8000	*Araucaria heterophylla, Ficus elastica*

HARVESTING

Foliage is harvested after they attain maturity and maximum freshness according to the species. The harvested foliage should be kept in cool and shady place and should not be heaped. The harvested foliage should be thoroughly washed. The high value foliage is waxed for better shelf life.

PRECOOLING

Precooling is required to remove the field heat and for extending shelf life after harvest.

GRADING

The foliage should be thoroughly cleaned with water. Some of the exporters use wax to extend the shelf life of foliage. Diseased and discoloured leaves should be removed. The leaves are graded according to size and quality.

PACKING

Packing is done according to the requirement in pack rooms after washing and hydration. The packages are labelled and transported to the destination. In case of high quality and high grade foliage the leaves are packed in Individual sleeves. Storage temperature depends on the species.

SPECIALITY FLOWER CROPS

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Speciality flower crops are minor or lesser- known cut flower crops with high prospects but grown on a small scale to satisfy the market demands.Speciality flower crops mostly belong to the following genera.

- Heliconias
- Alpinias (Shell gingers)
- Costus (Spiralgingers)
- Etlingeras (Torch gingers)
- Hedychiums (Butterfly gingers)
- Hitchenias (Praying mantle gingers)
- Kaempferias (Peacock gingers)
- Curcumas (Hidden or Surprise gingers)
- Boesenbergias
- Globbas (Dancing ladies)
- Zingiber (Edible gingers)

HELICONIA - FALSE BIRD-OF PARADISE, PARROT FLOWER

Heliconia belongs to the family Heliconiaceae, which is a member of a larger taxonomic category called the order Zingiberales. Heliconiasare native to South and Central America. They are popular as ornamental plants and cut flowers because of their brilliant colours and exotic appearance. Their enhancing beauty has made them, a best landscape plant. They exhibit a wide array of colours led by red, pink, orange, yellow, green combined with different sizes and shapes. Due to its exotic appearance and brilliant colours, it fetches premium price in the market. Leaves of some varieties of heliconia are also sold as cut foliage for flower decoration. H. *psittacorum*and some of its hybrids (e.g. 'Golden Torch') are particularly promising because of their attractive flowers, long straight clean peduncles, prolific year-round flower production, excellent postharvest characteristics, and few pest problems. The inflorescences can be used in a manner similar to those of bird of paradise, but they are less massive and are therefore, easily incorporated into smaller floral arrangements. In India, West Godavari district of Andhra Pradesh, Kerala, Karnataka, Assam and other North Eastern states are the major producers of Heliconia.

TAXONOMY

Heliconias are the only genus in the Heliconiaceae family. The genus has about 200 to 250 species and many cultivars. Many species show potential as commercial cut flower crops.

Heliconiasderive their beauty from highly modified leaves or bracts. Colour varies from pink, red, orange, yellow and different combinations. The stalk length of Heliconia range from 0.5 to 3.0 m and Inflorescence size range from 10 to 50 cm. Depending on the variety, heliconiaswill range in height from 2-20 feet, often with extensive rhizomatous growth.

Heliconias are broadly classified as Erect heliconias and Pendent heliconias. Erect heliconiasstand straight with bracts pointing up whereas Pendent heliconiashang with bracts pointing down. There are four types of Inflorescences in Heliconia viz**.,** Inflorescence erect and in one plane; Inflorescence erect and in more than one plane;Inflorescence pendant and in one plane;Inflorescence pendant and in more than one plane.

Important species of Heliconia which show potential as commercial cut flower cropsinclude *H.stricta*, *H.rostrata*,*H.psittacorum*(cv.Goldentorch),*H. p*(cv. LadyDi),*H.p*(cv.Choconiana),*H. latispatha*,*H. bihai(*cv.Lobsterclaw*)*,*H.chartacea*(cv.SexyPink),*H.wagenariana*,*H.spp*(cv.Pink) etc.Heliconia varieties for cut flower purpose include*H psittacorum* 'Golden Torch',*H psittacorum* ' Lady di', *H psittacorum* 'Petra', *H. psittacorum* 'Jamaikan dwarf ', *H psittacorum* 'Kenya red', *H. psittacorum*cv. St.Vincents' Red, *H. psittacorum*cv. Choconiana, *H. psittacorum* 'Alan Carle', *H. psittacorum*cv. Parakeet. *H. psittacorum c*v. Sassy, H. 'Kathy', H 'Strawberiesand cream', *H. rostrata* 'Parrot's beak', *Heliconiarostrata* cv. *Ten Days*, *Heliconiarostrata,*H. 'Guyana', *H. wagneriana*, *H. latispatha* (latispathadistans), *H. bihai*cv. Lobster claw, *H.bihai*cv. Sexy pink, *H bihai*, *H. bihai* Schaefer, H. 'Temptress', H. 'Pedro Ortiz', *H. collinsiana*, H. 'She ', H. 'Prince of Darkness', *Heliconiametallica*, H. 'Tropics', H. 'Fire flash',H. 'Parakeet' , H. 'Yellow Parrot', H. 'Parrot' , H. 'Golden Torch Adrian', H. 'Golden Torch sunshine', H. 'Red Christmas', H. 'Irish', H. 'Firebird', H. 'Andromeda', *Heliconiahirsuta,,* H '*Kawauchi*' , *Heliconia* '*Rauliniana*' upright, *Heliconia caribaea,, Heliconia* '*Jacquinii*'etc.

DESCRIPTION OF IMPORTANT SPECIES AND CULTIVARS IN *HELICONIA*

HELICONIASTRICTA

*Heliconiastricta*has beautiful inflorescence resembling lobster claws. Colours are ranged from red, gold, orange, maroon and green singly or in combination These exotic tropicalsare ideal for small arrangements. Their inflorescence ranges from 5" –12" long and are not too heavy. Bucky, Dwarf Jamaican, Fire bird, Royal Tagami, Lobster claw etc. are some of the cultivars of *Heliconiastricta*

HELICONIAROSTRATA-HANGING LOBSTER CLAW

They are the traditional and most recognized heliconias. They have magnificentpendant inflorescence of alternating bracts each 6 –10 cm long, scarlet red tipped with cream to yellow. A deep red colour covers most of each bract with yellow green tips. They bloomyear-round and areone of the hardiest varieties. They have downward-facing flowers, the flowers thus providing a source of nectar to birds.

HELICONIAPSITTACORUM

The *psittacorum*(or parrot's beak) heliconiasare small, dainty and exotically tropical in nature. They resemble the plant known commonly as Bird-of-Paradise. Flower heads appear to be hand painted. Flower heads glow with brilliant colours and greenish yellow flowers with black spots near apex. They bloom abundantly throughout the year.Andromeda, Lady Di, Sassy, Golden torch etc.are some of the cultivars of *Heliconiapsittacorum.*

HELICONIALATISPATHA

They have erect inflorescence with well separated boat shaped bracts. Inflorescence is orange yellow at the base and red towards tip. Flowers are greenish in colour. They are native to Central and South America.

HELICONIABIHAI

They are commonly known as Wild plantain/ Fire bird. They have greenish yellow flowers clustered in the axils of large stiff boat shaped crimson red flattened bracts with pointed tip and are arranged in two ranks on erect inflorescence.

PROPAGATION

Heliconias are propagated vegetatively by using rhizomes, side shoots and suckers arising from the mother plant.Each sucker produces around 20-40 side suckers in one year of planting depending on the variety. Hence, cultivation of heliconia for planting material is also profitable since suckers are sold at a cost of `Rs. 30 to 250 -5000 depending on the variety. A well grown sucker with sprout is the ideal planting material in Heliconia.

CLIMATE AND SOIL

The optimum temperature for growth of Heliconia is 21-35^{0}c. They love the shade and can also be planted as intercrop in coconut or arecanut plantations. Soil should have a good moisture holding capacity and slightly acidic.

LIGHT

Growth and yield of Heliconia are improved under more light intensity. More light intensity penetration increases the flower production and yield will be 4 times more than 63% shade.Under lower light intensity, bract colour is slight intense. Shade grown plants will be taller and weak and productivity will be low.

SPACING AND PLANTING OF HELICONIA

Heliconiasare fast growing plants with more number of side suckers there by drawing water and nutrients continuously from the soil. For easy management and flowering, it is planted at a spacing of 1.5m x1.5m. Pits of 1.5-2 cubic feet is made and filled with well decomposed organic manure for better rooting. Immediately after planting, plants are watered thoroughly for better establishment. Generally, it takes about 30-45 days to get the sucker to establish. Hence periodic watering is important.

INTERCULTURAL OPERATIONS

Suckering is the important phenomenon of heliconia. Hence nutrition has to be maintained for better suckering and flowering. Generally, NPK at the ratio of 40:20: 20 g / m^2 /year in the basins of heliconia plants gave maximum response for flower weight, leaf area and all vegetative characters. Application of well decomposed FYM @ 4 kg / m^2 or green manure has beneficial effects on flower and sucker production in heliconia.Weeds in young heliconiaswill need to be manually removed in the first few months. In mature stands of Heliconia, weeds are not a problem.

FLOWERING

Generally, heliconia starts first flowering at 6-8 months after planting depending on the variety. Around 10-15 flowering suckers/clump/year could be produced depending on the variety.

HARVESTING

Heliconia flowers are harvested when 3-4 bracts are already open. Flowers are harvested with peduncles of 70 cm long with leaf. Erect and pendulous terminal inflorescence are found in Heliconia.Bracts are colourfuland boat shaped with up to 20 florets/ bract. Flowers are harvested-in the early day when turgid. Mid-day harvest results in poor post-harvest life.Inflorescence of Heliconia last longer if harvested from well irrigated field. If it is for long distance transport, the leaves are removed and flower spikes are properly packed in CFB boxes with cushioning material.

YIELD AND INCOME

On an average, 600-700 plants of heliconia can be planted in one hectare. Each clump of heliconia can produce 5-10 flowering suckersin one year. The average price of heliconia flower ranges from Rs.5 to Rs.20 depending upon the variety. Hence a minimum income of around 25,000/ha to maximum of 90,000/ha can be realized depending upon the variety of heliconia planted. In addition to flower, production of sucker is also an important income generation activity. Sucker production depends on the variety and it ranges from 15-35 suckers per clump. Even 5-10 suckers per clump has to be periodically removed to maintain the spacing and lighting for plants. Average price of sucker is around Rs.20-50 depending on variety. An average of Rs.10/sucker can yield up to Rs.50, 000/ha through sale of sucker and it will be an additional income to the farmers. The yield per sq.m in Heliconia is 60 to 120 marketable stems/m^2 /year, depending on variety.Average yield is assumed to be 80 stems/m^2 .

USES OF HELICONIA

Heliconia is popularly used as a cut flower because of itsbrilliant colour, exotic form, long straight peduncles and excellent post-harvest life. They can also be used in the landscape for gardening purpose.The species like *Heliconiapsittacorum, Heliconiastricta, Heliconiaangusta,* cv. Golden torch etc. can be used as potted plants as well inthe Interior landscape. Leaves are used as cut foliage.

***ALPINIAPURPURATA*– RED GINGER**

Alpinia purpurata belongs to the family Zingiberaceae, which is a member of a larger taxonomic category called the order Zingiberales. They are commonly known as red ginger. It has evergreenfoliage. The plant grows to a height up to 12 ft and width up to 3 ft. The peak flowering period in *Alpinia purpurata* is during early summer to late summer.

SOIL REQUIREMENT

Alpinia purpurata prefers a well-drained fertile soil. The growth is best under porous sandy loam to clay loam soils. The optimum soil pH for its growth is 6 -7.5. Soil should have a good amount of organic matter.

CLIMATIC REQUIREMENT

Being a tropical plant, *Alpinia purpurata*can tolerate temperatures up to 30^{o}C.Partial shade is required for optimum flowering. It can grow up to an elevation of 1500 ft.

PROPAGATION

Alpinias are propagated by offshoots, rhizomes, seeds and micropropagation.

SEED PROPAGATION

Seeds are rarely produced in *Alpinia*.Sow seeds shallow in a moist, slightly acidic, well drained organic medium. Seeds germinate in 2–3 weeks period.

RHIZOME PROPAGATION

Divide the rhizomatous mat into small clumps of one to four stems.Plant them 2 inches below the surface in vermiculite or any well drained medium.Rhizome propagated plants of Alpinia typically produce marketable flowers within a year.

OFFSHOOTS
Alpinia inflorescences develop aerial offshoots (small plantlets) from the sides of the bracts (the bract axils). Rooting of offshoots is improved with 500 ppm auxin (IBA or NAA), although they can be rooted without hormone treatment.

PLANTING
First prepare the bed by ploughing to a fine tilth. Sterilize the bed by applying Dazomet @ 30g/sq. m. It can be planted at a spacing of 30cm x 30 cm. Around 40 plants could be accommodated in beds of size 3x1m.Closer spacing increases yield / unit of production area, but yield per plant is reduced whereas less dense plantings permit greater per-plant yields.

MANURING AND FERTILIZATION
The recommended basal dose for cultivation of *Alpinia purpurata* is 10 to 15 tons of FYM/ha along with 75:75:50 kg/ha of NPK. Increasing nitrogen fertilizer increases the number of marketable flowers.

IRRIGATION
Alpinia purpurata requires 1 inch or more of water per week from irrigation during droughty periods. Always keep the soil moist. The best flower quality is achieved with generous irrigation.

PRUNING
Pruning should be practised in *Alpinia purpurata*to remove spent flowering shoots and yellowed and unsightly foliage. Cut off spent flowers at the ground.

HARVESTING
Inflorescences are harvested in the early morning while still turgid. Harvest bracts which are about two-thirds to three-fourths open, as an immature flower has a longer shelf life than a mature flower. Floral spikes are harvested about 4 - 5 months after stem emergence. Production is year-round, greatest number of flowers is produced during summer months.

GRADES AND STANDARDS
For Standard grade, an inflorescence length of 6 inches is preferred.

STORAGE
Store red ginger at 12.5-15°c.Make sure that the flowers do not exhibit chill damage symptoms such as off coloured (greyish or bluish) blooms.The inflorescence has a strong geotropic response and should be stored upright in water to avoid bending. A holding solution of 2% sucrose (w/v) is recommended. To maintain the best quality, the relative humidity should be greater than 90%.

PACKING
Allow flowers to air-dry before packing. Stems are packed flat, singly or bunched, in standard or insulated fibreboard boxes or cartons.Single stems are layered in rows in the box. Bunches may be wrapped in a polyethylene film, or moistened, shredded newspaper may be packed around bunches, with unshredded newspaper separating the layers.

SHIPPING

To prevent geotropic bending during shipping, it is preferable that the boxes be kept upright, so that the stems are in a vertical orientation. Holding temperature should not be lower than 15^{o}c.

USES OF RED GINGER

It works well in tropical-theme landscapes. It is useful as a tall informal hedge or screen. It is a good backdrop or foundation planting, especially in front of blank walls. It can be used as a shrub border in mass plantings or as a specimen plant. It can be harvested as a cut flower.

OTHER SPECIES OF *ALPINIA*

Alpiniazerumbet, Alpiniagalangal, Alpiniacalcarata, Alpinianigra, A. vittata Bull., *A. conghigera, A. malaccensis*and *A. smithiae*are other important species of Alpinia.

ETLINGERAELATIOR- TORCH GINGER

Torch Ginger is also known as torch lily, wild ginger or Philippine wax flower. It belongs to the family of Zingiberaceae. It is native to Malaysia and Indonesia. Torch ginger is a herbaceous clumping plant that can be propagated sexually (seeds) and asexually (rhizomes). Torch ginger inflorescence consists of three colours viz., red, pink and white.*Etlingeraelatior* grow like typical Alpinia gingers, with canes that rise from the ground and flat lance-shaped leaves on the top of the cane, standing upright. Flowers emerge from roots on shorter stalks that cluster around feet of larger leaf canes. Flowers have red / pink / white waxy flower bracts.

GROWING CONDITIONS FOR TORCH GINGER

They prefer bright light.They are water lovers and need to be kept continuously wet. Provide good drainage to prevent root rot.

PROPAGATION

Propagation of Torch Ginger is by root division. Divide a viable piece of root with at least 3 growing nodesand place into rooting medium. Water consistently and lightly until new growth starts to emerge.

FLOWERING

It takes about 12 months after planting to start flowering. The red/ pink/ white portion of the torch ginger inflorescence is actually the bracts. The true flower is cone-shaped and appears between the large waxy bracts. It is an excellent ornamental and landscaping plant in urban areas. The extravagant and showy inflorescence is used as a cut flower.

COSTUS SPECIOSUS - CREPE GINGER

Costusspeciosus is commonly known as Cane Reed / Spiral Flag / Crepe Ginger / Spiral Ginger / Malay Ginger / Setawar/ SetawarHalia/ White Costus/SetawarTawar/ Wild Ginger. It belongs to the family Costaceae.Costus is native to Indo-Malayan region. In India the plant naturalizes in Sub-Himalayan tract, in parts of central India and in the Western Ghats of Maharashtra, Karnataka and Kerala.There are two varieties of *C.speciosus viz.,*nepalensis found only in Nepal and Arunachal Pradesh and var. argyrophyllus having wide distribution in India.*Costus speciosus* have broad, lanceolate, dorsally silky leaves, borne spirally on stout, erect or sometimes ascending stems.The flowers are white, with a large incurved lip.These are clustered in terminal globose heads characterized with large and shiny brown or red bracts.*Costusspeciosus*perenniatesthrough underground rhizome which lies a few centimeters below the soil surface. Stems sprout during the month of April, flowering commences during July and continues till the end of September. The fruits ripen during the middle of November, after which the leaves are shed and majority of the canes start drying up. The underground portion remains dormant from December to March.

SOIL

They are grown on a variety of soils ranging from coastal alluvium to heavy brown forest type. It grows more luxuriantly on alluvial soils having sandy to clay loam texture with a pH of 5.7-7.5.

CLIMATE

It can be grown from sea level to about 1500 m elevations. But the areas situated at elevations between 400 and 600 m above mean sea level and having a subtropical climate with rainfall ranging between 1000-1500 mm bear good quality material.High humidity and minimum temperature of 13° C is best for its cultivation.

PROPAGATION

Costus can be propagated by seeds, stem cuttings and rhizomes. Commercially it is propagated only through rhizome cuttings. Rhizomes have a number of nipple shaped buds. Formation of buds on the rhizomes is poor during April. Cuttings of rhizome pieces for propagation should have at least two viable buds. The rhizome pieces weighing around 40g should be selected for planting.

LAND PREPARATION

Land is ploughed 2-3 times and soil is brought to a fine tilth. FYM at the rate of 15 tonnes is applied and mixed well with the soil. Furrows are opened at 50 cm apart.

PLANTING

Best period of planting is from 3rdweek of April to 3rdweek of May. Rhizome pieces are placed at a depth of 8-10 cm taking care to place eye buds facing upwards, horizontally in rows 50 cm apart and covered with soil. The crop is irrigated immediately after planting. After 70-75 days about 90-95 percent sprouting is obtained.

MANURES AND FERTILIZERS

It is a rhizomatouscrop and to compensate the biomass production, heavy manuring is required. 45 kg N, 30 kg P_2O_5 and 30 kg K_2O along with 15 ton of FYM per hectare is the recommended dose of fertilizers. The farm yard manure and half dose of phosphorus and potash are applied in 2 split doses at 20 and 60 days of planting, the remaining half dose of phosphorus and potash is given along with the second dose of nitrogen after 60th day of planting.

IRRIGATION

The crop requires a liberal supply of water for successful growth. The crop planted during April and May requires to be irrigated at least two to three times a month till the outbreak of monsoon.

OTHER SPECIES OF COSTUS

*Costuserythrophyllus***,** *Costusmalortieanus***,** *Costuspictus*etc. are other important species of Costus.

COSTUSWOODSONII (SYN: COSTUSSPIRALIS, ALPINIASPIRALIS, COSTUSPISONIS)

It is commonly known as Red Button Ginger, Scarlet Spiral Flag, Red Cane, Panamanian Candle Ginger, Indian Head Ginger, Dwarf French Kiss, Dwarf Cone Ginger.*Costuswoodsonii*isnative to Mesoamerica (Costa Rica, Nicaragua, Panama) and Colombia in South America.It isan ornamental perennial evergreen herb. Leafy cane-like stems emerge from its underground rhizomes. Being rhizomatous, it forms a decent clump and presents a dramatic cluster with elegant stems in various stages of growth and flowering. As typical of spiral gingers, the leaves spiral around the thick green stems which are normally upright but may sometimes be leaning and gently spiralled, creating a dense appearance. It grows 1.5-2 m in height and spread about 0.6-1 m wide.Dwarf cultivars of *Costuswoodsonii* are 'Dwarf Lipstick', 'Red Button' and 'French Kiss'.Red Button Ginger flower profusely throughout the year in tropics and other warmer regions. In fabulous contrast with the green foliage, lipstick-red inflorescences appear at terminal stems. The flowering spike is made up of waxy red bracts, tightly overlapping like fish scales, to form an erect, cigar-shaped or torpedo-like flower head, 6-10 cm tall.Flowersare true reddish-orange with inconspicuousorange-yellow labellumwhich peek out one at a time from between the red bracts, lasting for only a day per flower.

GROWTH REQUIREMENTS

LIGHT

It prefers filtered light to full sun. It tolerates partial shade to full shade but flowers best in warm and sunny locations.

MOISTURE

Water regularly and moderately. It enjoys a humid environment.Occasional misting is encouraged if the weather is too hot and dry.

SOIL

It prefers moist, fertile or humus-enriched and well-drained soil. It is salt-tolerant and known to grow well near the beach.

PROPAGATION

It is propagated by rhizomes, division of clumps, plantlets, or stem cuttings. Prune off the whole stem with its spent flower head and subdivide into cuttings for propagation.

USES

It adds beauty and charm in perennial beds and borders or as an exotic garden / landscape specimen.Its compact and small stature make it very ideal for container gardening or in raised planters to decorate homes, patios, decks, as well as entrances to hotels, shopping malls and other commercial buildings. Its eye-catching and long-lasting inflorescences will be splendid as cut flowers in floral arrangements and thus greatly valued in the floral industry

***HEDYCHIUM* – BUTTERFLY GINGERS**

Theorigin of butterfly gingers is in NE India and Himalayan region. Approximately 50 species are reported from *Hedychium.* It has high ornamental value. Flowers of butterfly gingers often possess very strong and pleasant smell.*Hedychiumwardii (*Yellowbutterfly ginger) and *Hedychiumcoronarium* (White butterfly ginger) are the popular species.Butterfly Ginger is one of the nicest gingers for the home landscape. Its fragrance is so enjoyable.Purewhite, showy flowers emerge from one large bud at the tip of each unbranched stem. Each flower lasts about one day. Several hundred flowers can appear from each bud during a 6-week period. Each stem grows to about 5-feet-tall. These herbaceous perennials spread by underground rhizomes, often forming dense clumps of multiple stems. Large, simple leaves are borne on either side of the thick green stems. Unfortunately, individual flowers do not last after they are cut from the plant.

PROPAGATION
Rhizomes can be dug any time and divided for propagation.

LIGHT REQUIREMENT:
Plant which grows in partial shade / full sun flowers best. Those in the shade often grow but few flower buds are produced.

PLANT SPACING: 60 cm to 90 cm

USES
It is used for Border planting; mass planting and are also suitable for growing indoors.Butterfly Ginger can be placed near a walk or window so that the fragrance can be enjoyed. The foliage texture makes them nicely suited for creating an accent in a shrub border when it is not in flower.

***ZINGIBERSPECTABILE* - BEEHIVE GINGER**
The plant is popular for its inflorescence. Inflorescence is attractive in garden and as cut flower in floral arrangements**.** Beehive ginger is erect, from 6-8 feet tall, and the inflorescences are basal. The bracts are pale yellow in a young inflorescence, becoming red as it matures, especially if it gets some full sun. It needs moist environment, avoid the soil becoming totally dry. It works great in floral arrangements when combined with heliconias and foliage.It can be propagated by division, stem cuttings and seeds.All parts of the plant have a strong gingery fragrance. Fresh flower will last 7 to 10 days in clean water.Flowering is during July through November.

***STRELITZIAREGINAE*– BIRD OF PARADISE**
Bird of paradise is a plant with a marvelous combination of distinctive shapes and brilliant colours. Bird of Paradise is native to South Africa. It is closely related to the banana. It is a tropical herb that is a member of Musaceaeor the Banana family. It is a majestic crop grown on regions having moderate subtropical climate. Its name comes from the spectacular and unique flower shape. The flower resembles a brightly coloured bird in flight. The bird of paradise is a spectacular blossom. The showy bloom is actually a combination of blue petals and orange sepals that emerge from a beak-like bract (modified leaf). Long stemmed flowers emerge from green boat shaped bracts which are bordered in red or purple. The numerous pointed petals of brilliant orange are contrasted with an arrow-shaped tongue of vivid blue. The plant forms a 3-to 5-foot-tall clump that can be used as a focal point in landscape or in mass plantings.It requires a good amount of sunlight. The plant is trunkless, compact and clustering but slow growing with fleshy roots. It has a banana shaped stiff-leathery, concave, bluish gray leaves with a pale red midrib. The leaves are attached to a long stalk that sometimes reaches up to 2 feet in length.

MANURES AND FERTILIZERS

The plant should be fertilized according to the growing conditions. Most Bird of Paradise flowers is under fertilized. Bird of paradise responds well to INM. Application of 110:35:70kg of NPK/ha/year plus FYM in 4 splits Jan, April, July and Oct enhances growth. Plants applied with 75 g N, 20 g P_2O_5 and 25 g K_2O/ m^2 was found best treatment for most of the parameters viz., maximum plant height, leaf blade length, leaf blade breadth, leaf stalk length, number of leaves per plant, plant spread, flower spike length, vase life of flowers. Overwatering especially in winter will lead to root rot which will spread just above the surface.

Bird of paradise is an easy to grow crop in garden. It exhibits a slow growing habit-forming clump plant. It grows well in sunny to semi shaded areas. It is wind resistant but sensitive to cold temperature. It is a hardy crop. It can come up well in all types of soil and climate form dry to cold weather.

PROPAGATION

The plant is propagated through division of clumps, suckers, seeds and tissue culture.

Under natural circumstances the birds pollinate the flowers. Germination is a slow process, it takes 1-2 months. So, it is commercially propagated through divisions. Clump divisions flower faster.

SPACING

Suckers of Bird of Paradise are planted at a spacing of 1.5 m X 1.5 m. Best planting season is during monsoon, August -September.

FLOWERING

Bird of Paradise flowers after one year of planting. The average yield is 6-8 flowers per plant per year.

CONCLUSION

Cultivation of speciality flower crops is increasingly regarded as a viable diversification in Floriculture due to increased per unit returns. Speciality flower crops are one of the most successful components of diversified horticultural industry. It has emerged as a major diversification option in Floriculture industry.

TURF GRASS MANAGEMENT

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The term 'Turfgrass' refers only to the plant itself, whereas 'Turf' includes a portion of the medium in which the turfgrasses are grown. Turfgrasses are used for a variety of purposes. Utility turfs exist to stabilize the soil, reduce dust and glare and absorb pollution from road traffic. Turfgrasses are the most important feature on golf courses, athletic fields and other sports fields requiring a resilient playing surface. The word turf (torf, torfa) is derived from **Sanskrit word 'darbhus'** meaning a turf of grass. The word lawn originally meant "an open space between two woods" and later "an open space covered with grass". The word in its present sense appeared in USA after civil war and has replaced such a term as "Front meadow", "grass yard", "home green", "yard way" or "homestead meadow".

A turf is a piece of the upper soil layer with the matted vegetation growing on it. An interconnecting community of turfgrasses and the soil adhering to their roots and other belowground organs form a turf. The term **turf** and **turfgrass** are thus different in that one are refers only to plant community (turfgrass), while other represents a higher level of ecological organization (turf) by including a portion of the medium in which the turfgrasses are growing. When the surface layer of the turf is harvested for transplanting it is called 'sod'.

Lawn turfs serve a decorative function by enhancing the beauty of a landscape and providing areas for recreational play. It is a natural green carpet. Being an important feature of landscape a garden, without a lawn it is not considered complete. Today growers offer hundred of selections for landscape designers who envision their backyard canvases swept with fulsome grasses.

CHARACTERISTICS OF IDEAL TURF:

1. It should remain fresh and green throughout the year.
2. It should be cold or drought resistant.
3. It should not look patchy.
4. Quick growing and should persist regular mowing.
5. Soft to touch.
6. Not giving fowl or bad odour.
7. Tolerate to diseases and pests.
8. Tolerance to smog, salinity, compaction, cold traffic (wear) and other environmental adversities.
9. Adapted to a wide range of climatic conditions.

SELECTION OF TURF

Turf selection is a key for the successful management of turf as per the purpose, environment, shade, soil type, water availability, quality of water as well as budget. Turfgrasses grown for their aesthetic appeal, moderate maintenance and moderate to high quality are placed in the lawn turfgrass category. Sports turfgrasses function as athletic or recreation play surfaces, generally receive high maintenance, and are of high quality.Warm-Season grasses are of tropical origin and can thrive during the scorching summer heat. They are tough, resistant to drought, disease and insect attacks but susceptible to the cold spells of winter.Cool-season species grow well in cool temperatures range between 15° to 24°C. A typical growing season starts with a flush of growth in the spring, then slowed (sometimes to dormancy) in the summer, followed by another flush of growth in the fall. Cool season areas have cold winters with temperatures that fall below freezing and having warm/hot summers. These types of grass turn brown during the hot seasons. The description of different turf is given in the below table.

Common Name	Botanical Name	Region/Climate	Special Traits	Use and Utility
Kentucky bluegrass	*Poa pratensis* L.	Temperate	Broad adaptation, apomixes	Lawns, Sports, Golf
Perennial ryegrass	*Lolium perenne* L.	Temperate	Rapid establishment, Broad adaptation	Lawns, Sports, Golf
Creeping bentgrass	*Agrostis stolonifera* L.	Temperate	Low growth habit, aggressive spreading	Golf
Tall fescue	*Festuca arundinacea* Schreb.	Temperate	Broad adaptation, drought tolerance	Lawns, Sports, Golf
Creeping bentgrass	*Agrostis stolonifera* L.	Temperate	Low growth habit, Aggressive spreading	Golf
Bermuda Grass	*Cynodon dactylon* (L.)	Tropical/ sub-tropical	Aggressive spreading, drought tolerance	Lawns, Sports, Golf, Low maintenance areas
Zoysia grass	*Zoysia japonica*Steudel; *Zoysia matrella* (L.) Merrill	Tropical/ sub-tropical	Dense sod, slow growth rate	Lawns, Sports, Golf, Low maintenance areas
Centipede grass	*Eremochloa ophiuroides* (Munro) Hack.	Tropical/ sub-tropical	Low-fertility, acid-soil, and drought tolerances	Lawns, Low maintenance areas
Seashore paspalum	*Paspalum vaginatum* Swartz	Tropical/ sub-tropical	Salt and drought tolerances	Lawns, Sports, Golf, Low maintenance areas
St. Augustine grass	*Stenotaphrum secundatum* (Walt.) Kuntze	Tropical/ sub-tropical	Aggressive spreading, shade Tolerance	Lawns, Low maintenance areas
Bahiagrass	*Paspalum notatum* Flugge	Tropical/ sub-tropical	Drought and low-fertility Tolerances	Low maintenance areas

TURF ESTABLISHMENT

Establishing a durable lawn requires soil testing and proper site preparation. The initial investment in site preparation should be considered over the many years that a field provides recreational use. For example, improper root zone construction and grading inhibits the movement of water away from the surface and consequently increases the duration of wetness of the lawn particularly during wet weather. This condition leads to more rapid deterioration of the lawn. The major points to be considered when establishing turfgrass are given below:

A. GRADING

All rough debris including large stones, parts of tree branches and roots, etc. must be removed. Unless sand-based root zone construction is used, a gentle sloping grade (1 to 1.5% slop) away from the central is strongly recommended; this is often referred to as "crowning" the field.

After soil preparation, it is mandatory that turfgrass should be established as quickly as possible as if left bare, it will be subjected to water and wind erosion along with weed encroachment. Lawn grasses can be propagated by both sexual and asexual means but asexual methods are widely adopted as it takes less time to establish properly.

B. SOIL PREPARATION

It is very important to prepare the soil properly by using the steps given below before seeding or sodding.

1. Soil testing:

Any field that is being prepared for seeding or sodding should be sampled for soil testing. Applications of nitrogen (N), phosphorous (P), potassium (K) are recommended whereas other nutrients can be obtained from soil. Once established, sampling a field every year is generally sufficient to monitor soil pH, N, P and K levels, however, it is advisable to sample soil before any reseeding or over seeding.

2. Liming:

Proper liming is essential for vigorous and healthy root and shoot growth of turf. Applied fertilizer and other soil nutrients are used more efficiently by the germinating turfgrass seedlings or newly transplanted sod when the soil having proper pH (6.5 to 6.7). The adjustment of soil pH is considerably more effective if materials are incorporated into the soil before seeding rather than after seeding with surface applications. Thus, it is vital that soil testing be performed before seeding so that proper amounts of lime can be incorporated into the soil during the preparation of the field for seeding or sodding.

Note: lime, P and K can be applied and incorporated in the soil at the same time.

Applying the recommended amount of lime, phosphorus and potash fertilizer and incorporate uniformly into the soil (6 to 8 inches deep), prior to the deepest tillage operation (*i.e.* moldboard plough).

C. INCORPORATION OF PRE-PLANT FERTILIZERS

Soil requiring extensive changes in pH, phosphorus and potash levels deep within the soil profile (greater than two [2] inches) but nitrogen should apply at upper level. Placing nitrogen too deep within the soil profile increases the probability of leaching which is undesirable.

After incorporation of lime for pH maintenance, nitrogenous, phosphorus and potash fertilizer, or a "starter" fertilizer is recommended after soil testing. Out of the total amount of pre-planting fertilizer application, 30–60% of N should be given from slowly available nitrogen source. Slowly available forms of N include sulphur-coated urea, IBDU, methylene urea, polymer coated urea, or natural organics. Surface fertilizations of N that are lightly tilled (incorporated no more than two inches) should be applied separately once with deep incorporation of lime, P and K and before seeding. After the emergence of seedlings, surface applications of N are applied when decline in shoot color, growth and vigor is evident.

D. SOIL AMENDMENTS

These include peat moss, high quality composts, bio solid products, sand, gypsum, lime, etc. are best considered during the development of specifications for the initial construction or re-construction of a field. Very sandy or finer-textured (clay) soils often benefit from the addition of organic matter to improve physical and nutritional properties of the soil and it also provides more rapid turfgrass establishment.

1. Seeding
2. Dibbling
3. Turfing / sodding
4. Turf plastering
5. Hydro-seedling
6. Astro – turfing

TURFGRASS MAINTANANCE

Cultivated turfgrass is a pervasive feature of the urban landscape in the developed regions of the world. Turfgrass provides at least three major benefits to human activities: functional, recreational and ornamental. Functional uses include wind and water erosion control, thereby reducing dust and mud problems surrounding homes and businesses. Metropolitan areas and suburban residences profit from the cool, green pleasant environment afforded from healthy lawns, with landscapes frequently complemented by numerous trees, flowers and shrubs. Ornamental or aesthetic attributes of turfgrass are also highly regarded. Properly landscaped homes and businesses may also benefit financially from higher resale values when compared to poorly landscaped residences.

The most common turfgrass used in tropical and subtropical regions of our country is *Cynodon dactylon* or doob. Among cool season grasses the genera *viz., Poa, Festuca, Agrostis* and *Lolium* holds important position. The green colour of lawn serves as contrasting background to colourful flowers in the garden. The pre-existing lawns maintenance is a very tedious work if one requires the lawn to be lush green throughout the year.A beautiful lawn starts with preparation and selecting the right grass. Proper maintenance keeps it growing and looking its best. The condition of lawn depends on the selection of variety as much as on good management.

The most important practices of management are discussed below:

A. Irrigation: Proper watering techniques are a critical aspect of lawn watering, equal in importance to the issues of when to water and how much to water.It is often said that many turfgrass problems may be attributed to improper watering.Select sprinklers and systems for uniformity of coverage across whatever area they are designed to water. Sprinklers that do not throw the water high into the air usually are more efficient. The prevailing winds are less disruptive of distribution patterns and the potential for evaporation loss is reduced.Water should never be applied at a rate faster than it can be absorbed by the soil. The amount of water to apply at any one time will depend upon the water-holding capacity of the soil, the amount of moisture present when irrigation is started, and drainage.A sufficient amount of moisture should be applied to insure that the entire root zone will be wetted.The frequency of irrigation depends on the type of grass, the soil's physical properties, and the climatic condition, especially rainfall, humidity, temperature, and wind movement.On most general turfgrass areas, the time to apply moisture is just as the plants begin to wilt.The exception is on newly seeded areas which must be kept moist during the period the seed is germinating and seedlings are becoming established. Frequent, shallow watering tends to keep the upper layers of soil near a point of saturation most of the time. This encourages shallow rooting and promotes weak turf which is susceptible to disease and insect attack as well as damage from traffic. The best time to water your lawn is the early morning because the sun will help dry the grass. Night-time watering can result in prolonged moisture on the blades, which can open the door for some diseases.

B. Weeding: Weeds are the biggest menace to a beautiful lawn. Weeds in turfgrass cause reduction in turf growth and quality due to competition for nutrients, light and water. Weeds also detract uniformity and beauty of lawns due to the distinct contrast in colour and texture between the desired grass plants and weeds. Weed proliferation should be avoided by purchasing pure planting material free of weed seed, by pre-treating the lawn area with herbicides before planting but after planting the only way out is regular hand weeding.

C. Rolling & Mowing: It is the most important practice for a visually pleasing and well trimmed lawn. Mowing improves turfgrass appearance and uniforms its surface by periodic removal of a portion of leaves or tillers. The objective of light mowing is to help the grass anchor itself firmly and keep the surface levelled. Accordingly, proper cutting height and mowing frequency must be defined in order to maintain an attractive and vigorous turf. Never remove more than 1/3 of the grass blade length at any one time. A healthy lawn can survive an occasional close cut. Repeated close mowing produces a brown lawn and has several harmful side effects. Cutting height may extremely vary (from ≈0.3 up to 10 cm) on the basis of the intended use of turfgrass, species/cultivar and the period of the year. In addition, mowing frequency should be tailored to the shoot growth rate of the turf and environmental conditions by avoiding single removal of more than 30–40% leaf tissue. Mowing interval is expressed as number of days between successive mowing and is dependent of the increase in culm length of the turfgrass. Very frequent mowing can result into less rooting, reduced rhizome and shoot growth, depleted carbohydrate reserve and increased shoot density and succulence. Rolling is important for rhizomatous roots to get proper anchorage on the ground and also in levelling. There are many patterns by which a lawn can be mowed.

D. Fertilizer application: Chemical fertilization is the most common means of supplying turfgrasses with their nutritional requirements as inorganic fertilizers are the sources of nutrients available instantly to the plants. Inorganic fertilizers have been used in various forms to improve the productivity of the growing soil. Careful consideration of the nutritional requirements of the turf, based on soil fertility, expected quality of the turf, use of the turf, suitability of the growing environment, grass species and varieties present, and available management resources is a must for proper nutrient management. The necessary nutrients needs to be added at proper timing (late summer, late spring for cool season, late spring to midsummer for warm season) proper application rate, proper material selection and proper placement. In today’s world, need of the hour is reduction of fertilizer application to the lowest possible level to maximize efficient use of nutrients by the plants in the turf system while eliminating waste and minimizing nutrient loss. Awareness of the potential for adverse impact from nutrient contamination on precious natural resources, particularly water, from off-site movement of nutrients due to factors such as misapplication, runoff, erosion and leaching. In general, top-dressing refers to application of thin layer of manure or fertilizers, but in case of turf management, it refers to the distribution of a thin layer of soil over turfgrass area. After spiking, raking or scrapping, the turf should be top-dressed with the mixture of well-rotten FYM and loamy soil in a proportion of 1:1 of 1 cm thickness. After top-dressing, sprinkled with a hose is advisable. Top dressings are often applied on newly established turfgrass.

E. Aeration: Aeration or aerification refers to the process of mechanically removing small plugs of thatch and soil from a turf area to improve soil aeration (coring, spiking and slicing). The aeration process is also commonly called core aeration or simply aeration.It helps in improved air exchange between the soil and atmosphere, enhanced soil-water uptake, improved fertilizer uptake and use, reduced water runoff and puddling, improved turfgrass rooting, reduced soil compaction, enhanced heat- and drought-stress tolerance, improved resiliency and cushioning and enhanced thatch breakdown. Equipment with hollow tines removes soil cores. Equipments having solid tines divot the soil surface. The turf should be spiked, raked or scrapped during February or September. Annual aeration is beneficial for most lawns. Lawns growing on heavy clay or subsoils, and lawns exposed to intense use benefit from more than one aeration each year. After proper watering to turf, spiking can be done by inserting fork about 10 cm deep at 10-15 cm interval. Tines at least 1/2 inch in diameter or more are suggested for severe compaction or thatch problems. Using a garden rake, raking of turf should be done after mowing and removing the grass clippings. Applying fertilizer after aeration helps the lawn compete against weeds. Water the lawn carefully after aeration, particularly in areas where drought and high temperatures are common.

F. Thatch control: Thatch control is most important practice for smooth and even looking lawns. Thatch is a layer of living and dead grass stems, roots and other organic matters. Thatch is developed due to imbalance of organic matter produced by the turfgrass and the rate of its decomposition. It depends on growth rate and growth habit of the turf along with its maintenance. Any species of grass that spreads by above ground stolons or below ground rhizomes develops thatch. e.g. *Cynodon* and *Zoysia* are prolific thatch producers. Some amount of thatch is necessary for some places like sport field but excessive thatch is always undesirable. Development of thatch is influenced by grass species, fertilization, soil pH, mowing height, pesticide application, frequency of racking and soil type. High fertilization and intensive maintenance develop moderate to heavy thatch.

Thatch can be controlled by soil-borne microbes and earthworm. Maintainance of soil pH, aeration and moisture can help to increase microbial activity that control thatch production. Efficient use of fertilizers, pesticides and irrigation water helps in reducing production of more roots and leaves. When thickness layer of thatch exceeds 1.5 cm, it can become problem and should be reduced by dethatching. One of the most common methods of thatch control is vertical mowing, sometimes called ‘verticutting’. The blades of vertical mower cuts vertically into the turf canopy, severing lateral stems and removing thatch that develops on the surface of the soil, then it is raked and removed. Dethatching should be performed at times of vigorous growth and should be avoided before anticipated periods of environmental stress such as drought. After dethatching, light fertilizer and irrigation should be applied for speedy recovery of turf.

Power rake – It is used for thatch removal. This is a lawn- mower type machine with tines instead of blades that rip the thatch out of the ground. Hand raking is then needed to remove the debris.

Vertical mower – Also called a verticutter which is similar to a power rake but cuts down through the thatch into the soil. A verticutter is better than a power rake if the plan is to overseed after thatch removal. It cuts deeper into the soil and therefore provides better seed-to- soil contact. Raking up the debris is neccesary before sowing the seed.

DRY FLOWERS – AN EVERLASTING ORNAMENTALS

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INTRODUCTION

Flowers are closely associated with mankind from the dawn of civilization. Flowers, the crowning beauty of God's creation, are inseparable part of human joy and sorrow. It is said that man is born with flowers, lives with flowers and finally dies with flowers. The scope of utility and importance of flowers have been realized throughout the world and in this modern age, floriculture has developed into a profitable industry. Floriculture has tremendous potential for export besides home consumption. There is an increasing demand all over the world for the decoration of living and working places with eco-friendly things like foliages and flowers. Fresh flowers and foliages though exquisite in their beauty are highly expensive, perishable and delicate in nature and cannot retain their beauty and fresh look for a long time in spite of using best chemicals for enhancing vase life. Moreover, fresh flowers and foliages are not available all round the year in all places. In this context flowers can be dried, preserved and processed to retain its beauty as well as everlasting value. Value added Floriculture is a process of increasing the economic value and consumer appeal of a floricultural commodity or product through processing or diversification.Value-addition ensures high premium to the grower and provides more acceptable quality products for the domestic and export market.

WHY USE VALUE ADDITION IN FLORICULTURE?

- Unstable prices in the market for raw commodities
- Changing consumer preferences
- Make more money by cutting out the middleman
- Utilization of the waste item to make some useful product

The surplus produce of their floriculture farms can be turned into value-added products to supplement their household income through the technique of dehydration / drying.The use of dried flowers has made it possible to enjoy their beauty for several years.

ADVANTAGES OF DRY FLOWERS

- Cheaper, economical and long lasting
- Range of products - eco-friendly and bio-degradable
- Year-round availability even in winter and off season.
- Survive hot summer and cold winter
- Not easily perishable - minimum upkeep and maintenance
- Minimizes the handling losses
- Offers wide range of suitable and striking colors
- Less transportation costs

Dry decorative materials are globally accepted as naturals since they are eco-friendly, long lasting and generally inexpensive. India exports dried flowers to the tune of 5% to world trade. Dried flower industry records a growth rate of 15% annually. Dried flowers are long lasting, can be used several times and also meet the decorative demand throughout the year. India, with its vast resources, varied products and experience in the field of dried flowers and plant parts enjoy a distinct advantage in the world export market. The country also enjoys the benefit of cheap labour and favourable climate as against other countries. The beauty and value of the dried flowers are that they can be kept and cherished for years, which survive the cold of winter and heat of summer. With growing eco-consciousness, the use of more and more nature-friendly things like these come as a natural choice for decoration. The life of dried flowers varies according to the species, texture of their petals and total consistency of flowers. Dried flowers can be effectively used for making decorative floral craft items for interior decoration and commercial exploitation.

FACTORS RESPONSIBLE FOR LOSS OF FRESH LOOK OF FLOWERS

- Microbial activity
- Ageing process

Hence the objective of dehydration is to reduce the moisture content.

PRINCIPLES OF DEHYDRATION

Preservation by dehydration is based on the principle of reducing moisture content by which chemical changes are brought to a standstill andmicroorganism growth are checked. The key to drying flower is to withdraw 50-90 percent water from the flowers without distorting the shape or destroying the appearance of flowers and foliage.

FACTORS AFFECTING DEHYDRATION

- Atmospheric humidity
- Airflow
- Temperature
- Embedding material
- Method of drying
- Moisture content of the flowers
- Type and shape of the flowers

STEPS IN DRY FLOWER PRODUCTION

1. SELECTION OF MATERIALS

Plants for preserving can be collected throughout the year. Flowers at different stages of development can be picked for drying purpose. Avoid collecting plants when they are wetor moist from dew. After cutting, strip the leaves from the stem, since foliage on the stems do not dry properly Almost all plant materials can be dried everything from flowers, foliage and branches to grains, cones, nuts, berries and other fruits. Select plant materials that are without pest or disease problems as any flaw in the bloom will be magnified in drying process. Stems, twigs, branches, bark, leaves/foliage, flowers, thorns/spines, fruits, cones,seeds, roots, lichens, fleshy fungi, mosses, selaginellas, ferns, *etc.* can be utilized for making various value-added floral crafts and flower arrangements which are non-perishable and have longer life indoors.

2. TIME AND SEASON OF HARVEST

Flowers should be picked as they reach their peak of bloom. If picked past their prime, when they start turning brown, flowers will continue the browning process and no amount of after care would prevent this. The best time to pick flowers is early in the morning on dry days after the dew has dried off. Too late picking should be avoided because the sun is too strong then and it can cause blooms to fade. It is best to cut the flowers and planting materials in the morning hours after the dew and surface moisture has evaporated from the plants. Avoid harvesting over matured flowers as they will generally shed upon drying and will not hold up well in arrangements. Use only plants and flowers free of insect and disease damage as the damage becomes more obvious after drying. Start the drying process immediately after plucking

3. METHODS OF DRYING

There are several methods of drying flowers. The quality and appearance of driedflowers and other ornamental plant parts isgreatly influenced by the method of dryingor the drying technique being followed.Various techniques involved for theproduction of dried ornamental plantmaterial includes air drying / drying under shade, press drying,embedded drying, hot air oven drying, microwave oven drying, freezedrying, or by the use of glycerine etc.

1. AIR DRYING

One of the easiest means of drying flowers is to air dry them in hanging bunches. Air drying is a very common method of drying where plant materials are attached to rope/wire and are kept in hanging position either in dark or in the sun for quick drying. Air drying requires a warm clean dark and well-ventilated area with low humidity. Air drying flowers is one of the easiest methods of preservation and gives plants a crisp look that lasts for years. One needs rubber bands and either paperclips or florist wire for air drying process. Cut flowers of good quality at prime conditions or slightly immature are suited for air drying. Remove foliage from the stems. Large flower heads should be hung individually. Most flowers can be dried on their stems. However, some flowers have a weak stem and hence a wire should be inserted before drying to support the flower. Group the stems into small bunch and tie with a rubber band. It will pull tighter as the stems shrink during drying. Hang the flowers upside down in a well ventilated, warm, dry, dark area. Avoid damp rooms or direct sun on the flowers. Good air circulation is important. The drying process normally takes two to three weeks. The flowers are then stored in airtight containers to prevent then from insects and rodents. Crisp textured flowers like helichrysum, helipterum, limonium, salvia, statice, gomphrena, golden rod, celosia, calendula, zinnia, larkspur, ornamental grasses etc can be easily dried by this method. Flower heads of hydrangea and gypsophilla can be dried by putting their stems in a little water. Blue and yellow flowers retain their colour when air dried but pink flowers fade. Air drying of flowers under shade may take from one to two weeks or more depending on the moisture content of the cut stems and relative humidity. Such air-dried flowers should be stored in an airtight container until ready to use.

ADVANTAGES

- Simple and cheaper method
- No special equipment

DISADVANTAGES

- Time consuming
- Weather dependent
- Shrinkage of petals
- Unnatural straight stems

2. PRESS DRYING

Pressed flowers are especially suitable for flower pictures, as well as decoration on note paper, cards and many other items. Most foliage and simple flowers with few petals press very well. Pansies are an excellent flower for pressing at all stages of flower development. Ferns make excellent pressed plants. Leaves and branches with foliage can be pressed to form plant materials with natural curve. In this process, the faster flowers dry, the better they retain colour. Flowers should not be exposed to excessively high temperatures because high temperature may turn the flowers brown.

COLLECTION FOR PRESSING

Flowers with different stages of development up to full maturity are used to get more variety in design. Plants with fleshy stems and leaves as well as flowers with very thin petals are avoided. Wilted materials are not pressed and flowers that are flat press best.

METHOD

- Flowers and foliage are sandwiched between layers of an absorbent material. This should be clean and hold the flowers firmly.
- Apply weight or pressure for at least 5 to 10 days or until the plants are dried.
- Place in a warm, well-ventilated place.
- After the first week, check the absorbent material for excess moisture, and replace the material if necessary.
- Reposition the flowers if needed.
- After drying store them in an airtight container.

ABSORBENT MATERIALS

Flowers are generally placed between a non-glossy type of paper. Newspaper, old telephone directories or catalogs are suitable. After placing the flowers in the folded books, stack them several layers deep. Place boards beneath and on top of the stack. Put the stack in a warm, dry place with a heavy weight on top. Another material suitable for pressing is cardboard. This forms a system including cardboard, newspaper and blotter pads. Corrugated cardboard is cut into sheets slightly larger than the sheets of folded newspaper. Flowers are positioned on one side of opened newspaper. Then the newspaper is closed and a sheet of blotter paper is placed on either side. Then the layers are stacked and tied or taped together and placed in a warm ventilated place.

Suited flowers and foliages for Press drying

Flowers	**Foliage**	**Ferns**
Pansy	Thuja	*Adiantum*
Ixora	Marigold	*Nephrolepis*
Mussaenda	*Cassia biflora*	Golden fern
Candytuft	*Casuarina*	Silver fern
Chrysanthemum	*Grevillea robusta*	
Euphorbia	Rose foliage	
Lantana	*Haematoxylon*	
Larkspur	*Calliandra spp*	
Pentas	*Taxodium distichum*	

ADVANTAGES

- Simple
- Retains colour

DISADVANTAGES

- Materials is in two-dimensional
- Brittle
- Time consuming

3. EMBEDDED DRYING

To overcome the problem of petal shrinkage, the flowers can be dried by embedding in desiccants. Embedding the flowers in a granular, desiccating material is probably the most commonly used method. Several materials are used as drying agents. All the agents used vary in cost and in the results, they produce. It is important to use the correct procedure when covering the flowers so that their form is maintained. The drying agent in the mixture helps support the flower while removing moisture, preserving the flower's shape and form. A good embedding material should have characteristics likefineness, inertness to water vapour, optimum weight and non-bleaching. Drying agents commonly used areSilica gel, Cornmeal, Borax, Common Sand, Alum, Perlite, Quartz sand, Sawdust etc.

BORAX

Borax detergent combined with cornmeal or sand is an expensive material for drying flowers. This mixture is used for flowers that are less stiff.

SILICA GEL

Silica gel is fairly expensive moisture-absorbing desiccant. It is an excellent product for drying flowers. It is lightweight, dries flowers faster than borax mixtures do and can be re used if dried properly. It must be kept in airtight containers at all times. Silica gels absorbs moisture and so the crystal in the gel change colour.

COMMON SAND

Clean sand can be treated to produce a product similar to oolitic sand. Builders sand should be washed. Put the sand in a bucket of water with a couple of squirts of liquid dishwashing detergent. Stir it and pour off the water. Continue to add fresh water until the added water remains clear. Then, dry the clean sand.

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METHOD OF EMBEDDING FLOWERS IN DESICCANTS

Plastic / Aluminium / tin containers are used for embedding flowers and foliages at room temperature in a well-ventilated room. About one-inch layer of the desiccating material should be poured into the bottom of container and the flower stems has to be pushed into the medium. After this step, desiccant has to be poured gently and gradually all around and over the flower up to 4 to 5 cm above, so as to fill all the crevices in between the petals without disturbing the shape of flowers. After embedding the flowers with desiccants, the containers have to be kept at room temperature in a well-ventilated room for dehydration

CONTAINERS

Flowers dried in borax mixtures should be left uncovered during the drying process. Low cardboard boxes with tight, strong bottoms are ideal. This allows air circulation. Flowers dried in silica gel must be placed in airtight containers because silica gel absorbs moisture from the air. Candy tins, plastic containers, coffee cans, large-mouth jars, or any other container with a tight-fitting lid may be used.

ADVANTAGES

- Retains colour and form
- Support the petals more rigidly
- Maintains shape on drying
- Avoid petal shrinkage

DISADVANTAGES

- Labour intensive
- Expensive

4. HOT AIR OVEN DRYING OF FLOWERS

For quick drying, the pressed or embedded materials may be kept in hot air oven at 40-45^{o} C.Electrically operated hot air oven at a controlled temperature of 40-50^{0} c is used for drying flowers in an embedded condition.Flowers can be embedded either in sand or in silica gel in earthen/plastic/tin/glass pots and pots are kept for dehydration in hot air oven. The hot air oven is thermostatically controlled.The temperature is maintained 40 – 45^{0}C. The different flowers suited for hot air oven drying include *Helipterum roseum*, Chrysanthemum, Gerbera, *Gomphrena globosa*, *Helichrysum bracteatum*, Rose, *Zinnia linearis*, Bougainvillea, Narcissus, Dahlia, Gladiolus, *Tagetes patula*, *Tagetes erecta*, Nymphaea sp. etc. Different flowers take different time to dehydrate in hot air oven ranging from 48 to 120 hours.

Drying time in hot air oven for different flowers and foliage plants

Plant	**Hours in oven**		
	35-39^{0}C	**40-44^{0}C**	**45-49^{0}C**
Paper flower			48
Chrysanthemum			48
Candytuft			48
Helichrysum			48
Gerbera			48
China aster		48	
Euphorbia		48	
Larkspur		48	
Rose buds and small flowers		48	
Zinnia		48	
Bougainvillea	48		
Dahlia	72		

Narcissus	72		
Gladiolus		96	
Medium and large roses		72	
Very large roses		96	
Nymphea			120

ADVANTAGES

- Faster dehydration
- Temperature can be maintained
- Independent from weather conditions
- Superior quality product

DISADVANTAGES

- Costlier
- Brittle flowers due to lack of humidity

5. MICROWAVE OVEN DRYING OF FLOWERS

Microwave drying is quick and relatively simple. It takes only a few minutes and provides dried flowers that look fresher and more colourful than obtained by other methods. Flowers with thick petals are not suitable for drying in microwave. Silica gel, a container safe for microwave and fresh flowers are needed for the process. Here, drying is based on the principle of liberating moisture by agitating water molecules in the organic substances with the help of electronically produced microwaves. Drying is exceptionally fast and gets completed within a few minutes and generates little heat.This is a silica gel flower drying method. Brightly coloured flowers dry best. Flowers such as lilies, roses, zinnias, sunflowers, strawflower, and dahlias work well with this process.

METHOD

- Partially fill a container with silica gel, place flower in container with the stem side down. Slowly shift the silica gel around the flower until it is covered.
- Place the container in the oven. Place 1 cup of water in the rear left corner of the Radar range. Heat on full power and the prime time. Large flowers take longer heating times.
- After heating,standing time of 10 minutes to few hours is needed for best results. Allow the flower to stand in the silica gel until the gel becomes cool. Generally, 4 to 6 hours are required. If the flower is removed too soon it will be warm and limp, and will not be able to hold its form.
- Microwave dried flowers tend to absorb moisture, so spray the petals with hair spray.
- Place them in an airtight container until they are used.

Drying period for flowers in microwave oven

Plant	**Microwave oven(minutes)**	**Setting time(hrs)**
China aster	3	2
Chrysanthemum	3	3
Dahlia	3	4
Snap dragon	3	2
Delonix regia	2	2
Carnation	3	3
Bougainvillea	3	3
Gerbera	3	2
Gladiolus	3	5
Straw flower	2.5	3
Paper flower	2	3
Candytuft	3	2
Ixora	2	3
Pride of India	3	2
Narcissus	3	2
Nymphea	4	5
Pentas lanceolata	1.5	2.5
Limonium	2.5	2
Phlox	2.5	2

ADVANTAGES

- Unbelievably fast
- Quality product

DISADVANTAGES

- Costly

6. FREEZE DRYING

Freeze dried flowers are fresh flowers that have been specially dried to preserve their natural shape, colour and beauty. Freeze drying is accomplished by a process called sublimation. It requires a special freeze-drying machine.It involves first freezing the flowers at (-)100^{0}C for at least 12 hours. A vacuum pump slowly pulls the water out of the flowers as a vapor in one chamber, and then the vapor condenses as ice in another chamber.Because of this process, the shape and natural colour of the flower is maintained.For Roses it takes 15 – 17 days and for other flowers normally 10 – 12 days. Major flowers dried by this method are roses, carnation, bridal bouquets, etc.

ADVANTAGES

- Texture, structure, size,shape, colour etc are similarto fresh ones

DISADVANTAGES

- Equipment cost
- Precise processing techniques required

7. GLYCERINE DRYING

It refers to the replacement of the moisture content in the flower or foliage with a mixture of glycerine and water (1: 3). Glycerin does not preserve the green colour, but the foliage retains its soft, pliable feel and can be painted or used naturally in arrangements. Foliage preserved with glycerin can be wiped or cleaned and lasts long. The time to pick foliage to preserve using glycerin is in the middle of the plant's growing season. The flowers and foliage recommended for drying using glycerine are Eucalyptus, Silver Oak, Thuja, Camellia, Plumeria, Magnolia, Maple, Beech, Ferns, Ivy, Cherry, Mistletoe, Mahonia, Rhododendron, Bells of Ireland, Hydrangeas, Mexican orange blossom etc.

METHODS

- Remove damaged or withered leaves, and prune the foliage to the desired outline.
- Split woody stem ends 3 to 4 inches from the end or crush them.
- Mix 1-part glycerin to 2-3 parts water and heat the mixture.
- Pour the mixture into a heavy container.
- Stand the branches upright in the solution.
- Check the branches often, and add water to keep the solution several inches up on the stem.
- Allow the branches to absorb the solution for 2 to 6 weeks, depending on the size and texture of the leaves.
- Place stems of foliages in the glycerin solution for 3-6 days for soft stem and six weeks for woody stem.
- The completion of process is indicated by the change of leaf colour to golden brown.

ADVANTAGES

- Retain natural shape and flexibility,
- Lasts indefinitely.

DISADVANTAGES

- Preservation destroys natural colour
- Colour changes,
- Dried materials will have greasy feeling.

POST DRYING PROCEDURES

BLEACHING AND DYEING

Items to be bleached must first be dried**.** Place dried plant material in a solution of one cup bleach (200 ml) and two gallons (4 L) water**.** Bleach chemicals used generally are Chlorates, Hypochlorites and Sulphites.Use plastic, glass or enamel containers**.** Do not use metal containers. Weight materials down so that it will be submerged at all times**.** Leave material in solution for 5-6 days, longer if necessary**.** Remove after bleaching has occurred and rinse thoroughly**.** Leave material in a water bath for a day or two. Hang outside to dry and whiten**.** To dye bleached materials, dip for 5 minutes in a boiling dye solution**.**

USES OF DRIED FLOWERS

Many value added products can be made from dried flowers such as collages, flower pictures, flower balls, greeting cards, covers, pomanders, festive decorations, bouquets and wreaths, sweet-smelling potpourries, decorative floral craft items, wall hangings and wall plates, floral designs, calendars, topiaries, swags, flower arrangements, landscapes, sheaths, floral album and for interior decoration etc.

PACKING OF DRIED FLOWERS

Dried flowers are fragile and require careful handling. Card board boxes, poly lined or wax paper lined cartons are normally used for packing dried flowers. Metallic tins and thermo cool boxes are also used for packing dried flowers. The dry flower arrangements are to be kept in transparent polypropylene boxes (100-200 gauges) for display. Moth balls and silica gel pouches should be kept inside the packing to avoid insect and moisture damage. Specimens should be packed in closed boxes or in sealed plastic bags containing mothballs. Superior grade of cartons or boxes are used for packing dried plant material. Packets of silica gel should also be placed in the boxes to absorb any moisture in the air. They should not be roughly handled during transport and distribution.

STORAGE OF DRIED FLOWERS

Dried materials should be stored in a dark, dry airtight and moisture proof containers container. A layer of tissue paper should be placed between flowers to reduce breakage. Spraying the dried flowers with a clear plastic spray will prevent them from absorbing water during humid periods and prevent dust from sticking and discolouring the petals. It is better to keep silica gel crystals at the bottom of the storage containers like desiccators, glass jars or plastic jars to prevent the dried plant material from spoilage and for their future utilization.Protect the material from direct sunlight or high light intensity, especially from incandescent lamp.

CONCLUSION

Dry flower is an important product of the floriculture industry, which is gaining importance and popularity at a faster rate in the international trade. Dry flowers can be chosen as an eco-friendly alternative to fresh flowers. It is economical and long lasting since it can be reused several times compared to fresh flowers. Creative possibilities are greater in dried flowers since we can increase the length of flower stalk by using artificial stems. The various flower drying techniques discussed above have the ability to develop newmarkets through diversification of products. There is need to create sufficient awareness about the potential of dry flower technology. Proper education or training on dehydration technology need to be imparted to farmers/florists, rural women, house wives, unemployed youths etc.

MICRO-PROPAGATION IN ORNAMENTAL CROPS

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Floriculture industry has emerged as one of the important and growing commercial trades in agriculture. A big volume of cut flowers and potted plants are sold on daily basis across the world. In terms of production value Netherlands, US, Japan, Italy, Germany and Canada are the largest producers and exporters of cut flowers and plants while Germany, US, France and UK are the major consumers (Getu, 2009). In India, with over 161,00 ha land under flower cultivation (Starman et al.,1995), suitable climatic conditions and commercial floriculture displaying high potential per unit area than most field crops, floriculture is being perceived as a lucrative business.

Recent modern techniques of propagation have been developed which could help growers to meet the demand of the horticultural industry in the succeedingcentury. Micro-propagation is an ideal approach for large-scale propagation of ornamental plants, including those having value in the foliage and flowering plants industry. It is an advanced vegetative propagation technology for producing a large number of genetically superior and pathogen-free plants in a limited time and space (Chieri Kubota, 2001). The plant cells, tissues or organs are grown on artificial medium in test tube and maintained under controlled environmental conditions. The part which is cultured is called explant. It can beany part of a plant. 'Tissue culture' is commonly used term to describe all types of plant cultures, namely callus, cell, protoplast, anther, meristem, embryo and organ cultures. It relies on the phenomenon of cellular totipotency, a capacity to generate a whole plant from any cell/explant. Single cells, plant cells without cell walls (protoplasts), pieces of leaves, stems or roots, embryo, anther can be used to generate a new plant.

STEPS INVOLVED IN MICRO-PROPAGATION

1. SELECTION OF MOTHER PLANT AND COLLECTION OF EXPLANT

The plant tissues are removed from an intact plant in a sterile condition. Clean stock materials that are free of viruses and fungi are important in the production of the healthiest plants. Once the plant material is chosen for culture, the collection of explant(s) begins and is dependent on the type of tissue to be used; including stem tips, anthers, petals, pollen and other plant tissues. The explant material is then surface sterilized, usually in multiple courses of bleach and alcohol washes, and finally rinsed in sterilized water.

2. MULTIPLICATION

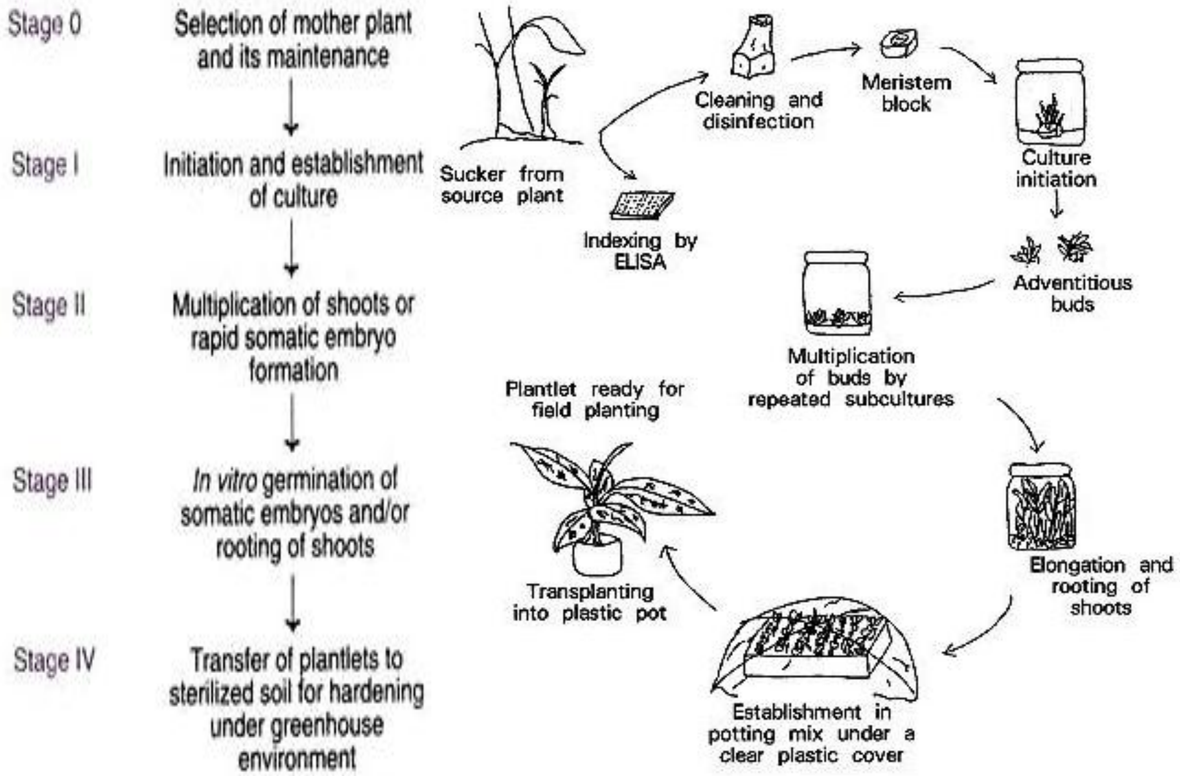
Multiplication is the taking of tissue samples produced during the first stage and increasing their number. Following the successful introduction and growth of plant tissue, the establishment stage is followed by multiplication. Through repeated cycles of this process, a single explant sample may be increased from one to hundreds and thousands of plants. Depending on the type of tissue grown, multiplication can involve different methods and media

3. ROOTING AND ACCLIMATIZING

After the formation of multiple shoots, these shoots are transferred to rooting medium with a high auxin\cytokinin ratio. After the development of roots, plantlets can be used for hardening. "Hardening" refers to the preparation of the plants for a natural growth environment. Until this stage, the plantlets have been grown in "ideal" conditions, designed to encourage rapid growth. Due to the controlled nature of their maturation, the plantlets often do not have fully functional dermal coverings. This causes them to be highly susceptible to disease and inefficient in their use of water and energy. Hardening typically involves slowly weaning the plantlets from a high-humidity, low light, warm environment to what would be considered a normal growth environment for the species in question.

4. TRANSFER TO SOIL/ FIELD

In the final stage of plant micro-propagation, the plantlets are removed from the plant media and transferred to soil or (more commonly) potting compost for continued growth byconventional methods



REQUIREMENTS FOR *INVITRO* PLANT TISSUE CULTURE/ MOCRO-PROPOGATION

1. NUTRIENT MEDIUM

The plant tissue culture medium contains the nutrient essential for cell growth and its composition varies depending upon the type of plant tissues or cell that are being used for culture. A typical nutrient medium contains inorganic salts (both micro and macro elements), an energy source (usually sucrose), vitamins (e.g., nicotonic acid, thiamine, myoinositol), amino acids and growth regulators or plant hormones (auxins like 2,4-D and cytokinins such as BAP and gibberellins). An optimum pH (usually 5.7) is also very important. The medium can be liquid or solid. Usually a gelling agent agar (a polysaccharide obtained from a red algae *Gelidiumamansi*) is added to the liquid medium for its solidification.

2. ASEPTIC CONDITIONS (STERILIZATION)

Nutrient medium contains sugar which increases growth of microorganisms (bacteria and fungi). These microbes compete with growing tissue and finally can kill it. It is essential to maintain aseptic conditions in tissue culture. The plant material must first be surface sterilized to remove any bacteria or fungal spores that are present. The aim is to kill all microorganisms without damaging the plant material. The explants are transferred into the suitable sterilized nutrient medium in culture vessels at sterile conditions under HEPA filtered air provided by a laminar flow cabinet.

3. GROWTH CONDITIONS

Growing the culture in the growth chamber or plant tissue culture room, having the appropriate physical condition artificial light; 16 hours of photoperiod, temperature (26°C) and relative humidity (50-60%) is required.

PROTOCOL TO BE FOLLOWED FOR PLANT TISSUE CULTURE: (ILIEV ET AL 2010. PLANT MICRO-PROPAGATION)

1. SURFACE DISINFECTION OF EXPLANTS

METHOD:

1. Place several filter papers into each of the glass Petri dishes. Wrap the petri dishes, glass beakers, scissors, scalpels, forceps in aluminium foil. Disinfect it and bottles of distilled water in an autoclave at 120° C, 15 lb steam pressure for 20 min.
2. Disinfect the laminar flow cabinet by exposing the work bench to ultraviolet illumination for 3 h. Spray the work surface of the cabinet with 95% (v/v) ethanol; allow to dry.
3. Remove the epidermis from stem segments and scale leaves from buds of woody speciesd.
4. Wash the explants under running tap water for 5 min.
5. Wash hands thoroughly with bacteriocidal soap before commencing work.
6. Disinfect the explants in the laminar flow cabinet. Place the explants in anautoclaved beaker. Wash the explants in 70% (v/v) ethanol for 2 min. and 5% (w/v) NaClO, containing 20 drops per litre of Tween 20 for 15–30 min. After immersion in each solution, wash the explants 3 times with sterile distilled water for 3, 5 and 10 min; discard the washings.
7. After surface disinfection, keep the plant material in distilled water in petri dishes in the laminar flow cabinet to prevent drying.
8. Before preparing the explants, disinfect the forceps and scalpels using a glass bead sterilizer or by flaming using the alcohol lamp for 10–15 seconds.
9. Remove the cut ends of the explants (e.g. apical or axillary buds, leaves, petioles, flowers, seedling segments) with a sterile scalpel before placing the explants on the culture medium.

2. PREPARATION OF CULTURE MEDIUM

METHOD

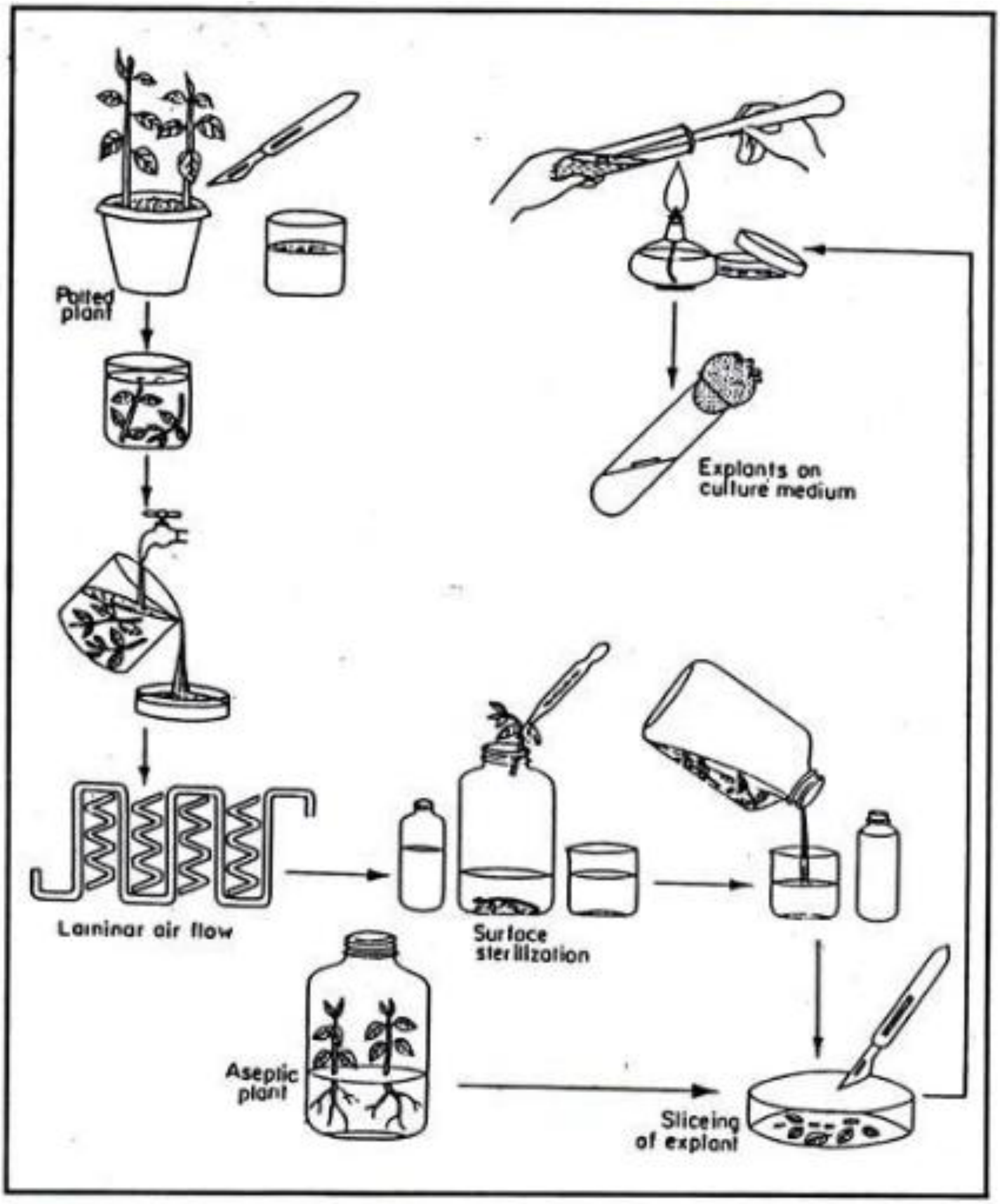
1. To prepare 1 lit. MS medium, add MS stock solutions and make up volume to 500 ml of double distilled water in a 2 lit.beaker.
2. Prepare separate stock solutions of each plant growth regulator.

3. Add heat stable supplements to the medium before autoclaving, such as 30 g sucrose, 8 g agar, the desired plant growth regulators in a specific volume of stock solution. Adjust the medium to the final volume (1 lit.) by adding double distilled water.
4. Adjust the pH of the medium to 5.6–5.8 with 1 M HCl or KOH and heat in microwave oven until the gelling agent is dissolved.
5. Autoclave the medium at 121° C at 15 psi for 20 min .
6. Dispense the medium into the culture vessels in the laminar flow cabinet. Close the vessels after cooling.

PREPARATION OF STOCK SOLUTIONS FOR EACH PLANT GROWTH REGULATOR.

1. Dissolve auxins (NAA, IAA, IBA and 2,4-D) in 1 ml ethanol and make up to 100 ml with distilled water.
2. Dissolve cytokinins (kinetin, zeatin, BAP, 2-iP) and ABA in 1 ml 1 M NaOH or 1 M KOH; make up to 100 ml with distilled water.
3. Store the stock solutions in 100 ml flasks in a refrigerator (not frozen) for not more than 2 months.
4. Filter sterilization of heat sensitive compounds. Fill the PP/PE syringe with the solution of heat labile constituents (e.g. zeatin, 2-iP, IAA, GA3, citric acid, ascorbic acid). Mount a syringe membrane filter on the syringe and filter the solution into a sterile flask. Dispense the filter sterilized solution into convenient aliquots (e.g. 10–20 ml) in sterile, screw-capped vessels. Perform this operation in a laminar flow cabinet.

Notes:
1. Heat labile constituents, such as some growth regulators and organic compounds (e.g. zeatin, 2-iP, IAA, GA3, citric acid, ascorbic acid), should not be autoclaved but filter sterilized before adding to the autoclaved culture medium after the medium has cooled to 40–50° C in the laminar flow cabinet.
2. The pH of the culture medium is usually adjusted to 5.6–5.8. For acid-loving species, a lower pH is required (4.5 or less).
3. To minimize contamination by micro-organisms, a broad-spectrum biocide/fungicide for plant tissue culture may be added to the medium at a concentration of 2–20 ml/l, which effectively prevents or reduces microbial contamination.
4. Cytokinins (BAP, kinetin, 2-iP, zeatin) are added to the culture medium to induce axillary or adventitious shootsdevelopemnt.
5. Auxins (2,4-D, NAA, IAA) induce callus formation.
6. IBA is generally used to induce adventitious roots.
7. GA3 or polyamines added to the medium will promote shoot elongation.
8. Culture media should be used within 2 to 4 weeks of preparation and can be stored for 6 weeks before use, if refrigerated.



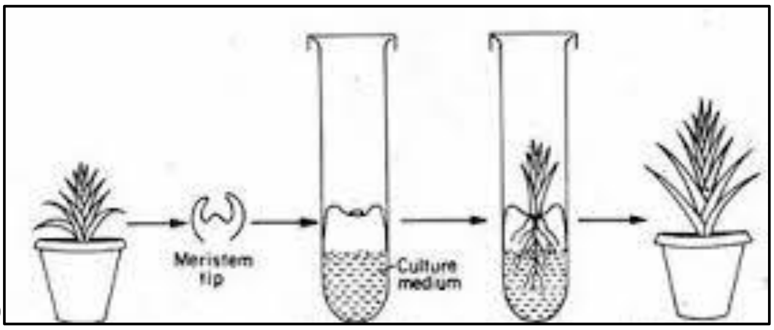
Flow diagram illustrating the procedure for surface sterilization of plant material and inoculation of explant for culture.

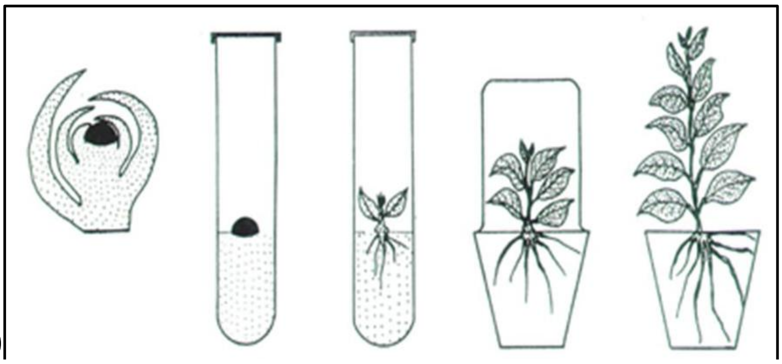
METHODS OF MICRO-PROPAGATION

There are many methods being used for plant micropropogation based on the aim. The general methods which are being used for micro-propagation of ornamentals are discussed here.

1. MERISTEM CULTURE

Meristem culture *in vitro* is used for the elimination of viruses and related pathogens from a large number of vegetative propagated plants and it is the main method used in plant virus elimination programs. An already existing shoot meristem grows inthe meristem culture and adventitious roots regenerate from these shoots. In the shoot tip beyond the youngest leaf lies the primordium meristem. It measures up to 250 mm in length and 100 mm in diameter. In addition to the apical meristem one or three leaf primordia would be present in a shoot tip of 100–500 nm. When virus elimination is the objective, to obtain disease-free plants, shoot tips of up to 10 mm are generally used.

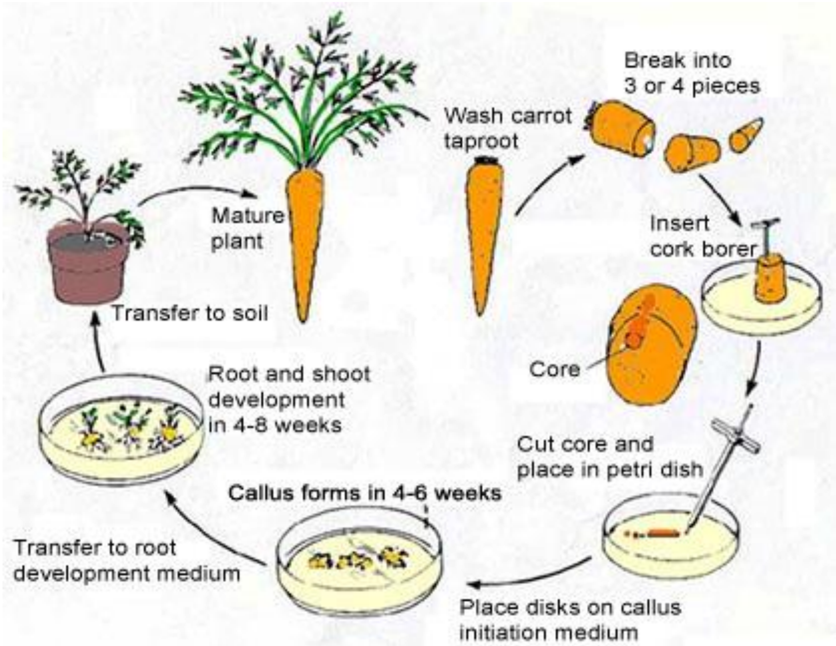
a) 

b) 

a) 100-500nm shoot apical meristem with leaf primordia taken as explant
b) 10mm apical meristem taken as explant

2. CALLUS CULTURE

The plant cells, tissues or organs when grown aseptically on artificial nutrient medium in glass vials under controlled experimental conditions to produce unorganised proliferative mass of cells (callus) is called callus culture. The whole plant can be regenerated in large number from callus tissue, it is good source of genetic or karyotype variability, Cell suspension culture in moving liquid medium can be initiated from callus culture and it is also very useful to obtain commercially important secondary metabolites.



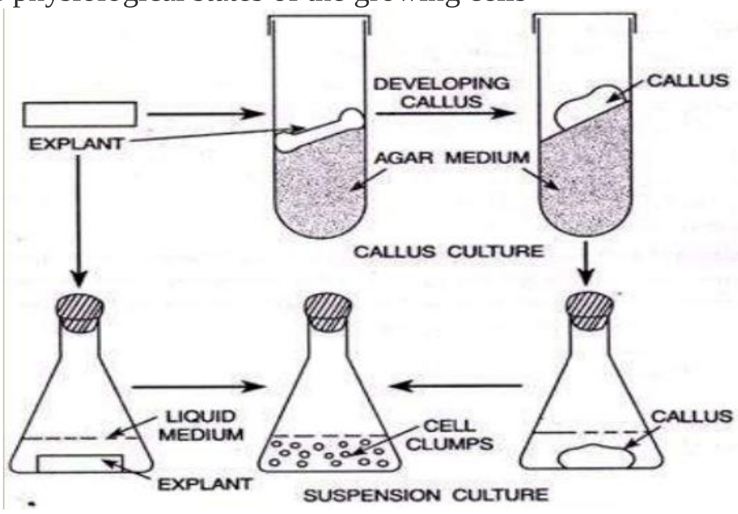
Flow diagram illustrating the procedure for callus culture

3. SUSPENSION CULTURE

The *culture* of tissue and cells cultured in liquid nutrient medium, producing a *suspension* of single cells and cell clumps. To achieve an ideal cell suspension, most commonly a friable callus is transferred to agitated liquid medium where it breaks up and readily disperses. This suspension can then be propagated by regular sub-culture of an aliquot to fresh medium. Movement of cells in relation to nutrient medium facilitates gaseous exchange, removes any polarity of the cells due to gravity and eliminates the nutrient gradients within the medium and at the surface of the cells.

Broadly speaking there are two types of suspension cultures.

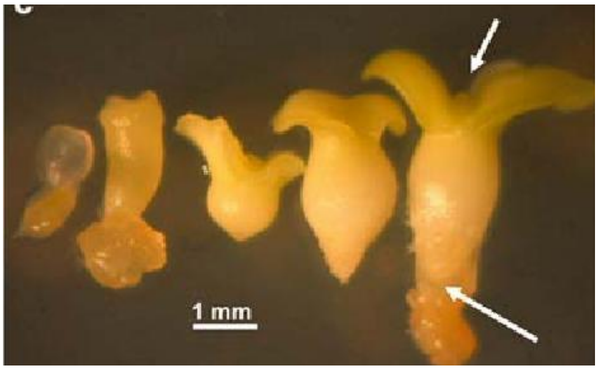
1. **Batch Culture**: The cell material grows in a finite volume of agitate liquid medium.
2. **Continuous Culture** The large culture vessel is kept dispersed continuously by bubbling sterile air through culture medium and the old liquid medium is continuously replaced by the fresh liquid medium (on depletion of some nutrients in the medium) to stabilize the physiological states of the growing cells



Flow diagram illustrating the procedure for suspension culture

4. EMBRYO CULTURE

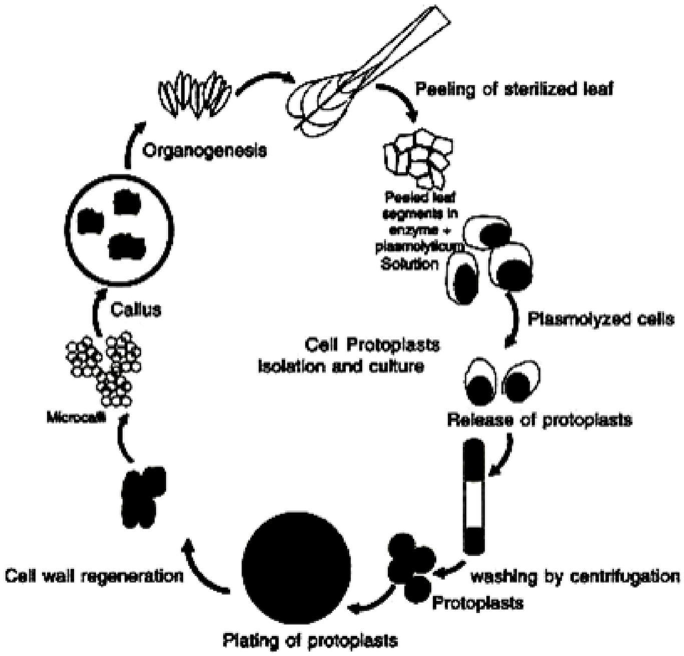
Embryo culture is the culture of isolated immature or mature embryos. Zygotic or seed embryos as explants are often used to initiate callus cultures and regenerate plant. This technique is often used to recover embryo with degenerated endosperm tissue obtained fromcrossing between the two distant species. This culturing of embryo (hybrid) in *in vitro* conditions is known as embryo rescue and is widely used for crop improvement.



Flow diagram illustrating the procedure for embryo culture

5. PROTOPLAST CULTURE

In plants, where fairly distant species could be crossed, it has not always been possible to obtain a viable plant. In order to overcome this barrier protoplast culture was developed where not only isolated protoplasts but their fusion product, a somatic hybrid, can also be regenerated into whole plants.



Flow diagram illustrating the procedure for protoplast culture

MAIN ADVANTAGES OF MICRO-PROPAGATION

1. Rapid multiplication of plants within a short period and on small space.
2. Plants are obtained under controlled conditions, independent of seasons.
3. Sterile plants or plants which cannot maintain their characters by sexual reproduction are multiplied by this method.
4. The rare plant and endangered species can be multiplied by this method and saved.

5. Production of virus-free plants for floriculture, horticulture and agriculture industry.
6. Large-scale growth of plant cells in liquid culture in bioreactors for production of valuable compounds.
7. Cross distantly related species by protoplast fusion and regeneration of the novel hybrids.
8. Rapid *in vitro* selection of stress tolerant plants salt, drought, heavy metal, low temperature, herbicide resistant plants can be done using these methods.
9. Regenerate the whole plants from plant cells that have been genetically modified.
10. Rare mutants can be multiplied using micro-propagation techniques.

Post-Harvest Management in Ornamental Crops

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INTRODUCTION

Floriculture has emerged as a viable diversification option in the agri-business. It is a rapidly expanding dynamic industry recording a growth rate of more than 15 per cent per annum in the last two decades. Rapid urbanization, increased income levels and changes in social values resulted in increase of domestic market both for modern (cut flowers) as well as traditional (loose flowers) flowers significantly. Improvement in the general level of well being in the country and increased affluence particularly among the middle class is also another reason for increase in the volume of local flower market. The quantum of Indian floricultural exports, although, increased manifold since early nineties, still there is huge scope to become a key player in the world flower trade. The floriculture industry in India is characterized by growing traditional flowers (loose flowers) and cut flowers under open field conditions and protected environment conditions respectively. Flowers are highly perishable unlike other horticultural or agricultural crops. Owing to poor keeping quality the post harvest losses in floriculture are significantly higher than any other sector. Although there has been significant increase in the area, production and productivity of flower crops in the last two decades, there is an urgent need to minimize the huge post harvest losses in terms of the value of the produce which are estimated to be 30-40 per cent of farm value. The post-harvest behaviour of flowers is an outcome of the physiological processes, occurring in leaves, stem, flower bud, leafless peduncle or scape connecting bud to the stem. Some of these processes may act independently to affect the senescence and vase life of cut flowers but most of them are inter-related. The nature and extent of postharvest damage is typical for each crop or cultivar. The post harvest losses become important especially when dealing with the export of fresh flowers to distant and foreign market. Therefore, patient, soft and expert handling of flowers is of utmost importance after harvest.

The post-harvest quality of flowers depends upon mainly three factors.

1. Pre harvest factors
2. Harvest factors
3. Post harvest factors

PRE-HARVEST FACTORS

1. GENETIC OR INHERENT MAKEUP

Postharvest lasting quality of flower species and cultivars vary considerably due to differences in their genetic make-up. Specialty flowers like *Heliconia*& ginger lilies (more than a month); orchids (few weeks) have a higher vase life compared to other flowers like rose, carnation & gladiolus. Within the same crop also, differences in vase life could be seen among the varieties. Gladiolus varieties White Prosperity, Sancerre, Suchitra, Eurovision, Nova Lux, Rose Supreme and Trader Horn possess the better vase-life compared to other varieties (Table.1).

Table.1. Variability among the gladiolus varieties in respect of vase life.

Cultivar	Vase life (days)
Applause, Hunting Song, Jacksonville Gold, Mayur, Melody, Nova Lux, Rose Supreme, Sancerre, True Yellow, White Goddess, White Prosperity	>7-10
Happy End, Praha,, Red Charm, Suchitra, Yellow Stone	>6-7
Anglia, Bis-Bis	>5-6
Source: Singh et. al. (2008)	

2. GROWING CONDITIONS

Most cut flower crops require well-lighted conditions. On the contrary, too high light intensities cause scorching and dropping of leaves and abscission of petals. Flower crops are also specific in their temperature requirements. Optimum temperature and photoperiod, media qualities, etc differ from crop to crop (Table.2) Flowers also require adequate nutrients for good longevity. High nitrogen doses should be avoided as they increase susceptibility to diseases. For example, iron deficiency is commonly observed in gladiolus in north India, causing heavy yield losses. Flowering crop should also be grown away from the industries which release toxic effluent, gases, damaging the foliage as well as flowers. Flowers damaged by pathogens, insects and pests also show high ethylene production resulting in poor vase-life.

Table. 2. Optimum growing conditions for commercial flowers grown under protected conditions

Crop	Temp Day/ Night (^{0}C)	Photo-period (h)	Media		CO_2 (ppm)	Nutrition NPK (g/m^2/month) & ppm
			pH	EC (mmhos/ cm)		
Rose	28/18	14	6.2-6.8	0.7	1000-1500	30:10:25 (200:150:200)
Carnation	18/13	16	6.0-7.0	1.2	500-1500	30:20:10 (250:100:200)
Chry'mum (standard)	16/10	10	6.2-6.7	1.0	700-900	30:10:15 (200:200:200)
Lilium sp. (Asiatic)	18/12	50% shade	6.5-7.0	1.0	1000-1500	30:20:20
Gerbera	16/12	14	6.0-7.0	1.0	800-1200	20:15:20 (260:180:390)
Alstroemeria	18/15	16	6.0-7.0	1.4	1000-1500	20:10:15

HARVEST FACTORS

The most important factors for harvest are when, how and where—"when" the plant material will reach the optimum stage of development and "when" during the day to harvest. Each plant material has its own best harvest stage and this can vary depending on the use of, and market for, the plant material (Table.3). Materials for preserving usually are harvested more mature than those for fresh, wholesale markets. Some general rules of thumb for when to harvest are: spike type flowers— harvest when one-fourth to one-half of the individual florets are open; daisy type flowers— harvest when flowers are fully open. The other "when" is, when the best time of day for harvesting flowers is. The best time is the coolest part of the day and when there is no surface water from dew or rain on the plants.

Table.3. Optimum stage of harvesting in commercial flower crops

Name	Type	Stage of harvest
Rose	Red and Pink cultivar Yellow Cultivar White Cultivar	First two petal beginning to unfold Slight earlier than red and pink Slightly later than red and pink
Chrysanthemum	Standard	Outer petal fully elongated
	Spray	50 % of flowers show colour
Lilium,Iris, Freesia		Coloured buds
Carnation	Standard	Paint brush stage
	Spray	At least two flowers fully open
Gladiolus		1-5 bud showing color
Dahlia variabilis ***Tagetes erecta*** ***Zinnia elegans***		Fully open flowers
Tulipa gesneriana		Half colored buds

Right stage, method and time of harvesting of flowers are of considerable importance to ensure their long vase-life. The stems should be cut with sharp knives or secateurs. Hardwood stems should always be given slanting cut to expose maximum surface are to ensure rapid water absorption. The flowers of dahlia and poinsettia release latex upon cutting. To overcome such problem, stems should be given a dip in hot water (80-90^{0}C) for a few seconds.

The flowers of rose, carnation, gladiolus, tuberose, daffodils, lily, iris, freesia and tulip should be harvested at bud stage since their buds continue to open in water.. The flowers of snapdragon, Harvesting of flowers at bud stage is always preferred as their buds have long vase-life, are less sensitive to ethylene, easy to handle during storage and transport and are less prone to diseases and pests.

POST HARVEST FACTORS

1. ENVIRONMENT

The environment (temperature, relative humidity and gaseous composition) of the place where the flowers are handled is also crucial in determining the ultimate keeping quality of the flowers. At higher temperature, opening of flower buds and rate of senescence hastens. Cool chain should be maintained through-out. Cool chain includes the temperature regulation at all stages right from pre-cooling to final shipment. As far as possible, flowers are to be handled at lower temperatures. At low temperature, rate of respiration; ethylene production; transpiration rate; and micro-organism multiplication would be low/minimum. Cut flowers should be kept at 90-92% relative humidity which helps to maintain turgidity and increases vase life. Lower Humidity results in higher rate of transpiration. Exposure to air pollutants, ethylene from external sources (storage along with veg's/fruits) adversely affects the post-harvest life and quality of fresh flowers.

Table. 4. Optimum storage temperature for commercial cut flowers

Storage	Crop	Storage temperature
Dry storage	Carnation	0 to 1°C
	Chrysanthemum	1°C
	Gerbera	2°C
	Gladiolus	4 °C
	Rose	0.5 to 2 °C
Wet storage	Anthurium	13°C
	Carnation	4°C
	Chrysanthemum	4°C
	Gerbera	4°C
	Rose	2 to 5 °C
	Gladiolus	4°C

2. WATER RELATIONS

The termination of life of the harvested flowers depends on water uptake and transport, water loss and the capacity of the flower tissue to retain its water. A water deficit and wilting develop, when the transpiration exceeds absorption of water. The rate of water uptake of cut flowers depends on transpiration pull, temperature and composition of solutes . Disruption of water columns in stem vessels by air embolism and resistance to water flow in stems, also develop water deficit. Acidification of water and addition of wetting agent and flower food in the holding solution markedly improve water uptake of cut flowers.

Water relations would be having a significant bearing on the internal metabolic events (respiration, transpiration, accumulation of ethylene) which continues in the flower system even after the harvest.

Respiration: The rate of respiration depends on quantity of carbohydrates available in the harvested flowers, temperature and the use of certain chemicals to regulate it. With higher temperature, there is faster rate of respiration and burning of the tissue. Consequently, the life of flowers is shortened.

Transpiration: Higher the humidity in the air, less is the transpiration rate and vice-versa. Increased transpiration rate results in water stress and wilting of the flowers. Water deficit develops and wilting occurs when the transpiration exceeds water uptake/absorption.

Post-harvest deterioration is a result of depletion of carbohydrates due to increased respiration rate, decline in membrane stability index (MSI) due to microorganisms, water stress and increased accumulation of ethylene. To Improve water relations of cut flowers, re-cutting the stems in water, quick hydration (conditioning), maintenance of ***Cool Chain*** should be practiced.

3. POST-HARVEST OPERATIONS

The method of handling as per the specific recommendations of respective flower is very important. Basic operations like pre-cooling, sorting & grading, pulsing, storage, packaging, transport, etc as per standard recommendations should be followed. Mechanical injuries (brusing, sorting & discarding of wilted flowers) should be minimized. Improper handling (bruising/injuries) – affects aesthetic appearance, facilitates infection by disease organisms through injured areas and also respiration and ethylene production higher in injured plant.

PRECOOLING AND STORAGE

Precooling is a treatment given to flowers to remove the field heat immediately after harvest. It can be done with ice cold water, cold water or forced air.This is done either by forced air cooling or hydro-cooling to bring down temperature from 20^0-30^0C to 1^0C in a relatively short period. Other methods are room cooling and vacuum cooling. Flowers can be stored for a longer period at low temperature. There are two methods of cold storage-wet and dry. Wet method is short-term storage, in which cut stems are dipped in water. Dry storage is more labour-intensive method and costly. The controlled atmosphere based on reduction of respiration rates, conservation of respirable substrates during, storage, and delay in ethylene-triggered changes cause senescence. It involves the use of increased level of CO_2 and decreased levels of O_2 in the atmosphere, low storage temperature and prevention of the build-up of endogenous ethylene. Optimum storage temperature varies with the flower, rose, carnation, chrysanthemum, etc should be stored at low temperatures (0 – 1^0C) whereas the tropical flowers like anthurium should be stored at 13^0C (Table.4).

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Wet storage	Anthurium	13°C
	Carnation	4°C
	Chrysanthemum	4°C
	Gerbera	4°C
	Rose	2 to 5 °C
	Gladiolus	4°C

CONDITIONING/HARDENING

Restores the turgor of flowers wilted after harvest, storage or transport. Conditioning is done with de-mineralized water supplemented with germicides and acidified with citric acid. Some wetting agents like tween 20 @ 0.01-0.10% can be used for this purpose.Loading of flowers with high concentration of silver nitrate or nickel chloride of cobalt chloride for a short period of time is known as ***impregnation***. It is helpful in reducing the attack of microbes and synthesis of ethylene. It is generally practice in crops like Gerbera, Carnation, Chrysanthemum and Gladiolus.

PULSING

Treating the flowers with high concentration of sucrose and germicide for a short period of time, in order to improve the shelf life and to promote flower opening. Pulsing is beneficial especially for flowers destined for long storage period or long distance transportation.

BUD OPENING

Use of germicides, sucrose and hormonal solution to promote the opening of immature buds in crops like chrysanthemums, rose, carnation, gladiolus, and snapdragon.

GRADING, BUNCHING AND PACKAGING

After harvesting the flowers should be graded according to various grades as per specification for local and distant market. Then these should be pulsed and made into bunches of 5,10,20,50,100. Cut flower should be packed in corrugated cardboard boxed or sleeves. Packaging must ensure protection of flowers against physical damage and for this cotton or newspaper can be used as cushion.

COLD STORAGE

After pre-cooling and pulsing the flowers can be stored at low temperature i.e. in cold store to regulate the flower market or to avoid the glut in the market. Controlled atmospheric (CA) modified atmospheric (MA) or hypobaric (LP) storage method can be used to enhance the post-harvest life of flower.

PACKING AND TRANSPORTING

Packaging ensures garden fresh of flowers to the consumers. Lower rate of transpiration, respiration and cell division during transportation, are essential for long storage life and keeping quality. Before packing, flowers should be dried. They should be treated with systemic insecticides and miticides Packing must ensure protection of flowers against physical damage, water loss and external conditions detrimental to transported flowers. Boxes made of corrugated fibre boards are good. Flowers sensitive to geotropic bending must be transported in an upright position. The flowers should be transported at an optimal low temperature. The relative humidity of the air during precooling and shipment of cut flowers should be maintained at the level of 95-98%. Lack of light during prolonged transportation particularly at high temperature causes yellowing of leaves in many flowers. Shipment of flowers is usually done by truck, air and sea. For short distance and time period shorter than 20 hr, cut flowers may be transported in insulated trucks without regrigeration after precooling and proper packing. Air shipment is quickest and usually the temperature is not controlled during the flight The flowers should be pulsed with STS prior to air shipment. Flower should be transported in corrugated cardboard boxes. The flowers which are sensitive to ethylene, ethylene scrubbers containing $KMnO_4$ should be added to those boxes. Some of the flowers are like gladiolus and snapdragon are sensitive to geotropic bending, so these should be transported in upright position. Some of the flower crops show yellowing during transportation due to lack of light, therefore there should be a provision of light inside the transporting vehicle. Packaging in thermocol boxes was found highly beneficial for flower strings of marigold & tuberosein addition to bamboo baskets and corrugated fibre boxes.

HOLDING SOLUTIONS

After pulsing and storage, flowers are held in a solution containing sucrose, germicide ethylene inhibitor and growth regulator. It’s basically aimed at providing nourishment to the cut flowers. The flowers can be kept in holding solution either at wholesaler, retailer or consumer level.

4. USE OF PRESERVATIVES/POST-HARVEST CHEMICAL TREATMENTS

Preservatives in the form of tablets or powder are prepared from a mixture of chemicals-sugars, germicides, salts and growth regulators. Various types of conditioners are sugar and biocide, antiethylene compound, and hydrated compound. An ideal preservative solution consists of sucrose (respiratory substrate for providing nourishment), biocide/germicide (aimed to kill the microorganisms including bacteria), acidifier (to bring-down the pH of the solution & to increase the uptake), anti-ethylene compounds (viz., AOA, AVG, 1-MCP, etc to minimize the damage from ethylene), etc. Optionally, growth regulators (especially kinetins, BAP, gibberellins), mineral ions (which facilitates solution uptake), could be added in the solutions. Cytokinins delay senescence of some cut flowers. Depending upon the concentrations, GA in some cases promotes longevity of flowers, while this is also used in bud opening solution. The IAA promotes ethylene production of isolated carnation petals. In contrast, the senescence and abscission of poinsettia flowers is delayed by auxin. Commercially ready to use preservatives are also available (Chrysal, Fleurvital, Eurofleur, Ever bloom Flora life, Oasis, Petal life, Rose life and Seven up). The flowers like gladiolus, carnation, chrysanthemum and freesia are benefited most by the pretreatment. Antiethylene compounds in preservative solutions reduce the action of ambient ethylene as well as autocatalytic production of ethylene by fresh cut flowers. Fresh cut flowers responding to silver thiosulphate are carnation, orchids, gypsophila, gladiolus, gerbera, snapdragon, alstromaeria, agapanthus, anemone and sweet pea. Greatest improvement in cut flower quality and longevity is obtained when DICA or DDMH were combined with sucrose.

Preservatives can be effectively used in various solutions used in different stages of post-harvest handling *viz*., pre-cooling (removal of field heat), conditioning (aimed at rehydration of the cut flowers), pulsing (loading of substrate), bud opening (opening of flower buds harvested in bud stage), holding/vase solutions (to hold flowers continuously till the termination of vase life).

Post-harvest chemical treatments with boric acid (2-5%) and packaging by keeping ice packs in alternate layers was found effective for loose flowers of jasmine and tuberose. Glycerinization for preservation of cut foliage using optimum concentration of glycerine as per the crop species was found effective. Glycerine preserves foliages by replacing the natural moisture present in leaves with a substance that reduces its form, texture and sometimes colour. Glycerinised foliages could be used for preparing different products with a cost benefit ratio of 1:2 to even 1:4. Irrespective of the post-harvest handling followed, ageing and senescence is a continuous process and is characterized by loss of carbohydrates, loss of proteins, loss of phospholipids, decline in membrane stability index (MSI), production of reactvie oxygen species (ROS), transcription of new mRNAs, and de novo synthesis of new proteins (wastage of limited resources).Molecular Breeding for inhibition of ethylene bio-synthesis (Antisense expression of enzymes involved in ethylene bio-synthetic pathway viz., ACC synthase and ACC oxidase) or genetic engineering at ethylene receptor level or by over expression of hormones like cytokinins would go a long way to significantly improve the keeping quality of flowers.

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ESSENTIAL OILS FROM FLOWER CROPS

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INTRODUCTION

Since, ancient times mankind all over the world, mainly depended on flora and fauna of plant kingdom to meet their requirement of fragrance and flavour materials. However, with advent of modem synthetic chemistry and mass production of synthetic fragrance & flavour materials such materials could find their way on account of their low cost and the consistency in the quality of production. But, by the middle of 20th century disturbing reports about the toxicity of large number of synthetic fragrance and flavour materials food additives became well known to the world. This development has forced the people, once again, to think natural plant materials to meet the needs of flavour and fragrance industry world over. With this trend getting stronger day-by-day, the demand for natural flavour and fragrance material is truly phenomenal. Nowaday the natural essential oils and their derivatives and isolates are replacing synthetic fragrances and flavour.

Essential oils are the secondary plant metabolites synthesized in different parts of the plant, such as, leaves, flowers, stems, roots and seeds. These are of great perfumery and pharmaceutical importance. Natural essential oils are considered to be biodegradable and have no residual toxicity. Due to improvement in the living standard and the liking for the natural essential oils as perfumery, flavouring and pharmaceutical ingredients, the demand for natural essential oils increased manifolds in the recent past. Today, estimated world trade of essential oil, flavour and fragrance industry is believed to be of the order of 11 billion US dollars (Rs. 55,000 crores). Although, India has been known for rose, khus, Vetiver, lemongrass and attars for several hundred years. Its present share in the world trade of essential oils, flavour and fragrance remained 4 - 5%.

The varied agro- climatic conditions, rich soil resources and abundance of human labours make India ideally suited for the production of almost all the essential oils and species. Farmers are, therefore, looking for new areas of cultivation. The emerging area of cultivation is an aromatic and medicinal crop, i.e. linked with fragrance, flavour, essential oil, Indian System of Medicines and Aromatherapy trade and Industry. Farmers and growers are increasing getting interested in this field because of better remuneration.India still imports some of the very important essential oils, such as, rose, patchouli, geranium,clary sage etc. to meet the demand of fragrance and flavour industry in the country.

HOW AND WHY ESSENTIAL OILS AFFECT THE BODY

The routes through which essential oils react with the body and its metabolism are called pathways. In the first phase, essential oils penetrate the epithelial tissues; these include the skin, nasal passages, bronchioles, lungs and gastro-intestinal tract. Once absorbed into the surface layer, essential oils quickly penetrate into the lymphatic and blood capillary systems, entering into the general circulation. This is true for the other epithelial tissues of the body, including sinuses and lungs. The essential oils in the lymph circulatory system can be carried directly to the liver or fed into the blood stream. As the oils circulate with the blood, body tissues and organs may choose any portion of the essential oil that it wishes to utilize in its metabolic processes, or simply receive the stimulation, sedation, or beneficial property of the oil as it passes through. Essential oil, because of their volatile nature, usually leave the body within 48 hours.

The most important pathway, in terms of its profound effect on the body, is through the sense of smell. When we smell essential oils, the vapor stimulates small hair-like extensions of our olfactory nerve. The olfactory nerve is the only nerve in the body that directly contracts the external environment and goes all the way to the brain. All of our other senses (touch, hearing, sight and taste) involve several nerves and synpatic junctions before the impulses reach the brain. The olfactory nerve stimulates the most primitive part of the brain known as the limbic system, also called the saurian or reptilian brain. This is important in the processing of and reaction to emotions, desire, appetites and memories. This direct connection is why essential oils can have such profound and immediate effects on very deep aspects of our beingness. Research indicates that very small quantities create this stimulation. Larger doses do not increase the response appreciably.

Many essential oil possess significant antimicrobial properties, in both liquid and vapour form. Clinical trials have shown that tea tree oil is highly effective in treating thrash. Another study has shown that aromatherapy massage with lavender oil was significantly more effective than both plain oil massage and a control group, in reducing heart rate, respiration, blood pressure and pain in patients in a hospital intensive care unit. There are many studies that demonstrate how essential oil can positively affect mood and sense of well-being.

USE OF ESSENTIAL OILS FOR COMMON AILMENT

S.No	**Ailment**	**Oil**	**Type of Use**
1.	Anxiety	Lavender Jasmine Marigold Neroli Vetiver Clary sage	Bath for alteast 15 minutes Inhalation Message with carrier oil In solar plexus
2.	Depression	Clary sage Marjoram Chamomile Sandalwood Lavender Frankincense Ylang-ylang	Bath Inhalation Message
3.	Irritability	Chamomile Lavender Marijoram Neroli Rose Vetivert Rosemary	Bath Steam inhalation
4.	Lack of confidence	Rosemary Petitgrain Neroli Jasmine	Inhalation (neat or in burner vaporiser)
5.	Aggressiveness	Lemon Chamominile	Message with carrier oil in Carrier oil in solar

		Jumiper Marjoram Ylang-ylang	Plexus Bath
6.	Pain/Muscle Tension	Eucalyptus , Juniper Black pepper Lavender Rosemary	Message Bath
7.	Fatigue/Excessive Tiredness	Lavender Neroli Juniper Rosemary Geranium	Bath-soak for 10 - 15 Message with carrier oil Rubbing in solar plexus

DOSE OF ESSENTIAL OIL

It is one of the very important aspects while preparing a product using essential oil or massage oil. The dose for general massage purpose is 2.5% of carrier oil. However, it varies depending on the case like aching muscles or rheumatism, it requires higher concentration (around 3%). Disorders related to the emotions, such as, depression, insomnia and stress (1.5 - 2%). Body oils for sensitive skin and facial lotions should be even more dilute (0.5 - 1 %). Babies, children and pregnant woman also require much diluted blends (0.5%).

THE AROMA BEARING CROPS AND THEIR IMPORTANCE

Essential oils are volatile component of aromatic or aroma bearing bearing crops, which gives aroma due to their volatility. Generally, aroma-bearing crops are those, which possess aromatic compounds, which are volatile at room temperature and give an odour. These compounds are found in essential oils preserve in plants cells, tissues, stomata and other parts of the plant. Usually, essential oils, are preserved in roots, leaves, seeds, bark, fruits, flowers and stems of plant. The essential oil from the different parts of plant can be derived by various methods of distillation like hydro distillation, hydro steam distillation, steam distillation and solvent extraction and super critical extraction etc.

IMPORTANCE OF AROMATIC PLANTS:

It can be described as follows. Aromatic plants are utilized for:

i. Production of essential oils wherein aromatic plants are used as raw material.
ii. Spices as such.

SCOPE OF CULTIVATION OF AROMATIC CROPS:

i. Provide sustained availability of raw materials:
Cultivation of improved varieties and clones provide regular availability of raw material to essential oils industry and ensure quality standard products. Production of high quality essential oils is a primary step for flavour and fragrance industry in the world.

ii. High Income generation:
The scope of cultivation of traditional crops is limited due to over production and lack of demand in the market. Farmers are looking for new crops, which could be more remunerative in comparison to traditional crops to supplement their income. The aroma bearing crops particularly, high yielding clone/varieties are quite popular among growers for production of essential oils.

iii. **Value addition through processing:**
The essential oil derived from such crops can be re-distilled or processed further to yield their isolates, which are used directly in the flavour and fragrance industry world over. These isolates are also in demand in local and overseas market.

iv. **Utilization of unproductive lands:**
Some aromatic crops, such as, lemongrass, chamomile, Vetiver, Palma Rosa and basil can be successfully grown in low fertile, reclaimed or degraded type of land where cultivation of normal crop is not feasible.

IMPORTANT AROMA BEARING CROPS, THEIR FAMILIES, BOTANICAL NAMES AND PARTS USED

Sl. No.	Common Name	Botanical Name	Family	Habit	Parts Used
I.	Musk dana	*Abelmoschus moschatus*	Malvaceae	Annual herb	Seeds
2.	Sowa	*Anethumgraveolens*	Umbelliferae	Annual herb	Seeds
3.	Dil seed	*Apium graveolens*	Umbelliferae	Annual herb	Seeds
4.	Davana	*Artemisia pallens*	Compsitae	Annual herb	Ariel parts
5.	Ylang Ylang	*Cananga odorata*	Annonaceae	Perennial tree	Flowers
6.	Cedarwood	*Cedrus deodara*	Pinaceae		Wood
7.	Lemongrass	*Cymbopogon flexuosus*	Gramineae	Perennial herb	Leaves
8.	Citronella	*C. winierianus*	Gramineae		
9.	Palmarosa	*C.martinii*			Leaves/ Flowering tops
10.	Eucalyptus	*E. citrodora* *E. globulus*	Myrtaceae	Perrenial tree	Leaves
11.	Iris	*Iris pallida*	Iridaceae	Perennial herb	Rhizome
12.	Jasmine	*Jasmine sambac*	Oleaceae	Perennial shrub	Flowers
13.	Lavender	*L. officinales*	Labiatae	Perrenial herb	Ariel parts
14.	Japanese mint	*Mentha arvensis*	Labiatae	Perennial herb	Ariel parts
15.	Bergamot mint	*M. citrata*	Labiatae	Perennial herb	Ariel parts
16.	Peppermint	*M. piperita*	Labiatae	Perennial herb	Ariel parts
17.	Spearmint	*M. spicata*	Labiatae	Perennial herb	Ariel parts
18.	Chamomile	*M. chamomilla*	Compositae	Annual herb	Flowers
19.	Sweet basil	*Ocimum basilicum*	Labiatae	Annual herb	Arial parts
20.	Geranium	*Pelargonium graveolense*	Geraniaceae	Perennial shrub	Leaves
21.	Patchouli	*Pogostemon*	Labiatae	Perennial	Leaves

		patchouli		herb	
22.	Rose	*Rosa damascena*	Rosaceae	Perennial shrub	Flowers
23.	Clary sage	*Salvia Sclarea*	Labiatae	Perennial herb	Ariel parts
24.	Sandal wood	*Santalum album*	Santalacae	Perennial tree	Heart wood
25.	MarigolW	*Tagetes minuta* *T. erecta* *T. patula* *T glandulifera*	Compositae	Annul herb	Ariel parts
26.	Khus	*Vetiveria zizanioides*	Gramineae	Perennial herb	Roots
27.	Vanilla	*Vanilla planifolia*	Orchidaceae	Perennial herb	Fruits (Beans)

ESSENTIAL OILS FROM ROSES

The essential oil from flowers of rose species is one of the costliest and sweetest fragrant materials known to the world from the ancient times. It is a perennial plant with an average life span of 15-20 year. Certain species can survive up to 50 years. Rose oil has very wide application for making high grade fragrance. Perfumer, cosmetics and tobacco industries are major consumer. On limited scale it is also used for flavoring purposes.

There are three species of rose (Rosa damascena Mill, R. centifolia L and R. gallica L) that are currently grown for the production of rose water, oil, concert, absolute and attar. Of the above species, Rosa damanscena is the most important for quality rose oil extraction and is widely cultivated in Turkey, Bulgaria and India. The main compounds in damask rose essential oils are geraniol and citronellol. The essential oil of this plant is highly valuable and is used to cure depression, insomnia and for stress reduction. Rosa centifolia is cultivated Southern France, Morocco and Egypt, whereas Rosa gallica which resembles Damask rose is cultivated in Ukraine. The total world production of rose oil is estimated to be 55-60 tons annually, of which the oil of Damask rose account for 15-20 tons only. Bulgaria shares 80% of the Damask rose oil production, Turkey 15% and the rest 5% by other countries, including India.

The important centres of rose cultivation are Hasayna (Aligarh), Kannauj and Sikandarpura (Ballia) in Uttar Pradesh and Pushkar (Ajmer) and Haldighati in Rajasthan. The Damask rose, (R. damascene) cultivation is confined to Hasayan, where it is grown in around 2000 hectares of land. Here the major flower produced is used to production of rose oil, rose water, rose attar. The true rose oil production of rose oil, rose water, rose attar. Another species of rose R. chinensis (Edward) which called Cheenia Gulab or Bharahmase locally is also used for production of essential oil because it flower throughout the year. In India total rose cultivation for essential oil extraction is done in an area of around 2500-3000 hectares.

The rose is a very remunerative crop if cultivated scientifically. Its full flower yield is obtained from third and subsequent years of plantation. This yield level is maintained until ten years of plantation thereafter it tends to decline. Thus, with an average recovery of 0.020%, oil yield during third and subsequent years vary from 0.4 to 0.60kg/ha/year. Considering an average recovery of 0.03% oil in temperate climate, the oil range from 1.20kg to 1.50 kg/ha/year. The average rate of rose oil in the market is to the tune of Rs.14-16 lakhs/

kg. The much needed intervention for this sector is the efficient method of oil extraction and improved varieties of roses for essential oil.

ESSENTIAL OILS FROM JASMINE

The jasmine essential oil agro-industry has attained the status of an export oriented highly valuable enterprise. French jasmine is being cultivated in Morocco. South Africa. Egypt. Syria,Tunisia, The U.A.R, Sicily, India and China. A report indicates that only a part of the demand is being fulfilled by India. The agro-climate of India has been found to be excellent for production ofsufficientquantities of high quality jasmine concrete and absolute.

Jasminum grandiflorum L. is one of the good oil yielding species of jasmine. Surabhi and Co-1 are the two varieties released under it. Optimum flower yield of these varieties can be obtained by planting them at 1.8 x 1.8 metres. Pruning is done in the middle of December at 0.90 metre height. Defoliants like paraquat dichloride at 3,000 ppm, Potassium iodide at 3,000-4,000 ppm or pentachlorphenol at 2,000 ppm can be sprayed. To induce early flowering and enhancement of flowering duration, spraying of 100 ppm Cycocei and 5,000 ppm B vine is recommended. Irrigation is given at fortnightly intervals.

Under South India condition the yield is 500 kg of flowers per hectare in the first year, 5 t/ha in second and third years and about 10 t/ha onwards. The flowers are harvested in early morning, then the flowers are processed in the extraction machine. The flowers are treated by solvent extraction method three time for 40 minutes, 30 minutes and 20 minutes. Then the flowers are discarded and the liquid (miscela) is heated at 60^0 C. The gasified hexane is condensed for re-use. The remaining small amount is a thick liquid which is passed tothe vacuum drier. After drying, the matter is called jasmine concrete. It is a brown colour waxy material having true aroma of jasmine flowers. To make absolute, the concrete is dissolved in absolute alcohol. Then it is filtered at very cold temperature, the resultant material is called jasmine absolute. It is a semi- viscous brown-coloured material having the odour of fresh jasmine flowers. Quality parameters of absolute are determined by gas liquid chromatography. Absolute is used for blending purposes to make various essential oil products.

ESSENTIAL OILS FROM TUBEROSE

Tuberose (*Pclianthes tuberose* L.) is essentially a leading commercial crop because of its multipurpose uses. The tuberose flower has a strong odour and on extraction yields strong highly valued essential oil. The long flower spikes arc excellent cut flowers when arranged in vases, bouquets apart from using single flowers for garlands and- others. They are commercially cultivated in West Bengal, Karnataka, Andhra Pradesh, Tamil Nadu and in Maharashtra.

Crops can be grown in light sandy loam to clay loam. The crop is well suited for cultivation in tropical to sub-tropical and temperate climates. A temperature range between 20 to 30°C is considered ideal for this crop. April to May is the best time for planting; sequential planting can also be practised to obtain flowers throughout the year.

Tuberose is commercially propagated by bulbs and bulblets at 30 x 30cm spacing. Irrigation is essential for high yields; it is required to keep the plot weed free, mulching is beneficial. Flowers are ready for harvest in about 3-4 months of planting. Flowers are harvested with a portion of stalk when they are fully opened. About 15-17 tons of flowers can be obtained per hectare. Extraction of tuberose flowers with petroleum ether yields 0.08 to 0.11 per cent of concrete which gives 18 to 23 per cent of absolute on treatment with alcohol. A concrete yield of 17 to 18 kg per hectare can be obtained, which gives 3.5 kg absolute and 0.80 kg distilled oil.

ESSENTIAL OIL PRODUCTION

The main methods used to obtain essential oils from plant material are water distillation, steam and water distillation, steam distillation and expression with the exception of the latter process, all others need heat to release the oil. The detail of these processes is as follows.

WATER DISTILLATION

The principle of water distillation is to boil a suspension of an aromatic plant material and water so that its vapours can be condensed. In water distillation the plant material is always in direct contact with water. An extremely important factor is that in stills where the water is boiled by direct contact with the fire, the water present in the still must always be more than enough to last throughout the distillation, otherwise the plant material can overheat and char. As a result, the oil can assume a variety of off notes, generally known as still notes.

The plant material in the still must be kept agitated as the water boils, otherwise agglomerations of devise material will settle at the bottom of the still and become thermally degraded. A way to avoid this is to ensure that the charge of plant material is readily dispersed into the water such as might be found in powdered material. Certain plant material like cinnamon bark is very rich in mucilage. As a result, if the cinnamon bark is powdered such that the charge can readily disperse in the water. Water distilled oils are commonly darker in colour and have much stronger still notes than oils produced by other methods. If the oil contains higher boiling components, the distillation time is increased over oils that contain only monoterpene hydrocarbons and oxygenated constituents. It is generally not possible to put enough water in the still and oxygenated constituents. It is generally not possible to put enough water in the still and have it last for the whole distillation cycle. To compensate for this, a cohobation tube is placed in the side of the still and water is constantly returned to the pot.

The oils produced by water distillation tend to be of lower quality than oils produced by other methods for the following reasons.

- The oil components like esters are sensitive to hydrolysis while others like acylic monoterpene hydrocarbons or aldehydes are susceptible to polymerization.
- Oxygenated components, such as, phenols have tendency to partially dissolve in the still water so their complete removal by distillation is not possible.
- As water distillation tend to be small, it takes a long time to accumulate much oil to good quality oil is often times mixed with the bad quality oil.
- The distillation process is treated as an art by the local distillers and often tries to optimize both their yield and quality.
- Water distillation is a slower process than either steam and water or steam distillation, consequently, it is less energy efficient.

An advantage of water distillation is that for plant material that has a tendency to agglomerate or to agglutinate into an impenetrable mass when steam is passed through it (like Rose petals), water distillation is reputed to be the preferred method of oil isolation. The only advantage of water distillation is that the cost of process equipment is extremely low, the design of the stills, condensers and collection flasks are simple. Water distillation is still used around the world to produce a few essential oils.

STEAM AND WATER DISTILLATION

In steam distillation, the steam can either be generated in a satellite boiler or within the still, although separated from the plant material steam and water distillation is the better of these processes. Like water distillation, it is a widely used process in rural areas as it does not require a more capital expenditure than water distillation. Also, the design of equipment that is used is generally very similar to that used in water distillation, only the plant material is supported above the boiling water on a perforated grid. In fact, it has become the traditional progression from water distillation to steam water distillation.

It follows that once the rural distiller has produced a few batches of oil by water distillation, there is a realization that the quality of oil that was produced is not very good because of its still notes. As a result, some modifications are made using the same still. A perforated grill or plate is fashioned so that the plant material is raised above the water. This reduces that capacity of the still but affords a better quality of oil. If the amount of water will not last long enough to allow the completion of distillation, a cohobation tube is allowed and condensate water is added back to the still manually, thereby ensuring that the water, which is being used as the steam source will never run out. It is also believed that this will, to some extent, control the loss of dissolvedoxygenated constituents in the condensate water because the re-use of the condensate water will allow it to become saturated with dissolved constituents, after which no more will dissolve in it.

STEAM DISTILLATION

As the name suggests, steam distillation is the process of distilling plant material with steam generated outside the still in a satellite steam generator generally referred to as a boiler. As in steam and water distillation, the plant material is supported on a perforated grid above the steam inlet. A real advantage in the satellite steam generation is that the amount of steam can be readily controlled because steam is generated in a satellite boiler. Consequently, the amount of heat with which the plant material will come in contact is acceptable and should not cause any thermal degradation of it. The process of steam distillation is the most widely accepted process for production of essential oils on the large scale. Throughout the flavour and fragrance supply business it is a standard practice. As obvious drawback to steam distillation is that much higher capital expenditure is needed to build up such facility in some situations, such as the large scale production of low cost oils such as, rosemary, Chinese cedarwood, lemongrass, eucalyptus, citronella etc.

THE CHEMISTRY OF DISTILLATION

Essential, volatile or ethereal oils are mixtures composed of volatile liquids and solid compounds, which vary widely in regard to their composition and boiling points. Every substance with a determinable boiling point is volatile and possesses a definite vapour pressure, which depends on the prevailing temperature. This is very low in case of high boiling substances. Hence the intensity of an odour may be considered as a manifestation of the volatility of the substance that emits the odour.

Majority of the essential oils has always been obtained by steam distillation or by Hydro distillation. Distillation may be defined as the separation of the components of a mixture of two or more liquids by the virtue of the difference in their vapour pressure.
In general there are two types of distillation.

1. Distillation of non-miscible liquid mixtures, which therefore, form two phases. This is achieved by Hydro distillation.
2. Distillation of completely miscible liquid mixtures, which therefore form only one phase. This is generally achieved by fractional distillation.

One important criterion in distillation of liquids is its boiling point. Boiling point of a liquid may be defined as the temperature at which, under atmospheric or any other specified pressure, a liquid is transformed into a vapour; i.e. the temperature at which the vapour pressure of the liquid equals the pressure of the surrounding gas or vapour. Any reduction in pressure above a liquid causes a lowering in boiling point. A liquid consisting of different fractions possesses different boiling points. Therefore, as the lower boiling constituents vaporize or distill off, the boiling point of the liquid rises and finally approaches that of the highest boiling constituent.

DISADVANTAGES OF WATER DISTILLATION
1. The oil components like esters are sensitive to hydrolysis while others like acyclic Monoterpene Hydrocarbons or aldehydes are susceptible to polymerization (the pH of water is often reduced during distillation so that hydrolytic reactions can be facilitated).
2. Oxygenated components such as Phenols have a tendency to partially dissolve in the still water so their complete removal by distillation is not possible.
3. As water distillations tend to be small (being operated by one or two people), it takes a long time to accumulate much oil, so good quality oil is often times mixed with bad quality oil.
4. The local distillers treat the distillation process as an art and few often try to optimize both their yield and quality.
5. Water distillation is a slower process than either steam and water or steam distillation, consequently, it is less energy efficient.

ADVANTAGES OF WATER DISTILLATION
1. The cost of process equipment is extremely low.
2. The designs of the stills, condensers and collection flasks are simple.
3. There is no need of electricity.
4. For the plant material that has a tendency to agglomerate or to agglutinate into an impenetrable mass when steam is passed through it (like rose petals), water distillation is reputed to be the preferred method of oil isolation.

ADVANTAGES OF STEAM AND WATER DISTILLATION OVER WATER DISTILLATION
1. Higher oil yield.
2. Oil components of the oil are less susceptible to hydrolysis and polymerization (the control of wetness on the bottom of the still affects hydrolysis, whereas the thermal conductivity of the still walls affects polymerization)
3. If refluxing is controlled, then the loss of polar compounds is minimized.
4. Oil quality produced by steam and water distillation is more reproducible.
5. Steam and water distillation is a faster process than water distillation so it is more energy efficient.

Distillation Techniques at a Glance

	WATER DISTILLATION	WATER AND STEAM DISTILLATION	STEAM DISTILLATION
Type of plant material	Finely powdered, flowers, not well adopted for high boiling constituents.	Well suited for herb and leaf materials.	Well suited for seed, root and wood material containing high boiling oils.
Rate of distillation	Relativity low	Fairly good	High
Temperature within the still	About 100°C	About 100°C	Can be modified according to plant material.
Quality of oil	Depends upon careful operation; "burning" of plant charge must be avoided, especially when distilling with direct fire.	Usually good.	Good, if operation is properly conducted all around.
Yield of oil	In most cases relatively low, due to hydrolysis because water soluble and high boiling oil constituents are retained by residual water in the still	Good, if no excessive wetting and lumping of the plant charge occurs. This would prevent steam from penetrating the charge thoroughly and result in abnormally low oil yield.	Good, if plant material is properly comminuted, evenly charged, and distillation properly conducted. Lumping of the charge or steam channeling might cause abnormally low yield of oil.

EQUIPMENT OF DISTILLATIONS

The equipment required for carrying out distillation of the plant material depends upon the size of the operation and the type of plant material. The three main parts:

1. Retort or Still proper
2. Condenser
3. Receiver

Retort or Still proper: It is commonly called as the tank and serves primarily as a container for the plant material, and as a vessel in which the water or steam comes in contact with the plant material and vapourises its essential oil. For water distillation simple equipment is sufficient, since water and charge can be introduced the cover put in place and heat applied under the retort. For water and steam distillation a grid is inserted sufficiently for above the real bottom of the still so that the boiling water and plant material (the latter supported by the grid) do not come in contact. The water is boiled either using a steam jacket or through a closed steam coil or in more simpler apparatus by a fire directly beneath the still. In case of direct steam distillation the grid may be closer to the real bottom. Here the steam is introduced through a steam line, usually through a perforated coil or cross below the false bottom.

Care must be taken for direct steam distillation. To ensure adequate steam distribution, the steam pipe inside the retort should be arranged in the form of a coil with small holes 1/8 inch in diameter, drilled in top of each arm throughout its length. The total surface of these small holes should not be larger than the orifice of the coil or of the arms of the cross. Otherwise the steam will escape from the first holes without reaching the entire length of the coil or cross. In other words the steam should be injected into the retort in such a way that it will evenly be distributed olf the bottom of the retort and on rising will penetrate the plant charge uniformly. Larger stills are equipped with two steams. Coils, each with a separate steam value prior to injection the steam is freed form excess water through a water separator.

The bottom of the retort is provided with a drain valve sufficiently wide, so that any water condensing within the charge and dripping to the bottom can be drawn off in the course of distillation otherwise such residual condensed water will accumulate and engulf the steam coil due to which the entering live steam will first have to pass through a layer of water, becoming wet in the process. In other words instead of direct steam there would be water and steam distillation.

This arrangement completes the still proper. Needless to say, all joints must be soldered steam tight, as any steam leak will result in loss of essential oil and fuels.

Condenser: It is the second major part of the distillation equipment. Here again the size and design are variable. The condenser serves to convert all the steam and the accompanying oil vapours into liquid. This requires the removal of an amount of heat equivalent to the heat of vapourisation of the vapours plus steam, and a small additional amount of heat to cool the condensed material (condensate) to a convenient temperature below its boiling point.

The most commonly used condenser is that in which the coils are inserted into a tank supplied with a running cold water, which enters form below and flows against another commonly used condenser called the 'Tubular Condenser'. In this, the condenser tubes are arranged in a single vertical bundle, the number and length depending on the amount of condensation to be accomplished, in such a way that the vapours to be condensed enter the tubes and cooling water circulates around the tubes. This is more advantageous since a more rapid flow of cooling water results in more efficient cooling. This is the type of condenser, which was used for our experiments. In plants the tubular condenser is commonly used.

The maximum efficiency of a condenser is attained when the condensate has been cooled to a sufficiently low temperature by heat transfer to the cooling water, which then flows out at a temperature approaching that of the incoming vapours. This affect is however rarely achieved usually it suffices if the cooling water flows out at the temperature of 80° C and the distillate at temperature of about 25-30°C.

The Receiver or the Oil Seperator

The third most essential part of the distillation equipment is the condensate receiver or decanter or the oil separator. Its function is to achieve a quick and complete separation of the oil form the condensed water. The condensate flows from the condenser into the oil operator, distills water and oil separates automatically.

Volatile oil and water are mutually insoluble because of the difference in their specific gravities. The two liquids form two separate layers. Usually oils being lighter than water float on top of water. The receiver should be so designed to permit the removal of water where the oil being distilled is heavier or lighter than water. This type of receiver is also known as ' Florentine Flask'. Wider the separation between the specific gravities of the two insoluble liquids. Faster and efficient the separation

The separated oil is finally set-aside until suspended water droplets; solid nuclear and impurities have separated. This is then filtered and stored in well-filled, airtight containers in a cool dark cell or in an air-conditioned room.

ENFLEURAGE OR COLD FAT EXTRACTION

Where the distillation may have deleterious effects on an essential oil through hydrolysis, polymerisation or resinification or where delicate oils become 'lost' in large volumes of water or where the flowers continue to produce fragrance after the harvest, enfleurage is usually practised. Fat possesses a high power of absorption and if brought in contact with fragrant flowers, readily absorbs the perfume emitted. This principle, methodically applied on a large scale, constitutes enfleurage.

The success of enfleurage depends to a great extent upon the quality of fat base (crops) employed. Utmost care must be exercised when preparing corps. If the corps is too hard, the blossoms will not have sufficient contact with the fat, curtailing the power of absorption and resulting in a subnormal yield of flower oil. On the other hand, if it is too soft, it may engulf the flowers so that the exhausted ones are difficult to remove and retain adhering fat, which entails considerable shrinkage and loss of corps. The consistency of the corps must, therefore, be such that it offers a semi-hard surface from which the exhausted flowers can easily be removed.

Since the whole process of enfleurage is carried out in cool cellars, every manufacturer must prepare his corps according to the temperature prevailing in his cellars during the month of the flower harvest. Many years of experience have proved that a mixture of one part of highly purified tallow (ox fat or sheep fat) and two parts of lard (fat of swine) gives corps of the required type.

PROCEDURE

Enfleurage and Defleurage: Every enfleurage building is equipped with thousands of so called 'chassis', which serve as vehicles for holding the fat corps during the process. A chassis consists of a rectangular wooden frame, 5 cm high, about 50 cm long and about 40 cm wide. The frame holds a glass plate upon both sides of which the fat corps at the rate of360 g each side or l kg for every 2.5 kg of flowers is applied with the help of spatula at the beginning of the enfleurage process. When piled one above the other, the chassis form airtight compartments, with a layer of fat on the upper and lower side of each glass plate.

Every morning during the harvest, freshly picked flowers arrive and having first been cleaned of impurities, such as leaves and stalks, are then strewed by hand on the top of the fat layer of each glass plate. Blossoms wet from dew or rain must never be employed, as any trace of moisture would turn the corps rancid. The chassis are charged and left in the cellars for 24 hours or longer depending upon the type of flowers. During this period the flowers come in direct contact with the fat layer on which they are resting and lose their fragrance in the absorptive fat whereas the fat layer above them absorb only the volatile perfume given off by the flowers.

After 24 hours, when the flowers have emitted most of their oil and start to wither, they should be removed from the corps with the help of tweezers, which is referred to as defleurage. The careful removal of the flowers is very important to avoid any objectionable odour.

Although most of the exhausted flowers will fall from the fat layer on the chassis glass plate when it is struck lightly against the working table, some flower particles will still adhere, which are removed manually. Immediately following defleurage, the chassis are recharged with fresh flower. For this purpose, the chassis are turned over and the fat layer which in the previous operation formed the top is now directly charged with flowers. In the case of jasmine, the entire enfleurage process lasts about 70 days; daily the exhausted flowers are removed and the chassis is charged with fresh ones.

At the end of the harvest the fat is relatively saturated with the flower oil and possesses the typical fragrance. The perfumed fat must then be removed from the glass plates between the chassis. For this purpose, it is scraped off with a spatula and then carefully melted and bulked in closed containers. This final product is known as 'Pomade' and in the past, was directly utilised without further treatment.

At the end of the enfleurage, the fat corps loses about 10 per cent of its weight because of various manipulations. In other words, the total yield of the fragrant pomade is less than the fat corps originally applied to the chassis. Most of the loss is caused by the fat adhering to the exhausted flowers when they are removed every 24 hours.

ALCOHOLIC EXTRACTS (EXTRAIT)

In the early days of perfumery, the fragrant pomades were used directly without further treatment. More recently, alcoholic extracts with the use of high quality alcohol have been made. In the trade they are known as extraits.

Since no heat is applied during the process of enfleuragc and while washing of the pomade with alcohol, the extraits contain the natural flower oil as emitted by living flowers. The only disadvantage possibly is a slight fatty by 'by note' which can be eliminated to a certain extent by freezing and filtering the alcoholic washings. However, this 'by note' is not always considered objectionable as it imparts a certain roundness and fixation value to the finished perfumes, especially in conjunction with synthetic aromatics.

In order to prepare extraits, the pomades are usually processed during the winter months when the factories are not busy with other work. For this purpose, the pomade is charged into especially designed equipment called a 'batteuse' which is a closed copper vessel heavily tinned inside and equipped with strong stirrers around a vertical shaft. Several batteuses are arranged in batteries, the stirrers of each battery being driven by a powerful motor. This work which goes on for several months, is carried out in cool cellars in order to prevent loss of alcohol by evaporation. The alcohol used in the process travels from one batch of pomade to the next (constituting, in turn, the third, second and first washings of successive batches), until it becomes enriched with flower oil and is drawn out as the alcoholic extrait. For the last washing, fresh alcohol is used, which also, in turn, becomes gradually enriched by the continuous process just described. When extended to a fourth or fifth washing, this method extracts the pomades so efficiently that the exhausted fat is quite odourless. Being useless for re-use in enfleurage, it is usually employed for making soap.

The fully saturated washing is run through a refrigerator and cooled to well below freezing temperature, if possible to -15° C. Most of the fat dissolved in the alcohol separates by this treatment. The cold alcoholic solution is then filtered at low temperature. The quantity of alcohol to be used for washing each batch for pomade is calculated with a view to obtain finally one kg of extrait per kg of pomade. Some alcohol is lost by evaporation during the process of stirring.

MACERATION OR HOT FAT EXTRACTION

Certain flowers such as jasmine and tuberose give their greatest yield of flower oil upon extraction with cnfleurage because their physiological activities continue for a further 24 hours or more after harvesting. However, the physiological activities in flowers like rose, orange, violet and acacia are stopped after picking; therefore, when extracted or distilled they yield only as much oil as contained in the flowers at that moment. Since no further oil develops in these flowers, the long and rather complicated method of enfleurage would prove ineffective. Hence, other methods must be resorted to whereby a medium actually penetrates the plant tissue and dissolves all the flower oil present in the oil glands.

In this case, a batch of hot fat is systematically treated with several batches of flowers until it becomes quite saturated with the flower perfume. The fragrant fat thus obtained, depending upon the flowers used, is called 'orange pomade' or 'pomade rose', etc. and is sold as such or it may be treated further by washing it with strong alcohol, exactly as jasmine and tuberose pomades obtained by enfleurage.

Every extraction lasts for about one-and-a-half hours. On a commercial scale, a batch of 80 kg corps is heated to about 80°C temperature, charged with 20 kg of fresh flowers each time until one kg of corps has been treated with about 2 to 2.5 kg of flowers. During the process of maceration, when the corps is left standing for about an hour, it cools and solidifies. The mass is then reheated, melted and strained through metal sieves and filter bags, whereby the exhausted flowers are eliminated.

The method of maceration is rather cumbersome but it served its purpose in the earlier days when no better process was available. Its products (extraits and absolutes of maceration) often show a fatty 'by note' which originates from the fat corps and modifies the character of the original flower perfume. A further disadvantage is that the fat content in the absolute of maceration easily turns rancid, thereby developing a sharp disagreeable note.

SOLVENT EXTRACTION

Although solvent extraction is comparatively a recent process in essential oil production, it had been known as early as 1835 that volatile solvents could be used to extract the essences from flowers more conveniently than by maceration. This method, once developed, was quickly adopted for processing all types of perfumes from the flowers that do not continue to produce fragrance once they are picked. The principle of extraction with volatile solvents is simple. Fresh flowers are charged into especially constructed extractors at room temperature and treated carefully with purified solvent, usually petroleum ether. The solvent penetrates the flowers and dissolves the natural flower perfume, together with some waxes and other albuminous and colouring matter. This solution is subsequently pumped into an evaporator and concentrated at a low temperature. After the solvent is completely driven off in vacuum, the flower oil is obtained. Since no heat is applied in the method at any stage, the oil is saved from harmful effects of higher temperatures and, therefore, more purely represents the natural perfume as originally present in the flowers.

Quality of Solvent: Ideally the solvent used for the extraction should posseses the following properties:

1. It should completely and quickly dissolve all the odoriferous principles of the flowers, yet as little as possible of such inert matter as waxes, pigments, albuminous compounds, etc. In other words, the solvent should be selective.
2. It should possess a sufficiently low boiling point to permit its being easily removed without resorting to higher temperatures. Yet the boiling point should not be too low, as this would involve considerable solvent loss by evaporation in a warm climate.
3. The solvent must not dissolve in water, since the water present in the flowers would be dissolved and accumulate in the solvent.
4. The solvent must be chemically inert, that is, it should not react with the constituents of the flower oil.
5. The solvent must have a uniform boiling point when evaporated and should not leave any residue.
6. The solvent should be low priced and, if possible, non-flamable.

There is no solvent yet discovered which satisfies all the requirements. Considering the above facts, highly purified petroleum ether appears to be most suitable with benzol ranking next.
Extraction Process: The extractors to be used for solvent extraction may be stationary or rotary, commonly with a capacity of about 1,200 litres and holding up to 200 kg of flowers per charge. Three to four washings with solvent are usually required. About five hours are required for processing a batch of flowers, including final steam distillation of the spent material to recover solvent. The concentrated washings are filtered, then evaporated in a water bath type of still in which the temperature never reaches 60° C. Final purification of the oil in order to obtain the concentrated oil and to get rid of waxes or albuminous impurities may be done under vacuum to precipitate out the impurities.

The chief disadvantages of the process are the need for comparatively elaborate and expensive equipment and for precision control by trained supervisors. Hence, solvent extraction will probably never replace distillation in rural areas or among the backward populations. For low priced oils, the process is uneconomical as a considerable amount of purified solvent is unavoidably lost, an amount that might perhaps represent the difference between profit and loss in the enterprise.

EXPRESSION

Expression of essential oil is practised in certain special cases, as in the production of citrus oils from juices and waste rinds from citrus canning factories. In general, expression involves squeezing any plant material at great pressure in order to press out the oils or other liquids. The process is carried out by hand-operated presses or crushers in isolated rural areas or by gigantic mechanical presses ill industrial centres. In the production of citrus juices, the oil is unavoidably expressed from the fruit. The oil is then separated from the juice by centrifuging.

SUPERCRITICAL FLUID EXTRACTION (SCFE)

This is the most recent method of extraction of essential oil from materials of plant origin where the fragrance and flavour ingredients resemble their source. Supercritical carbon dioxide has the density of a liquid, low viscosity and diffuses like a gas. It is an excellent solvent for a wide range of natural substrates.

Advantages:

1. Through this method a broad range of low to medium molecular weight compounds like esters, aldehydes and terpenes can be extracted.
2. Extracts contain no residual CO_2 solvent and is similar to the natural product.
3. As the extraction is conducted at a temperature low enough (critical temperature 31°C), the organoleptic properties are unimpaired.
4. It has the status of 'safe food grade solvent' and can be used for processing of multiple products.

Extraction Process: For extraction, the raw material is enclosed in a cylindrical container with porous ends, which is located in the extraction chamber. Temperature and pressure are selected (above its critical temperature at 31°C and pressure 73.8 bar) according to the material and desired end product. Supercritical CO_2 circulates through the-material, dissolving the essential oil. Solvent and solute then circulate into a separator where the pressure is maintained below the supercritical point. The CO_2 becomes gaseous and its solute precipitates before collection. Further, the gaseous CO_2 is taken to a heat exchanger where it is again cooled and liquefied. The liquid CO_2 goes back into the extraction unit for further use .

STORAGE OF ESSENTIAL OILS

It is one of the most important aspect and little is known about the processes which causes the spoilage of essential oils. Usually they are following reactions:

a. Oxidation.
b. Resinification.
c. Polymerization
d. Hydrolysis of esters.
e. Interaction of functional groups .

The above processes are activated by attributes like Heat, Air (oxygen), Moisture and Light. Essential oils are in general colourless, particularly when they are fresh, but on storage they may develop colour. To prevent this following precautions should be taken.

(a) Protection from sun light.
(b) Storage in a cool place.
(c) Storage in dry environment.
(d) Stored in amber coloured bottles.
(e) Bottle should be filled up to brim.

The high terpene content of citrus oils, pine needle oil, tagetes, turpentine etc. are very much prone to oxidation and resinification. Light is less harmful than moisture. Essential oil of lavender and Bergamot which contain high percentage of ester (linallyl acetate) turns acid after improper storage, during partial hydrolysis of ester. The aldehyde content gradually diminshes in case of oil of lemongrass and this process is much faster if aldehyde is stored after isolation from oil. This is probably due to presence of some antioxidant in oil. Oils containing alcohol like sandalwood, Geranium are quite stable and can withstand prolonged storage.

Essential oil should be freed from metallic impurities and moisture. It should be stored in tightly closed container at low temperature and protected from light. For small packing, amber coloured glass bottles are suitable. But for large quantifies they should be stored in metal drums, heavily tin lined if possible. A layer of carbon dioxide or nitrogen gas is blown inside container before it is sealed in order to replace air above oil and hence to protect it from oxidation.

In order to remove moisturefrom essential oils addition of anhydrous sodium sulphate can be done. The container is thoroughly shaked, keeping aside and then filtered using suitable methods. Calcium chloride should not be used for removal of moisture as it form complex salt with certain alcohols. In case of viscous oil like Vetiver the problem of moisture could be tackled by addition of common salt and then allowing mixture to stand until, the supernatant oil has become clear. The lower layer could be filtered.

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CULTIVATION OF GLADIOLUS FOR CUT FLOWER PRODUCTION

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INTRODUCTION

Gladiolus, the queen of the bulbous plants grown in many parts of the world. Gladiolus flowers are in demand for their elegant attractive spikes of different hues and good keeping quality. Its magnificent inflorescence with a variety of colours has made it attractive for use in herbaceous borders, beddings, pots, and cut flowers. Moreover, its easy cultivation and wider adaptability have made it so popular among growers. Nowadays in India, gladiolus has become a very popular flower and millions and millions of spikes are being sold every year and its important cut-flower in both domestic and international market. The remarkable beauty of the flower spikes, bright snow white, red, pink, orange and array of colour bloom have attracted a large number of flower lovers. Among geophytes, it ranks second next to tulips in international florist trade and first in domestic trade. In the plains, gladiolus flowers are available during the winter months only. Very high temperature during the summer days may adversely affect the flower spikes. In India around 1500 ha is under gladiolus cultivation and mainly cultivated in UP, Uttarakhand, West Bengal, Haryana, Punjab, Delhi, Karnataka, Andhra Pradesh, Maharashtra and Himachal Pradesh.

BOTANY

Gladiolus, a herbaceous perennial, belongs to the family Iridaceae and sub-family lxioideae with basic chromosome number of 15. The leaves are sword shaped and have overlapping bases, and the flowering stem is spike. The single spike may have 10-18 florets. The corms are bulb-like, globose or ovoid, having series of nodes, wholly covered with tunic or husks and orient strictly in vertical fashion within the soil.

SOIL

Well drained organic matte rich soil with the pH of 6 is highly suitable. Gladiolus can be grown in a wide range of soil but the best results are obtained from sandy loam soils which are friable, well-drained and rich in organic matter. It is better to grow on fairly acidic soils with a pH range of 5.5 to 6.5. In light soil, adequate amount of well-rotten organic matter should be applied and in very heavy soils, coarse sand may be added to improve the texture.

CLIMATE

In the plains, it is grown as a winter season crop while on the hills, it is grown as summer season crop. Gladiolus prefers sunny situation and requires at least 80 % of the total sunlight for their proper growth and development otherwise blasting may occur or plants may remain blind. The long day conditions of 12 to 14 h increase number of florets, spike length. Low light intensity causes failure in flowering. But high light intensity at high temperature also affects growth adversely. Temperature should range between 27°C and 30°C. Low temperature (1-4°C) and low light intensity cause flower blasting. Prolonged high humidity in atmosphere may promote infection by pathogens.

FIELD PREPARATION

The land should be prepared at least one month prior with thoroughly ploughed and leveled. It should be free of weeds and pathogens that is why it is advisable to give a rest period to the land and, therefore, green manuring should also be done with sunhemp, dhaincha, moong, or other leguminous crops can be used. The cover crops are turned into the soil 2 months prior to planting. The first ploughing is done to a depth of 30 cm and the field is left as such for 1 month. The second ploughing is done 3 to 4 weeks before planting. This is followed by rolling the field to a fine tilth.

PROPAGATION

Gladiolus is bulbous crops and can be propagated by both sexually and asexually. Sexual propagation through seeds is followed only by breeders to evolve new varieties. Asexual methods followed in gladiolus are through corms, cormels, division of corms. Gladiolus also propagated though micro-propagation and it is getting popularity to get disease-free planting material. However, commercial method of propagation is through corms and cormels. On an average one corm produces 1-3 daughter corms and 25-50 cormels per plant. Their size can vary from 2-20 cm in circumference. Cormels give rise to one corm and numerous cormels. Production of cormels can be improved by shallow planting of corms, removal of flowering spike at an early stage, proper nutrition and improved cultural practices. Small sized corms are usually used as planting stock, which on subsequent years give rise to flower grade corms.

SELECTION AND TREATMENT OF CORMS

A large size corm is preferred to get taller and healthy plants, early and uniform flowering and heavier spikes. The sprouted corms should only be selected for planting. A well retarded corm which has passed the dormancy period (3-5 months after harvesting) should be selected for planting. Two or three weeks, prior to planting, the cold stored (4-10°C) corms and cormels should be kept in a well ventilated room with a temperature of 30-35°C to break the dormancy and to encourage the root swelling. The brown dry scales or the tunics should be removed to encourage the sprouting. Before planting, the gladiolus corms should be disinfected properly to reduce the change of disease attack. The disinfection of corms is done by submerging the corms in a solution of Bavistin (0.2 %) for about 1 hour. The corms should be planted immediately after the disinfection treatment.

PLANTING MATERIAL

The planting material should be free of diseases and mechanical damage. Commercially the plants are grown from corms of specific size. A corm with 4.5-5.0 cm diameter and more than 40 g weight has been ascertained to be moderate. Bigger corms take shorter period to bloom as compared to smaller corms. Each corm generally has 6-15 buds depending on the size but only 2-3 of these can produce good bloom. In order to get one large bloom, all the eyes except the strongest and closest to the center are removed (de-eying) with a sharp-pointed knife.

TIME OF PLANTING

In India, optimum time for planting gladioli is September-October in the plains and March-April in the hills, whereas in Bangalore condition it can be planted throughout the year. However, for best quality flowers it should be planted during October-November and for corm production, it should be planted during June under Bangalore condition.

PLANTING DEPTH

Gladiolus being a bulbous crop, need deep planting to ensure vertical and straight growth of the shoot as well as to prevent them from lodging. Deep planting also facilitates greater multiplication of daughter corms and cormlets. Generally a planting depth of 7-15 cm is suggested. Larger corms as well as lighter soil requires more planting depth in comparison to smaller planting material and heavier soil.

PLANT SPACING

Plant spacing basically dependent upon the size of the planting material. However, it also varies with varieties and season of growth. Under North Indian plains a spacing of 30 x 20 cm is recommended.

VARIETIES

A number of gladiolus varieties have been found to grow well under Indian conditions

Table 1: Gladiolus cultivars suitable and developed in India

Sr. No.	Institute	Cultivar
1.	Indian Agricultural Research Institute, New Delhi.	Gunjan, Neelam, Anjali, Archana, Mayur, Agni, Rekha, Suchitra, Pusa, Suhagin, Sanjeevani, Dhanvantari, Noorpur and Neelkanth, Pusa Manmohak, Pusa Kiran, Pusa Shubham Pusa Sarang, Pusa Shingarika.
2.	India Institute of Horticulture Research, Bangalore (Karnataka)	Arka Amar, Arka Naveen, Arka Gold, Arka Kesar, Arka Suvarna, Meera, Nazrana, Poonam, Sapna, Aarti, Apsara, Shobha, Darshan, Shakti, Sindoori Tilak, Dheeraj, Sagar and Kum Kum.
3.	Punjab Agricultural University, Ludhiana, Punjab	Punjab Dawn, Punjab Elegance, Punjab Lemon Delight, Punjab Beauty, Punjab Morning, Shan-e- Punjab
4.	Mahatma Phule Krishi Vidyapeeth M.P.K.V., Pune	Shree Ganesh, Phule Ganesh, Phule Neelrekha, Phule Tejas, Phule Prerna
5.	National Botanical Research Institute, Lucknow, (U.P.)	Archna, Arun, Basant Bahar, Gazel, Hans, Indrani, Jwala, Kalima, Malhar, Manisha, Manmohan, Manohar, Mohini, Mridula, Mukta, Pitamber, Priyadarshini, Rim Jhim, Sada Bahar, Sanyukta, Smitha, Tambari, Kohra and Triloki.
6.	Horticulture Experimental and training Centre, Chaubatia, Almora (U.P).	Chaubatia Arunima, Chaubatia Ankur, Chaubatia Tripti and Chaubatia, Shobit.

THE COLOUR WISE CLASSIFICATION OF INTRODUCED VARIETIES IS GIVEN BELOW:

Pink: American Beauty, Day Dream, Miss America, Applause, Dawn Pink, Deciso, Friendship, Priscilla
Green: Green Star, Oasis, Lemonlime, Green Bay
Orange: Fiesta, Peter Pears, Saxony, Autumn Gold, Coral Seas
Red: Red Advance, Red Majesty, Intrepid, Black Prince, Hunting Song, Oscar, Victoria, Red Beauty, Rosiebee Red.

Yellow: Jester, Jester Gold, Gold Field, Anglia, Aurora, Folk Song, Golden Harvest, Golden Peach, Jacksonville Gold, Yellow Stone, Novalux.
White: White Friendship, White Prosperity, Amsterdam, Classic, Cotton Blossom, White Friendship, Snow Princess,
Purple: Purple Flora, Chemistry, Blues, Tropic Seas, China Blue, Blue Moon, Her Majesty, High Style

Commercial Cultivars: American Beauty, Amsterdam, Apollo, Appleuse, Bonair, Christan Jane, Eurovision, Gold Field, Her Majesty, Friendship, Eurovision, Gold Field, Green Wood &Packer, Trader Horn, Spic and Span.

GROWTH AND FLOWERING

Genetic constitution of the plant growing environment, nutrition, soil moisture etc. are the important factors influencing the growth and flowering of gladiolus. The role of growth substances in the regulation of growth and flowering is also well-known.

A. ENVIRONMENTAL FACTORS

Flower induction in gladiolus is autonomous. Inflorescence initiation always follows a definite number of leaves usually 8-10. Further development of flower spikes and also of individual florets are affected by environmental factors, mainly light, temperature and water deficit.

1. LIGHT

Among the factors related with light photoperiod and light intensity are important.

A. Photoperiod

Earlier flowering was induced in gladiolus with 12-hour light but the spikes were shortest and flowers fewer as compared to 15-hour photoperiod. However, artificial light from 30 minutes to 90 minutes at midnight from the date of sprouting brought about, effect similar to that of long photoperiod.The flower bud apparently differentiates as the stem elongates regardless of day length, but the flower often aborts at various stages before the formation of ovules and pollens, when the day is short due to low light intensity. Lengthening the day with artificial light in winter months increased flower production.

In winter, photoperiodic low light intensity extension of natural day length (LD) delayed flowering and increased the number of florets, the number of secondary inflorescence and sometimes the flowering percentage also. Plant response to long-day treatment was similar at all stages of flower development.

B. Light intensity

Gladioli prefer high light intensities but very high intensities without provision for temperature control adversely affects growth, although low light intensity is the main cause for failure in flowering of gladioli.

Total solar radiation is an important factor affecting winter flowering as low light intensity in winter affects flower development directly, whereas short-day has a dual effect, one of reducing the total daily solar radiation and the other photoperiodic effect of reducing the time from planting to flowering.

2. TEMPERATURE

When gladiolus plants are exposed in pots to low night or day temperature of 20°C at various stages of development and reported that 2 and 5 to 6 leaf stages are found to be most sensitive to low night temperature, which reduced the flowering percentage at both stages and the number of florets per spike at 2 leaf stage plants were tolerant to high temperatures (up to 50°C) so long the air humidity and soil moisture level were optimum.

B. GROWTH REGULATORS

Growth regulators have been found to influence the growth and flowering of gladiolus.

It has been found that the GA treated corms sprout and flower earlier. It has been seen that if the plants are sprayed thrice with 100 ppm of GA_3, the flower quality is improved and there is better corm multiplication.

Treatment with GA increases the weight of cormels and IAA that of corms. GA_3 and IAA solution hastens differentiation of floral primordia but kinetin retards corm sprouting and shoot apex differentiation.

Gladiolus being a very popular flower is in constant demand throughout the year. However, in cold regions it is difficult to grow the crop outside in the field during the winter months. Gladiolus can successfully be grown in different structures like glasshouse, plastic tunnels, hot beds etc. The advantages of glass-house are manifold as it provides protection against unfavourable condition. It ensures desired temperature, light and humidity. The carbon dioxide content of the air is also enhanced, assuring better photosynthetic activity.

MANURES AND FERTILIZERS

Gladiolus has got underground organs in the form of corms and cormels which provide food to sustain plant growth for initial few weeks. However, cormlets being smaller in size have lesser-stored food and hence require more frequent fertilization. Gladiolus requires both macro and micro-nutrients for its growth. Fertilizer dose is recommended on the basis of soil tests. The recommended N:P:K: ratio for North Indian condition is 200:150:150 kg/ha. The source of nitrogenous fertilizer is very important. Ammonia source of nitrogen and low pH favour rot problem caused by *Fusarium*.As a general rule, large plants and large flower spikes respond more to fertilizer because they need more photosythates to meet their requirement.

Deficiency of any of the essential nutrients may hamper the growth of plant and is expressed in the form of specific symptoms. N deficiency causes blindness, pale green colouration of foliage and reduction in the number of florets per spike as well as number of spikes per corm. However, P deficiency leads to dark green foliage and purple colouration in the lower leaves. In case of severe deficiency of K, the older leaves show marginal leaf burn. Ca plays very important role in production of quality flowers. A mild deficiency results in a disorder “topple” which causes breaking over of gladiolus in the vase after most of the florets have opened. In severe Ca deficiency, florets do not open normally and petals curve inward with breakdown of internal tissues. The deficiency problem is more common in light sandy soils. These deficiencies can be corrected by additional supply of the particular nutrient to the plant.

AFTERCARE
Once the corms are planted, they should be taken care for optimum moisture content in the soil. Lack of moisture can delay sprouting. When the plants attain a height of 20 cm, they should be hilled up to the height of 10 to 15 cm. This enables the plants to grow them erect even during high winds and severe rains.

IRRIGATION
The frequency of irrigation depends on the weather conditions, soil type and rainfall. During warm weather, watering should be done superficially twice a week whereas in cold weather once in 10 days is enough.

WEED CONTROL
A wide variety of weeds attack gladiolus crop. The common weeds are *Chenopodium album, Panicum sp., Amarathus retroflexus, Digitaria sanguinalis, Echinochloa crus-galli, etc.* Mechanical or manual weeding is often labour consuming and expensive. Moreover, it often damages the root system. Hence, an efficient system of chemical weeding is required. However, in India, the growers generally follow hand weeding. Weeding is done 4-8 times as per the requirement. The first weeding is done within 4 weeks of planting, second weeding during top dressing and rest as per the requirement. A range of herbicides are available in the market. Before crop emergence, contact herbicides like diquat, paraquat (0.8 kg a.i./ha), and glyphosate (1 kg a.i./ha) can be used. Besides these, some common herbicides used in gladiolus field are Atrazine, Simazine, Basalin @ 2-4 kg/ha.

HARVESTING
In gladiolus, florets are borne alternatively on long slender spikes. These spikes are harvested for cut flowers. The quality of spikes are judged by the number of florets per spike, length and width of spikes, and number of florets opening at a time. An ideal spike should be in tight bud stage with 3-4 buds showing colour so that they may easily open one by one in the vase. For a commercial cultivar, there should be 7 florets open at a time after cutting and when arranged in vases. The spikes should be harvested with a sharp knife in the morning when they are still turgid and are kept in a bucket full of water to remove field heat. While cutting, there must be 4-5 leaves left on the plant which will help in corm development in the subsequent period.

YIELD
Generally one plant produces single marketable spike and one plantable corm. However, sometimes twin buds may sprout resulting in 10-15 % more yield than the actual number of corms planted. By planting 1.5 lakh corms about 2.0 lakh spikes can be harvested from 1 ha area.

POSTHARVEST TECHNOLOGY

POSTHARVEST HANDLING OF SPIKES
The harvested spikes are given a series of pre-treatments to enhance the shelf-life. First of all they are pre-cooled at $5\text{-}7^0$ C under shade followed by pulsing. Pulsing solution consists of sucrose (20 %) and 8-HQC (200 ppm) for 24 hours. Different floral preservatives have been identified not only to improve shelf-life but also to improve bud opening. Gladiolus being a multifloret system, requires comparatively more amount of sugar (4 %) even in vase solution.

STORAGE OF SPIKES

Spikes should be stored at 4-5^{0}C in dry storage or wet storage with their bases dipped in water. Dry storage can store spikes for up to 7 days. During storage the spikes should be held vertically to avoid negative geotropic bending. This is a common problem in gladiolus during storage and transportation. It arises due to downward lateral movement of auxin when the spikes are held horizontally resulting in elongation of cells thereby causing upward bending of spike tips.

GRADING, PACKING AND TRANSPORT

The cut spikes are categorized on the basis of their quality. They may be categorized on the basis of variety, number of florets, spike length, freshness, colour, etc. According to the North American Gladiolus Society, gladiolus spikes are graded into four grades:

Grade	Spike length (cm)	Minimum No. of florets
Fancy	>107	16
Special	96-107	14
Standard	81-96	12
Utility	<81	10

The graded bunches are counted in separate bundles of 50-100 spikes and packed in cardboard, wooden or bamboo baskets with adequate perforation for ventilation. Generally, cardboard boxes of 100 cm x 25 cm x 10 cm size are used. The upper part of the spikes bearing florets should be wrapped with tissue paper to avoid bruising due to friction during handling. Also, the spikes should be arranged head to tail alternatively, and tied with cotton wool so that they remain in position. The bottom should be given a small diagonal cut for exposing maximum capillary tissue in order to maximum water uptake. The spikes should be transported as soon as possible to the destination. It is always better to use refrigerated vans for transportation.

POST HARVEST HANDLING OF CORMS AND CORMELS

Generally the corms are lifted at 45 days of flowering with the help of spades, and *khurpi*. At the time of lifting, the soil should be dry and loose. In order to meet this requirement, irrigation should be withheld at least 2-3 weeks before the operation. Harvesting of corms at right stage is very important. Lifting is done during April-May in the plains while during Oct-Nov. on the hills. Early harvesting may result into early flowering in the following season but is often accompanied with loss of viability of corms. Late harvesting subjects the corms to natural hazards like overwintering or damage due to rains in various parts of the country leading to fungal or bacterial infection as well as rotting. The late harvested corms produce longer spikes with more numbers of florets.

The lifted corms and cormels are dried in a shady and well ventilated place for about 14 days. The corms are cured for two to three weeks at 15-23^0. While curing, the layers of corms should not be more than three. Curing is followed by cleaning, grading and storage. Before storage, corms and cormels should be dipped in 0.2% Captan at least for 1 hour and are dried in shade for about 2 weeks again. Then, they are packed in shallow wooden crates or gunny bags and are stored at a temperature of 3-7^{0}C with 68-75% relative humidity till the next planting season. The corms undergo a period of dormancy. In order to break the dormancy, the corms are brought to a warmer condition about 20 days before planting. Sprouting can also be induced by treatment with 0.3% ethylene chlorohydrin or 4% thiourea or 100 ppm GA_3.

PHYSIOLOGICAL DISORDERS

i) **Flower abortion:**This is primarily due to poor light condition. Sometimes, in greenhouses etiolated plants are observed. This may be due to the inbalanced relationship between light and temperature.

ii) **"Topple":** It results due to deficiency of calcium. The symptom is breaking over of gladiolus in vase after most of the florets have opened.

iii) **Fluoride injury:** Gladiolus is very sensitive to fluoride toxicity. It expresses the effects of fluorine even at a level of 1 ppb. The effect is expressed in the form of tip burn on leaves. Fluoride toxicity can be reduced by spraying 5 % lime or magnesium sulphate.

DISEASES AND PESTS

Gladiolus is attacked by a large number of pathogens. The common diseases are as follows :

i)*Fusarium oxysporum*F. *gladioli* is the common pathogen of gladiolus causing 'vascular disease' or 'dry rot' or 'core rot'. The symptoms are dry rot in storage and wet rot coupled with plant yellowing and bending in the field. Corm splitting into halves show radiating dark coloured streaks and ultimately the center of the entire corm rotten. The plants show geotropic bending. Pre-planting or post harvest dusting of corms with 10-20 % Captan, benomyl or thiabendazole is recommended. Hot water treatment is also effective against this pathogen.

ii)*Botrytis gladiolorum*is a soil fungus and causes gray mould or neck rot or floral rot. Cool and humid weathers are conductive for the pathogen. During severe winter when temperature goes below 4^0 C, *Botrytis* is the major problem affecting the gladiolus cultivation in northern plains. Symptoms are small red-bordered and rusty-coloured specks on leaves and stems, watery spots on the flowers, etc.

iii) Septorial leaf spot caused by *Septoria* sp., root rot caused by *Stromatinia gladioli, Curvularia* blight caused by *Curvularia trifolii* f. *gladioli* and storage rot by *Penicillium* sp. are the other common fungal diseases. These pathogens can be controlled by applying a proper combination of different fungicides. Diathane M-45 @ 0.2 % or Maneb @ 0.2 % can take care of these diseases.

PESTS

Many insects and pests attack gladioli at different stages of growth and development. The *aphid* (*Aphis gossypii),* thrips (*Taeniothrips simplex),* and cut worms *(Agrotis segetum)* are the common insect-pests of gladiolus. Usually these pests suck sap of the plant or feed on the foliage. Sometimes, nematodes may also cause problem. *Meloidogyne* and *Trichodorus* attack gladioli corms and roots.

CONTROL MEASURE

Pest management can be done by use of chemical pesticides as well as cultural practices. Ploughing during summer exposes pupae to predators. Collection and destruction of egg masses and leaves infested with larvae reduces pest built. Storing of infested corms at 2^0 C for 6 weeks and treating them in hot water at 46^0 C, completely kills thrips on the corms.

NUTRACEUTICAL POTENTIAL OF NATURAL PIGMENTS FROM FLOWERS

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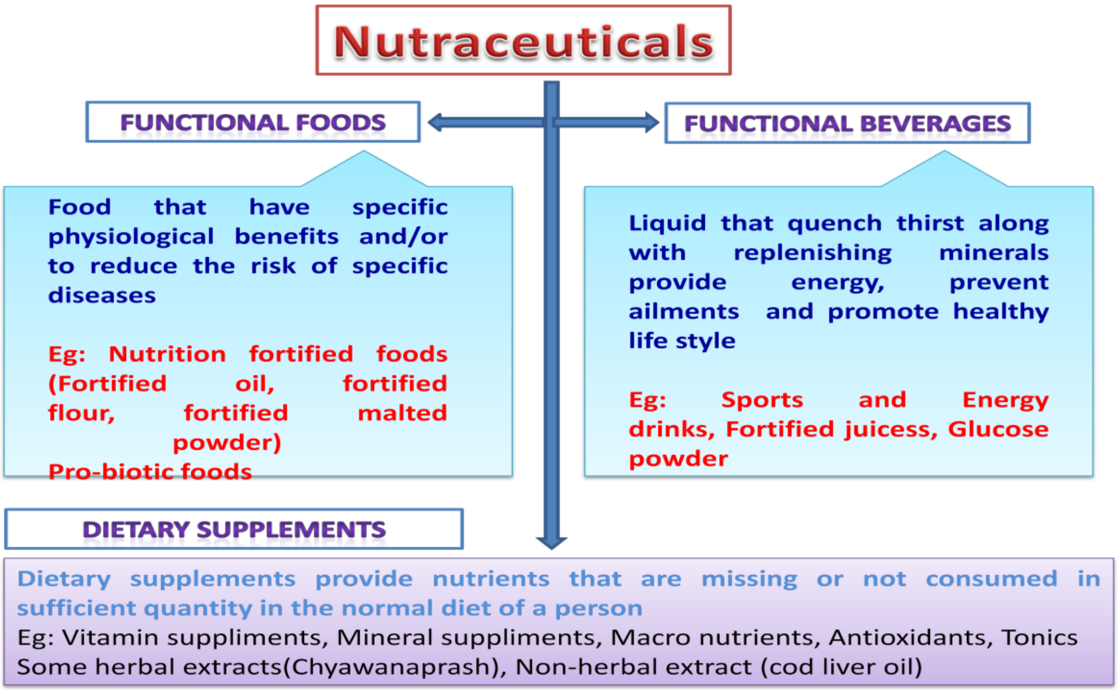
INTRODUCTION

The term "Nutraceutical" was coined from the words "Nutrition" & "Pharmaceutical".Nutraceutical can be defined as "A food or part of food or nutrient that provides health benefits including the prevention and treatment of a disease." They can be classified mainly in to three. They are functional foods, functional beverages and dietary supplements. Functional foods have specific physiological benefits and reduce the risk of specific diseases.Nutrition fortified foods such as Fortified oil, fortified flour, fortified malted powder and Pro-biotic foodscome in this class. Functional beverages quench thirst along with replenishing minerals. Thus provides energy, prevent ailments and promote healthy life style. Examples include fortified juices, and glucose powder. Dietary supplements provide nutrients that are missing or not consumed in sufficient quantity in the normal diet of a person.Vitaminsupplements, Mineral supplements, Macro nutrients, Antioxidants, some herbal and Non-herbal extracts come in this class of nutraceuticals.



PIGMENTS FROM FLOWERS

Plant pigments have a long history of use by humans. Pigments are chemical substances which reflect few wave lengths of the visible light making them appear colourful. These pigments can be used in *medicines, foods, clothes, furniture, cosmetics*, and in other coloured products. Plant Pigments are generally classified in to chlorophyll, carotenoid, flavonoid and phytochromes. Among these, carotenoids and flavonoids are the major classes of pigments.

The **anthocyanins** from flavonoids and **lutein** from carotenoids are the two important pigments with nutraceutical applications.

Anthocyanins are of particular interest to the food colorant industry due to their ability to impart vibrant colours. They have been used as traditional herbal medicines due to their diverse physiological abilities to treat conditions such as hypertension, pyrexia, liver disorders and urinary problems. Anthocyanins are the largest group of water-soluble pigments in theplant kingdom and belong to the family of compounds known as flavonoids which are part of an even larger group of compounds known as polyphenols. Anthocyanins are responsible for the red, purple and blue colours in fruits, vegetables, flowers and grains. Anthocyanins are widely distributed in the human diet and the estimated daily intake has been found to be 12.5 mg/day in the United States. Therefore, they can be incorporated as a functional food ingredient into our diet. Studies have demonstrated that anthocyanin extracts can improve sight acuteness, display antioxidative and radical-scavenging activity and to act as chemoprotective agents. Anthocyanins also play a role in anti-diabetic properties such as lipid lowering, insulin secretion and vasoprotective effects.

Lutein and Zeaxanthin are often found together in foods and human tissues. These are present in the green leafy vegetables and also in yellow and red coloured fruits. Generally, compared to Zeaxanthin, Lutein is present in greater amount in human blood and tissues. Lutein from diet can be either in free form or bound in ester form. Lutein shows a high antioxidant activity (Chopra et al., 1993), and can act as a potential cancer-prevention agent (King et al., 1995). The flowers marigold and chrysanthemum are rich in lutein.

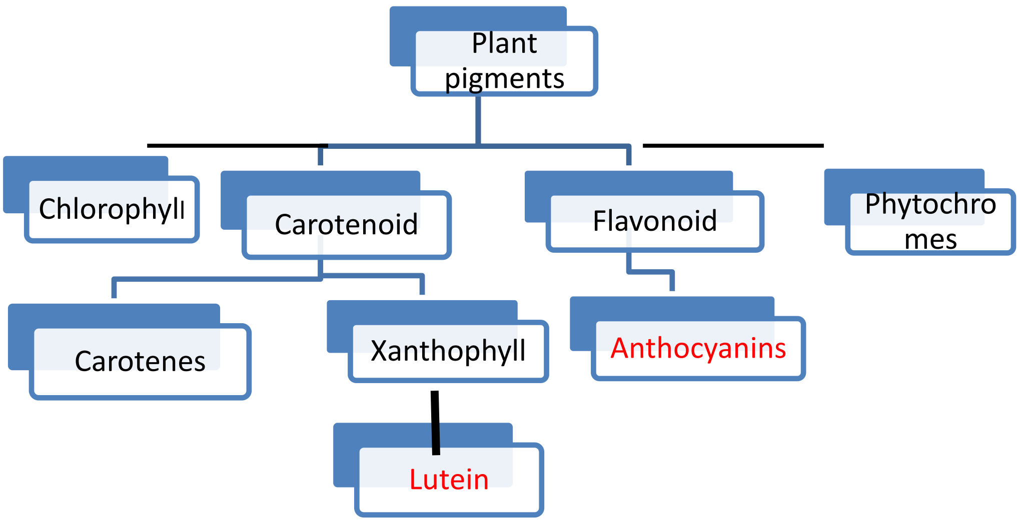


Figure: classification of plant pigments

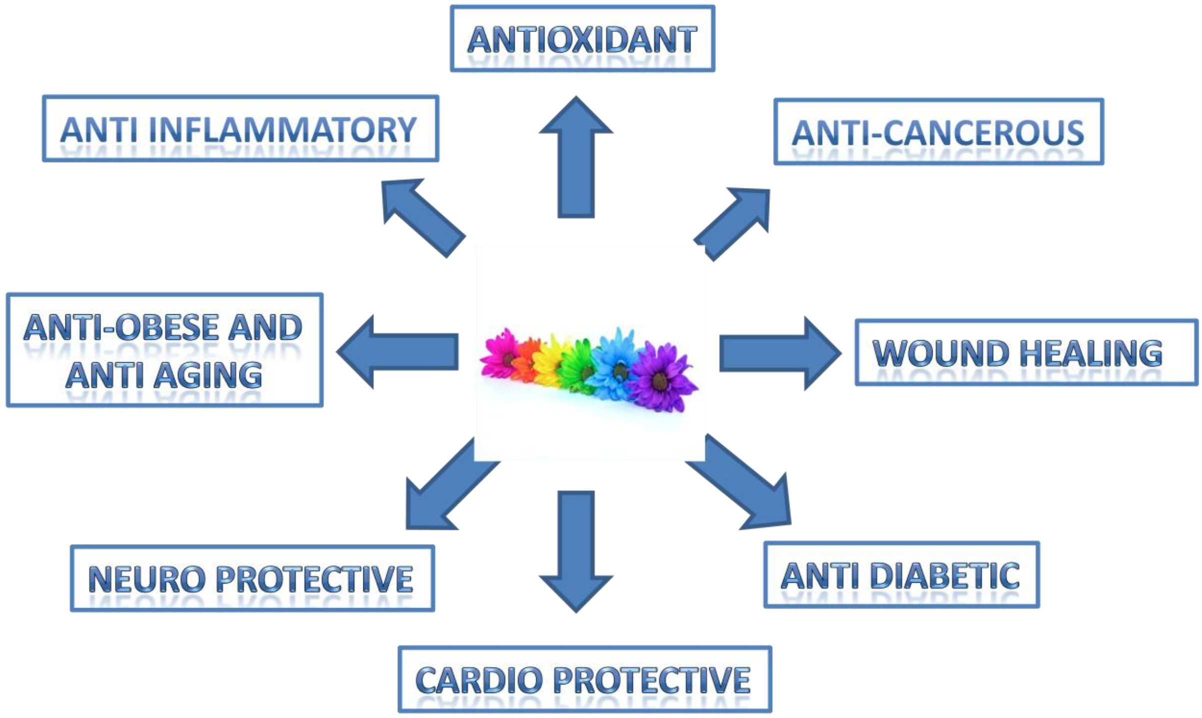


Figure: Nutraceutical property of pigments from flowers

EXTRACTION OF ANTHOCYANINS FROM ROSE

The ratio of carotenoids and anthocyanins determines the shade of rose colour. Among anthocyanins, **cyanidin glycosides** and **peonidin glycosides** are reported in larger amounts in roses. The anti-inflammatory properties of rose hips have shown to be useful in the treatments of patients suffering from knee osteoarthritis.Researches had reported the use of rose petals to alleviate cold,sore throats and congestedbronchial tracts**.**Attention has been given to the nutraceutical properties of anthocyanins because of their ability to inhibit free radicals and their capacity to reduce cardiac diseases.

Hand pressed rose petals will be collected .Extractionwill be performed with acidified alcohol (1%HCl) .The extraction procedure will be continued till the complete removal of anthocyanin from the petals. The extracts will be collected and evaporated using a rotary vacuum evaporator at 40°C and the slurry will be collected .The slurry then loaded on to a preconditioned column and gave some time for the anthocyanin to get adsorbed on the column. The column will be washed with acidified water to remove all sugar moieties or other impurities present and the adsorbed anthocyanin pigments will be removed by washing with acidified ethanol.

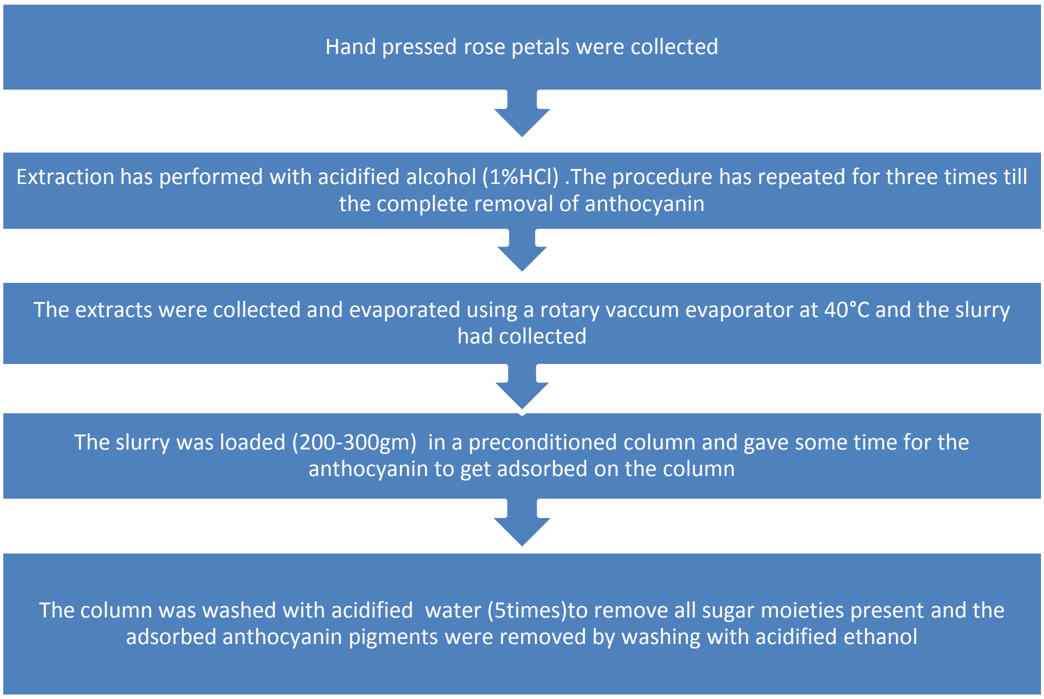


Figure: Procedure for extraction of anthocyanin from rose

EXTRACTION OF LUTEIN FROM MARIGOLD

Marigold flower is one of the richest sources of natural carotenoids. The major carotenoid in marigold is lutein.In flowers, lutein generally exists in the form of lutein fatty acid esters.Lutein and Zeaxanthin have been associated with a lower risk of eye disease in the elderly.Lutein has reported to be beneficial in several aspects to human health such as supporting eyes and skin, and reducing the failure of the eyesight due to age-related macular degeneration (AMD), coronary heart disease and cancer.Lutein is a potential antioxidant which reduces the risk of chronic diseases such as cancer and enhance immune activity (Chew *etal*., 1996).Lutein reduces the auto oxidation of cellular lipids and age related macular degeneration (Pratt *etal*., 1999).Lutein and zeaxanthin intake has been linked to reduced risk of prostate cancer.

100gmof dried floral powder will be extracted with 500mlof Hexane. The extraction will be carried out in a water bath at 40°C for four hours.The mixture was allowed to stand for20min at room temperature and allow the residues to settle. The solvent fraction will be separated and the remaining solid will be collected for saponification.Solid fraction (Marigold oleoresin) around 1gm will be added to ethanol containing0.6gm of KOH. This has to be kept in a shaker with 150rpm speed at 50°C for 4 hours. To thesaponified mixture, 50mlof ethanol will be added and then transferred toa separating funnel. Add100ml of 5% Na_2SO_4 solution and 80ml of diethyl ether. All components will be allowed to mix and then separated in to two layers. The Upper phase (luteinfraction) will be collected.

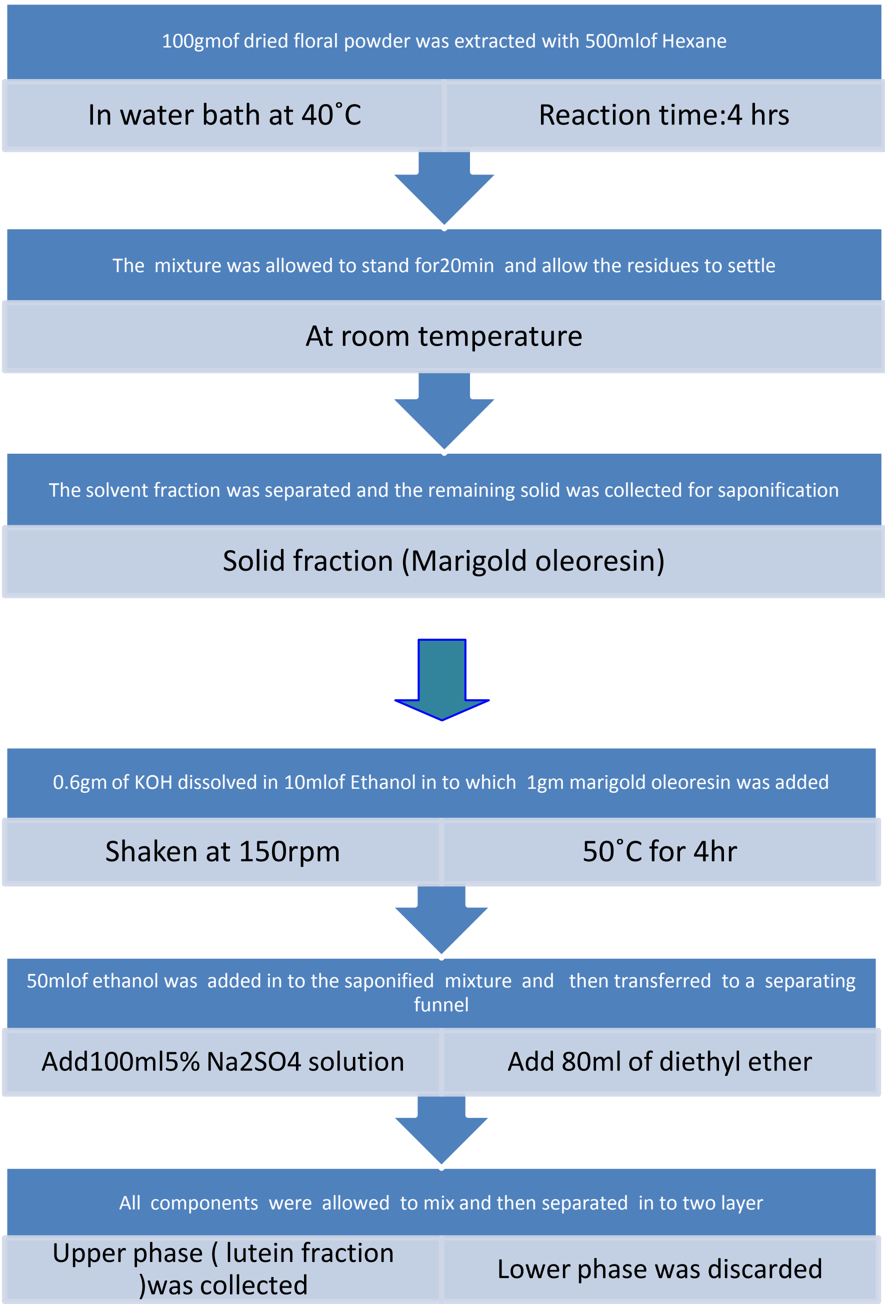


Figure: Procedure for extraction of leutin from marigold

IDENTIFICATION AND MANAGEMENT OF VIRUS DISEASES OF ORNAMENTAL CROPS

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A virus is a **set of one or more nucleic acid** template molecules, normally **encased in a protective coat** or coats of protein or lipoprotein, that is **able to organize their own replication** only within suitable host cells. It can usually be transmitted between hosts.

HOW TO DETECT PLANT VIRUS INFECTIONS

A **symptom** of plant disease is a visible effect of virus infection on the plant. Symptoms may include a detectable change in color, shape or function of the plant as it responds to the pathogen.

Direct and Indirect Damages Associated with Plant Virus Infections:

- Reduction in growth
    - Yield loss (Including symptomless infection)
    - Crop failure
- Reduction in vigour
    - Increased sensitivity to frost and drought
    - Increased predisposition to attack by other pathogens and pests
- Reduction in quality or market value
    - Defects of visual attraction: size, shape, colour
    - Reduced keeping quality
    - Reduced consumer appeal: grading, taste, texture, composition
    - Reduced fitness for propagation
- Cost of attempting to maintain crop health
    - Cultural hygiene on farm, including vector control
    - Production of virus-free propagation materials
    - Checking propagules and commodities on export/import (quarantine programmes)
    - Eradication programmes
    - Breeding for resistance
    - Research, extension, and education.

From Waterworth and Hadidi (1998).

SYMPTOMS OF PLANT VIRUS INFECTIONS

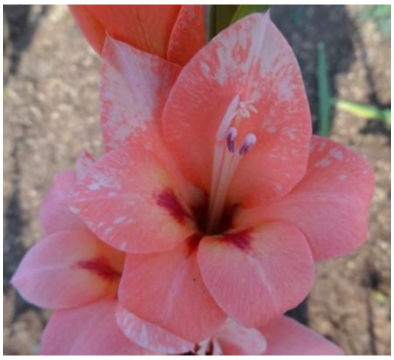
1. EFFECTS ON PLANT SIZE

Reduction in plant size is the most general symptom induced by virus infection. The degree of stunting is generally correlated with the severity of other symptoms, particularly where loss of chlorophyll from the leaves is concerned. Stunting is usually almost entirely due to reduction in leaf size and internode length. Leaf number may be little affected. Root initiation in cuttings from virus-infected plants may be reduced, as in chrysanthemums. In vegetatively propagated plants, stunting is often a progressive process. For example, virus-infected flower bulbs may become smaller in each successive year.

2. MOSAIC PATTERNS AND RELATED SYMPTOMS

One of the most common obvious effects of virus infection is the development of a pattern of light and dark green areas, which creates a mosaic effect in infected leaves. In dicotyledons, the areas that make up the mosaic are generally irregular in outline.In monocotyledons, a common result of virus infection is the production of stripes or streaks of tissue lighter in colour than the rest of the leaf. A variegation or “breaking” in the colour of petals commonly accompanies mosaic or streak symptoms in leaves. The breaking usually consists of flecks, streaks, or sectors of tissue with a colour different from normal.

Mosaic Symptom in Chrysanthemum



Colour breaking in Gladiolus

3. YELLOW DISEASES

Viruses that cause a general yellowing of the leaves are not as numerous as those that cause mosaic diseases. The first sign of infection is usually a clearing or yellowing of the veins in the younger leaves followed by a general yellowing or reddening of the leaves.

4. LEAF ROLLING

Virus infection can result in leaf rolling, which is usually upward but occasionally downward.

5. RING SPOT DISEASES

Ring spots are a pattern of concentric rings and irregular lines on the leaves and sometimes also on the fruit. The lines may consist of yellowed tissue or may be due to death of superficial layers of cells, giving an etched appearance. In severe diseases, complete necrosis through the full thickness of the leaf lamina may occur.

6. NECROTIC DISEASES

The death of tissues, organs, or the whole plant is the main feature of some diseases. Necrotic patterns may follow the veins as the virus moves into the leaf.

Veinal Necrosis, Necrotic Spots On Leaves, Browning Of Petals, And Stem Necrosis. Under Severe Conditions, Extensive Necrosis Leads To Complete Drying And Death Of The Plants.

7. DEVELOPMENTAL ABNORMALITIES

Besides being generally smaller than normal, virus-infected plants may show a wide range of developmental abnormalities. Such changes may be the major feature of the disease or may accompany other symptoms. For example, uneven growth of the leaf lamina is often found in mosaic diseases. Dark green areas may be raised to give a blistering effect, and the margin of the leaf may be irregular and twisted.

The symptoms caused by Rose mosaic virus are highly variable. The most common symptoms include; chlorotic bands or ring spots, wavy lines, yellow vein banding, oak-leaf pattern, and general mosaic (splotches of yellow and green on leaves). Colour-breaking (mottled flower colour) is also observed. Symptom development on only a portion of a plant is common

HOW THE VIRUSES SPREAD FROM PLANT TO PLANT?

A. MECHANICAL TRANSMISSION

Mechanical inoculation involves the introduction of infective virus or viral RNA into a wound on the plant's surface. This form of transmission occurs naturally with a few viruses such as Tobacco mosaic virus (TMV) and Potato virus X (PVX).

B. SEED TRANSMISSION

About one-seventh of the known plant viruses are transmitted through the seed of at least one of their infected host plants. Seed transmission provides a very effective means of introducing virus into a crop at an early stage, giving randomized foci of primary infection throughout the planting.

C. POLLEN TRANSMISSION

Some viruses are transmitted from plant to plant via pollen. As with seed transmission, two mechanisms appear to operate in pollen transmission: gametic infection of the embryo and direct infection of the mother plant.

D. VEGETATIVE PROPAGATION

Vegetative propagation is an important horticultural practice, but it is also, unfortunately, a very effective method for perpetuating and spreading viruses. Economically important viruses spread systemically through most vegetative parts of the plant. A plant once systemically infected with a virus usually remains infected for its lifetime. Thus, any vegetative parts taken for propagation, such as tubers, bulbs, corms, runners, and cuttings, will normally be infected.

E. GRAFTING

Grafting is essentially a form of vegetative propagation in which part of one plant (the scion) grows on the roots (the stock) of another individual. Once organic union has been established, the stock and scion become effectively a single plant. Where either the rootstock or the individual from which the scion is taken is infected systemically with a virus, the grafted plant as a whole will become infected if both partners in the graft are susceptible.

F. INVERTEBRATE VECTORS

Many plant viruses are transmitted from plant to plant in nature by invertebrate vectors, members of the Insecta and Arachnida classes of the Arthropoda, and the Dorylaimida order of the Nematoda. The Homoptera feed by sucking sap from plants and are numerically the most important suborder containing plant virus vectors. Three of the most common vectors of plant viruses are aphids, leafhoppers, and whitefly.

There are two major types of interaction between a virus and its vector: nonpersistent and persistent. Features of the interactions are outlined in the table below.

Two genera of plant viruses are transmitted by nematodes. Nepoviruses are transmitted by species in the genera Xiphinema and Longidorus, and tobraviruses are transmitted by species of Trichodorus and Paratrichodorus. All three tobraviruses are nematode transmitted, but only about one-third of the nepoviruses are transmitted by these vectors. With the exception of Tobacco ring spot virus (TRSV), which is reported to also have aphid vectors, none of the viruses in these two genera is known to have invertebrate vectors other than nematodes; some nepoviruses are pollen transmitted.

RELATIONSHIPS BETWEEN PLANT VIRUSES AND THEIR VECTORS

There are two major types of interaction between a virus and its vector: nonpersistent and persistent. Features of the interactions are outlined in the table here, and the pathways that the viruses have with their vector are shown in the figure.

Virus Transmission Group		Transmission Characteristics							
Site in vector	Type of transmission	Virus product interacting with vector	Acquisition time (max. dose)	Retention time (half-life)	Transtadial passage	Virus in vector haemolymph	Latent period	Virus multiplies in vector	Transovarial transmission
Externally – borne	Nonpersistently transmitted stylet-borne	Capsid +/– helper factor	Seconds to minutes	Minutes	No	No	No	No	No
	Nonpersistently transmitted foregut-borne (semipersistent)	Capsid +/– helper factor	Minutes to hours	Hours	No	No	No	No	No
Internally-borne	Persistent circulative		Hours to days	Days to weeks	Yes	Yes	Hours to days	No	No
	Persistent propagative		Hours to days	Weeks to months	Yes	Yes	Weeks	Yes	Often

Insect and Nematode Vectors of Plant Viruses

G. FUNGAL TRANSMISSION OF VIRUSES

Several viruses have been shown to be transmitted by soil-inhabiting fungi or protists. The known vectors are members of the class Plasmodiophoromycetes in the division Myxomycota or in the class Chytridiomycetes in the division Eumycota.

DIAGNOSTICS OF PLANT VIRUSES

1. METHODS INVOLVING BIOLOGY OF THE VIRUS

A. Indicator Hosts: Since the early days of plant virology, searches have been made for suitable species or varieties of host plant that will give clear, characteristic, and consistent symptoms for the virus or viruses being studied, usually under glasshouse conditions. Many good indicator species have been found in the genera Nicotiana, Solanum, Chenopodium, Cucumis, Phaseolus, Vicia, and Brassica. Certain plant species such as Chenopodium amaranticolor, C. quinoa, and Nicotiana benthamiana react to a wide range of viruses.

2. METHODS THAT DEPEND ON PHYSICAL PROPERTIES OF THE VIRUS PARTICLE

A. Electron Microscopy:

Knowledge of the size, shape, and any surface features of the virus particle is a basic requirement for virus identification. Electron microscopy can provide this information quickly and, in general, reliably. For the examination of virus particles in crude extracts or purified preparations, a negative-staining procedure is used. Commonly used negative stains are sodium phosphotungstate, ammonium molybdate, or uranyl acetate, depending on the stability of the virus to these stains. Approximate particle dimensions can be determined. Depending on size and morphology, a virus may be tentatively assigned to a particular taxonomic group.

3. METHODS THAT DEPEND ON PROPERTIES OF VIRAL PROTEINS

A wide variety of methods has been developed for demonstrating and estimating combination between antibodies and antigens. The most widely used are the enzyme-linked immunoabsorbent assay (ELISA), immunoabsorbent electron microscopy (ISEM), and “dot blots” that employ either polyclonal or monoclonal antibodies.

ELISA:

The principle of the direct double-antibody sandwich procedure is summarised in the Figure (A). The technique is widely used but suffers two limitations:

1. It may be very strain specific. For discrimination between virus strains, this can be a useful feature, but for routine diagnostic tests, it means that different viral serotypes may escape detection. This high specificity is almost certainly due to the fact that the coupling of the enzyme to the antibody interferes with weaker combining reactions with strains that are not closely related.
2. It requires a different antivirus enzyme-antibody complex to be prepared for each virus to be tested.

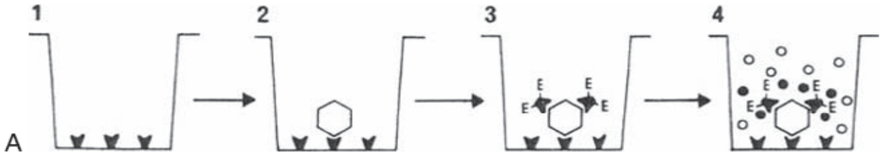


Fig. Immune detection of viruses. A. Principle of the ELISA technique for plant viruses (direct double-antibody sandwich method). (1) The gamma globulin fraction from an antiserum is allowed to coat the surface of wells in a polystyrene microtitre plate. The plates are then washed. (2) The test sample containing virus is added and combination with the fixed antibody is allowed to occur. (3) After washing again, enzyme-labeled specific antibody is allowed to combine with any virus attached to the fixed antibody. For instance, alkaline phosphatase is linked to the antibody with glutaraldehyde.) (4) The plate is again washed and enzyme substrate is added. The colourless substrate *p*-nitrophenyl phosphate (open circle) gives rise to a yellow product with alkaline phosphatase (filled circle), which can be observed visually in field applications or measured at 405 nm using an automated spectrophotometer. [Modified from Clark and Adams (1977; *J. Gen. Virol*. **34**, 475–483).]

IMMUNOABSORBENT ELECTRON MICROSCOPY

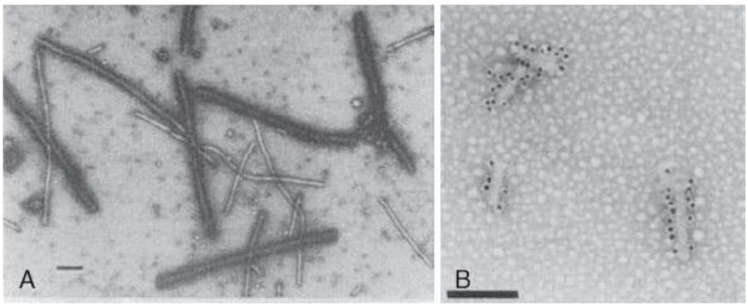


FIGURE 13.1 Immune specific electron microscopy (ISEM). A. A natural mixture of two potyviruses from a perennial cucurbit, *Bryonia cretica*. The antiserum used has decorated particles of only one of the viruses in the mixture. One particle near the centre is longer than normal and decorated for only part of its length. This particle probably arose by end-to-end aggregation between a particle of each of the two viruses. Bar = 100 nm. [From Milne (1991; in *Electron microscopy of plant pathogens*, K. Mendgen and D.E. Lesemann, Eds., pp. 87–102, Springer-Verlag, New York).] B. Gold particle labeling of virus particles. *Rice tungro bacilliform virus* (RTBV) particles were treated first with anti-RTBV protease rabbit antiserum and then with gold-labeled goat antirabbit serum. Bar = 200 nm. [This article was published in *Virology*, **205**, J.M. Hay, F. Grieco, A. Druka, M. Pinner, S.-C. Lee, and R. Hull, Detection of *rice tungro bacilliform virus* gene products *in vivo*, pp. 430–437, Copyright Elsevier (1994).]

4. METHODS THAT INVOLVE PROPERTIES OF THE VIRAL NUCLEIC ACID:

POLYMERASE CHAIN REACTION

DNA fragments of interest can be enzymatically amplified in vitro by the polymerase chain reaction (PCR). The technique involves the hybridisation of synthetic complementary oligonucleotide primers to the target sequence.and synthesis of multiple copies of complementary DNA of the sequence between the primers using heat-stable DNA polymerase. The process goes through a series of amplification cycles, each consisting of melting the ds template DNA molecules in the presence of the oligonucleotide primers and the four deoxyribonucleotide triphosphates at high temperature (melting), hybridisation of the primers with the complementary sequences in the template DNAs at lower temperature (annealing), and extension of the primers with DNA polymerase (DNA synthesis).PCR (and RT-PCR) has proved to be a verypowerful tool for virus detection and diagnosis.It can be used to directly produce a DNA productof predicted size that can be confirmed bygel electrophoresis. The choice of primers canbe used to distinguish between strains of avirus or, with primers containing a variety ofnucleotides at specific positions (degenerateprimers), be used for more generic determinations.Strains can also be distinguished byamplifying a region that has differences inrestriction endonuclease sites.

MANAGEMENT OF VIRUS DISEASES

There are four basic approaches to controlling plant virus diseases: avoiding infection, stopping the vector, protecting the plant, and breeding for resistance.

A. Removal of Sources of Infection

To eliminate these sources, it may be worthwhile to remove infected plants (rogue) from a crop. If the spread is occurring rapidly from sources outside the crop, roguing the crop will have no beneficial effect.

B. Virus-Free Seed

Where a virus is transmitted through the seed, such transmission may be an important source of infection, since it introduces the virus into the crop at a very early stage, allowing infection to be spread to other plants while they are still young.

C. Virus-Free Vegetative Stocks

For many vegetatively propagated plants, the main source of virus is chronic infection in the plant itself. With such crops, one of the most successful forms of control has involved the development of virus-free clones—that is, clones free of the particular virus under consideration. Two problems are involved. First, avirus-free line of the desired variety with good horticultural characteristics must be found. When the variety is 100 percent infected, attempts must be made to free a plant or part of a plant from the virus. Second, having obtained a virus-free clone, a foundation stock or “mother” line must be maintained virus free, while other material is grown up on a sufficiently large scale under conditions where reinfection with the virus is minimal or does not take place. These stocks are checked that they are “virus free” (e.g., below a set level of detected virus) and are then used for commercial planting.

D. Modified Agronomic Practices

Virus infection can be reduced by modifying agronomic practices such as breaking the infection where one major susceptible annual crop or group of related crops is grown in an area and where these are the main hosts for a virus in that area by ensuring that there is a period when none of the crop is grown.

E. Quarantine Regulations

Most agriculturally advanced countries have regulations controlling the entry of plant material to prevent the introduction of diseases and pests not already present. Many countries now have regulations aimed at excluding specific viruses and their vectors, sometimes from specific countries or areas. The setting up of quarantine regulations and providing effective means for administering them is a complex problem.

F. Vector Control

i) Insecticides

The application of insecticides is currently one of the main ways of controlling insect pests of plants. To prevent an insect from causing direct damage to a crop, it is necessary only to reduce the population below a damaging level.

Control of insect vectors to prevent infection by viruses is a much more difficult problem, as relatively few winged individuals may cause substantial spread of virus.

ii) Insect Deterrents

The application of various chemicals or materials can deter aphids from landing on or feeding on crop plants. Spraying mineral oils on plants affects the feeding behaviour of aphids and leafhoppers and can give some protection against nonpersistent viruses.

iii) A tall cover crop will sometimes protect an under sown crop from insect-borne viruses.

The first two approaches involve agronomic practices such as using clean planting material, changing the planting time, and using insecticides against vectors.

- Insecticides are better at preventing the spread of viruses with a persistent interaction with their vector than those with a nonpersistent interaction.
- Plants can be protected by inoculating them with a mild strain of the virus (crossprotection). This is only viable with high cost perennial crops.
- Breeding for resistance is considered to be the best approach but has the difficulties of sources of resistance genes in sexually compatible species and the durability of resistance is a challenge.

IDENTIFICATION AND MANAGEMENT OF PHYTOPLASMA DISEASES OF ORNAMENTAL CROPS

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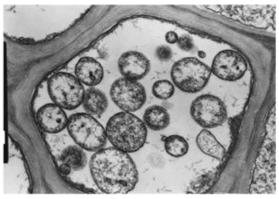
WHAT IS PHYTOPLASMA ?

- Phytoplasmas are bacteria that are devoid of cell wall, having non-helical shape.
- They cause Yellows disease in a number of crops.
- They live in phloem tissue.



Electron micrograph of phytoplasmas (AssuntaBertaccini, 2009)

HOW TO DETECT PHYTOPLASMA?

The following symptoms are observed in plants during phytoplasma infection.

Plant height reduces

Leaves turn yellow

Puple top: leaves turn into purple

Leaf margins disappear

Little leaf

Witches broom appearance

Reduced flower size

Fusions of petals and sepals

Virescence: Petals will turn green.

Phyllody: Leafy structures from flowers

White leaf in turf grass

HOW IT SPREADS?

- Mechanical through cutting tools
- Parasites like cuscuta
- Insect vectors : Leaf hoppers, Plant hoppers and Psyllids

Plant Hopper

Leaf Hopper

Psyllid

and Cuscuta

- Phytoplasma from plant enters insect when hoppers feed on infected plants.
- Phytoplasma get multiplied in insect body.
- They get stored in salivary glands of hoppers.
- Enter a new plant when attacked.

HOW TO MANAGE PHYTOPLASMA INFECTIONS?

- Use of clean propagation material
- Use of resistant cultivars
- Use of insect proof net in nursery
- Mulching for avoiding weed growth and repelling leafhoppers.
- Installing yellow sticky traps @ 4 traps per 100 sq. mt. for trapping leafhoppers in the field.
- Good agricultural practices like rouging infected plants, weed control, habitat management to enhance natural enemy activity.
- Rouging and burning of alternate hosts and weed hosts (Cuscuta, Parthenium, Brinjal etc.)
- Rouging and burning of dodder infected plants to check spread of phytoplasma infestation.
- Cuscuta must be destroyed before it produces seeds or infestations will spread.
- Application of Kaoline as a particle film will repel leafhopper from landing on treated plant.
- Spray with dimethoate 30 EC @ 2.0 – 2.5 ml/l. or imidacloprid 17.8 SL @ 0.25 – 0.5 ml/l. for managing leafhoppers.
- Use of antibiotics like Oxy-tetracycline @500ppm
- Use of plant growth regulators like auxins to recover from symptoms
- Use of plant immunity activators like Benzothiadiazol, Acibenzolar methyl etc.

IDENTIFICATION AND MANAGEMENT OF FUNGAL AND BACTERIAL DISEASES IN ORNAMENTAL CROPS

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ICAR-Directorate of Floricultural Research, Pune

An accurate diagnosis of disease is important for successful implementation of an IPM program. Different pathogens are controlled by different fungicide chemistries. Bacterial diseases are not controlled with fungicides, and some bacterial diseases are easily mistaken for fungal diseases. Some fungicides have a narrow spectrum of activity. Abiotic factors such as high soluble salts, nutrient imbalances, or chemcial injury can mimic the symptoms of plant pathogens. The ability to make an accurate diagnosis on-site is dependent on a disease that has unique symptoms. There are a number of diseases that can be easily identified on-site and there are many that can only be diagnosed in a lab.

DISEASES OF FLOWERS AND THEIR MANAGEMENT

DISEASES OF ROSE

1. Rose Black Spot

Causal agent :*Diplocarpon rosae*

Symptoms : Primarily develop dark spots on the upper leaf surface and these spots occasionally develop feathery edges and can expand up to 1/2-inch in diameter. The leaf spots may also have yellow halos surrounding them. With severely infected plants, the leaves may turn yellow prior to leaf drop.

Management :

- Remove infected canes.
- Remove and destroy fallen leaves.
- Water in a manner that keeps foliage surfaces dry.
- Apply one of the following to protect new foliage: chlorothalonil, propiconazole, neem oil, mancozeb, thiophanate methyl, thiophanate methyl + mancozeb, chlorothalonil + thiophanate methyl, copper hydroxide, ziram, captan, trifloxystrobin, or triforine.

2. Rose powdery mildew

Causal agent :*Podosphaera pannosa*

Symptoms : A white, powdery fungal growth appears on the leaves and shoots. Upper, lower or both leaf surfaces can be affected. There may be discolouration (yellow, reddish or purple) of the affected parts of the leaf, and heavily infected young leaves can be curled and distorted.

Management:

- Collection and burning of fallen leaves.
- Spray with Wettable sulphur 0.3% (or) Carbendazim 0.1% 2-3 sprays at 15 days interval is effective.
- Sulphur dust at 25 kg/ha.
- Use of sulphur at higher temperature conditions will be phytotoxic.

3. Rose Crown Gall

Causal agent :*Agrobacterium tumefaciens*

Symptoms : Crown gall first appears as small overgrowths on the stem (trunk), crown, and roots – usually near the soil line, frequently at a graft union. At first, the gall or tumor is white or flesh-colored, more or less round, and quite soft and spongy. The enlarging gall gradually develops an irregular, convoluted, rough, corky surface and a hard woody interior. The outer tissue gradually darkens. When the infection is severe, infected plants lack vigor, their leaves are stunted and may turn yellow or red, and the shoots often die back. As the galls continue to enlarge, plants may wilt and die.

Management :

- Do not plant infected material.
- Steam sterilized beds where infected plants were grown. Remove and destroy infected plants.
- Apply Agrobacterium radiobacter to protect healthy plants.

4. Botrytis Blight or Gray Mold on Roses

Causal agent :*Botrytis cinerea*

Symptoms : The disease is also known as petal fire or Botrytis mold. Infection starts from the sepals as black-brown specks that cover the flower in due course. The buds turn brown and decay. Sometimes partially opened buds are attacked, and the individual petals turn brown and shrivel. In cool moist weather the flower is covered with greenish-grey or darkish growth of the fungus.

Management :

- Space plants and provide ventilation to avoid excessively high humidity.
- Remove fading flowers and yellowing leaves.
- Apply chlorothalonil, dichloran, trifloxystrobin, fenhexamid, iprodione, or azoxystrobin to protect healthy tissue.
- Heat and ventilate to maintain low humidity.

DISEASES OF MARIGOLD

1. Leaf spot and Flower blight of Marigold

Causal agent : *Alternaria* sps.

Symptoms : Brown necrotic spots develop on leaves, which get enlarged at the later stage of infection. The fungus also infects the young flower buds and the infected buds shrivel and become dark brown in colour. The entire foliage gets damaged causing blight.

Management :

- Spray with Mancozeb 0.2% or Copper oxy chloride@ 0.2% or Propiconazole 0.1%

2. Botrytis Flower Blight of Marigold

Causal agent :*Botrytis cinerea*

Symptoms : Flower parts become necrotic and die. A gray mass of spores develops on necrotic tissue during wet conditions.

Management :

- Remove all dead and dying plant parts (particularly blossoms) on and around plants.
- Avoid overhead irrigation or apply such that plants are not wet for extended periods of time.
- Space plants for good air circulation.
- Apply chlorothalonil, dichloran, trifloxystrobin, fenhexamid, iprodione, or azoxystrobin to protect healthy tissue.

DISEASES OF CHRYSANTHEMUM

1. Leaf Spots of Chrysanthemum :

Causal agent : ***Septoria chrysanthemi, S. chrysanthemella, Alternaria* species, and *Cercospora chrysanthemi* .**

Symptoms : first appear as yellow spots which turn brown to black. Spots often occur on lower leaves first and can coalesce into large necrotic areas and finally death of the entire leaf.

Management:

- Diseased plant debris should be collected and burnt.
- Irrigation should be regulated.
- Fortnightly spraying with carbendazim 0.1 per cent or benomyl 0.1 per cent or mancozeb 0.2 per cent or copper oxychloride 0.3 per cent or 0.1% azoxystrobin, or 0.2% chlorothalonil, thiophanate methyl @ 0.1% .

2. Powdery mildew of Chrysanthemum :

Causal agent : *Erysiphe cichoracearm*

Symptoms : As it name implies is characterized by a white to ash-gray powdery growth on leaves and occasionally stems. Foliage may become puckered or distorted; severely infected leaves will shrivel and die. The disease is most serious during hot, humid weather. Unlike most fungal diseases, free water is not required for Powdery mildew infection; high humidity encourages disease development.

Management :

- Shade and overcrowding of plants should be avoided to reduce the disease.
- Spraying with wettable sulphur 0.2 per cent or triforine 0.03 per cent or thiophanate-methyl 0.05 per cent or dinocap 0.025 per cent or dinocap 1.0 kg/ha or cabendazim or benomyl 0.1 per cent at 10 to 15 days interval controls the disease.

3. Fusarium Wilt :*Fusarium oxysporum f.sp. chrysanthemi*

Symptoms : yellowing of foliage, stunting, and wilting often along one side of plant.Plants may appear water stressed and foliage may brown and die.Stems - reddish brown discoloration of the vascular system.spread in contaminated soil and infected cuttings and is favored by warm temperatures

Management :

- Pathogen free cuttings or plants and pasteurized growing media.

- Soil drenching with Copper oxychloride 2.5 g / lit or Trifloxystrobin +Tebuconazole @ 0.75 g / lit or Difenoconazole @ 0.5ml / lit.
- Avoid highly susceptible cultivars.
- Soil drenching with Carbendazim @ 1 g/l .

DISEASES OF TUBEROSE

1. Blight / Leaf and flower spot:*Botrytis elliptica*

Symptoms : Spots are orange to reddish brown and oval on the leaves. They coalesce and blight the leaf. Infection starts from the lower leaves. If the disease occurs early, the entire apical growth of the plant is killed. Flower buds rot or open to distorted flowers with irregular brown flecks.

Management :

- Dense planting, shady or low spots with little air circulation should be avoided.
- The diseased plant parts should be removed.
- Spraying with Bordeaux mixture 1.0 per cent for every 15 days controls the disease.

DISEASES OF CARNATION

1. **Fusarium wilt : *Fusarium oxysporum* f. sp. *dianthi***

Symptoms: In young plants, the first sign of the disease is fading or greying of the normal colour of the leaves with wilting of the leaves and young stems. It is followed by eventual collapse of the whole plant. When older plants are infected, similar symptoms are produced but the older leaves may show chlorosis followed by an indistinct purple-red discolouration. The vascular tissues of infected stems is stained dark brown. Mature plants show wilt symptoms over a period of several months before they die and eventually become straw coloured.

Management:

- The diseased plants should be removed immediately after noticing the disease.
- Soil drenching with Carbendazim @ 1 g / lit or Difenoconazole@ 0.5 ml / lit at weekly intervals.
- Pseudomonas fluorescens as soil application @ 15 g / m2 and foliar application @ 5 g / lit at monthly intervals.
- Soil drenching with Bacillus amyloliquefaciens @ 5 ml / lit at monthly intervals.

2. *Alternaria* leaf spot: *Alternaria dianthi*

Symptoms: The chief symptom is blight or rot at leaf bases and around nodes, which are girdled. Spots on leaves are ashy white. The centre of old spots are covered with dark brown to black fungal growth. Leaves may be constricted and twisted and the tip may be killed. Branches die-back at the girdled area and black crusts of conidia are formed on the cankers.

Management:

- To reduce the disease incidence, humidity may be kept low by providing proper air circulation.
- Disease-free planting material should be used. Spray Tebuconazole @ 2 ml / lit or Propiconazole @ 2 ml / lit.
- Bacillus subtilis as soil application @ 15 g / m2 followed by foliar application @ 5 g / lit at monthly intervals.

2. **Cottony rot: *Sclerotinia sclerotiorum***
   Symptoms : Stems rotted; flower rot is similar to gray mold. Cottony, white fungal mass may occur on rotted tissues. Black sclerotia may form inside or outside the stem.

Management :

- Spray foliage with iprodione or thiophanate-methyl@ 0.1%

DISEASES OF JASMINE

1. Leaf spots: *Alternaria jasmini, Alternaria alternatata, Cercospora jasminicola*

Symptoms: On the affected leaves dark brown spots in concentric rings or circular to irregular reddish brown spots of 2 to 8 mm dia appear on upper leaf surface. During humid conditions, the spots in each leaflet enlarge very quickly and coalesce. Later, blighted leaflets dry and easily fall off. They are also brittle. In a severely affected, garden, large number of fallen leaves can be easily seen on the ground near the base of the diseased vine. Oval to elongated light brown spots develop on petioles, stem, calyx and even on tubular corollas. In severe cases of infection vegetative buds and young branches dry up. The disease spreads through wind-borne conidia.

Management:

- Diseased and fallen leaves should be collected and burnt.
- Spraying Mancozeb 0.2 % or Azoxystrobin 0.1%. Spraying can be repeated at 7 to 10 days interval covering all the foliage in the vines

2. Collar rot and Root rot – *Sclerotium rolfsii*

Symptoms : Plants at all stages are infected. First the older leaves become yellow followed by younger leaves and finally death of the plant. In the root black discoloration can be seen. On the infected tissues and stem surface white strands of mycelia and mustard like sclerotia are seen.

Management

- Soil drenching with Trifloxystrobin + Tebuconazole @ 0.75 g / lit or Difenoconazole @ 0.5 ml / lit.
- Soil application of Pseudomonas fluorescens @ 25 g / m2 and foliar application of P. fluorescens @ 5 g / lit at monthly intervals after planting.
- Soil drenching with Copper oxychloride 0.25% or 1% Bordeaux mixture or application of FYM with Trichoderma viride @ 10 g + 100g FYM / plant

DISEASES OF GERBERA

1. Root rot : *Rhizoctonia solani*

Symptoms : The infection results in stunted growth. Ultimately the entire plant dry. *Rhizoctonia solani* causes more losses and can attack older plants.

Management

- Soil sterilization controls the diseases.
- Drenching with Pseudomonas fluorescens 2g/litre of water
- Hexaconazole (0.1%), propiconazole (0.1%), mancozeb (0.1% and 0.2%) and captan (0.1%)

2. Powdery mildew: *Erysiphe chichoracearum* and *Oidium erysiphoides* f.sp. *gerbera*

Symptoms : The fungus forms white powdery coating on the foliage.

Management

- Spraying with 0.2% Wettable sulphur controls E. Chichoracearum.
- Diseased leaves should be removed and destroyed.
- Apply sulfur or copper-based fungicides to prevent infection of susceptible plants.

3. Blossom blight : *Phytophythora palmivora*

Symptoms : The disease appears as light brown, irregular, water soaked spots on flower stalks and petals. The spots increase rapidly and coalesce with one another and form distinct depressed lesions. Under humid conditions the infections become severe involving the entire flower head and resulting in blossom blight and stalk rot. The disease is favoured by drizzling rains and cool moist weather. The fungus is soil-borne and the infection starts from the base touching the soil.

Management

- Use of disease free soil for cultivation reduces the disease incidence.
- Affected flowers should be collected and destroyed. Excessive watering should be avoided.
- Spray Cymoxanil (8%) + mancozeb (64%) (Curzate M-8) @ 0.1%, carbendazim (12%) + mancozeb (63%) (Saaf) @ 0.1%, tebuconazole 250EC (Folicur) @ 0.1%.

APPLICATION OF BIO-CONTROL AGENTS AND NEW GENERATION FUNGICIDES FOR MANAGEMENT OF DISEASES IN FLOWER CROPS

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Plant diseases result in severe yield and economic losses, and are very difficult to eliminate by any knownmethod of control. Persistent use of synthetic pesticides has led to serious ecological problems with knownconsequences on human, wildlife and environment. As a result of growing concerns about health and environmentalproblems associated with pesticides, there are accelerated efforts from scientists and entrepreneurs to developmechanisms to effectively promote biological strategies for disease control. Identifying, understanding and utilizingmicroorganisms or microbial products to control plant disease and enhance crop production are integral parts ofsustainable agriculture. In recent times significant strides have been made in research aimed towards biocontrol ofdiseases. Since biological control is relatively new area, research is needed in many areas, particularly, in production,formulation, delivery and commercialization of biopesticides.

In recent times Biological control is an important component of IPM system instead of itsindependent use. In most of the cases the bioagents are effective in laboratoryconditions only, and not at all that successful under field conditions. The investigations onepidemiological aspects of the disease as well as developments of the bioagents are, therefore,crucial to keep the biocontrol recommendations under varying environmental conditions.Among fungal bioagents,*Trichoderma* is very promising candidates for the biologicalcontrol of plant pathogenic fungi.This is also known for secreting secondary metabolites in theenvironment which affects on wide spectrum of various fungal groups,especially pathogenic fungi.Reports by various workers showed that*Trichoderma* spp. is a powerful antagonist of parasitic soilfungi of *Pythium, Phytophthora, Sclerotinia, Sclerotium, Rhizoctonia, Fusarium, Verticillium,Gaeumannomyces* etc.

When planning the application of antagonisticbiological control, it is very important to consider abiotic and biotic factors affecting the biocontrolagents under field conditions. The environment (the effects of temperature, water potential andpH) effectiveness of antagonist and its ability to survive in an ecosystem, host exudates presenceof chemicals, metal ions, and the antagonistic bacteria in the soil are important factors to decidethe fate of biological control of plant pathogens. In spite of various abiotic factors biotic factors ofantagonists like; ability to colonize the substrate and competent with other microorganism in theniche, production. Most of the *Trichoderma* strains are mesophilic and grow well in a wide range oftemperature from 15-35^{o}C. Low temperatures in winter may cause a problem during biologicalcontrol by influencing the activity of the*Trichoderma*. *Trichoderma* cannot tolerate dry conditions; however, we may need these agents against plant pathogenic fungi which are able to grow andcause disease even in dry soils.

The pH characteristics of the soil are also considered to the most important parameters affecting the mycoparasitism activities of*Trichoderma*strains. *Trichoderma*strains are able to grow in a wide range of pH from 2.0to 6.0 with an optimum at 4.0.Mycoparasitism of

*Trichoderma*strains were found to be able to display various enzyme activitiesunder a wider range of pH 3.0 to 6.0, however a large no of enzymes in higher quantities is produced between the pH of 5.0 to 6.0. Therefore*Trichoderma* are more effective in acidic soil, than slightly alkaline soil (above pH 7.0).In the IPM strategy, we may have to combine*Trichoderma* strains with chemical pesticidesor metal compounds; therefore it is important to collect information about the effects of pesticidesand metal ions on the biocontrol strains. Antagonistic soil bacteria may also have negative effectson the biocontrol abilities of *Trichoderma* strain; therefore it may be advantageous if a biocontrolpossesses bacterium-degrading abilities as well.

METHODS OF APPLICATION OF *TRICHODERMA*

1. **Seed treatment**: 6 - 10 g of *Trichoderma* powder per Kg of seed before sowing.
2. **Nursery treatment**: 10 - 25 g of *Trichoderma* powder per 100 m^2 of nursery bed. Application of neem cake and FYM before treatment increases the efficacy.
3. **Cutting and seedling root dip**: 10g of *Trichoderma* powder along with 100g of well decomposed FYM per litre of water and dip the cuttings and seedlings for 10 minutes before planting.
4. **Soil treatment**: Apply 5 Kg of *Trichoderma* powder per ha after turning of sun hemp or dhaincha into the soil for green manuring or mix 1kg of *Trichoderma* formulation in 100 kg of farmyard manure and cover it for 7 days with polythene. Sprinkle the heap with water intermittently. Turn the mixture in every 3-4 days interval and then broadcast in the field.
5. **Plant Treatment**: Drench the soil near stem region with 10g *Trichoderma*powder mixed in a litre of water.
6. **Wound application**
7. **Furrow application**

TECHNIQUE OF ENRICHMENT OF FYM WITH *TRICHODERMA* FOR SOIL APPLICATION

- Enrichment of the FYM should be done in a shaded place either in the field or near the manure pits
- 100kg of fully decomposed FYM is spread out on the ground and a little water is sprinkled over it
- One kg of Talc formulation of *Trichoderma* or one kg of *Trichoderma* culture on sorghum grains is uniformly sprinkled on the FYM
- Thoroughly mixed with a spade.
- The heaps were kept for 15-20 days with intermittent mixing.
- After 20 days FYM would be completely enriched with *Trichoderma* and can be used in field or nursery beds.
- In main field it can be applied at the plant base or in furrows.

Substrates for mass multiplication: Wheat bran, wheat straw, FYM, press mud, coir pith, ground nut shell, rice bran, etc
Carrier/ food base materials: Talc, vermiculite, molasses, gypsum, kaolin, peat, sodium alginate, $Cacl_2$

DIFFERENT FORMULATION:

- Talc based formulation:
- Vermiculite-wheat bran formulation (Lewis et al. 1991)

- Pesta granules (Connick et al. 1991)
- Wheat flour- kaolin (Prasad & Rangeswaran 1998)
- Alginate prills (Fravel et al. 1985)
- Press mud based formulation
- Coffee husk
- Oil-based formulations

SOME CONSIDERATIONS FOR BIOAGENTS

1. Should have the ability to secrete increased level of cell wall lytic enzymes (glucanses, chitinases, cellulases), antibiotics and plant growth promotion.
2. Tolerance of high or low temperatures (necessary to survive other IPM treatments).
3. Suitability for formulation as foliar sprays and/or soil enhancements (e.g. high sporulation levels, rapid growth in bulk conditions).
4. Strains should not be harmful for beneficial organisms
5. Long-term survival in field conditions.
6. Good interactions with other *Trichoderma* strains present in the cropping systems.
7. Compatibility with agrochemicals used in the crop.
8. Shelf life and CFU of commercial bioagents.
9. Consistent and broad spectrum action.
10. Safety and stability. Low capital costs, availability of career materials, economical and viable market demand.

APPLICATION OF NEW GENERATION FUNGICIDES:

- The process of fungicides discovery has undergone a noteworthy change over the period of time.
- After the era of broad spectrum multisite and site specific systemic fungicides, several novel action fungicides of different chemical classes have been developed in the past two decades.
- These are more eco- friendly as these are used at much lower doses as compared to the earlier compounds.
- Most important among these are the Strobilurins (QoIs), derived from *Strobilurus tenacellus*, a wild mushroom (Kumar and Gupta 2012).

Some new generation fungicides are as follows.

- Oxazolidinediones (faoxadone),
- Phenoxyquinolines, (quinoxyfen),
- Anilinopyrimidines (cyprodinil, pyrimethanil),
- Valinamides (iprovalicarb, benthiocarb)
- Mandelamides, (mandipropamid),
- phenylpyrroles (fenpicloil, fludioxonil),
- MBIs (carpropamid)
- Spiroketalamines (spiroxamine),
- Benzamides (mandipropamid),
- Cyanoimidazoles (cyazofamid),
- Thiocarbamates (ethaboxam) and
- Amdoximes (cyflufenamid),
- Phenoxyquinolines (quinoxyfen),

- Imidazoles (fanmidone),
- Benzamides (fluopicolide, zoxamide)

These recently introduced new generation fungicides to the market represent major advances in technology, potency against target diseases, selectivity, safety and rate reduction. However, they tend to have single site modes of action which makes them potentially affected by target site resistance (Leadbeater 2012). Thus now it is very important, along with existing products and based on resistance management strategies, to proactively devise recommendations for new fungicide classes, as well as maintaining existing products.

FUTURE PROSPECTS

Complete elimination of chemical pesticides for controlling plant pests and diseases inmodern agriculture may be impossible, but a logical reduction in their application isfeasible. To have a sustainable agricultural system with minimum contamination and risks to theenvironment, a combination of all available methods should be applied to manage pest problemsand this can be achieved by Integrated Pest Managementmay be the safest solution for management of pest problems including fungal diseases in everycropping system and with no doubt biological control is one of the most important components ofIntegrated Pest Management which can lead us toward a sustainable agricultural system in thefuture. Based on current global changes in agriculture and nutrient supplies, beneficial soilmicrobiomes will have an even more important role in plant productivity and disease managementin the future.

PROSPECTS OF BULBOUS ORNAMENTAL CROPS

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INTRODUCTION

Flower Bulbs are plant species that survive not only by seed but also by specialized underground storage organs (eg. bulbs, corms and tubers). They are also called geophytes. The word '***bulb'*** althoughis more easily understood and widely used to describe all the underground organs, botanically there are significant differences among various organs *viz*., rhizome, tuber, tuberous root, etc (Table.1). They are organs of perennationand vegetative propagation and also serve as storageorgans.Most of the bulbous plants burst into glory once in a year,either by producing a crop of handsome flowers or attractivefoliage, or both simultaneously. During this period theyare the loveliest objects of adoration in pots, beds or clumps.

Bulbous plants grow under a variety of soil and climaticconditions and can be used for multiple landscaping uses. There is no portion of the garden where one orthe other type of bulbous plants will not grow. These plantscan thus brighten up every nook and corner of the gardenwith a pleasing colour and are also suitable for window androof gardening. Many species of bulbous plants are capable ofimparting colour and warmth when planted even under theshade of trees, at the foot of a wall, in hard rocky areas andmarshy and swampy places.Some bulbous plants such as caladiums, alocasia andcolocasia are valued immensely for the beauty of their foliage.Some species do well only in hills. However, all species thatcan be grown successfully in the plains do extremely well inthe hills also.

Table.1. Brief description of specialized modified underground structures broadly called Bulbs

S. No.	Organ/ Structure	Description	Examples
1	Bulb	A specialized organ growing below the soil or occasionally protruding above it. A true bulb is a specializedunderground complete miniature of a plant encased in fleshy modified leaves called scales	
	Bulb - Tunicated	When fleshy scales are tightly packed, completely encircling those within and are typically enclosed in a papery tunic, which covers and protects the bulbs from surface damage and drying.	Narcissus, Tulip, Hyacinth
	Bulb – Non-tunicated	When the fleshy leaves are not covered with any tunic and are formed from modified scale leaves	Lilium, Fritillaria
2	Corm	Corm is a condensed form of rhizome. It is the swollen base of a stem axis which becomes short, compact and is covered by scales like leaves. Corm generally persists for only a single year and is replaced by a new one above it.	Gladiolus, Crocus, Freesia and Liatris.

3	Rhizome	Rhizome is a specialized underground stem structure in which the main stem axis grows horizontally at just below the ground surface.	Canna, Zantedeschia, Hedychium, Iris, Convullaria
4	Tuber	Tuber is a specialized kind of swollen underground modified stem structure with a terminal and several lateral eyes which function as storage organs Tubercle, which is a small tuber produced aerially in the axils of leaves in Bowiea volubilis.	Gloriosa, Tuberous Begonia, Caladium and Musa
5	Tuberous roots	Fleshy swollen roots that store food material are known as tuberous roots. Tuberous roots are also known as root tubers which are formed as result of massive enlargement of roots instead of stem.	Dahlia, Ranunculus, Eranthis, Ipomea and Mirabilis
6	Stem tuber	A stem tuber is a shorten and much thickened underground stem that function as storage organ. A stemtuber has nodes (eyes) present in a regular order over the surface. Nodes are arranged spirally, beginning with the terminal bid at the end opposite of the stolon.	Caladium, Cyclamen, Begonia

Commercial flower production may be achieved using several methods. The bulbs, corms and tubers can be grown in the open, under protection of glass or plastic, with or without heating, for cut flowers or pot plant sales. Flowering date may be 'natural season' *i.e.* controlled by ambient temperature, or it may be out of season *i.e.* forced by special treatment of the 'bulbs' prior to and/or after planting. In commercial conditions, it is a common practice to force a succession of crops into flower. More sophisticated techniques are required to produce earlier flowers and for the accurate timing of successions of flowering dates, involving the use of controlled temperature facilities. These includes

- Speeding the development of the shoot within the bulb by early lifting, rapid cleaning and grading, and storage at high temperature
- Identifying the stage of completion of flower initiation, transferring the bulbs to low temperature to start the cold treatment
- Planting the bulbs at the most appropriate time
- Accurately controlling temperature to achieve the most rapid satisfaction of cold requirement and identifying the stage
- Transferring to the glass house at optimum temperature to achieve anthesis at the earliest possible date

PROPAGATION

The end point of growing bulbs is the flower. A major concern of the flower grower is the timing of flowering, so that the flowers are regularly and predictably available out of season as well as the natural flowering time. 'Bulb' plants are ideal for this purpose because of their partial or complete independence from current photosynthesis for the development and growth to anthesis of the flower, the final saleable product.

Various specialized modified underground structures are the means of propagation in case of bulbous plants like:
Bulbs, Corms, Rhizomes, Stem Tubers, Tuberous roots, Tuberous stems, Tubercles, Bulbils, Pseudo stems, etc. These specialized structures are used for propagating the ornamental bulbous plants. Micro propagation is also followed.

PLANTING
The greatest advantage of growing bulbs in anatural way is that they can be left undisturbed to flowerfor many years. But it is mostly the hardier types which canbe selected for this purpose.

Most of the bulbs need copious watering in early stages butafter the leaves wither it is stopped, as at this stage sap stopsascending and watering is not going to be beneficial.However, no attempt must be made to remove foliage (orthe flowering stalk) before it has withered and decayed tosuch an extent that it can be pulled away with the least effort.

Planting of bulbs depends on the time of flowering and the climatic conditions prevalentin a particular area; thus, it differs from place to place. Inplaces like Delhi, dahlia tubers are planted from Augustto September in order to have them in bloom from Januaryto March, while in Bangalore the planting is done in May soas to have flowers in October. In the hills, most of the bulbous plants are planted inFebruary after the danger of frost and snow is over. Somespecies do well only in the hills, whereas all species grownsuccessfully in the plains do extremely well in the hills.

THREE STAGES IN THE LIFE HISTORY

Bulbous plants passthrough three stages in their life-history: the blooming period,the rest period, and the growing period. In nature, most ofthem usually go to rest after flowering and put forth beautifulflowers or vegetative growth immediately after this period isover. Some produce leaves and flowers simultaneously, but in some as *Haemanthus multiflorus* the flowers are followed bythe foliage; or, as in Narcissus, Gladiolus and Freesia, the foliageprecedes the flowers. Nevertheless, in most of the cases, leaves start withering after flowering and soon die. At this stage,watering is stopped so that food reserves could be stored inthe bulbs. After this accumulation, the plants go to rest andenter the rest period which may extend over a few weeks.

In some bulbs, lateral buds develop on the stem disc in theaxils of the scaly leaves. Eventually, these develop into daughterbulbs. Sometimes, the parent bulb may die during the seasonitself and only one- or two large daughter bulbs may be leftbehind as in tulip; or the parent bulb may continue to growwhile the daughter bulbs remain attached to it as in Narcissus.

Some plants as *Alpinia, Pancratium latifolium, Hippeastrum*and *Crinum* do not shed their leaves completely, therebymaintaining elegance of the spot in absence of flowers. However,growth stops from December to January in these cases.At this stage, the bulbs are dug out, separated and stored forfuture use.

LIFTING AND STORAGE

After complete withering & drying of the leaves, the bulbsare dug out, the roots are cut away and so is the top. Theyare then stored in dry, dark, airy place until the next plantingtime.During storage, both dampness and too dry conditions should be avoided. The former creates favourable conditions for growth ofthe green mould *Penicillium gladioli*. Corms of Gladiolus are highly susceptible to thismould, which attacks and gradually destroys the stemdisc. The central core is then affected. It also dies as aresult of rot. Similarly, the tubers of Dahlia and Caladiumsuffer badly. Dahlia is attacked by *Sclerotinia sclerotiorum*, andnarcissi and daffodils by *Penicillium narcissi*.

To avoid fungal contamination, all mud and dirt should bewashed off the bulbs at the time of division and separation.They should be dried properly in a shady and airy place, and,when moderately dry, stored in dry sand in boxes in a cooland airy place. The sand: may be changed after every two weeks till replanting. When proper drying is not possible,the bulbs should be treated with copper-lime dust. A too drycondition during storage is equally bad, as it results in shrivellingup of the bulbs, tubers and rhizomes and prevents theirrejuvenation next season.

Bulbs of some species need transplanting immediately afterseparation. But, when the site for replanting is not ready,these may first be planted separately in small pots and latertransplanted to the required sites.

Where bulbs are to remain in the ground after the foliagehas died down, these should never be watered till growth restarts in the next season. If watering is continued, they rotand perish.

CRITICAL FACTORS FOR OUTDOOR BULB PRODUCTION

- Selection of either the bed or row planting system
- Selection of planting times, depths (based on bulb hardiness), and densities
- Agronomic factors (soil requirements, drainage, nutrients levels, irrigation systems, winter protection systems)
- Systems to control of foliar diseases and insects
- Control of weeds
- Rouging and required field inspections
- Harvesting times (based on physiological maturity of the bulbs)

COMMERCIALLY IMPORTANT GEOPHYTES

Important bulbous ornamentals for Indian conditions are gladiolus, tuberose, lilium, freesia, daffodils, alstroemeria, amaryllis, crinum, Foot ball lily (*Haemanthus multijlorus), narcissus, Begonia, Dahlia, Iris, Agapanthus, Gloriosa, Hemerocallis, Hyacinthus, Ornithogalum, Nymphea, anemone, cyclamen, ranunculus, etc.*

1. LILIUM

All over the world the lily occupies a prominent place in horticulture as a cut flower (within top 5), pot and garden plant.

VARIETIES/HYBRIDS

Longiflorum hybrids- trumpet-shaped, pure white flowers with a distinctive fragrance and year- round forcing ability. Important cultivars are: Ace, Nellie White, Snow Queen, Casa Rosa, Deliana etc.

Asiatic hybrids– available in wide range of colours (orange, white, yellow, pink, red, purple and salmon) and early to late flowering. Important cultivars are: Brunello, Elite, Navona, Pollyanna, Tresser, Dreamland, Prato, Vivaldi, Torento, Grand Paradiso, Shiraj, London, Detroit etc.

Oriental hybrids- late-floweringwith big and showy flowers with a pleasant fragrance. Imp cultivars are; Stargazer, Siberia, Tiber, Casendra, Barnini, Lombardia, Casa Blanca, Le Reve etc.

LA hybrids -Pavia, Brindisi, Ceb- Dazzle, Diabolo, Fangio, Samur, Ercolano, Cilesta, Bestseller, Honesty, Indian Summerset, Mastermind, White Heaven etc.

PROPAGATION

Propagation of lilies may be achieved both vegetative and sexual methods. Lilies can be multiplied through seeds, bulb scales, bulblets and bulbils. It can also propagate through tissue culture. Commercially scaling and tissue culture are very popular propagation technique of lilium. Propagation through scaling is the cheapest, effective and rapid vegetative propagation for conservation and multiplication of an elite or new clone.

If bulbs are stored for longer periods, temperatures are lowered to -1, -2 or -4^{0}Cand bulbs can be held in moist peat for many months. Consequently, year round forcing is possible. Prior to freezing, bulbs are first cooled (9-12 weeks) and then frozen. The packing material used for storing bulbs must be moist. Moisture is required because; i) the cold treatment is a cold and moist physiological process and ii) lily bulbs lose water and the prevention of desiccation during storage; particularly during long term storage is necessary. Depending on the propagules (seedlings, bulbils, and tissue cultured propagules), bulb programming methods are to be modified to increase the potential number of flowers.

GROWING ENVIRONMENT

Most of the lilies are commercially grown under protection in greenhouse or polyhouse, and under shading nets. In order to maintain cool temperatures, side ventilation as well as roof ventilation is essential to allow natural airstreams flowing inside the structures to counter the heat building up inside.

These require sufficient light (a quantitative long day plant and requires about 2000– 3000 foot candles of light) and proper ventilation.Lilies prefer cool temperature, free from water logging and strong winds. Asiatic lilies are relatively easier to grow and can be grown in elevated locations, even in the plains during the cooler months. Oriental hybrid lily can be successfully grown in cool hilly regions.

TEMPERATURE:

Asiatic lilies require a night greenhouse temperature of 13-17^{0}C and not higher than 21^{0}C day temperature while oriental lilies require 17-18^{0}C night greenhouse temperature and day temperature should be ideally around 29^{0}C. In general, Asiatic lilies take 30-35 days to flower after they reach the visible bud stage of development and oriental take 50-55days. Lastly, when seasonally warm temperatures occur, try to keep the soil and air temperatures below 20^{0}C. Temperature below 15°C can result in bud drop and yellowing of the foliage in oriental hybrids. Extremely high light intensities and the accompanying high temperatures can cause ‘flower abortion’, leaf scorch and or leaf sun burning.

HUMIDITY

About75 to 85% is optimum. If the humidity is close to 100% the plants can become wet. It will occur when the temperature drops too much during the night. This increases the risk of Botrytis infection on leaves and cell bursting. Lower humidity (below 60%) in combination with warm weather results in leaves becoming weak & hang down. In order to prevent this, give enough water in the morning and put a shade net above the lilies. Humidity can be controlled with proper ventilation, circulation, heating and screening.

CO^2:

Enrichment of CO_2 (800-1000 ppm) has a positive effect on the growth and flowering of lilies. Use of 1000 ppm CO_2 in conjunction with supplemental lighting improved plant quality, reduced flower bud abortion and reduced the number of days to flower. A higher concentration (±2000ppm) is needed for the Longiflorum hybrids as this group needed high levels of CO_2.

GROWING MEDIA

Lilies can be forced into flower in almost any type of soil. Well drained light soils, however, are preferred. A pH of 6 to 7 for the Asiatic & longiflorum hybrids and a pH of 5.0 to 6.5 for the oriental, OA and LO hybrids is good. EC should be less than 1.0 and Chlorine in the soil should not exceed 1.5 mmol/lit. Artificial media like cocopeat is widely used.

Raised beds (25 cm) of 1 m width and convenient length (as per the dimensions of the structure) are good. Beds may be spaced at 40 cm.

PLANTING DEPTH

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 at 4-6 inch depth is optimum. Care should be taken that there should be 3-4 inch of soil/media over the bulb.

PLANTING DENSITY

Varies with the group of liliums (longiflorum/Asiatic/oriental) grown, bulb size, type of soil and planting season. For flowering during months with high temperatures and high light intensities, the planting density can be higher. In darker periods (winter) or under conditions of low light, the planting density should be lower. On heavy soils such as peat soils, the plants will display denser habits so that a lower planting density should be applied. The following table indicates the planting densities per square meter area according to the bulb sizes.

Table. 1. Optimum planting density for lilium as per bulb size per net square meter

Bulb size (cm)	**Bulb /m^2**	**Planting distance (cm)**
8-10	49	15 x15
10-12	42	16 x15
12-14	36	16 x18
14-16	36	16 x18

MULCHING

Mulching is advantageous for lilies as it keeps the soil cool & moist, loose, discourages weeds, controls soil borne pathogens and control black body radiation. Materials like rice hulls, rice straw, pine needles, upgraded black peat, etc can be used.

STAKING

A crop produced during the winter months always require support; at other times of the year, cultivars taller than 80-100cm will usually need support. The usual way of providing this support is the use of wire grids similar to those used in chrysanthemum cultivation. These grids are then raised as the crop grows taller. Such a grid can also be used during planting as a way to determine planting density.

IRRIGATION

Too much or too little watering will result in uneven, delayed emergence and growth; reduction in stem length; incidence of Pythium (by excessive watering); and even flower bud desiccation among certain susceptible cultivars. Water requirement in summer is 6 to 8 lit / m2 / day and in other season are 4 to 5 lit / m2 / day. First two weeks, irrigate only by using water can or shower. Third week onwards it is recommended to use drip system. Lilies are sensitive to salt. High salt contents will produce roots that are hard, brittle and yellow to brown in colour. A high salt content will also reduce the roots capacity to absorb water, and this will lead to a reduction in the height of the crop. 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.

FERTILIZATION

For satisfactory growth and flowering, regular supply of nutrients is essential. 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 15:15:15, NPK@ 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.

HARVESTING AND POST HARVEST TREATMENTS OF 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.

1. Prevent the stems drying out during and after harvesting.
2. After harvesting, stems are graded according to number of flower buds per stem, length, the sturdiness of stem, and any disorders affecting leaves and flower bud.
3. During bunching, trimming of 10 cm of foliage from the end of the stems and the stems cut to equal lengths and subsequently sleeve the flowers.
4. Immediately after bunching, the cut flowers should be placed in cold water in cold storage room at 2-3ºC. Add 2% sucrose and 100 ppm GA3 as a preservative agent to water to improve vase life of flower.
5. When dispatching lily flowers, use only perforated boxes to maintain a proper temperature during transport.

PROCEDURE FOR POST HARVEST TREATMENT OF THE BULBS

1. 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.
2. 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).

3. After 5 weeks remove the bulbs from soil along with dried stem.
4. Remove dried stem carefully without damaging the bulb.
5. Wash bulbs with clean water and treat with 2% Bavistin solution for 10 minutes.
6. 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.
7. Immediately after air drying, pack the bulbs in plastic crates with moist coco peat wrapped with perforated plastic sleeves.
8. Coco peat used for packing must be sterilized.
9. Keep the crates in cold storage at 20C for 6-8 weeks or 2 weeks and then at -10C for 6 weeks for longer storage.
10. Keep crates open for one day in cold storage and then close with plastic sleeves.

2. TULIP

Tulip is a hardy bulbous rooted plant and considered to be a major flowering bulb belonging to the family Liliaceae under Monocotyledonae. There are about 160 species with centre of origin in Central Asia.

VARIETIES

White* -** Snow Star, Inzel, Pax, Hibernia and White Dream; ***Yellow* -** Bellona, Christmas Gold, Koreol, Makassar, Monte Carlo; ***Red* -** Albury, Appldoorn, Arme, Bing Crosby, Capri, Cassini, Charles; ***Pink/Rose* -** Angelique, Blenda, Christmas Marvel, Don Quichotte Esther; ***Lavender* -** Attila, Negrita, Prince Charles; ***Scarlet* -** Red Riding Hood and Gander; ***Orange* -** Jimmy, Orange Monarch, Orange Sun and Princess Irene; ***Purple – Nigrita; ***Apricot* -** Apricot Beauty; and ***Biocolour* -** Invasion, Leen von der Mark, Merry Widow, Mirjorana, Wirosa

PROPAGATION

Tulips are propagated by bulbs. Propagation rate depends on the number of bulb scales. The number varies from two to six. In large size bulbs fine fleshy scale and one tunic may be present, while in small size bulbs one fleshy scale and one tunic is available. Tulip scales are concentric and each scale possesses sub-terminal hole through which the shoot grows. A flowering tulip bulb has 5 to 6 scales including tunic. The largest innermost bulb derived from a flowering mother bulb has a flat side. Bulb size for flowering should be 10 to 14 cm in circumference, depending upon the cultivar. In general, a 8-cm or large bulb normally requires a single season to become flowering size, a 5 to 7 cm bulb two seasons, 5 cm and less three seasons.

SOIL AND CLIMATE

Generally tulips grow well in the hills as compared to the plains. The bulbs need a long period of chilling to ensure adequate emergence and especially stem extension. Well drained, sterilized growing medium of 6 to 7 pH is good. The soil should be low in soluble salts. The soil temperature of $13^{o}C$ is to be maintained specially for the first 2 to 3 weeks, when the bulbs are rooting. Sandy loam soil with perfect drainage is suited for tulips. The plants perform better in sunny locations.

LIGHT

Tulip forces best in 1,000 to 2,500 ft candles of light intensity. In very late forcing some shading is necessary in the green house.

TEMPERATURE

The optimum temperature range for tulip is $17^{o}C$ at night and $24^{o}C$ during day.

PLANTING

Planting density depends on the size of the bulb variety and varies from place to place. Ground or raised beds may be used with spacing of 15x15cm or 10x10cm. The bulbs are generally planted with the nose about 6.0cm below the surface of the planting medium.

WATERING

The planting media should be kept moist at all times. Specially during rooting period, over watering is to be avoided. After leaves begin to expand, it is to be seen that the foliage does not get wet. This will assist in controlling *Botrytis*. Irrigation must be stopped with first sign of senescence of leaves

VENTILATION

If grown in green house, adequate ventilation is needed. Building up to relative humidity in the green house should be avoided. Increased relative humidity will lead to *Botrytis*, stem topple or flower abortion.

FERTILIZATION

A fertilizer dose of 200 kg N, 100 kg P_2O_5, and 200 kg K_2O is recommended (Rees, 1992). To prevent stem topple, application of $Ca(NO_3)_2$) is essential. A NPK fertilizer mixture of 8:8:8 may also be used at the rate of 1 kg per 33 row meter immediately after planting and 1 kg again at shoot emergence (Bhattacharjee and Chandra, 2003).

DISEASES OF TULIP

Tulip Fire: caused by *Botrytis tulipae* wherever tulips are grown and can cause very severe damage or even a complete loss of crop. It can be controlled by treatment such as systemic fundicides or fungi-toxic fumigation.

Storage Rot: caused by *Pencillium* sp. controlled by: Captan dust application before packing

Root Rot:*Pythium* sp. controlled by *Trichoderma harzianum*.

Basal Rot: caused by *Fusarium oxysporum f. sp. Tulipa*. Can be controlled by Benomyl or Carbendazim or Mancozeb, etc.

PESTS OF TULIP

Eelworm: infected bulbs are soft with discolored outer fleshy scales, usually yellowish, but sometimes with pronounced brown rings. Careful inspection of stock and removing diseased plants can almost eliminate eelworm.

Aphids:*Dysaphis tulipae.* Spray of endosulphan at various concentrations is significant to use.

HARVESTING

The flowers are harvested at a stage when buds come in 50 percent coloured stage. Bulbs are lifted when 75 percent of the leaves get dried out.

POST HARVEST HANDLING

Stage of Harvest: When half the bud is colored and half is green.

Storage: flowers can be stored for 3 days at 3 ^{0}C. to avoid the stem bending they should be stored vertical.

Transportation: Flowers are transported dry at 1^{0}C in moisture retentive boxes, should be packed loose to avoid the CO_2 conc.

POST HARVEST HANDLING OF BULBS

Lifting of the bulbs: When the leaves get dried out the bulbs can be harvested. Generally this stage comes after 3-4 months of the flower harvest.

Bulb Skinning: Soil and the debris are removed and the bulbs are dried in the shade. Wetting the bulbs one day before skinning improved the performance of the machine and allowed the bulbs to be conditioned for a longer period of time.

PHYSIOLOGICAL DISORDERS

Flower Abortions or Blasting:
Causes:

i. High temperature during transport.
ii. Ethylene produced by fungus during storage
iii. Soil desiccation during forcing
iv. Use of too small bulbs
v. Too early or too long 5^{0}C treatment.
vi. Too many temperature drops below 5^{0}C during treatment.

Stem topple: Collapse of the small portion of the internode just beneath the flower. The cause is lack of calcium. It can be avoided by maintaining the green house temperature around 16 to 18^0 C and application of calcium salts.

Chalking: White spots developed on the stored bulbs which resemble chalk. Poor handling of bulbs encourage this disorder.

3. ALSTROEMERIA (Alstroemeria sp., Alstroemeriaceae)
Alstroemeria has been best known for its ability to produce long-lasting cut flowers with post harvest life of 2-3 weeks. It can be used with elegant flowers or mixed with pompons or spray carnations. Alstroemeria grown in the garden and treated as annuals or tender perennials. The plants have ever-blooming habit in the garden and continue flowering throughout the year except in the frost.

VARIETIES

Number of Hybrids are available for cultivation in greenhouse as a cut flower crop. New hybrids are being produced, extending the flowering season and widening the colour range (bronze, orange, pink, red, yellow and white).
Amor (Yellow); Tiara (Red); Rosita&Cinderella (Dark pink); Capri (Pink); Serena (Maroon); Aladdin (Yellow); Pluto (Orange); White Wings (White).

PROPAGATION

Alstroemeria is propagated through seeds, division of rhizomes and micro propagation. A fortnight prior to division of rhizomes, the plants are severely pruned, leaving only the youngest shoots having a height of 15-20 cm from ground. Rhizomes should be carefully uprooted without disturbing the tuberous roots. Then with sharp disinfected knife rhizomes are cut into portions, each having tuberous roots and growing tip. Singh et al. (2007) recommended that rhizome portions of 2.1-2.6 cm length with 3-4 feeder roots is best for production of quality planting material.

SOIL AND CLIMATE

In open cultivation, alstroemerias require moist but well drained soil rich in humus with a pH of 5.5-7& EC less than 1.0. In sandy soils, incorporation of organic matter into the topsoil helps in the improvement of water retention. Alstroemeria thrives well in cool subtropical climatic conditions and need partial shade.

TEMP& LIGHT

A temp of 15^0C is optimum until the plants are established later on10-13°C is best. An advantage of the crop is that it does not require high temperatures and it can tolerate winter temperatures as low as 5°C. In summer, it is advisable to keep the soil temperatures below 20°C. It has been found that a day temperature of 20°C and a soil temperature of 12-14°C is near the optimum for continuous production.

Flower production is low in winter, increasing as light increases, but can be improved by supplementary lighting or a treatment providing 13 hr photoperiod, which results in early flower initiation.

PLANTING

Rhizomes are normally planted between during autumn (Sept –October) in beds of 1m wide (two rows in a bed with a spacing of 40-50 cm)) in the greenhouse. The planting density is 4 plants /m^2 is ideal. Rhizomes are planted 7-10 cm deep in the soil.

IRRIGATION

Alstroemeria plants should be kept moist and cool. The irrigation system must be adjusted to soil. Normally water is provided through sprinkler or drip system. It requires quality water for better growth, being sensitive to high fluoride and salts. Top 30 cm layer of soil should be kept moist as most of the roots are located in this zone.

STAKING

Plants grow 50-150 cm tall depending upon cultivar. Staking is required to hold the plants. It can be provided by placing 3-4 layers of net of 20x17 or 20x20 cm size.

FERTILIZATION

Fertigation solution should have 350g ammonium nitrate, 130g super phosphate and 800 g potassium nitrate per 20 liters of water for 1 sq.m area. Schedule of 2 fertigations/ month during October to May and a single fertigation per month for rest of the months should be followed

HARVESTING

Flowering can start in autumn or be delayed until the following spring, depending upon the cultivar. Alstroemeria is harvested when at least some buds are open on each stem for local market and for distant market some buds must show colour. It is done by pulling the stems out of the soil. The yield of flowers is around 180 stems per square metre from two flushes.

GRADING

Alstroemeria flowers are graded mainly into two classes Class A (Stem length-80 cm, rigid and 3or more flower stems/stalk.) and Class B (Stem length 60-70cm, 3 or more flower stems/stalk)

POST-HARVEST MANAGEMENT

Alstroemeria flowers may quickly become limp after harvest and as such should be immediately placed in water, preferably with some preservative or germicide added to it.

Holding solution containing sucrose 4% + 8-HQC (200 ppm) + BA 25 ppm and pulsing solution containing sucrose 10% + 8-HQC (300 ppm) + BA 25 ppm was found to be best treatments.

STORAGE OF RHIZOMES

The rhizomes of Alstroemeria can be stored during the winter in the colder regions if they are kept cool (1-30 C) and not allowed to dry out. Storage in peat moss, thick grade vermiculite or some other light, well drained compound is optimal.

DISEASES AND INSECT PESTS

Root rot (caused by *Pythium* sp.) and Foot rot (caused by *Rhizoctonia* sp.) are the important diseases to be taken care of. Insect pests invading alstroemeria include Red spider mite (*Trialeurodes vaporariorum*), leaf miner (*Liriomyza trifolii*), thrips and aphids.

4. FREESIA(Freesia sp., Iridaceae)

Freesia plants have considerable demand in the global market for cut flowers and as potted plants.

PLANTING

Generally, the 5-7 cm size corms are used. The corms are planted in September- December to produce blooms for longer duration. Freesia corms, for cut flowers must be pre-treated at 30°C for at least three months. **Spacing:**The corms should be planted in the greenhouse on well drained 20-25 cm raised beds.

TEMPERATURE

For good germination, a fairly high temperature of 18-22°C is required. Growing temperatures chosen depend on time of year and the target flowering period. For slow growth in winter, 10°C is adequate, but it is more rapid at 12-15°C.

Flowers are harvested with a knife, when the first floret is just opening and two others are showing colour, the position of the cut depending on the market. Flowers can be stored dry at 0 to 0.5 °C for 7 days or at 9- 10°C for 5 days.

Freesia corms are lifted when the foliage turns yellow and the water supply should be stopped until the leaves turn brown and the plants die down naturally. Storage of corms at 3-5 °C after harvest will maintain the corm dormancy.

Depending upon the cultivar, pre-planting storage and forcing temperature, freesia flowers in 110-120 days.Freesias should be forced in medium to high intensity (2000 ft candle) at 10-

13°C temperature. Temperatures above 17°C should be avoided, especially during the short days of winter. Enriching the greenhouse with 1000 ppm CO_2 during the daytime is also beneficial.

5. DAFFODIL (*Narcissus pseudo narcissus* L., Amaryllidaceae)

VARIETIES

Dutch Master, Golden Harvest, Unsurpassable, Actaea, Yellow Sun, Marget Mitchell, Carlton, Hollywood, Mount Hood, Ice Follies, Barrett Browning and Geranium.***(Narcissus – small/miniature types & Daffodils – large trumpet shaped)***

PROPAGATION

Commercially propagated through bulbs. Other methods include Offsets, Scooping, Scoring, Coring, Sectioning and Micro propagation

SOIL AND CLIMATE

Daffodils are not very demanding in their soil requirements but good results are found on sandy loams to medium/heavy loam soil with good soil structure, adequate organic matter, good drainage and water holding capacity. The pH of the soil should range from 6.0 to 6.5.

TIME OF PLANTING

Aug. - Sept. has been found to be the idle planting time for daffodils.

DEPTH OF PLANTING:

Thrice the size of the bulb (www.bbc.uk.in),Twice the size of the bulb (Bose, 1999)

DENSITY OF PLANTING

20 - 25 /m^2 (Anonymous)to 30, 40, 50 /m^2 (Cavins and Dole, 2002) depending on the bulb size and variety.

PLANT NUTRITION

It depends upon the soil type and climate of the region. High levels of nitrogen should be avoided as it delays flowering. It requires moderate amount of phosphorus and high level of potassium. N : P : K = 125 : 150 : 300kg/ha (UK)

IRRIGATION

Narcissus requires copious watering. Constant moisture is required for better flower and bulb production.

MULCHING

Mulching which conserves the moisture, checks the emergence of the weeds, and protects the crop from winter or cold damage, and also at times increasing soil temperature which promotes better growth and development is recommended.

WEED CONTROL

Simazine (0.5 kg a.i./ha), Alicep (6kg/ha), Alipur (4.21kg/ha) may be applied as pre emergence weed killers. Bentazone (1.7 or 3.4 kg/ha) can be applied as post emergence weed killers. Weeds can also be controlled manually.

PEST AND DISEASE CONTROL

The diseases caused by fungi and viruses and attack of pests result in considerable damage and loss of bulbs and flowers of daffodils. These should be avoided by taking preventive measures before planting by carefully inspecting the planting material and the medium as well.

HARVESTING OF FLOWERS

The flowers are harvested at Goose neck stage.

POST HARVEST HANDLING OF FLOWER

Flowers are put in water immediately after harvesting to maintain turgidity and also the flowers can directly be stored in cold storage 0-2° C wrapped with polythene singly or bunched or in clean newspaper in upright position. The flowers are graded according to quality and scape length. The flowers can be transported to distant markets by keeping them in wooden cases or boxes through various transport vehicles.

DEADHEADING

When narcissi flower-heads have faded, it is best to remove them. Otherwise the plant will divert energy from building up the bulb, which is necessary for next year's display, and put it into seed production.

LIFTING OF BULBS AND CURING

The bulbs are lifted from field when the leaves dry down completely nearly after nearly 45-60 days of flowering. The bulbs after harvesting are cured. In this process bulbs are cleaned thoroughly by removing the adhering soil in order to avoid any attack by disease and insect-pest as the soil contains moisture.

GRADING OF BULBS

Generally, bulbs are graded into groups with a 2cm range, e.g. 10-12cm, 12-14cm, 14-16cm.

DISORDERS

SOFT ROT

A soft rot of narcissus bulbs frequently occurs when large quantities of fresh bulbs are kept in unventilated spaces where temperatures rise to30°C or above. The breakdown of bulb tissue occurs rapidly.

GRASSINESS

Few flowers are produced and large numbers of leaves appear from the bulb which tends to split and produce many daughters. A number of factors can cause this condition but the most likely are the killing of the main shoot by bulb-fly or bulb scale mite or by too severe hot water treatment, which stimulates the initiation and growth of new lateral.

Bullhead condition in 'Cheerfulness' fail to emerge from spathe, which remains dry and membranous resembling a drumstick.

HOT-WATER TREATMENT DAMAGE

a very high temperature of the hot water can damage the growing parts of the bulb. To reduce the shock, the bulbs are exposed first to a slightly hot water treatment of 35°C rather than the 44°C treatment.

6. IRIS (*Iris* sp., Iridaceae)

VARIETIES

Beverly Sills (pink), Dusky Challenger (purple),Badlands (dark purple), Immortality (White), Caesars Brother (purple), and Black Gamecock (deep purple)

PLANTING

The bulbs of iris are planted in October to November and bulbs with 6-7 cm and 7-8 cm size are used for planting. Smaller planting stock results in small rounds, with a lower flowering percentage. The bulbs are lifted in the following season, just before complete senescence and those intended for preparation and early forcing require rapid drying, combined with a heat treatment of 30°C with a good airflow. Bulbs smaller than 8 cm intended for replanting are kept cool and well ventilated to lower the flowering percentage in the field thereby produce more flats. The optimum storage temperature for planting stock is 12-15°C.

HARVESTING & PH HANDLING

Iris flowers are harvested when the flower bud is just enough to show colour as in case of Wedgewood iris. In contrast, Blue Ribbon variety is harvested when the tepals open. Conditioning of flowers with warm water or preservative solution containing 200 ppm 8-HQC, 50 ppm $AgNO_3$ along with 5% sucrose is beneficial. Flowers of iris can be stored for longer periods under low temperature of -0.5 to 0°C.

Dutch iris is commonly forced to get flowers from December to June. Immediately after harvesting, the bulbs are treated at 30°C for several weeks to accelerate the development of bulbs for early flowering. The effect of high temperature declined during the $11^{th}$and 15^{th}day.

After the warm temperature treatment, the apical meristem remains vegetative and requires low temperature exposure at 9-13°C for 6-8 weeks for the initiation of the buds. The temperature required however, varies with the cultivar. The low temperature treatment can, however be delayed if the bulbs are not scheduled for early planting. Such bulbs can be stored at 21-27.5°C in open trays in well ventilated areas. Successful early forcing depends on the use of large grade bulbs (10 cm and above) while 8-9 cm ones are acceptable for later forcing.

CULTIVATION OF CALLA LILY AND LILIUM

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CALLA LILY

Calla lilies are one of the most popular plants which are cultivated for their exotic blooms and glossy handsome foliage. Plants look impressive with their spectacular bursts of colours such as golden, pink, red, mauve, peach, white, yellow etc. White callas have advantage over other rhizomatous flowering plants as they can be successfully planted along ponds and lakes as border plants. It is commercially used as cut flower or flowering potted plants. The leaves are very attractive and are used in floral arrangements. Callas can be planted as a specimen plant for containers, in tubs and conservatory. White calla lilies are often used in landscape for planting along bog gardens and damp borders.

Genus : *Zantedeschia* spp.
Family : Araceae
Its common name is Arum lily or White lily (*Z.aethiopica*), Cape lily and Calla Lily or Golden Calla (*Z. elliottiana*) and Pink Calla (Z. *rehmannii*).

CALLA LILY CULTIVARS

Apple court: Habit dwarf, spathe white.
Bridal Blush: Spathe cream washed pink. Carmine Red- Deep red blooms.
Cameo: Peach/ Apricot blooms.
Dusty Pink: Light pink blooms.
Fire Light: Orange blooms.
Him Shweta: White blooms
Him Sumukh: Yellow blooms
Lady Luck: Spathe rich yellow, faintly washed orange.
Majestic red: Deep crimson red blooms. Green, spotted leaves.
Twilight: Bicoloured in light purple and white.
Picasso: Deep purple with cream edges, Green spotted leaves.
Treasure: Rich tone of red, foliage green.

PROPAGATION

Theconventional method of propagatingcallas is through division of underground rhizomes. It can also be propagated by seeds or through tissue culture. Some cultivars and spp. like *Z. aethopica*, *Z. elliottiana*,*Z. rehmannii* and *Z. albomaculata* can be multiplied through seeds. Seeds are formed at the base of the plant/ spath. For quicker germination, seeds are soaked in warm water for 24 hours at 21-27^0 C temperature. It takes a minimum of 2 years or 2 growth cycles to produce a flowering size rhizome.

CLIMATE

Callas grows best in temperate to subtropical climate. They enjoy full sunlight, cool and moist conditions. Direct sunlight is essential for brighter blooms of coloured cultivars, however in warmer areas they require some shade to prevent early fading of colours.

LIGHT

Zantedeschia is a day neutral plant so; it has no effect of photoperiod on flower production. White callas can tolerate a wide range of light intensities however excessively high or low light intensities may reduce spathe colour intensities.

TEMPERATURE

Most of the species need an average temperature of around 13-24^{0}C for satisfactory growth & flowering. For the coloured hybrids, day temperature of 18-21^0 C and night temperature at 16^{0}C is recommended. White calla lily (*Z. aethiopica*) needs the same day temperature as coloured lily and night temperature of around 13^{0}C for their proper growth.

SOIL

A well draining, loam soil, rich in organic matter and having pH 6.0-6.5 is ideal for calla cultivation. Good drainage is vital to avoid root rot and fungal diseases.

LAND PREPARATION AND PLANTING

Callas can be planted in raised beds for cut flower production. For bedding purpose, dig about 30 cm of the soil and apply plenty of well decayed farm yard manure (FYM) or compost. Planting of rhizomes in raised beds helps to produce quality blooms. Carefully inspect the rhizomes and plant only healthy rhizomes of the best commercial varieties. They should be free from any physical damage or diseases like soft rot or physiological disorder such as chalking. The flowering rhizomes are sold in different sizes starting from 3.8 cm to 6.3 cm. For the coloured hybrids, tuber grade 1 is 5 to 6 cm, grade 2 is 4 to 4.5 cm, and grade 3 is 2.5 to 3.5 cm in diameter. A rhizome of less than 2 cm across may produce foliage but fails to bloom. Before planting, rhizomes must be dipped in 2% Carbendazim+ 2% Mancozeb solution for an hour. Plant the rhizomes about 1 to 2 inches below the surface with their growing tips facing upright. Width of mature plants will reach about two to two and half feet and so it is important to give them enough room to grow and develop. Plant density varies from 10x10 cm to 50 x60 cm depending upon rhizome/ tuber size and expected width of plant. In mid hills, rhizomes of white calla lily or *Z.aethiopica* can be planted in September-October (autumn) where as rhizomes of coloured cultivars can be planted in February- March.

MANURES, FERTILIZER AND WATER REQUIREMENTS

Callas do not need heavy fertilization. Incorporation of large amount of organic manure during preparation of bed will promote successful cultivation of the plant. Callas require adequate moisture during active growth of the plant. Water lightly as growth begins then increases the frequency during full growth. Overhead watering should not be practiced otherwise it may damage the flowers. In coloured callas, avoid over watering and water logging in the bed as this may damage the roots. Frequency of irrigation is reduced during later stages when the flowers begin to fade.

POST-HARVEST MANAGEMENT

LIFTING OF BULBS (OR CORMS/RHIZOMES/ TUBERS) AND STORAGE

Rhizomes of coloured callas must have a rest period of 6-12 weeks prior to planting to allow them to regain energy for next year's growth and flowering. Callas can be left in the ground or lifted, when the plants become crowded and division of rhizomes is necessary. Plants are allowed to senesce by withholding irrigation water. Rhizomes of coloured species are lifted in September-October when the foliage has turned yellow & the plants completes one growth cycle. Lifted rhizomes should be washed, graded and treated with fungicides. They can be divided to obtain more rhizomes. Lifted rhizomes should be checked for any serious diseases such as soft rot, physical damage or physiological disorders like chalking. Plants grown on soil beds produce larger tubers than plants grown in pots. Rhizomes are air dried at 20-30^{0}C for one week. After one week, the coloured types are stored at 9-24^{0}C whereas *Z. aethiopica* types are stored at 2-9^0 C. Rhizomes are stored in sand or perlite or vermiculite till the next planting season. If tubers are not given a resting period of minimum 6 weeks, then flowering will be delayed.

STORAGE OF RHIZOME

The factors affecting storage of rhizomes are duration and temperature. Tubers of coloured hybrids should be placed in dry storage at 8^{0}C and at 70 to 80 % relative humidity. Tubers can be stored up to 6 months with the optimal storage temperature of 8^{0}C which reduces respiration and transpiration; the cool temperature does not vernalize the tubers. Higher temperatures, (i.e.13^{0}C), can be used for short term storage.

FLOWER HARVESTING

Flowers are cut rather than pulled when they are fully opened but it should be before the start of pollen shedding. Flowers should be placed in a 2% sucrose solution with a disinfectant for 6 to 12 hr to prevent stem splitting or rolling. Flowers can be held at 5-10^{0}C.

DISEASES (BACTERIAL, FUNGAL, VIRAL AND PHYSIOLOGICAL DISORDER)

Calla lilies are susceptible to bacterial soft rot (*Erwinia cartovora* var. *aroideae*) leaf spot fungus (*Phyllosticta richardiae*), crown rot (*Pellicularia filamentosa* and *Sclerotinum delphinii*) root rot (*Phytophthora richardiae*) and other viral disease like cucumber mosaic virus and tomato spotted wilt virus.

INSECTS–PESTS, NEMATODES

Calla lilies are attacked by several insects like long tailed mealy bugs, bulb mite, caterpillars, thrips and aphids.These insects can be controlled by proper monitoring and regular spray of insecticide like malathion or metasystox @1.5 ml per liter in water.

OFFSEASON LILIUM PRODUCTION

CSIR-IHBT is playing a catalytic role in promoting commercial floriculture in Himachal Pradesh. Motivation of farmers through advisory visits, training, demonstration, and distribution of planting materials by CSIR-IHBT led to extension of area under cultivation of commercial flower crops. Lahaul valley is situated at an elevation of 3000-4000m amsl and cut off from the outside world from October-end to mid-May due to heavy snowfall at Rohtang Pass that closes the pass during the winter. During winter, i.e. from November last to April because of western disturbances it snows heavily and the temperature goes down below minus. There is an average annual snow fall of about 7 feet. The weather remains pleasant during summers i.e. from May to mid-October. These 5-6-month time period is suitable for growing cash crops like potato, peas, cabbage, cauliflower and exotic vegetables which is an off season for the plains.

Lilium is a high value bulbous floriculture crop which has a fourth rank in the international flower trade. Normal season of growing lilies is from October to April in north India and low hills. In 2008, few farmers from Lahaul region visited CSIR-IHBT, Palampur and showed interest in growing floriculture crops. As per their request, Institute provided them training and established the first demonstration plot of Lilium cut flower and bulb production at farmer's field in village Khining, district Lahaul & Spiti. This lilium demonstration plot proved to be an off season crop for Delhi flower market which gave them higher returns than other vegetable cash crops. The impact of this intervention is evident by sale of cut flowers worth Rs. 50 lakhs from local farmers in Delhi flower market in 2010. Lilium cultivation increased nearly threefold increment in farm-income as compared to cultivation of potato and pea. As a result, growers were motivated and lilium cut-flower cultivation and bulb production get a boost in the valley.

In 2012, farmers made a society "The Tinan White Mountains Floriculture, Fruit & Veg. Aromatic & Medicinal Plants Growers Co-operative Mkt. Jagla, P.O. Gondhla, Teh. Keylong, Lahaul & Spiti, H.P.- 175140" for growing and marketing lilium in a cooperative manner. Afterwards three societies namely:

1) Pattan Valley Floriculture Society Ltd., Shansha, Lahaul&Spiti,
2) Mahadev Floriculture Society, Madagran, Udaipur, Lahaul&Spiti and
3) Ratanjot Floriculture Society Ltd. Besides cooperative society

SOCIOECONOMIC IMPACT ON LIVELIHOOD

Technological intervention of CSIR-IHBT has made significant impact on the livelihood of the tribal people inhabiting high altitude area of Lahaul-Spiti district in the state of Himachal Pradesh. The 3rd party Impact Analysis done by National Productivity Council (NPC), New Delhi revealed that the Lilium cultivation resulted 5 times higher income than that of pea cultivation and 6.67 times more than that of potato crop. This enabled the farmers to spend 24.55% more money on their assets, 20.51% more on children education, 17.96% more on house related expenses and 11.93% more money on clothing.Total net returns from the sale of Lilium flowers and bulbs per year was Rs. 116 lakhs and it has generated employment of 17400 mandays per year through Lilium cultivation.

VERTICAL FARMING IN FLORICULTURE

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INTRODUCTION

The quality of human life is affected due to lack of vegetation in urban areas. Vertical gardening is a relatively new concept of urban gardening. It is suitable for small spaces for adorning walls and roofs in various styles. There is possibility of growing plants in vertical space wherever space is a constraint. In the present era of rapid urbanization, horizontal space for outdoor gardens is very limited. In the late 1980's, Patrick Blanc have developed and commercialized the concept of Green walls. Stanley Hart White, Professor of Landscape Architecture, University of Illinois is the actual inventor of Green walls or Modern Vertical Gardens who patented a green wall system in 1938. The patent was for "Vegetation-Bearing Architectonic Structure and System".

Poor air quality has been associated with health problems throughout the world due to rapid urbanization and industrialization. Urban air pollution is a matter of global health concern. Neglecting the air pollution results in acute health risks like frequent illness, allergies, asthma, strokes, heart attacks, bronchial infection, dry eyes, sore throat, sinus, headache, cancer, cardiovascular emergencies, loss of concentration, nausea, dizziness, fatigue, skin and eye irritation, and many other ailments. A number of ornamental plants are believed to be potential scavengers of obnoxious gases to improve the air quality. Swatch Bharat Abhiyaan the flagship programme of the Government of India envisages on the mission 'Green India - Clean India' as part of the unique initiative. Vertical gardens allow plants to grow on walls and other non - horizontal surfaces. Plants in the vertical green wall systems can remove toxicants and obnoxious compounds from air, in addition to the basic photosynthesis that removes carbon dioxide and returns oxygen to the air. The air quality can be improved exponentially by use of vertical green wall systems. Vertical green wall systems reduce dust levels, stabilize humidity and temperature, lower noise levels and provides a refreshing environment. The greenery in vertical landscaping systems provide a feeling of pleasure, calm and relief from stress. Putting plants at eye-level also gives a sense of new appreciation to categories of plants like groundcovers, succulents and small perennials that usually faces hurdles to admire up close. Thus, vertical landscaping system or green wall system which included Ornamental crops improves the wellbeing and performance / work productivity of people.

GLOBAL PERSPECTIVE OF VERTICAL FARMING

In the modern era, incorporation of living organic systems, characterized by Green roofs and Green walls, with the inert structures in modern building, holds the potential for a new type of living architecture. A number of European Countries including Germany,Switzerland,Netherlands , Norway,Italy, Austria , Hungary, Sweden,UK Greece etc.have very active associations promoting green roofs.The architectural embedding of green facades in established structures worldwide is listed below

United States of America

- California Academy of Sciences building
- **Portland Expo Center**

Australia

- Council House 2 Building in Melbourne
- Central Park in Sydney

Canada

- Vancouver Convention Centre
- Edmonton International Airport Canada

Iceland

- Green roofed church, Iceland

France

- L'Historial de la Vendée at Les Lucs-sur-Boulogne, France
- Quai Branly Museum, Paris

Mexico

- Los Cabos International Convention Centre

Sweden

- Scandinavian Green Roof Institute (SGRI)

United Kingdom

- Rubens Hotel in London
- *Heathrow airport, London*
- Sainsbury's Millennium Store in Greenwich
- Westminster City Hall, London

New Zealand

- Christchurch airport, New Zealand

China

- Nanjing Vertical Forest in China

Singapore

- Singapore Changi AirporT\
- Sky Greens' A-Go-Gro System
- Sky Greens' vertical farm structure in Lim Chu Kang

Thailand

- Rainforest chandelier' at Bangkok's EmQuartier shopping mall

STATUS OF ADOPTION OF VERTICAL FARMING IN INDIA

In India, research related to greenery aspects on the building and Vertical Gardening is very limited. Mostly the research conducted so far in India discusses the thermal comfort based on the trees and shrubs planted in the outdoor space such as avenues or streets, roadsides etc. In India, Cities like Bangalore has added green pillars in order to reduce pollution while also improving the cityscape. The Bihar Rajya Pul Nirman Nigam Limited (BRPNNL) had executed plans to equip the pillars of the city's flyovers with vertical gardens consisting of air-purifying plants to curb air pollution. Vertical gardens are installed in 200 metro pillars by Kochi Metro Rail Limited at Kerala. Nagpur Metro Rail Corporation have created vertical garden on metro pillars near the Pride Hotel, Wardha Road.

These vertical gardens consisting of around 1300 plants is created by a Pune-based company. The pillars are constructed in an area of 600 sq. ft and are 30 ft long. Plants like, *Euphorbia*, *Yucca*, and *Sansevieria* are planted on the pillar. Vertical gardens have already started growing on flyover pillars near the College of Engineering, Pune. Vertical gardens on the flyover and metro pillars will undoubtedly enhance the beauty of Pune roads while providing fresh air.Following the success of Heathrow Airport, London, Singapore Changi Airport, Edmonton International Airport, Canada and Christchurch Airport, New Zealand in using

Green Walls in reducing travellers' stress, Mumbai's own Chhatrapati Shivaji International Airport also features verdant Living Walls.

RESEARCH WORKS DONE SO FAR IN VERTICAL FARMING

- Influence of green façades in providing thermal comfort
- Influence of green facades in atmospheric cleansing and related environmental benefits
- Dust mitigation
- Radiation absorption
- Pollution mitigation
- Urban forestry
- Energy saving potential of green façades
- Aesthetic appeal of green structures and other relevant studies on urban greening
- Acoustic attributes of urban greening
- Lifecycle , maintenance, cost effectiveness and overall sustainability of living walls

CLASSIFICATION OF VERTICAL GREENING SYSTEM

Vertical greening system is one of the world's hottest trends in gardening. The new modern concepts for landscape development are keen on using any kind of concrete or glass, turning them in real vertical gardens, being possible to overcome the development of the urban areas making a smooth transition for a healthy green urban environment. According to the method of growing, vertical garden can be classified as green façades and living wall system. Green façades are made up of climbing plants wherein plant shoot grows up the side of the building while being rooted to the ground. They grow directly on a wall or in specially designed supporting structures. Green façades thus make use of climbing plants which are attached directly to the building surface or supported by cables or trellis. In contrast, living wall systems are constructed from modular panels which contain soil or other artificial plant growth media, for example planter box system, foam system, geotextile fabric system or mineral wool system. The modular panels require hydroponic cultures using balanced nutrient solutions to provide all or part of the plant's food and water requirements.

Vertical greening systems is broadly classified as

- Green façades
- Green walls / Livingwalls

Green facades

Green facades are a type of vertical greening system in which climbing plants or cascading groundcovers are trained to cover specially designed supporting structures. Plants are either grown in the ground or in the elevated pots or containers where they are watered and fertilized. Plants will be rooted at the base of specially designed supporting structures, either in the ground or in intermediate containers / planters. Green facades can be fixed to existing walls or it can be built as a freestanding structure, such as fences or columns (TNAU, Agritech Portal). Green facades can be created in the following ways.

A. Can be created with Pots
B. Can be created with Rewind walls.

The three systems which can be used to create Green facades with Rewind walls are:

a. Modular trellis system
b. Grid system
c. Wire-rope net system

Green walls / Living walls

The Green wall system or Living wall system requires more care and maintenance such as fertilizer and water than the green facade systems that are planted into the ground. The Green wall system or Living wall system is composed of pre-vegetated panels, vertical modules or planted blankets (vegetated mat walls)that are fixed vertically to a structural wall or frames.
Green walls / Living walls are further subdivided into:

A. Modular living walls / Modular green walls
B. Vegetated mat walls
C. Landscape walls

A. Modular living walls / Modular green walls

Modular living walls / Modular green wallsare made up of recycled poly propylene, plastic or poly styrene material. It has attractive look, highly sturdy and durable in nature. The installation of modular living walls / modular green wallsis easy and quick. It has a frame/ supporting panel made of steel or plastic. It has easily detachable cups or pots or containers for growing plants. It provides immediate solution for making vertical gardens in your place of interest.

B. Vegetated mat walls

This system, pioneered by Patrick Blanc, is composed of two layers of synthetic fabric with pockets filled with the plants and growing media. The synthetic fabric walls are supported on a framework and backed by a waterproof membrane against the building wall. Nutrients and water are provided through an irrigation system at the top of the fabric wall

STRUCTURES AND COMPONENTS FOR LIVING WALL SYSTEM / GREEN WALL SYSTEM

At the installation site of the vertical living wall system or green wall system, the first step is to set up the suitable supporting structure for growth of the plants.

Kinds of structures / frames

The green wall panels or frameworks are made of different materials. The materials used for construction of green wall structures are:Metallic, Plastic, Steel,Bamboo, Expanded polystyrene,Synthetic fabric etc.

These structures support a great variety, diversity and density of plant species.
The various components that are required for the designing of living wall system / green wall system are as follows:

- Front panel
- Side panel
- Stabilizers
- Bottom drainage trays
- Detachable cups or pots or containers
- Geo textile pouches
- Hanging hooks

SUITABLEPLANTS FOR LIVING WALL SYSTEM / GREEN WALL SYSTEM

Choosing the right plants is very important for the sustenance of living wall system / green wall system. The plants selected for vertical garden wall system should be dense, compact, well-formed and slow growing in nature with healthy root system. The plants should be evergreen in nature, attractive and graceful in appearance and appealing to the eyes. Studying of local flora gives a good indication of which plants that might be used. The plant species should be chosen in such a way that it suits the aspect of the wall on which they will be growing. While selecting the plants for vertical green wall system, the pattern of sun exposure also should be taken into consideration. The decision of placing plants in various locations of wall units should be based on their moisture loving capacity.

PLANTSSUITABLE FOR VERTICAL GARDENING ACCORDING TO THE GROWING CONDITIONS:

Plants for Outdoor Green walls / Exterior Green walls

Herbaceous perennials:
Alternanthera green,
Alternanthera sessilis,
Asparagus densiflorus "sprengeri",
Asparagus densiflorus "myers"
Asystasia gangetica,
Duranta
Duranta variegata
Eranthemum nigrum,
Eranthemum red,
Ipomoea (Golden),
Ipomoea (Purple),
Irisine,
Mentha spp.
Pilea microphylla,
Pittosporum tobira,
Rhoeo golden (spathaceae sitara gold),
Rhoeo green,
Rhoeo tricolor (variegated),
Russelia euisetiformis
Succulents:
Geraniums
Jade plant,
Portuluca,
Aptenia
Sedums,
Shrubs:
Barleria cristata,
Buxus microphylla,
Cuphea,
Dusty miller,
Ficus species,
Plumbago auriculata (sky flower),
Plumbago indica (Lal chitrak),
Ruellia,
Song of India(Pleomele),
Trachelospermum jasminoides,
Ground covers:
Baby's tear,
Callisa repens ,
Tredascantia zebrina
Wedelia trilobata,
Grass like foliage forms:
Dianella tasmanica,
Ophiophogon,
Pandanus tectorius,
Pennisetum setaceum (Fountain grass)
Phalaris arundinacea,

Plants for Indoor Green walls / For shaded areas

Herbaceous perennials:
Aglaonema siam aurora (Red lipstick),
Aglaonema snow white,
Anthuriums,
Aralia,
Begonia,
Bromeliads,
Chlorophytum comosum,
Cryptanthes,
Epipremnum,
Erasinae (Reep),
Fittonia,
Heart leaf Philodendron,
Monstera species,
Neoregelia
Peperomia,
Philodendron Ceylon gold
Philodendron selloum,
Pilea,

Rhoeo discolor,
Sansevieria hahnii compacta,
Sansevieria trifasciata robusta,
Schefflera,
Spathiphyllum,
Syngoniums,
Shrubs:
Schefflera,

Ficus spp ,
Cordyline terminalis
Succulents:
Rheo discolor,
Setcreasea purpurea
Zebrina pendula,

Ferns:
Nephrolepis exaltata
Nephrolepis biserrata furcans
Nephrolepis cordifolia

GROWING MEDIA FOR LIVING WALL SYSTEM / GREEN WALL SYSTEM

The growing media used in living wall system / green wall system should meet the following requirementslike Weightless media , High Water holding capacity , High Nutrient holding capacity , Good Porosity and Neutral pH. The common media combinations used in living wall system / green wall system are Cocopeat, Perlite, Sphagnum moss,Vermiculite, Vermicompost , Shredded bark and Leaf molds.Soil is not generally used in living wall system / green wall system since it increases the weight of the green walls.

IRRIGATION AND PLANT NUTRITION FOR LIVING WALL SYSTEM / GREEN WALL SYSTEM

The irrigation system in a vertical green wall system should be designed in such a manner that it minimizes water consumption. The irrigation network of vertical living wall system consists of an automation-unit with equipment for control of nutrient injection and irrigation cycles. The average water consumption ranges between 2-5L /m^2/day in a vertical green wall system.Irrigation cycles typically last a few minutes and will be required several times a day.
It is better to keep irrigation volumes low as it minimises wastage of water and reduces run-off. Run-off from irrigation water should be collected in a tank at the base of the vertical green walls and recycled back through the green wall system. Green walls that use a high quality, water-retentive growing medium, and are not in an exposed or particularly hot and sunny location, thrive on a weekly watering regime. Irrigation must be available as soon as the plants are installed in the wall system. The irrigation system requires a water meter to monitor irrigation volume, and a pressure gauge to monitor the even application of water. For hydroponic green wall systems, the fertigation system may apply 0.5-20 litres of irrigation solution per square metre per day.The requirements of internal green walls are at the lower end of this range, whereas external green walls are at the higher end.

LIGHT REQUIREMENTS FOR VERTICAL GREEN WALL SYSTEMS

Direct sunlight can deliver over 100-000 lux whereas the average light level in an office is around 300-500 lux. Even if the least light demanding species are used, artificial light is normally necessary indoor. A few species will stay fine at 900 lux, but a slightly increased level at some parts of the surface will broaden the variation of species that can be used. An artificially illuminated surface has shifting light levels, due to the fact that light reduces with the square of the distance from the light source. Some areas might have 3000 lux and others 900 lux. The plant design is made with this in mind, taking advantage of the higher levels for more demanding and interesting species.

GENERAL CONSIDERATIONS IN VERTICAL FARMING:

- Watering: Appropriate time
- Careful selection of plants for wind prone areas (Succulent and hardy plants)
- Removing the dried leaves
- Keeping the structure clean
- Disposing the water from drainage system
- Pruning if necessary

- Timely application of fertilizers

PROBLEMS ENCOUNTERED IN CREATION OF VERTICAL GARDENS

Some of the problems encountered while creating Vertical gardens are:

- Getting a messy soil to stay in place when the planter is turned to 90^0 inclination.
- Watering and rooting problems.
- Growing problems of plants vertically.
- High installation rates, along with expenditure to keep gardens well-maintained
- Maintenance frequency and difficulty
- Failures in the irrigation system

MAINTENANCEOF VERTICAL GREEN WALL SYSTEMS

If the basic needs of the plants viz., light, water and nutrients are supplied through automated system, we can get healthy plants. It also greatly reduces the maintenance demand and makes the vertical garden possible even to use on high buildings or other places where accessibility is limited. The vertical garden should be designed in such a manner that the natural growth habit of the plant is taken into consideration, and for different species to have a dynamic co-habitat with adjacent species. It is better to use plants that are perennial in nature for vertical green walls, but as the years pass, a few will have to be replaced. Slight pruning measures could be adopted if plants in the vertical green walls are overgrown. These maintenance measures if promptly followed will ensure a long-lasting lush and attractive vertical green wall system.

IMPACT OF VERTICAL GARDENING

Vertical gardening is basically growing ornamental plants upwards on vertical surfaces, be it on the wall of a home, office, hospitals or on a large facade of a building. As horizontal space is a limitation for gardening for many urban areas in the present era, installation of a vertical garden is undoubtedly a promising option to include some greenery in the house / building. Vertical green walls can even be installed along highways, expressways, metros, railway lines, airports etc. to bring down the deleterious effects of noise pollution. Vertical gardening is more than just aesthetics; it can aid in cooling and insulation of buildings, and reduces the need and cost for high voltage air-conditioning units. Growing plants in the building can also help to filter air particulates and improve air quality as well as add some humidity. Vertical gardening also helps to save water by reducing the need for irrigation and watering. The greenery in vertical landscape system also softens the hard and rough look of concrete buildings in urban areas.

CONSTRAINTS

There are several constraints in Vertical gardening besides new emerging challenges.

- Climate change has started impacting the performance of Vertical gardening systems
- Quality standards of planting materials supplied by some private nurseries for Vertical gardening are not reliable
- Disease and pest problems in Vertical gardens still remain unsolved although persistent efforts are being made
- Much needs to be done for the development of inputs like Vertical gardening structure fabrication, media, drip irrigation system etc. in view of its magnitude of progress in the country
- The present marketing system of Vertical Gardens lacks scientific approach.

NEMATODES: A HIDDEN THREAT IN ORNAMENTALS

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Nematodes are very small roundworms. They live everywhere- in soil, plants, water and animals, including humans. Nematodes feed on bacteria, fungi, algae, plants and animals. A few thousand species attack plants; most nematodes feed on dead or decaying organic matter. Many nematode species are beneficial because they feed on bacteria, insects, fungi and other soil pests. The life cycle of a nematode is egg, four juvenile stages and adult. Adult females lay eggs that hatch into young nematodes called**juveniles**. Juveniles look like small adults. First and second stage juveniles are usually found still inside the egg case. For most plant-parasitic nematodes, egg hatching takes place during the second juvenile stage. After a total of four molts (shedding of their skin), the juveniles become adults. If males and females are present, they mate and produce more eggs. Typically, the life cycle of a plant-parasitic nematode is completed within 20 to 60 days. About 95 percent of plant-feeding nematodes live in the soil and feed in or on roots. Some consume aboveground plant parts. Plant-feeding nematodes feed by inserting a needlelike structure (**stylet**) into plant cells.

A number of nematode species can damage flowering plants including the root knot nematodes, *Meloidogyne* species, ring nematode (*Criconemoides xenoplax*), root lesion nematodes (*Pratylenchus* species), Soybean cyst nematode (*Heterodera glycines*), sugarbeet cyst nematode (*Heterodera schachtii*), citrus nematode (*Tylenchulus semipenetrans*), stem and bulb nematode (*Ditylenchus dipsaci*) and others.

LIFE CYCLE

Plant-feeding nematodes go through 6 stages- an egg stage, 4 immature stages and an adult stage. Many species can develop from egg to egg-laying adult in as little as 21 to 28 days during warm summer months. Immature stages and adult males are long, slender worms. Mature adult females of some species such as root knot nematode change to a swollen, pearlike shape, whereas females of other species such as lesion nematode remain slender worms. Nematodes are too small to be seen without a microscope.

It is believed that the root knot nematode survives from season to season primarily as eggs in the soil. After the eggs hatch, the second-stage juveniles invade roots, usually at root tips, causing some of the root cells to enlarge where the nematodes feed and develop. The male nematodes eventually leave the roots but the females remain embedded, laying their eggs into a jellylike mass that extends through the root surface and into the soil.

MECHANISM OF FEEDING AND SYMPTOMS OF DAMAGE

They inject an enzyme into the cell that dissolves the cell contents. The nematode then uses its stylet like a straw to remove the liquid cell contents. Nematode root feeding directly interferes with a plant’s ability to take up water and nutrients. Infected plants wilt and appear to be suffering from a lack of water or nutrients. These symptoms can easily be mistaken fordamage caused by other conditions. High nematode populations result in plant stunting, yellowing, a general decline in plant health and sometimes plant death. Nematode feeding can cause yield loss. The feeding sites also act as points of entry for other pathogens such as fungi and bacteria.

MODE OF DISPERSION / TRANSMISSION

Though nematodes are small, they can easily disperse over long and short distances. In the soil, nematodes move approximately **1 inch per year**. However, they can be transported from field to field or within a field by flood waters, dust storms, contaminated machinery and nursery stock or transplants.

Nematode populations are identified and located from field soil samples. Soil and root samples can be submitted to Nematode Project, MPKV, Rahuri for identification. After proper identification, a site-specific nematode management program can be developed. Details on how to collect and submit a proper soil sample is available at Nematode Project, Department of Agricultural Entomology, MPKV, Rahuri.

DAMAGE

Root knot nematodes usually cause distinctive swellings, called galls, on the roots of affected plants. Infestations of these nematodes are fairly easy to recognize; dig up a few plants with symptoms, wash or gently tap the soil from the roots and examine the roots for galls. The nematodes feed and develop within the galls, which can grow as large as 1 inch in diameter on some plants but usually are much smaller.

The formation of these galls damages the water and nutrient-conducting abilities of the roots. Galls can crack or split open, especially on the roots of vegetable plants, allowing the entry of soil-borne, disease-causing microorganisms. Root knot nematode galls are true swellings and can’t be rubbed off the roots as can the beneficial, nitrogen-fixing nodules on the roots of legumes. Root knot nematodes can feed on the roots of grasses and certain legumes without causing galling.

Aboveground symptoms of a root knot nematode infestation include wilting during the hottest part of the day even with adequate soil moisture, loss of vigor, yellowing leaves and other symptoms similar to a lack of water or nutrients. Infested vegetable plants grow more slowly than neighboring, healthy plants, beginning in early to midseason. Plants produce fewer and smaller leaves and fruits and ones heavily infested early in the season can die. Damage is most serious in warm, irrigated, sandy soils.

Root injury from other nematode species can produce aboveground symptoms similar to those from root knot nematodes. However, the actual injury to the roots is more difficult to detect. Roots can be shortened or deformed with no other clues as to the source of the injury. You can confirm a nematode infestation by collecting soil and root samples and sending the material to a laboratory for positive identification of the infesting species.

Although nematodes can kill annual plants, they rarely kill woody plants. Nematode injury to woody plants usually is less obvious and often more difficult to diagnose. Infested fruit and nut trees can have reduced growth and yields. Woody flowering plants that are heavily infested can have reduced growth and branch tip dieback and can defoliate earlier than normal.

DETECTING NEMATODES IN SOIL SAMPLES

Nematodes are too small to see without a microscope. Often you become aware of a nematode problem by finding galled roots on a previous crop. However, you also can use a simple bioassay to detect root knot nematodes in garden soil. Melons seeded in pots in moist soil collected from the garden will develop visible galls on the roots in about 3 weeks when pots are kept at about 27ºC if root knot nematodes are present. As a comparison, melons planted in heat-sterilized soil won't develop galls.

MANAGEMENT

Management of nematodes is difficult. The most reliable practices are preventive, including sanitation and choice of plant varieties. You can reduce existing infestations through fallowing, crop rotation and soil solarization. However, these methods reduce nematodes primarily in the top foot of the soil and they are effective only for about a year. They are suitable primarily for annual plants or to help young woody plants establish. Once nematodes infest an area or crop, try to minimize damage by adjusting planting dates to cooler times of the season when nematodes are less active. Try to provide optimal conditions for plant growth including sufficient irrigation and soil amendments to make plants more tolerant to nematode infestation.

1. SANITATION

Nematodes usually are introduced into new areas with infested soil or plants. Prevent nematodes from entering your garden by using only nematode-free plants purchased from reliable nurseries. To prevent the spread of nematodes, avoid moving plants and soil from infested parts of the garden. Don't allow irrigation water from around infested plants to run off, as this also spreads nematodes. Nematodes can be present in soil attached to tools and equipment used elsewhere, so clean tools thoroughly before using them in your garden.

2. RESISTANT OR TOLERANT VARIETIES AND ROOTSTOCKS

One of the best ways to manage nematodes is to use varieties and rootstocks that are resistant to nematode injury. Tomato varieties with the code VFN (*Verticillium*, *Fusarium*, Nematodes) on the seed packet or label are resistant to common root knot nematode species. Although even resistant tomato varieties can still exhibit some root galling under high nematode levels, they usually maintain their yield. For example in recent vegetable garden-type experiments on root knot nematode soil, nematode-resistant tomatoes yielded almost 6 times more tomatoes than a similar susceptible variety. An additional benefit of growing a resistant variety is the nematode levels in the soil decline rather than increase, making it more feasible to grow a susceptible crop the following season.

For fruit trees and vines, Nemaguard rootstock used for stone fruit and almond trees and Harmony and Freedom rootstock used for grapes provide protection against root knot and other nematodes. Citrus trees growing on Troyer and Trifoliate rootstocks are resistant to the citrus nematode. Consider replacing severely infested plants with plant species and varieties that are more tolerant of the nematodes present. Unfortunately, resistant varieties aren't available for many crops and ornamentals.

3. FALLOWING AND ROTATION

Growing a crop on which the nematode pest can't reproduce is a good way to control some nematodes. For example, the sugarbeet cyst nematode attacks only a limited number of crops including cole crops (broccoli, Brussels sprouts, cabbage and cauliflower) and related crops and weeds. Growing non-susceptible crops for 3 to 5 years reduces the sugarbeet cyst nematode population to a level where you can grow susceptible crops again. Unfortunately, rotation isn't as easy for controlling root knot nematodes, because so many vegetable crops and weeds are hosts of the pest.

However, with careful planning, rotation in combination with fallowing and solarization can reduce root knot nematode numbers. Annual crops that are useful in a rotation plan for reducing root knot nematode populations include small grains such as wheat and barley, sudangrass and resistant tomato and bean varieties.

Fallowing is the practice of leaving the soil bare for a period of time. Fallowing for 1 year will lower root knot nematode populations enough to successfully grow a susceptible annual crop. Two fallow years will lower nematode numbers even further. When fallowing, it is important to keep the soil moist to induce egg hatch and to control weeds on which nematodes can survive. As a result, eggs will hatch, but the nematodes will die if there is nothing to feed on.

You will need to repeat fallowing when you begin to see root injury again, as nematodes can build up to damaging levels even in a single season. A good way to conduct a fallowing program is to split the garden into thirds and fallow one-third every year or two on a rotating basis. If you intend to grow woody plants in a nematode-infested area, consider fallowing the soil for 4 years before planting. Table 1 gives an example of a rotation/fallowing plan that would be useful for root knot nematode control.

Table 1. Example of a Rotation Plan for a Root Knot Nematode-infested Garden[1].

Section	First winter	First summer	Second winter	Second summer	Third winter	Third summer
Section A	Fallow	Fallow	Fallow	Plant summer-susceptible crop	Plant winter/spring crop	Plant summer-resistant crop
Section B	Plant winter/spring crop	Summer solarize	Plant winter/spring crop	Plant summer-susceptible crop	Fallow	Summer solarize

Section C	Plant winter/spring crop	Amend soil, plant summer-susceptible crop	Fallow	Fallow	Fallow	Fallow or plant summer-resistant crop

[1]Garden is divided into three sections: A, B, and C.

4. SOIL SOLARIZATION

You can use solarization to temporarily reduce nematode populations in the top 12 inches of soil, which allows the production of shallow-rooted annual crops and helps young woody plants become established before nematode populations increase. However, solarization won't provide long-term protection for fruit trees vines, and woody ornamental plants.

For effective solarization, moisten the soil, then cover it with a clear, plastic tarp. Leave the tarp in place for 4 to 6 weeks during the hottest part of summer. Root knot nematodes, including eggs, die when soil temperature exceeds 52°C for 30 minutes or 54°C for 5 minutes. The effectiveness of solarization is reduced in cool coastal areas, where summer temperatures commonly remain below 27°C.

5. PLANTING AND HARVESTING DATES

Most nematode species are active during warm summer months and can't penetrate roots at soil temperatures below 18°C. Therefore, you can reduce nematode injury to fall-planted crops such as carrots, lettuce, spinach and peas by waiting until soil temperatures have dropped below 18°C. Plant summer vegetables as early as possible in spring before nematodes become active. Plants with larger root systems, even though nematode-infested, might be able to remain productive longer. It is also helpful to remove annual vegetables, including their roots, as soon as harvest is over, to prevent nematodes from feeding and breeding on root systems.

6. NEMATODE-SUPPRESSIVE PLANTS

Certain marigolds, *Tagetes* species, suppress root knot and lesion nematodes. French marigolds (varieties include Nemagold, Petite Blanc, Queen Sophia and Tangerine) are most effective. Avoid signet marigolds, *T.signata* or *tenuifolia*, because nematodes will feed and reproduce on these. Marigolds don't work well against the northern root knot nematode, *Meloidogyne hapla*, a species common in areas with cool winters. The effect of marigolds is greatest when you grow them as a solid planting for an entire season. When grown along with annual vegetables or beneath trees or vines (intercropping), nematode control usually isn't very good. To prevent marigold seed from getting in the soil, cut or mow the plants before the flowers open. As with other cultural control methods, nematode populations rapidly will increase as soon as you grow susceptible crops again.

7. SOIL AMENDMENTS AND IRRIGATION

You can add various organic amendments to the soil to reduce the effect of nematodes on crop plants. The amendments- which include neem cake, peat, manure and composts- are useful for increasing the water and nutrient-holding capacity of the soil, especially sandy soils. Because nematodes more readily damage plants that are water-stressed, increasing the soil's capacity to hold water can lessen the effects of nematode injury. Likewise, more frequent irrigation can help reduce nematode damage. In either case, you will have just as many nematodes in the soil, but they will cause less damage.

8. NEMATICIDES / PESTICIDES

Currently no chemical nematicides or soil fumigants are available to flower gardeners for nematode control.

Table 2 : Nematicides currently available on world markets

Sr. No.	Chemical name	Trade name	Formulation
	Fumigants		
1	Methyl bromide	Dowfume	Gas
2	1,3 dichloropropene	Telone/DD-95	Liquid
3	Ethylene dibromide[1]	Dowfume W-85	Liquid
4	Metam-sodium	Vapam	Liquid
5	Dazomet	Basamid	Dust (prill)
6	Methyl isothiocyanate	Di-Trapex	Liquid
7	Chloropicrin[1]	Larvacide	Liquid
	Organophosphates		
8	Thionazin	Nemafos	Granular or emulsifiable liquid
9	Ethoprophos	Mocap	Granular or emulsifiable liquid
10	Fenamiphos	Nemacur	Granular or emulsifiable liquid
11	Fensulfothion	Dasanit	Granular
12	Terbufos	Counter	Granular
13	Isazofos	Miral	Granular or emulsifiable liquid
14	Ebufos	Rugby	Granular or emulsifiable liquid
	Carbamates		
15	Aldicarb	Temik	Granular
16	Aldoxycarb	Standak	Flowable
17	OxamyI	Vydate	Granular or emulsifiable liquid
18	Carbofuran	Furadan/Curaterr	Granular or flowable
19	Cleothocarb	Lance	Granular

[1] Use restricted.

Fumigants perform best in soils that do not have high levels of organic matter (which deactivates the toxicant) and that is free-draining but has adequate moisture. In general, fumigants are most effective in warm soils (12° to 15°C) as dispersion is temperature related.

Methyl bromide, the most dangerous of the fumigants still in common use, has to be applied beneath a polyethylene sheet. In some countries this is done with specialized machinery that treats and covers the soil in one operation. The cover is removed some days later and the crop is sown or planted when all traces of the fumigant have dispersed.

Table 3: Examples of recommended nematicidal dosages and treatments for some important crops[1]

Sr. No.	Crop	Nematode pest	Nematicide	Application rate kg a.i./ha	Application techniques
1	Potato	*Globodera* spp.	Aldicarb	2.24-3.36	Incorporated in row
			Oxamyl	4.0-5.5	
			Carbofuran	4.0-5.5	
2	Tomato, cucurbits	*Meloidogyne* spp.	Aldicarb	3.36	Incorporated in 30-cm bands
			Ethoprophos	0.9-2.9	Incorporated in bands
			OxamyI	0.6-1.2	Incorporated in bands
			Fenamiphos	1.6-3.3	Incorporated in bands
			Dazomet	30-50 g/m^2	Incorporated in bands and irrigated Time interval before planting
3	Citrus	*Tylenchulus semipenetrans*	Fenamiphos	10.8-21.6	Annual treatment applied along drip-line
			Aldicarb	5.5-11.0	Annual treatment applied along drip-line
4	Grape	*Meloidogyne* spp.	Fenamiphos (e.c. formulation)	10.0	In bands for nursery use
		Xiphinema index	Aldicarb	5-10	In bands for nursery use
5	Banana	*Radopholus similis* and/or	Carbofuran	2-4 ga.i. per plant	Applied around plant 2-3 times per year
		Helicotylenchus multicinctus and/or	Ethoprophos	2-4 ga.i. per plant	Applied around plant 2-3 times per year
		Pratylenchus spp. and/or	Fenamiphos	2-4 ga.i. per plant	Applied around plant 2-3 times per year
		Meloidogyne spp.	Isazofos	2-4 ga.i. per plant	Applied around plant 2-3 times per year
			Ebufos	2-4 ga.i. per plant	Applied around plant 2-3 times per year

[1] Information taken from literature. Products may be unavailable for use in some countries. Economic and environmental justification should be evaluated before use. The omission of compounds does not imply that they are not equally suitable for nematode control.

Liquid fumigants EDB, metam-sodium and 1,3-D are applied to soil that has been prepared for planting. The soil surface is compacted with a roller after treatment which helps to seal the fumigant in the soil. Compounds releasing methyl isothiocyanate (dazomet, metam-sodium) work best in soils at >15°C. In cooler soils, the period between treatment and planting may have to be extended to allow sufficient time for the product to disperse.

The liquid fumigant DBCP is the only volatile compound that can be applied to growing plants without causing phytotoxicity. However, its manufacture has now ceased for toxicological reasons and its use is banned in many countries.

9. BIOLOGICAL CONTROL

Most commonly used nematicides are expensive or being withdrawn from the market due to their harmful effect on humans, their persistence in soil or their contamination of ground water, investigators are concentrating their efforts on integrating biological control agents in nematode management strategies. Commonly more than one microorganisms having nematicidal property occur with plant rhizosphere and are also commercially available in market.

Table 4. The advantages and limitations of potential biological control agents with different modes of action against plant-parasitic nematodes

Type of agent	Mode of action	Comments
Facultative parasites Trapping fungi	Traps produced on modified mycelium give rise to infective trophic hyphae	*Advantages:* easily produced *in vitro;* some species rhizosphere competent; wide host range. *Limitations:*difficult to ensure trapping activity coincides with activity of infective stages of cyst and root-knot nematodes; often do not produce resting structures and so may be difficult to formulate.
Paecilomyces lilacinus	*Hyphal penetration*	*Advantages:*easily produced *invitro;* rhizosphere competent; attacks the eggs of several nematode species; treatment of planting material (e.g. seed tubers) can be effective. *Limitations:* requires high soil temperatures; has given variable control in range of conditions; large numbers of propagules (10^6/g soil) required for nematode control; some isolates are pathogenic to humans.
Verticitlium chlamydosporium	*Hyphal penetration*	*Advantages:* easily produced *in vitro;* some isolates rhizosphere competent, and virulent (10^3 propagules/g soil required for nematode control); resistant resting spores produced; survives throughout growing season in soil. *Limitations:* seed treatments ineffective; efficacy dependent on nematode species, density and plant host.
Obligate parasitesPasteuria spp.	Adhesive spores	*Advantages:* most isolates highly virulent; infective spores resistant to drying; good shelf-

		life; reduce infectivity of nematodes as well as fecundity. *Limitations:* very difficultto culture in *vitro;* isolates are highly specific; no proliferation in soil in absence of nematodes.
Hirsutella spp.	Adhesive spores	*Advantages:* relatively easy to culture in *vitro;* attack infective nematodes in soil. *Limitations:* poor saprophytic competitor; limited spread in soil.
Rhizosphere bacteria	Toxins or modification of root exudates	*Advantages:* easy to culture *in vitro;* can be applied as seed treatments; reduce plant damage. *Limitations:* effective for a relatively short period; activity affected by crop cultivar and nematode species; little effect on nematode multiplication.
Endophytic fungi(non-pathogenic root-infecting fungi and mycorrhizae)	Competition in roots and modification of root exudates	*Advantages*:include agents with potential to control migratory endoparasitic nematodes in roots; may improve plant growth even in absence of nematodes; reduce damage caused by wide range of nematodes and limit their multiplication; can be mass produced and formulated; could be applied to seeds or transplant material; may reduce fungal root rots. *Limitations*:non-mycorrhizal fungi may be difficult to register as closely related to plant pathogens; efficacy affected by plant cultivar and other crops in rotation such as crucifers can reduce survival.

Sources: Kerry, 1987; Stirling, 1991; Sikora, 1992.

STUDY OF SOME OF THE IMPORTANT NEMATODES

1. SOYBEAN CYST NEMATODE

Host plants: Soybeans, dry beans, Chrysanthemum and other legume crops (green beans, green peas) and weeds (henbit, field pennycress, shepherd's purse).

Life cycle: The adult female soybean cyst nematode mates with a male and produces 150 to 500 eggs. Shortly after mating, she dies. But first she deposits a few eggs on the outside of her body. The other eggs remain in her dead body, which is called a **cyst**. In the cyst the eggs are protected from predators and environmental factors that would kill them. The eggs in the cyst hatch over the next eight years. Soybean cyst nematode eggs survive best under cool, moist conditions. The juveniles emerge from the eggs and immediately begin searching for food – soybean roots. Once the juveniles find a soybean root, they enter the root and begin to feed. A juvenile soybean cyst nematode molts four times before becoming an adult nematode. Under moderate soil conditions, it takes 21 to 24 days for a soybean cyst nematode to complete its life cycle.

Damage and symptoms: The most common aboveground symptoms of soybean cyst nematode damage are stunted and yellowed plants. Plant symptoms are usually not evenly distributed in a field. In early July, white female soybean cyst nematodes are found attached to plant roots. As the nematodes age, they become yellow.

The attached females are the only visible sign of a soybean cyst nematode infestation. Soybean cyst nematode infestations can reduce soybean yields by 30 percent without plants showing symptoms. Severe infestations can reduce soybean yields as much as 80 percent.

Management options: To prevent soybean cyst nematode infestations, practice crop rotation, plant nematode free seed and maintain clean machinery. Nematode resistant and -tolerant soybean varieties are available.

Fields with low to moderate soybean cyst nematode populations can be managed by practicing a three-year crop rotation. Longer rotations may be necessary for fields with large soybean cyst nematode populations. Soil fumigants are available but very expensive. Non-fumigant nematicides applied at planting may reduce soybean cyst nematode populations. In many situations, they, too, are very costly.

2. SUGAR BEET CYST NEMATODE

Host plants: Sugar beets, cabbage, mustard, cauliflower and many weeds.

Life cycle: All cyst nematodes develop in the same manner. Therefore, the sugar beet cyst nematode is very similar to the soybean cyst nematode. After hatching, the second stage juvenile (J2) nematodes enter the sugar beet roots to feed. As the nematode grows, it bursts from the root. The white to yellow adult females are exposed on the root surface. With ideal soil conditions, the sugar beet cyst nematode completes its life cycle in 25 days.

Damage and symptoms: Typically, the sugarbeet cyst nematode is found in the fibrous roots, but it can also feed on the storage root. Infected sugar beet plants are stunted, have yellow foliage, and wilt in warm weather. The wilting can be persistent even in soil with high moisture levels. You can see female sugar beet cyst nematodes on the plants roots without a hand lens. Severe nematode infestations may reduce yields.

Management options: Sugar beets are the only major host of sugarbeet cyst nematodes in Michigan, so crop rotation provides sufficient control. Typically, at least a three-year rotation out of sugar beets is recommended. However, in heavily infested fields a longer rotation (five to eight years) may be necessary. Currently, there are no sugar beet varieties that are resistant to the sugar beet cyst nematode.

3. CORN NEEDLE NEMATODE

Host plants: Corn and other grass plants

Life cycle: Female corn needle nematodes produce roughly one egg per day over several months. In the spring after the eggs hatch, the juvenile nematode feeds on young corn roots. As the soil temperature increases, the corn needle nematode migrates deeper into the soil and may stop feeding. In Michigan, it completes approximately one generation per year. The corn needle nematode is typically found in sandy fields with long histories of corn production and poor crop rotation. Unlike cyst nematodes, the corn needle nematode will not survive long without its host plant.

Damage and symptoms: Corn needle nematodes do not enter the root but feed close to the root tip, preventing the root from developing normally. The damage includes root tip swelling, stunted plants, small and barren ears at harvest, and a reduction (10 to 75 percent) in grain yields. The corn needle nematode prefers to live in coarse-textured or sandy soils. As the soil moisture decreases and temperature increases, the corn needle nematode moves deeper into the soil. During the summer, the corn needle nematode can be found 18 to 36 inches below the soil surface.

Management options: Soil sampling should be done in spring or fall, when the corn needle nematode is close to the soil surface. Sampling in the root zone during the summer will not detect it. Crop rotation, especially with soybeans or alfalfa, will reduce corn needle nematode populations. It is also important to maintain soil quality.

Non-fumigant nematicides do not provide control of corn needle nematode.

4. ROOT-LESION NEMATODE: Meloidogyne incognita Race-II

Host plants: More than 350 recorded host plants, including corn and sugar beets

Life cycle: After mating, females lay single eggs in roots or soil. Second stage juveniles (J2) hatch from the eggs. Like all nematodes, the root-lesion nematode goes through four molts before reaching the adult stage. Adults and the last three juvenile stages can enter the roots to feed at any time. Root-lesion nematode may take from 30 to 86 days to complete its life cycle.

Damage and symptoms: Root-lesion nematodes usually feed on the smaller plant roots, killing them. The feeding sites allow other pathogens such as fungi and bacteria to enter the root system. Root-lesion nematode infestations cause plants to grow poorly and have yellow leaves that may wilt in hot weather and can reduce crop yields. Infested seedlings are often stunted.

Management options: Root-lesion nematodes can attack a wide number plant. Therefore, crop rotation will usually not sufficiently reduce their populations.

Nematicides are available but should always be used on a field-by-field basis and with a nematode management program.

5. NORTHERN ROOT-KNOT NEMATODE: Meloidogyne incognita Race-I

Host plants: More than 300 recorded plants, including dry beans, soybeans, sugarbeets and forage legumes

Life cycle: The female northern root-knot nematode produces as many as 500 eggs. She carries these eggs in a slime like mass on the outside of her body. In early spring, second stage juveniles hatch from the eggs and begin to feed on roots. Their feeding causes the roots to swell. The root-knot nematode completes its life cycle in one to two months. There are overlapping generations per year.

Damage and symptoms: Root-knot nematode feeding produces small root swellings called galls. Nematode-infested plants do not compete well for water and soil nutrients. These plants often appear to be water stressed even though there is sufficient soil moisture.

Management options: Crop rotation is the most effective way to manage the root-knot worm. Usually a one-year rotation out of the host crop is necessary to reduce nematode populations. Soil fumigants effectively control root-knot nematodes and may be necessary when populations are high.

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PROTECTION OF PLANT VARIETIES AND FARMERS' RIGHTS AUTHORITY

S. B. Gurav
Dy Registrar, PPV&FRA Branch Office Pune

Plant breeding is of vital importance for the survival, development and evaluation of humankind. Plant genetic resources are the raw material for the development of new varieties of plants. Plant breeders provide an essential link in the transfer of basic research technology into agriculture and horticulture. Plant breeding, if it is to contribute more than the making of genetically minor changes to existing varieties, and if it is to exert responsible stewardship over germplasm resources, is dependent upon long-term financial support, research, education, planning and vision. It is important to provide an increased level of funding for plant breeding so that biological resources can be utilized with increasing effectiveness to ensure continued agricultural productivity with enhanced environmental harmony. The Plant Breeders Rights (PBR) are the means to create an environment within which private investors are induced to provide funding for plant breeding including associated long term support needs for germplasm and technology resources. PBR can help to provide a return on the investment in resources by a variety of means.

Enforcement of legal protection for innovation in plant breeding by the plant breeders and farmers / farming communities in producing suitable varieties of economic plants provide incentive for research, promote trade and regulate use of plant genetic resources. The issue of plant variety protection through enforcement of plant breeders' rights was brought into major focus by the General Agreement on Tariffs and Trade (GATT) that culminated into the establishment of the World Trade Organization (WTO) in 1995. India, having ratified the Agreement on Trade Related Aspects of Intellectual Property Rights(TRIPS) of WTO, had obligations to comply with its provision for giving effect to Article 27(3) (b) relating to protection of plant varieties. The Government of India enacted the Protectionof Plant Varieties and Farmers' Rights (PPV&FR) Act in 2001 (53 of 2001) to provide for the establishment of an effective ***sui generis*** system for protection of plant varieties, the rights of farmers and plant breeders and to **encourage the development of new plant varieties** of economic importance. The PPV&FR Rules were notified on 12 September, 2003. Subsequently, for the purposes of the Act, the Government of India under the section 3 (1) of this Act, established the Protection of Plant Varieties and Farmers' Rights Authority on 11 November, 2005.

PPV&FR AUTHORITY

The Authority is a body corporate, having perpetual succession and a common seal with the power to acquire, hold and dispose of movable and immovable properties and to contract, and shall by the said name sue and be sued. The head office of the Authority is at New Delhi and it isfunctioning from a leased space in the premise of ICAR in the Societies Block, National

Agricultural Science Centre, Dev Prakash Shastri Marg, Pusa Campus, New Delhi-110012. The Authority consists of a Chairperson and fifteen members as on 31 March, 2014.

OBJECTIVES OF THE PPV&FR ACT, 2001

The objectives of the Act are as under

- Establish an effective system for protection of plant varieties, the rights of farmers and
  plant breeders and to encourage the development of new varieties of plants;
- Recognize and protect the rights of the farmers in respect of their contribution made at any time in conserving , improving and making available plant genetic resources for the
  development of new plant varieties;
- Protect plant breeders' rights to stimulate investment for research and development both
  in the public and private sector for development of new plant varieties
- Facilitate the growth of seed industry in the country that will ensure the availability of high quality seeds and planting material to the farmers.

SALIENT FEATURES OF THE ACT

The Act is based on a ***sui generis*** system and is unique in a sense that it concurrently recognizes the rights of breeders, farmers, farming communities and researchers. It confers exclusive rights upon the breeder or his successor, his agent or licensee, to produce, sell, market, distribute, import or export of the registered variety. As far as farmers' rights are concerned, the Act recognizes a farmer as cultivator, conserver and breeder and provides that the farmers' variety can also be registered. Further, the Act provides for compulsory license of a registered variety, if the seeds/propagating material is not available to the public at a reasonable price or quantity. Any person or group of persons or any organization can also claim for benefit sharing, if the plant genetic material belonging to them is used in the development of a registered variety. The researchers are conferred the right to use any registered variety for conducting experiment or research and the use of a variety by any person as an initial source of variety for the purpose of developing the other varieties. **India is a pioneer country where a national legislation has been enacted to establish and secure Farmers' Rights**. The Act also recognizes the past, present and future **contributions of the farming communities** and provides an opportunity for the **award to farming communities/farmers** for their contributions in agro-biodiversity conservation.

PLANT VARIETY REGISTRATION

The PPV&FR Authority has finalized the distinctiveness, uniformity and stability (DUS) test guidelines for registration of 150 crop species covering cereals, pulses, millets, oilseeds, spices, vegetables, flowers, fruits, medicinal and aromatic plants and fiber crops. To mobilize and attract moreapplications, the Authority regularly organizes /supports awareness and capacity building programme (s) for the benefit of different stakeholders. The PPV&FR Authority has also established network of DUS test centres across the country under the Central Sector Scheme for the implementation of PPV&FR Act to verify the claims of candidate varieties by applicants,

maintenance breeding, multiplication of reference/ example varieties/ the varieties notified under section 5 of the Seeds Act, 1966 and generation of database for varietal characteristics as per crop specific DUS guidelines. In addition, DUS tests for the candidate varieties are being
conducted at crop specific centres. The data recorded as per the DUS test guidelines is submitted by these centres to Authority for further analysis. The Authority, in consultation with the ICAR institutes and SAUs has identified potential crop species of economic importance and supports projects for the development of the DUS guidelines. The Authority has established its National Gene Bank and Field Gene Bank(s) across the country. It regularly publishes Plant Variety Journal of India and maintains the National Register of Plant Varieties at Headquarters and also at its branch offices.

PLANT BREEDERS' AND RESEARCHERS' RIGHTS

Breeders' Right is one of the pivotal provisions of PPV&FR Act with far reaching implications in the context of Indian agriculture and global scenario. The breeder also enjoys provisional protection of his/her variety against any abusive act committed by any third party duringthe period between filing of application for registration and the final decision taken by the Authority. Similarly, researchers' right is also granted. However, for repeated use of a registered variety as an initial source of variety for the purpose of developing a new variety, the authorization of the breeder of the registered variety is necessary.

FARMERS' RIGHTS

The Act provides following rights to the farmers

- Right on seed: To save their own seed from their crop and use it for sowing, re-sowing,
  exchanging, sharing with and selling to other farmers provided that farmer will not be entitled to sell branded seed of a protected variety.
- Right to register their varieties: Traditional varieties developed or conserved by farmers
  and new varieties developed by them are eligible for recognition.
- Right for reward and recognition: Farmers engaged in the conservation of genetic resource of landraces and wild relatives of economic plants and their improvement through selection and preservation of plant genetic resources.
- Authorization of farmers' variety: Consent of the farmer is required, if his variety has been used in the development of a new variety
- Right of communities: To stake a claim attributable to the contribution of the people of
  any village or local communities in the evolution of any variety
- Right for Benefit Sharing: In case of important role of Farmers' varieties for breeding new plant varieties.
- Protection of innocent infringement
- Exemption from fees

REGISTRATION OF VARIETIES

Applications for registration of a plant variety and its denomination can be made under the following categories

A. New Variety: On the date of filing of application for registration of the variety has beencommercialized for period of less than one year then it is a new variety.
B. Extent Variety:Consist of the following categories
    a) Extant variety notified under section 5 of Seeds Act, 1966: Varieties notified under Section 5 of Seeds Act, 1966 are eligible for registration under this category.
    b) Farmers' variety: Traditionally cultivated and evolved by the farmers in their fields and includes wild relative or landrace or a variety about which the farmers possess common knowledge.
    c) Variety of Common Knowledge: Varieties which are not notified under Section 5 of Seeds Act, 1966 and are in commercial chain for more than a year.
    d) Public domain variety: These are not eligible for registration as they are already in public domain.
C. Essentially Derived Variety: A variety predominantly derived from an initial variety and should fall either under new or extant variety

PERIOD OF FIELD-TESTING OF VARIETIES

The application is processed and the applicant is required to deposit DUS test fees. After receipt of necessary fees and seeds the variety is sent to DUS test centre for conducting DUS test. The period of DUS testing is as follows:

- New Varieties: Two similar crop season at two locations.
- Farmers' Variety and VCK: One crop season at two locations.
- Extant variety notified under section 5 of Seeds Act, 1966: No DUS testing is conducted
  but variety is processed by an EVRC Committee which recommends for registration.
- EDV: DUS testing is not mandatory but field test is conducted to ascertain DUS criteria.

After the receipt of DUS test result, the application is processed and if the claimedcharacter and characters qualified in DUS test are same, the variety proceeds foradvertisement. If the claimed character and character qualified in DUS test are different, the applicant is required to amend the application. The application is advertised in PlantVariety Journal of India inviting opposition within a period of three months from the date of publication. If no opposition is filed or if opposition filed is rejected, the variety proceeds for registration.

PROTECTION PERIOD AND CROPS / SPECIES ELIGIBLE FOR PROTECTION

- Field Crops: 15 years from the date of registration of the varieties.

- Trees and Vines: 18 years from the date of registration of the varieties. Extant variety notified under section 5 of Seeds Act, 1966- 15 years from date of notification of that variety by the Central Government under Section 5 of the Seeds Act 1966.

RIGHTS CONFERRED

The registration gives exclusive right to produce, sell, market, export or imports the variety and its denomination which is subject to farmers' rights that farmers can use seeds of registered variety in an unbranded manner.

REWARDS TO FARMERS / FARMING COMMUNITIES

Section 45(2) of the Act reads with Rules 70 (2) (a) of PPV&FR Rules, 2003 provides for support and reward, to farmers, communities of farmers, particularly the tribal and rural communities engaged in conservation, improvement and preservation of genetic resources of economic plants and their wild relatives, particularly in areas identified as agro-biodiversity hotspots from National Gene Fund. To operationalize these provisions, Plant Genome Savior Community Award was instituted in 2009-10. A maximum of five such awards can be conferred annually. The award consists of Rs 10.00 lakh in cash, a citation and a memento. Besides, ten farmers were conferred the Plant Genome Saviour Farmer Reward of Rs. 1.5 Lakh each, citation and memento and Plant Genome Saviour Farmer Recognition certificates consisting Rs. 1.00 lakh, citation and memento presented to 20 farmers.

NATIONAL GENE FUNDS:is established by the Authority.

Protected Structures for Ornamental Crops

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1

WHY POLYHOUSE TECHNOLOGY ?

- The fruits and vegetables are missing in the diet of poor marginal Indian because of their overall shortage.
- Majority of farmers are not ready to shift their crop land to fruits and vegetable cultivation, hence under such condition (with Govt. support) poly houses can be the only answer for this.
- We need promotion of fruits and vegetables cultivation for financial support to the farmers and total food security to all.

2

- The poly house technologies are advanced in Israel, Holland, Spain, Italy, Kenya, South Africa, Japan and China which developed as a industry. But unfortunately much neglected in India.
- In India per head land holding is much less to complete the food / flower demand of the market.

  To overcome, this is necessary to have increased per unit area production.

3

4

- India and Holland having more or less same land under flower cultivation but in world's flower export, Holland's contribution is 70% and India's contribution is just 1% or even less because of advanced technology of poly houses in Holland.
- It is one of the way to develop the farming as an Industry, and farmer as businessman.
- Polyhouse is very much beneficial for quality and quantity production as per market demand as it is a type of protected farming.

PRINCIPLE OF POLY HOUSE

- Growth and healthy production of plants under controlled favorable conditions in closed or partially closed space is called poly house.
- Poly house concept emerged to undertake adverse environmental conditions such as excess of raining, high temperature, extreme cold condition, air flow etc.

5

Goal

The primary goal of the modifications made to the greenhouse environment is to maximize the crop production, which means to obtain the maximum rate of photosynthesis. This can be achieved by manipulating light, temperature and humidity variables.

The containment for the controlled indoor environment represents a barrier to the external disturbances (e.g. sunlight, wind, etc.). An individual can choose various materials and techniques for the most efficient and energy saving design of residential and non-residential buildings to make them less dependent on the outside weather conditions.

6

Advantages

1) Protection from excess rainfall, wind current, scorching sunlight and extreme cold conditions
2) It can be erected on unproductive soil
3) Under minimum space one can have maximum production of crop plants
4) Humidity is maintained
5) Efficient use of CO_2
6) Minimum labor requirement
7) Minimum use of water and fertilizers
8) Maximum use of space
9) A single person can have control over thousands of plants

7

Advantages continue….

10) Diseases and pests can be controlled easily
11) Water can be used economically
12) Production of crop throughout the year
13) Protection from birds, animals and human activities
14) Labor cost is reduced
15) Superior Quality and bumper yield.
16) Early / Delay of harvesting.

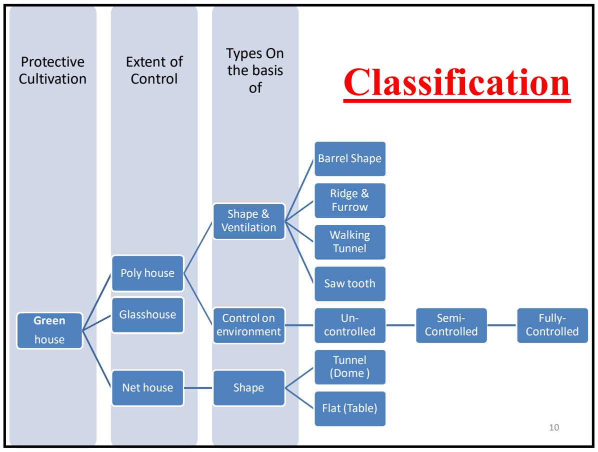
It's BUSINESS not just FARMING

8

Few another Benefits

- Reduction in labour cost
- Less fertilizer requirement, thus reduction in fertilizer cost.
- Low water requirement thus saving in water.
- Less chances of disease attack, thus reduction in disease control cost.
- Higher Efficiency of Water & Fertilizer Use.
- Cultivation in problematic topography.
- Cultivation in problematic soil conditions.
- Cultivation in problematic climate conditions.
- Requires less area to get yield and benefits.
- Easy to operate, maintain & control

9



Site Selection

11

Following things are taken into account

1. The selection Site should be free from pollution.
2. Water should be available regularly
3. Supply of electricity (Three phase) should be regular
4. Soil should be properly leveled and drained
5. Poly house should be near to road side means proper approachable road must be there to go toward poly house
6. Some space should be there nearby for further extension
7. Expertise and labors should be available when required.

SOME THINGS - IMPORTANT

- Water pH should be between 5.5 to 7 & electric conductivity of water should be 0.01 to 0.1
- pH of soil should be between 5.5 to 6.5 and electric conductivity 0.6 to 0.8
- Avoid the spraying herbicide on plantation soil to kill the weeds.
- Soil rich in organic manure (mostly red soil) should be preferred.

(This things save future cost and avoid loss)

12

Essential Documents

- 8 "A"
- 7 "A" & 12
- Quote of Plant
- Quote of Irrigation
- Quote of Polyhouse
- Blue print of Polyhouse
- Bed Layout
- Technical Back-up letter
- **Details** of Economic Projection
- Details of Crop
- Marketing scope of the Produce
- Owner's Profile
- Soil & water testing report
- Flower Buyer's Letter

13

Documentation Procedure

Application for L.O.I.

Proposal Submission to Bank

Sanctioning & Loan Disbursement

Start of Work

Links for Subsidy
NHM: www.nhm.nic.in
NHB: www.nhb.gov.in

14

FOUNDATION

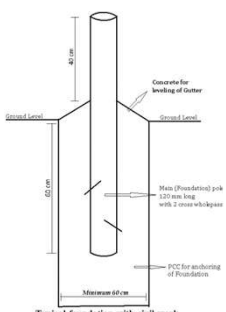
Deep Anchoring foundation

Two cross whole pass for tight holding

Gutter leveling from ground itself

120 cm long, 60 mm diameter of pipe

Straight and vertically upward direction



Typical foundation with civil work

15

16

Material Spreading

17

Material Fixing

18

Direction / Orientation of Polyhouse

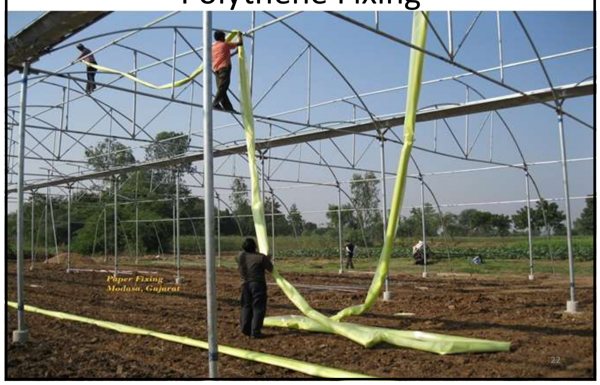
- Poly house should have light from all sides and wind current should not damage the poly house. To overcome these problems, Poly house should be preferably South-North in direction .

19

Erecting Structure

Erected Structure

Polythene Fixing

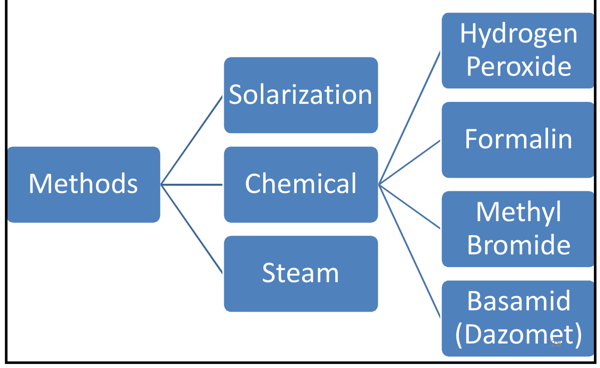


Continue….

Final Touch (Finishing)

Inside Activities

Soil Fumigation = Disinfection



Covered Soil after Application of Formalin

31

BED PREPARATION

- Choose proper media- soil, cocopeat or mixture or any other.
- Prepare bed according to the requirement of the crop (pot or tray as in case of cocopeat).
- Add FYM, Vermi compost, Organic fungicides along with basal dose (if any).

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33

PREPARED BED

34

READY FOR PLANTING

Drip Irrigation

36

- Spread laterals – Straight, proper spacing and discharge by dripper.
- Mount misters on the bed.
- Also fix the foggers below sliding net with proper spacing and should cover all area.
  Foggers must not drop the droplets of water.
- Mount micro sprinklers on the top of Polyhouse to lower the temp of polythene during hot summer.

Head Unit of Drip

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Out side Requirements

- Drip Head Unit
  - Filters
  - Ventury
- Water Storage tank
  - Proper EC & Ph
  - At least 3-4 days
  - Covered
- Civil
  - Office
  - Grading & Packaging room
- Fencing
- Labour quarter

38

Crop Care

- Daily Irrigation, Fertigation
- Daily Inspection for Identification of any Physical, chemical and / or Biological (Pest & Disease) injury to the plats.
- Daily opening & closing of rolling as needed.
- Avoid direct entry of any person or even air through door inside the poly house.
- Maintain the (optimum) required atmospheric condition in the polyhouse.
- If Possible go for "Preventive" control rather than "curative" or "erradicative"control.

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Harvesting

- ❑Harvest the produce at proper time, and it should be managed according to market demand.
- ❑Use proper method and equipment for harvesting.
- ❑Handle the produce properly.
- ❑Immediately transfer it in a bucket or either in cold storage.
- ❑Do the grading and proper packaging according to the distance of market, demand, rate, means of transport etc.
- ❑Skilled labour will serve the purpose properly.

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Scope for Crops Grown in Poly House

Floriculture: Roses, Orchids, Gerbera, Aster, Lilies, Marigold, Carnation, Chrysanthemum, Anthurium etc.

Vegetables: Cucumber (Seedless Khira), Coloured Capsicum, and Mostly exotic such as Asparagus, Broccoli, Brussels, Sprouts, Squash (zucchini), Celery, Cherry-Tomato, Chinese cabbage, Leek, Lettuce, Parsley etc.

Ornamental Nursery: And all types of shade loving plants or foliage plant which require minimum light for healthy growth

Polyhouse is also used for growing the seedling and hardening of tissue culture plants

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One Step Ahead

- Most of the time the owner prefers Mutually Controlled System or Semi Automatic Controlled System because of low investment. But in such type of Control Systems it requires a lot of attention and care. Also it is very difficult and cumbersome to maintain uniform environment inside the Green House. Ultimately this affects crop production, non uniform growth, low quality of the crop.
- Computerized Control System is the solution to come over this problem and to maximize returns. Computer provides a faster and precise operation in the Green House. Also it stores, displays and prints the Green House information as needed. Computer can do the following operations as per the pre-scheduled programme:

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Main Panel, Venturies & filter of Atomization system

and the operations are

- Starting and closing of Micro Irrigation System.
- Application of Liquid Fertilizer or Water Soluble Fertilizer (N:P:K) and other Nutrients to the plant.
- Operation of Misting System as required.
- Opening and closing of ventilators and side wall roll up curtains as needed.
- Operation of shading net / Thermal screen.
- Operation of cooling pad and fan.
- Operation of heating system.
- Operation of CO2 Generator, Climate Control, Temperature, Humidity, Heat Radiation, Control of EC, PH, PPM level in irrigation water etc. as required to the plant.

Another step to get ahead is the use of "*Cold Storage*" for stoage of the Produce.

It offers:-

- ✓ Long time storage of the produce
- ✓ One can supply the produce according to the rates in the market.
- ✓ It helps to increase export potential of the polyhouse produce
- ✓ Increase the life of produce

Cold Storage

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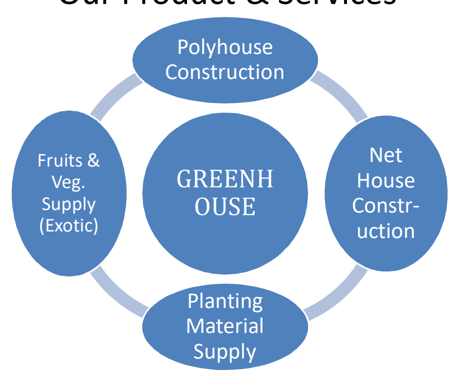
Our Product & Services



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Polyhouse

In Polyhouse We provide

- Construction of structure as per customer requirement.
- Land survey of site and line out of the structure.
- Foundation of Greenhouse.
- Fabrication & Erection of Greenhouse.
- Fixation of Poly film and Side Net.

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50

Specification and other details.

G. I. Structure with bay size 8.00 Mtr X 4.00 Mtr. Four Side Hokey at 2.00 Mtr.

Center height of Greenhouse = 6.50 Mt. & Gutter height = 4.00 Mt

Ventilation = 0.8 meter permanent open type. Close with Insect Net.

G.I. Gripper for Polythene fixing & G.I. Zigzag Wire for Polythene Locking.

200 microns UV stabilized LDPE Imported polythene Film.

Insect Net of 40 mesh OR 50% Shade Net at side ventilations.

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Continue….

Manual side Ventilation Opening & Closing Mechanism.

Two door with metal frame with cabin.

Misc. Accessories like nuts, bolts, hinges, handles etc.

Greenhouse will be erected using specially manufactured ***G.I. Steel Pipe***.

Foundation Pipe 60 mm	Colum Pipe 76mm
Ark Bottom Pipe 60 mm	Hokey Pipe 48mm
Parline & Ark Pipe 42mm	Hokey Parline 42mm
Curtain pipe 15mm.	

22 Gauge G.I. Sheet for Gutter / UV Stabilized Heavy Duty Flexible 1400 micron thickness Plastic Gutter Sheet.

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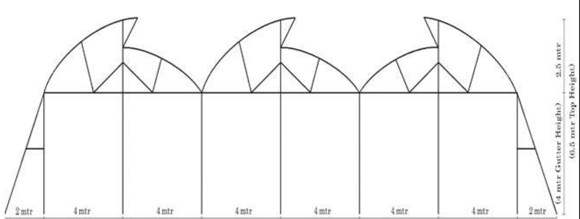

Front and last Truss line (Outside)

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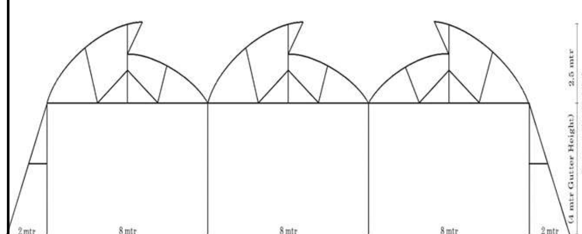
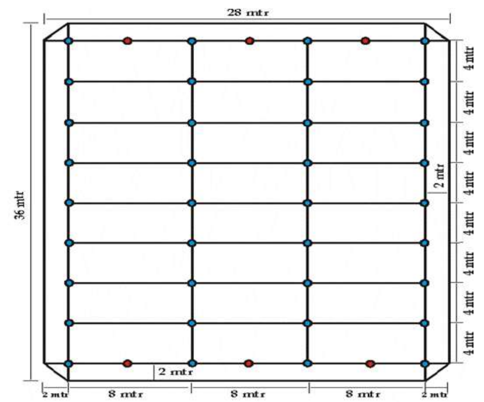


Typical Truss line (Inside)

54



Top view & Position of Foundation Placement

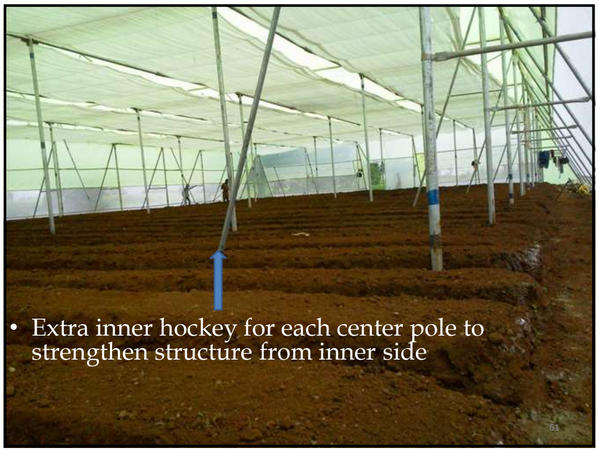
Why Malshej Agrotech

- Strict Supervision
- Timely completion
- No compromise in material selection and fixation
- Additional features – to avoid damage to structure during adverse climate

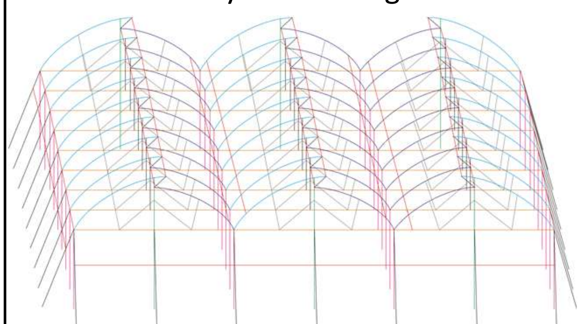
Why We ?

Additional features

❖Two (cross) metal frame door with cabin
❖Extra support hockey at each (08) corner
❖Cross rope guard to avoid bubbling of paper
❖Profile & spring locking with G.I. wire for insect net and curtain.
❖Extra inner hockey to strengthen the structure
❖Alternate Provision of UV stabilized, heavy duty, flexible plastic gutter sheet.



Saw tooth, Open ventilated, Multispan Polyhouse Design



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Net House

In Net house construction we provides

- ❑ Construction of structure as per your requirement.
- ❑ Land survey of site and line out of the structure.
- ❑ Foundation of Net house.
- ❑ Fabrication & Erection of Net house.
- ❑ Fixation of Shed Net.

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Specification and other details for Tunnel type (Dome shape)

G. I. Steel Structure with bay size 6.00 Mtr. X 4.00 Mtr.

Height of Net house = 5.00 Mtr. & gutter level height = 3.00 mtr.

G.I. Gripper & Zig Zag wire for Net Fixing.

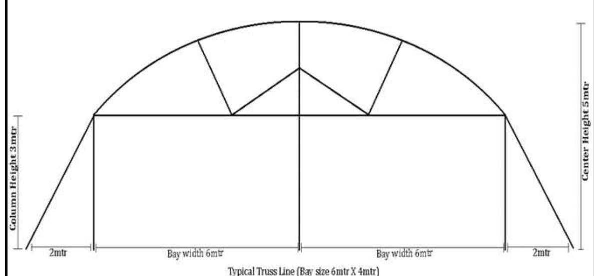
Net House Cover with 35 - 50% Shade Net, White / Green colour.

Misc. Accessories like nuts, bolts, hinges, Angles, S.D.S Screw, 1 Door etc.

Curtain cover from all 4 sides (bottom) of the structure.

Net house using specially manufactured G.I. Steel Pipe.

Foundation Pipe 48 mm,	Colum Pipe 60mm
Parline Pipe 42mm	Hokey Pipe 42mm
Side Middle Hokey 32mm	Arc Pipe 42 mm



66

Specification and other details for Table type (Flat shape)

G. I. Steel Structure with bay size 6.00 Mtr. X 6.00 Mtr.

Height of Net house = 3.00 mtr.

G.I. Gripper & Zig Zag wire for Net Fixing.

Net House Cover with 35 - 50% Shade Net, White / Green colour.

Misc. Accessories like nuts, bolts, hinges, Angles, S.D.S Screw, 1 Door etc.

Net house using specially manufactured G.I. Steel Pipe.
Foundation Pipe 48 mm, Colum Pipe 60mm
Parline Pipe 42mm Hokey Pipe 42mm
Side Middle Hokey 32mm

Scope for Crops grown in Net house

All types of Fruit Vegetables
- Tomato
- Khira / Kakadi
- Green capsicum
- Chilli
- Colour Capsicum
- Etc.

All leafy vegetable
- Palak (Spinach)
- Methi
- Corriender
- Shepu
- Arvi leaf
- Etc.

Khira (Cucumber) in Net House

Fruit and Vegetable Supply

- We Supply the Fruits and Vegetables, mainly "Exotic vegetables" to different Hotels and Malls.
- It gives strength to the marketing channel to sale the produce of the farmer for the best price.
- And also keep the regular demand for the produce of the polyhouse.

We fill proud to introduce the "Malshej Agrotech" as vendor of the "Bharti Walmart's-Best Price Modern Holesale Store".

Planting material Supply

We provide

- ✓ Seedling & seeds for Poly house plantation
- ✓ Planting material – cocopeat, vermicompost, seedling trays, etc.
- ✓ Other related material like – mulching film, Shade net, and Greenhouse accessories.

Our Assistance for Farmers

- Site selection
- Bankable project report preparation
- Introducing & developing marketing channel
- Guidance and consultancy to obtain best quality and bumper yield from the poly house
- Drip layout, design and material selection.

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Our Services to the Farmers

- Poly house / Net house Layouts
- Green house / Net house construction
- Fumigation (dis-infection) of the soil
- Bed Preperation
- Planting of the seedlings or plantation material.
- Erection of support system as in case of Carnation

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We satisfactory erected poly houses and net houses in the following sates

Gujarat

Our esteemed customers

- Mr. Ranjeet Singh Parmar – Modasa
- Mr. Ajij Bhai – Himatnagar
- Mr. Amit Bhai Patel – Siddhapur
- Mr. Shantu Bhai Patel – Mahua

and counting…..

Haryana

Our esteemed customers

- Mr. P. R. Sharma – Bhiwani
- Mr. Shilakaram Yadav – Rohatak
- Omsingh Puniya – Dharawanbas (3)
- Mr. Nitin Yadav – Gurgaon

and counting…..

In Maharashtra

Here are some of the delighted customers in Maharashtra

- Mr. Vishal Bhosale, Uruli Knachan, Pune
- Mr. Karbhari Kurhe, Newasa, A. nagar
- Mr. Dyaneshwar Maid, Sangamenr, A.nagar
- Mr. Navnath Lamkhade, Alepahata, Junnar
- Mr. Nivrutti Mansukh, Alephata, Junnar.

And 6 other from the same palce

Again counting as you supporting us…..

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Rose

Introduction-

A **rose** is a perennial flower shrub or vine of the genus ***Rosa***, within the family Rosaceae

- **Roses are the single most popular fresh cut flower with consumers.**
- **It is one of the oldest flowers in cultivations, i.e. over 5,000 years. Over 10,000 cultivars have existed over the centuries.**
- **Globally maximum volume of cut flowers are purchased during four key holiday months Feb/April/May/Dec.**
- **Production costs vary from nursery to nursery, season and due to other growing systems.**

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- **Selection of cultivar:**
- Sustainable to tropical climate: The varieties selected should be suitable for growing in tropical condition and it should have mainly excellent quality production.
- Production and stem length: The varieties selected should be resistant to disease and pest. A grower should select high yielding variety in combination with high market demand and mainly varieties which have longer stem length.

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Factors affecting Quality bloom production Rose

Quality Cut Roses

- Ideal genotype
- Recommended cultural operations
- Ideal Environment Maintenance
  - Temperature
  - Light
  - Relative humidity
  - Biotic stresses
  - Nutrient management

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- **Colour percentage:**

In general roses of different colours such as red, yellow, pink, orange, white, bicolour etc are grown & sold in market. The red coloured flowers are highly preferable in markets. It is recommended to have the following mix of colors.

Colour	Percentage
• Red	40 %
• Yellow	20 %
• Pink	20 %
• Orange	10 %
• White	10 %

84

Soil & Climate

A well drained soil ranging from sand to gravelly loam with a pH of 6.5 to 7.0

- Adding organic amendments such as composts, animal manures or peat is highly recommended
- Soil Fumigation
- The optimum night temperature for roses is about 14 to 18°C depending on the individual Cultivar
- The optimum temp.- 23'C
- Below 12'C & above 36'C – harm the production
- Optimum Humidity = 60-75 %

Plantation

- Remove pebbles from the bed before plantation.
- Adequate moisture must be available in the soil at the time of plantation.
- The seedlings should be dipped in Bavistin (0.2%) solution and then planted on bed.
- Plantation to be done by making holes or trenches on bed in a zigzag way.
- Planting should be avoided during the hottest period of the day/year and it should be done either in the morning or late in the evening.
- Planting Density = 7.5 plants per sq. mtr.

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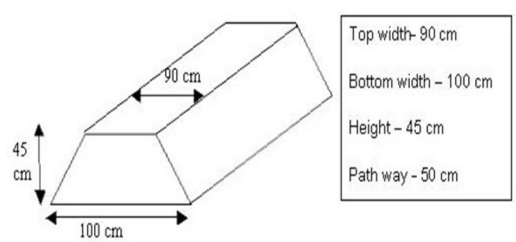
Dimensions of Bed



90

- **Care after plantation**:
- After planting, the soil around the plants must be kept humid and should not be over irrigated. Irrigate the plant with hose pipe immediately after plantation. During periods with strong sunshine or high temperature, the young plants must frequently be given an over head spray with water to assist establishment & reduce post planting losses. For first three weeks the irrigation should be done only by using hose sprayer & later on irrigation should be done by drip system. Mortality replacement should be done within the week after plantation.

91

Fungicide Drenching Schedule

S.No.	Fungicide	Dose	Time of drenching
1	Bavistin	1 g/litre	Immediately after plantation
2	M – 45	1 g/litre	3 days after plantation
3	Bavistin	1.5 g/litre	7 days after plantation
4	M – 45	1.5 g/litre	10 days after plantation
5	Bavistin	2 g/litre	14 days after plantation
6	M – 45	2 g/litre	17 days after plantation

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Planting method:

- Rose plant used for plantation should be two-three month old.& have minimum two dark green colour leaves. Bud union of rose plant should not be covered with soil, It should be 2 – 3 cm above the ground level. The sprout coming out of the union should face towards the path at the time of plantation.
- Rose plants are planted in a zigzag method on the bed.
- Planting distance: Plant to plant distance 17 cm and Row to Row distance 45 cm.
- Plant Density is 7.5 plants / sq. mtr.

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Special cultural practices :

For proper growth of rose plant and high production special cultural practices are to be carried out as follows:-

- Initial plant development/ mother shoot bending: If the young plant is allowed to flower immediately after planting there is serious risk that the important structural frame work of the plant will be impaired. The various types of plants require different treatment. First flower is pinched after one month from the date of plantation so that 2 to 3 eyes bud will sprout on main branch to grow as branches and these branches in turn will form buds. When the plant attains this stage of growth, the mother shoot is to be bent towards the direction of path. This cultural operation in rose plants is done to initiate bottom break ground shoot. The maximum leaf area is required to build up a strong root system. The mother shoot is bent nearer to the bud joint.

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1) Plant structure development: To develop more growing points and plant structure development plays an important role. After planting ground shoot will start growing from crown of plant. The weak ground shoots should be bent at ground level, for forming a basic and strong frame work of plant structure for production throughout their life cycle. The strong ground shoots should be cut at 5th five pair of leaves after four and half months from the date of plantation. The medium ground shoots should be cut at 2nd or 3rd five of leaves.
2) Bending in roses: Bending helps in maintaining enough leaf area on the plants. The maximum leaf area is required to build up a strong root system. Leaves are important for producing carbohydrates

95

Bending

Bending is done on 1st or 2nd five pair of leaves.

Care should be taken that the stem will not break and the leaves will not touch the soil on the bed.

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Disbudding

- side buds have to be removed. The removal of these buds is known as disbudding.
- It should not be done too early or too late.
- Pea size and shows slight colour then it is right time to do disbudding.

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Pinching

- Removal of unwanted vegetative growth from the axil of leaf below the terminal bud is called pinching.
- right stage and right time of pinching leads to apical dominance
- helps to get good quality flowers and buds and avoids wastage of energy

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Wild shoot (root stock) Removal

- unwanted growth that take place at the union on the root stock
- will deplete nutrients and checks growth and development of plant.
- They should not be cut but removed from its union by pressing it with thumb in order to check its further sprouting.

99

Continue…..

- Support of the plants
- Pruning or under cutting- Rose plant pruning or under cutting is necessary to decrease height of the plant
- Maintenance of beds
- Weeding and loosening of the soil
- Removal of Dieback - As the crop gets older (aged) dieback appear in the crop due to use of infected secateurs or wrong pruning practice or hard pruning.

Application of Bud Caps

- Bud caps are generally placed on the bud when they are of pea size.
- This helps to increase the bud size and shape to meet customer demand.

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Harvesting

Sr. No.	Particulars	Place of Cutting	Month from date of plantation
1	Ground shoot cutting	At 5th five pair of leaves from bottom of plant	3 to 3.5
2	First harvesting	2nd or 3rd five pair of leaves from first cut	4.5 to 5
3	Second/ Regular harvesting	2nd or 3rd five pair of leaves from first cut	6th month onwards daily harvesting

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Harvesting

- Use secateurs for Sharp cutting
- For export – Cut stage 0 & 1
- For Domestic market – Cut stage 2 & 3
- High Temp. – 2 time harvesting in a day
- Low Temp. – 1 time harvesting in a day
- Transfer the cut flowers immediately into bucket containing clean water.

103

The stems not to be harvested –

- Disease and pest affected stems.
- Damaged stems.
- Stems below 35 cm stem lengths.
- Too weak and too thick stems.
- Bended stems.
- Bent neck and bull head buds.
- The stems not harvested because of above reasons should be bent to increase leaf area on a plant.

105

Care of Crop (Rose)

Pests
- Aphids
- White fly
- Leaf minor
- Red Mites
- Thrips
- Caterpiller

Disease
- Crown Rot
- Root rot
- Fusarium
- Alternaria leaf spot
- Powedery , Downy mildew
- Bacterial Blight

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No. of pesticides & fungicides are available in the market for control – but care should be taken for better result is as follows

- PH of Solution = 6 to 6.5
- Immediate use of solution after preparation
- Smaller droplets = max. area coverage
- Add adjuvant like (Apsa 80) 5ml/15 lit.

110

Deficiency Symptoms

Nitrogen
- yellowing of the foliage that slowly and gradually covers the whole plant, passing from the oldest to the youngest leaves.
- Shorter internodes, reduced stem diameter and lighter colouring

Potassium
- necrosis at the borders of the oldest leaves.
- Shorter stems, bud necrosis and small discoloured flowers are ulterior consequences.

Calcium Deficiency

- Calcium deficiency in full-grown five-leaflet leaves in various stages.
- Symptoms of a Calcium-Boron imbalance

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Iron

- Iron deficiency in advanced stage.
- interveinal chlorosis (yellowing) on the youngest leaves.
- In Severe case - necrosis of the leaf apexes and interveinal zones occurs.

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Zinc

- Zinc defidiency in a mature in a shoot (left), compared to a healthy.
- plant shows slow growth, short internodes, deviant colour, bushy appearance and deviant leaf shape.

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Economics on
GREENHOUSE CULTIVATION OF ROSE

Sr. No.	Particulars	Detail
1	Greenhouse area	4000 Sq Mtr.
2	Project cost	Rs 42,52,000
3.	Bank loan (25.00%)	Rs 31,89,000
4.	Borrower's Contribution @ 25%	Rs 10,63,000
5.	Subsidy @ 50% OR 25 %	Vary As Per State
6.	Project capacity	8,40,000 Flowers /Year
7.	D.S.C.R. – Average	1.23
8.	B:C Ratio	1.85

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Sr. No.	Particulars	Detail
1	Crop	Rose
2	Area	4000 Sqm.
3.	Plants Required	30000 No.
4.	Capacity	840000 Flowers /year
5.	Growing Media	Red Soil
6.	Type Of Structure	Aerodynamic in shape with permanent open vents with curtain on sides

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ECONOMIC VIABILITY (ESTIMATED)

Particulars	Considerations
Erection Period Year	Two months of first Year
Polyfilm Life	Three Years (UV Stabilization)
Rose Plant Life	5 Year
Rose Plant Density	7.5 Plants / m^2
Plant Population	30000 Nos.
Production / Plant / Year	28 Flowers / Plant / Year
Total Production / Year	840000 Flowers
Rate / Flower	Rs 3 / Flower

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Proposed Project Cost (Component Wise) For 5000 m^2 Land & 4000 m^2 Polyhouse

Sr. No	Component / Item	Proposed Cost (Amount In Rs)
1	Land Development	
	(a) Land Leveling (Situational Factor) Approximate @ Rs 5 / m^2	25000.00
	(b) Fencing @ Rs 250 / Running mtr. (Approximate 290 Running mtr.)	72500.00
2	G.I Polyhouse Structure With Installation @ Rs 600 / m^2	2400000.00
3	Soil (Situational Factor) Approximate @ Rs 25 / m^2	100000.00
4	FYM & Compost @ Rs 25 / m^2	100000.00
5	Fumigation & Bed Preparation @ Rs 20 / m^2	80000.00
6	Drip Irrigation & Fogging System with installation @ Rs 80 / m^2	320000.00
7	Planting Material @ Rs 7 / Plant (30000 Plants)	210000.00
9	Plant Protection Measures (Fertilizers, Pestisides & Fungisides) @ Rs 50 / m^2	200000.00
10	Equpments (HTP & Other Miscellaneous) Approximate	50000.00
11	Labour 02 pairs @ Rs 7000 / Pair / Month	168000.00
12	Packaging & Transportation (Situational Factor) @ Rs 0.15 / Flower	117000.00

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Continue….

13	Water Storage Tank 10x10x10 Feet (1000 Ft^3) for 27000 Lit Water	50000.00
14	Labour Quarter 10x10 Feet (02 Rooms) @ 450 / Sq.Ft.(200 Sq.Ft.)	90000.00
15	Packaging & Grading Room Cum Office 10x15 Feet (150 Sq Ft.)	67500.00
16	Project Supervisor & Consultancy Charges	160000.00
17	Land Lease (Approximate) @ Rs 30000 For 5000 Sq..m	30000.00
18	Electricity (Approximate) @ Rs 1000 / Month	12000.00
19	Automation System (Optional)	
20	Cold Storage (Optional)	
	Total	**4252000.00**

Total Project Cost (Approximate) = Rs 42.52 Lakh

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PROJECTED MEANS OF FINANCE

Sr. No	Particulars	Amount (Rs in lakh)
1	Capital Project Cost	4252000.00
2	Bank Term Loan	3189000.00
3	Promoters Share	1063000.00
4	Subsidy	

Note : NHM Or NHB subsidy to be availed (Bridge loan contribution made by bank which is included in bank term loan).It varies as per state norms.

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CAPITAL MARGIN

Sr. No	Particulars	Amount (Rs in lakh)
1	Labour, Superviser & Consultancy Charges	3.28
2	Plant Protection Measures	2.0
3	Packing /Grading & Transportation	1.17
4	Land lease & Electricity	0.42
.	.Total	6.87

Total Working Capital Requirement per year
6.87
Total Working Capital Margin
3.435

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PROFITABILITY STATEMENT Considerations

Morit Period	Repay Period	Repyment (in Rs)	Interest	Depreciation
6 months	5 years	6.378	12.50 %	10 %

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DEPRECIATION (Rs in Lakh)

Particulars	I	II	III	IV	V
Fixed assets	30.50	27.45	24.71	22.24	20.02
Deprecition	3.05	2.74	2.47	2.22	2.00

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LOAN & INTEREST STATEMENT (Rs in Lakh)

Term Loan	I	II	III	IV	V
Opening Balance	31.89	28.4	21.3	14.2	7.1
Interest @ 12.5 %	3.98	3.55	2.66	1.77	0.88
Repayment of Term Loan	3.49	7.1	7.1	7.1	7.1
Loan Installment	7.47	10.65	9.76	8.87	7.9

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REPLACEMENT EXPENSES

Particulars	II	III	IV	V
Plastic & fixing (Rs in lakh)			3.0	
Total (Rs in lakh)			3.0	

Total replacement expenses for five years (II to VI) = 3.0 lakh

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Average Production cost of Rose

$$\text{Avg. Prod. Cost} = \frac{\text{Total w. c. of 5 yrs.+Depri. Of 5 yrs.+Total Repalcement Exp.+Total Intrest on loan}}{\text{Total Flowers Production of 5 yrs. In lakh}}$$

$$\text{Avg. Prod. Cost} = \frac{62.67}{38.48} = 1.62 \text{ Rs. Per Flower}$$

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PRODUCTION & SALES STATEMENT

Particulars	I	II	III	IV	V
Capacity Utilization (%)	75	100	100	100	100
Flower Production (Lakh)	6.30	8.40	8.40	8.40	8.40
Sale Of Flowers (Rs in lakh)	18.9	25.2	25.2	25.2	25.2
Production Cost (in lakh)	10.20	13.60	13.60	13.60	13.60
Gross Profit (lakh)	8.7	11.60	11.60	11.60	11.60

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WORKING ON D.S.C.R. (Rs in Lakh)

Particulars	I	II	III	IV	V
Profit before interest & depreciation	8.7	11.60	11.60	11.60	11.60
Interest on Term Loan	3.98	3.55	2.66	1.77	0.88
Repayment of Term Loan	3.49	7.1	7.1	7.1	7.1
Total Loan Servicing	7.47	10.65	9.76	8.87	7.9
D.S.C.R	1.16	1.08	1.18	1.30	1.46

Average D.S.C.R. for six years repayment is 1.23

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B:C RATIO

B:C Ratio = Average annual benefits / Average annual costs

= 23.94 / 12.92

= 1.85

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Highlights of the project

- ❑ Technically feasible
- ❑ Economically viable
- ❑ Less labour intensive
- ❑ Less power intensive
- ❑ Better scope of expansion
- ❑ Higher agricultural income
- ❑ Don't require promotional marketing
- ❑ Easy to implement
- ❑ Eco-friendly
- ❑ Multifold agricultural yield

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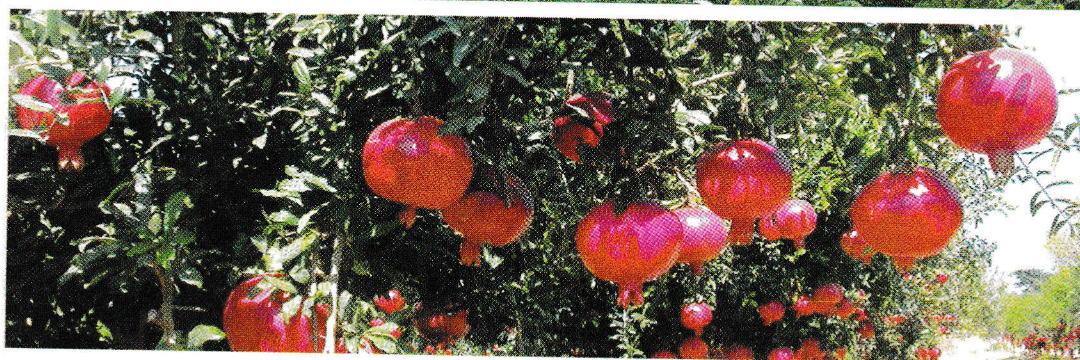
SCHEMES OF NATIONAL HORTICULTURE BOARD At a Glance



व्यावसायिक
बागवानी
के बढ़ते कदम

राष्ट्रीय बागवानी बोर्ड
National Horticulture Board

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National Horticulture Board

An Introduction

National Horticulture Board (NHB) was set up by the Government of India in 1984 as an autonomous society under the Societies Registration Act 1860. Board has its Head Quarters in Institutional Area, Sector 18, Gurgaon (Haryana).

Broad Objectives

- Development of hi-tech commercial horticulture in identified belts and make such areas vibrant with horticultural activity.
- Development of modern post-harvest management infrastructure as an integral part of area expansion projects or as common facility for cluster of projects.
- Development of integrated, energy efficient cold chain infrastructure for fresh horticulture produce.
- Popularization of identified new technologies / tools / techniques for commercialization / adoption, after carrying out technology and need assessment.
- Assistance in securing availability of quality planting material by promoting setting up of scion and root stock banks / mother plant nurseries and carrying out accreditation / rating of horticulture nurseries and need based imports of planting material.
- Promotion and market development of fresh horticulture produce.
- Promotion of Farm Mechanization in Horticulture through demonstration.
- Promotion of applied R & D for standardizing PHM protocols, prescribing critical storage conditions for fresh horticulture produce, bench marking of technical standards for cold chain infrastructure etc..
- Transfer of technology to producers/farmers and service providers.
- Promotion of consumption of horticulture produce and products.
- Promoting long distance transport solution for bulk movement of horticulture produce through rail etc..
- Carrying out studies and surveys to identify constraints and develop short and long term strategies for systematic development of horticulture.

Schemes/Programmes

Since its inception, NHB has taken up various programmes / schemes. The present schemes is set of intervention to achieve high quality commercial production, create Post Harvest infrastructure and cold chain facilities, and promote Transfer of Technology for Production and post harvest management.

1. **Development of Commercial Horticulture through Production and Post-Harvest Management:**

Credit linked projects relating to establishment of commercial production units in open field as well as under protected conditions and projects on Post harvest Management and primary processing of products are eligible for assistance under this scheme as per cost norms. However, release of Subsidy need not be credit linked in North Eastern States and for the institutions like Public Sector Units, Panchayats, cooperatives, registered societies/trust and public limited companies provided they can meet remaining share of the project cost out of their own resources. Such projects will have to be appraised by appraising agency approved by NHB.

Description of components and Pattern of Assistance

1.1 Commercial Horticulture Development in open field conditions on project mode:

National Horticulture Board will take up integrated commercial horticulture development projects in open field conditions on project mode , including components viz planting material, plantation, irrigation, fertigation, mechanization, precision farming, GAP etc. for projects covering area over 2.00 ha. (5 Acres) Integration of production unit with on farm PHM components and primary processing unit shall also be allowed in project mode. Cost of raising new plantation will vary from crop to crop, which will be taken into consideration while providing assistance to the beneficiary. Integrated production unit on Mushroom and tissue culture shall also be eligible for assistance under this component. The components like farm machinery and PHM infrastructure, irrigation and micro irrigation etc. shall be eligible under the scheme for assistance in existing/new orchards/projects to increase productivity.

Pattern of assistance

Credit linked back-ended subsidy @ 40% of the total project cost limited to Rs 30.00 lakh per project in general areas and @ 50% of project cost limited to Rs. 37.50 lakh in NE Region, Hilly and Scheduled areas.

1.2 Commercial Horticulture Development in protected cover on project mode-

The Board will also take up commercial horticulture development projects under protected cover on project mode including components viz planting material, plantation, irrigation, fertigation, mechanization, etc for projects having area over 2500 sq meter. Activities like construction of green houses, shade net house, plastic mulching, and plastic tunnel, anti bird /hail nets etc would be promoted. Provision has been made for selecting a variety of construction material for green houses and shade nets houses. Preference will be given to using locally available material to minimize cost of construction of such structures. However, for availing subsidy, all material /technology should conform to prescribed standards.

Pattern of assistance

Credit linked back-ended subsidy @ 50% of the total project cost limited to Rs 56.00 lakh per project as per admissible cost norms for green houses, shade net house, plastic tunnel, anti bird /hail nets & cost of planting material etc.

1.3 Integrated Post Harvest Management projects:

The Board will take up Integrated Post Harvest Management projects relating to Pack House, Ripening Chamber, Refer Van, Retail Outlets, Pre- cooling unit, Primary processing etc. NHB will also take up projects in component mode and for standalone projects of PHM components.

Pattern of assistance

Credit linked back-ended subsidy @ 35% of the total project cost limited to Rs 50.75 lakh per project in general area and @ 50 % of project cost limited to Rs. 72.50 lakh per project in NE , Hilly and Scheduled areas.

2. Capital Investment Subsidy Scheme for Construction / Expansion / Modernization of Cold Storage and Storages for Horticulture Products:

Component

Credit linked projects relating to Cold Storages including Controlled Atmosphere (CA) and their modernization are eligible for assistance under this component. Subsidy need not be credit linked for the institutions like Public Sector Units, Panchayats, cooperatives, registered societies/trust and public limited companies provided they can meet remaining share of the project cost out of their own resources. Such projects will have to be appraised by appraising agency approved by NHB.

Pattern of Assistance

The assistance will be given as subsidy @ 35% of the capital cost of project in general areas and 50% in case of NE, Hilly & Scheduled Areas for a storage capacity above 5000 MT up to 10000 MT.

3. Technology Development and Transfer for Promotion of Horticulture

Objectives

Projects for popularization of identified new technologies/tools/techniques for commercialization/adoption etc. with following sub-components:

Components	Pattern of Assistance
Setting up of block/mother plant and root stock nursery (Area above 4 ha)	Project based – 100% and only through Govt. agency/Public Sector @ Rs.100.00 Lakh/ha for effective nursery area including virus indexing, tissue culture lab etc.
Acquisition of technologies including import of planting material from other countries for evaluation and mass multiplication in order to increase production & productivity of horticulture crops	Rs.50.00 lakh/project. Project based – 100% and only through Govt. agency/ PSUs.
Import/procurement of Machines and Tools for horticulture for demonstration purpose	Rs. 50.00 lakh/ machine. 100% of total cost and only through Govt. agency/ Public Sector. Proposals of Growers Associations promoted by NHB and Co-operative Societies and Farmers Producers Organization may also be considered on merit as per direction of Board of Directors
Development & Transfer of Technology	Up to Rs.25.00 lakh/ project as 100% of total cost and only through Govt. agency /PSU
Long Distance Transport Solution	Project based Rs 2000.00 lakh
Product Promotion and Market Development Services- Horti-fairs	Rs. 25.00 lakh 100% of cost by Central Nodal Agency
Exposure visit of farmers (Outside State)	Project based as per actual 100% of the cost
Visit Abroad for Government Officers	Rs. 6.00 lakh per participant 100% of air / rail travel and course fee
Organization/participation in seminars/ workshops/exhibitions etc. for development of horticulture	(i) The financial assistance would be limited up to Rs.10.00 lakh for International event(3-5 days), Rs.5.00 Lakh for National event, Rs.3.00 lakh for State Level event and Rs.0.50 lakh for District Level event.
	(ii) In case of short duration (1-2 days) seminars, financial assistance would be limited to:

	- Rs.1.00 lakh per event for State Level event, - Rs. 2.00 lakh for National level event and - Rs 3.00 lakh for International event (for organizations/participation of international event within India).
Accreditation and Rating of Fruit Plant Nurseries	Accreditation system will be based on rating in a scale of single to five stars with appropriate weightage on production system, nursery management practices and quality of planting material produced. Board has also decided to consider Vegetable Nurseries for accreditation and rating which are producing seedlings for commercial production of vegetable crops either in open field or controlled condition like poly/ net house w.e.f. 01.12.2014

4. Market Information Service for Horticulture Crops

Objectives

- To generate information on wholesale prices, arrivals and trends in various markets of the country for important fruits, vegetables & flowers etc. and also on retail prices for increased number of selected markets,
- To analyze the trends of arrivals, prices and other related factors of the selected fruit and vegetables such as stock in storage, crop stand etc. and generate Market Intelligence Reports,
- To establish a nation-wide communication network for speedy collection and dissemination of market information data for its efficient and timely utilization,
- To prepare farmers' advisory and issue the same for the benefit of producer farmers especially by making use of statistics so generated and collected for optimizing returns to the producers,
- To collect and compile horticulture database and strengthen existing system of 'Crop Estimation Survey-Fruits & Vegetables' (CES-F&V) as far as possible,
- Information dissemination through publicity, advertisements, films, printed literature etc.,
- Development of technology packages in electronic form to be shared through IT.

5. Horticulture Promotion Services/Expert Services and Strengthening Capability of NHB

Under this component, specialized studies and surveys shall be carried and study / survey reports shall be brought out for use by targeted beneficiaries. In addition, technical laboratories shall be set up or cause to be set up and also provide technical services including advisory and consultancy services.

This shall be done by NHB with or without services of outsourced experts and under this scheme, 100% financial assistance is provided through Nodal Organizations.

Note: For further details, please refer operational guidelines published in February 2015, which is also available on NHB Website- www.nhb.gov.in

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