

Floriculture

Student Handbook

Class XI

Central Board of Secondary Education
Shiksha Kendra, 2, Community Centre, Preet Vihar, Delhi - 110301




BUILDING SKILLS • BUILDING FUTURE

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भारत का संविधान

उद्देशिका

हम, भारत के लोग, भारत को एक सम्पूर्ण [1][प्रभुत्व-संपन्न समाजवादी पंथनिरपेक्ष लोकतंत्रात्मक गणराज्य] बनाने के लिए, तथा उसके समस्त नागरिकों को:

सामाजिक, आर्थिक और राजनैतिक न्याय,
विचार, अभिव्यक्ति, विश्वास, धर्म
और उपासना की स्वतंत्रता,
प्रतिष्ठा और अवसर की समता
प्राप्त कराने के लिए
तथा उन सब में व्यक्ति की गरिमा
और [2][राष्ट्र की एकता और अखंडता]
सुनिश्चित करने वाली बंधुता बढ़ाने के लिए

दृढ़संकल्प होकर अपनी इस संविधान सभा में आज तारीख 26 नवम्बर, 1949 ई॰ को एतद्द्वारा इस संविधान को अंगीकृत, अधिनियमित और आत्मार्पित करते हैं।

1. संविधान (बयालीसवां संशोधन) अधिनियम, 1976 की धारा 2 द्वारा (3.1.1977) से "प्रभुत्व-संपन्न लोकतंत्रात्मक गणराज्य" के स्थान पर प्रतिस्थापित।
2. संविधान (बयालीसवां संशोधन) अधिनियम, 1976 की धारा 2 द्वारा (3.1.1977) से "राष्ट्र की एकता" के स्थान पर प्रतिस्थापित।

भाग 4 क

मूल कर्त्तव्य

51 क. मूल कर्त्तव्य – भारत के प्रत्येक नागरिक का यह कर्त्तव्य होगा कि वह –

(क) संविधान का पालन करे और उसके आदर्शों, संस्थाओं, राष्ट्रध्वज और राष्ट्रगान का आदर करे;

(ख) स्वतंत्रता के लिए हमारे राष्ट्रीय आंदोलन को प्रेरित करने वाले उच्च आदर्शों को हृदय में संजोए रखे और उनका पालन करे;

(ग) भारत की प्रभुता, एकता और अखंडता की रक्षा करे और उसे अक्षुण्ण रखे;

(घ) देश की रक्षा करे और आह्वान किए जाने पर राष्ट्र की सेवा करे;

(ङ) भारत के सभी लोगों में समरसता और समान भ्रातृत्व की भावना का निर्माण करे जो धर्म, भाषा और प्रदेश या वर्ग पर आधारित सभी भेदभाव से परे हों, ऐसी प्रथाओं का त्याग करे जो स्त्रियों के सम्मान के विरुद्ध हैं;

(च) हमारी सामासिक संस्कृति की गौरवशाली परंपरा का महत्त्व समझे और उसका परिरक्षण करे;

(छ) प्राकृतिक पर्यावरण की जिसके अंतर्गत वन, झील, नदी, और वन्य जीव हैं, रक्षा करे और उसका संवर्धन करे तथा प्राणिमात्र के प्रति दयाभाव रखे;

(ज) वैज्ञानिक दृष्टिकोण, मानववाद और ज्ञानार्जन तथा सुधार की भावना का विकास करे;

(झ) सार्वजनिक संपत्ति को सुरक्षित रखे और हिंसा से दूर रहे;

(ञ) व्यक्तिगत और सामूहिक गतिविधियों के सभी क्षेत्रों में उत्कर्ष की ओर बढ़ने का सतत प्रयास करे जिससे राष्ट्र निरंतर बढ़ते हुए प्रयत्न और उपलब्धि की नई उंचाइयों को छू ले;

[1](ट) यदि माता-पिता या संरक्षक है, छह वर्ष से चौदह वर्ष तक की आयु वाले अपने, यथास्थिति, बालक या प्रतिपाल्य के लिये शिक्षा के अवसर प्रदान करे।

1. संविधान (छयासीवां संशोधन) अधिनियम, 2002 की धारा 4 द्वारा (12.12.2002) से अंत: स्थापित।

THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a [1]**[SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC]** and to secure to all its citizens :

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the[2] [unity and integrity of the Nation];

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949, do **HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.**

1. Subs, by the Constitution (Forty-Second Amendment) Act. 1976, sec. 2, for "Sovereign Democratic Republic" (w.e.f. 3.1.1977)
2. Subs, by the Constitution (Forty-Second Amendment) Act. 1976, sec. 2, for "unity of the Nation" (w.e.f. 3.1.1977)

THE CONSTITUTION OF INDIA

Chapter IV A

FUNDAMENTAL DUTIES

ARTICLE 51A

Fundamental Duties - It shall be the duty of every citizen of India-

(a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;

(b) to cherish and follow the noble ideals which inspired our national struggle for freedom;

(c) to uphold and protect the sovereignty, unity and integrity of India;

(d) to defend the country and render national service when called upon to do so;

(e) to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;

(f) to value and preserve the rich heritage of our composite culture;

(g) to protect and improve the natural environment including forests, lakes, rivers, wild life and to have compassion for living creatures;

(h) to develop the scientific temper, humanism and the spirit of inquiry and reform;

(i) to safeguard public property and to abjure violence;

(j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement;

[1](k) who is a parent or guardian to provide opportunities for education to his/her child or, as the case may be, ward between age of six and forteen years.

1. Ins. by the constitution (Eighty - Sixth Amendment) Act, 2002 S.4 (w.e.f. 12.12.2002)

Preface

Floriculture or flower farming is an integral part of Horticulture which involves growing of cut flowers, potted flowering and foliage plants, and bedding plants in greenhouses and/or in fields. There are several thousand different species of flowers and plants that are grown as commercial crops. About two decades back or so, the floriculture was just a pastime for a few and hobby of flower lovers, but now it has opened a new vista in agri-business i.e., commercial floriculture. Thus, taking into consideration the different points i.e. bio-aesthetic planning, floral garden, indoor decoration, social functions and religious functions the demand for floricultural plants is increasing day by day and to meet out the same, there is a good scope for growing and raising of Ornamental or Floricultural plants.

It is high time that school children should have knowledge about importance and production of flower crops. Therefore, the vocational/professional course on 'Floriculture' for class XI has been introduced to equip the students with knowledge and skills in the area of floriculture. This will provide information on various aspects of floriculture viz., importance and scope of floriculture and landscaping, history of gardening in India and styles and types of gardens, principles and elements of landscape gardening, annual and perennial ornamental crops, principles and methods of propagation and production of ornamental crops, commercial seed production in flower crops etc.

The course would be very helpful for getting an exposure on flowers, which will further motivate and encourage students to come up as entrepreneurs in the area of floriculture and landscaping. This course is an effort to sensitize students in the field of floriculture. Student will get an opportunity to choose a career in floriculture and they may further pursue professional degree in this area. This course has been designed to provide entry level job skills to students and will help to meet the human resource requirement for floriculture and landscaping.

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Chairman, CBSE

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Contents

Chapter 1

Importance and Scope of Floriculture and Landscape Gardening

OBJECTIVES

After going through this chapter, students will be able to understand :

the importance and significance of floriculture and landscape gardening in India

the scope and prospects of floriculture and landscape gardening in India

INTRODUCTION

When we pay attention to floriculture then a number of questions comes in our mind. One of them is what the importance and scope of floriculture. Floriculture has been part of Indian culture and is entwined in the social fabric of our customs. 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 another. The gradual shift from sustenance agriculture to self-sufficiency in agriculture brought about change in life styles and increased the per capita income, which fuelled the growth of floriculture sector in the recent years. The floriculture industry in India is characterized by growing traditional flowers (loose flowers) and cut flowers under open field conditions and protected environment conditions, both. 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 Indian floriculture, which is mostly in the hands of small and marginal farmers.

NATIONAL SCENARIO

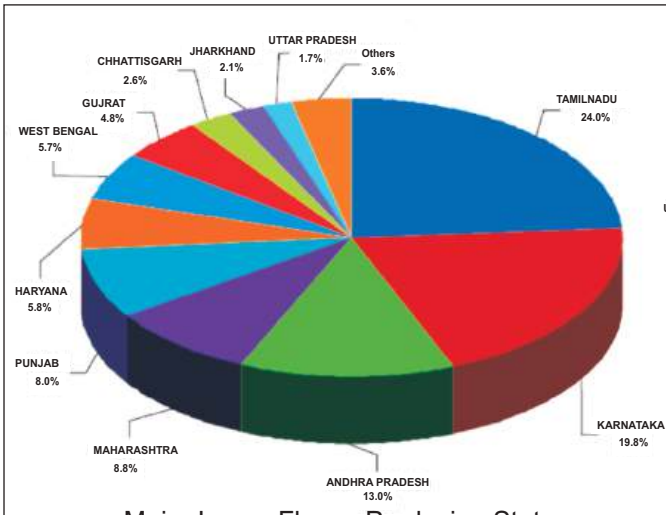
Indian floriculture is characterized by the cultivation of flowers that are basically suited for garland making, worship and decoration. The Indian floriculture industry has been shifted from traditional loose flowers to cut flowers for niche and export markets. India is one of the leading countries in floriculture with an area of 1.91 lakh ha producing 6903 million cut flowers and 10.31 lakh metric tonnes of loose flowers during 2010-11 (Table 1).

Table 1 : Area and production of flower crops in India

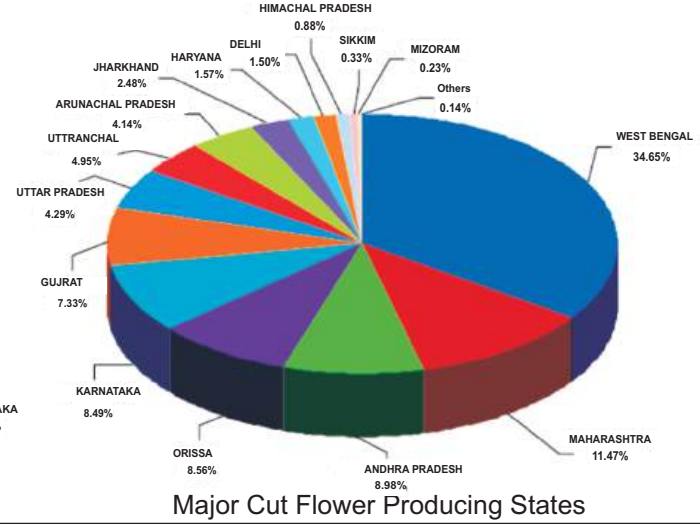
Year	Area (in Lakh ha)	Production	
		Loose (in Lakh MT)	Cut (Million Nos.)
2006-07	1.44	8.80	3717
2007-08	1.66	8.68	4365
2008-09	1.67	9.87	4794
2009-10	1.83	10.21	6667
2010-11	1.91	10.31	6903

The major loose flower growing states are Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Punjab, Haryana, West Bengal, Gujarat, Chhattisgarh, Jharkhand, Uttar Pradesh, etc. The states like West Bengal,

Maharashtra, Andhra Pradesh, Orissa, Karnataka, Gujarat, Uttar Pradesh, etc. have emerged as major cut flower growing states. North Eastern and other Himalayan states in the recent times have become major hubs for growing quality flowers. The anthurium from Mizoram, carnations from Himachal Pradesh, orchids from Sikkim, gerbera from Uttrakhand made a significant impact in recent times.



Major Loose Flower Producing States



Major Cut Flower Producing States

Today over 50 Export Oriented Units (EOU's) in India are engaged in cultivation and export of flowers contributing 0.04% (Rs.286 crores) to global floriculture trade, which is conservatively estimated at 6 billion US dollars.

Export of floricultural produce from India.

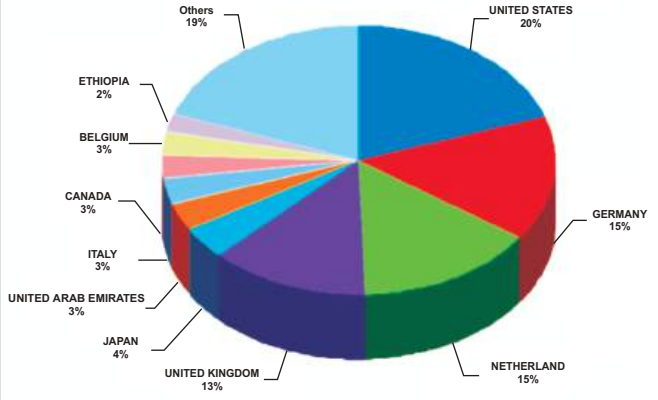
2008-09		2009-10		2010-11	
Quantity	Value	Quantity	Value	Quantity	Value
30798	368.81	26814	294.46	27776	286.45

Owing to steady increase in demand of flowers, floriculture has become one of the important commercial trades in agriculture. India exports about $ 66 million flower produce consisting of

Cut Flowers	**$ 31 million**
Foliage	**$ 29 million**
Live Plants	**$ 06 million**
Bulbs and Tubers	**$ 06 million**

Hence, commercial floriculture has emerged as Hi-tech activity. Due to steady increase in demand of flowers, the floriculture has become one of the important commercially viable propositions among agriculturists and the traders in farm produce. During the festive season, these flowers are sold at a much higher price.

Floriculture sector is generating higher income and employment opportunities, promoting greater involvement of women and enhancement of exports. India has now emerged as the second largest grower of flowers in the world. India is exporting flowers and flower products to different countries viz., United States, Germany, Netherland, United Kingdom, Japan, United Arab Emirates, Italy, Canada, Belgium, Ethiopia, etc.



Country-Wise share of Exports of Flowers from India

SIGNIFICANCE AND IMPORTANCE

Flowers symbolize purity, beauty, peace, love and passion. To a Japanese flower-arranger each flower express one or more meaning. To an Indian, flowers have a much greater significance. The aesthetic value of flowers in our daily life cannot be over-emphasized. In our society, no social function is complete without the use of flower. Floral garland, *gajaras* and *venis* are needed for marriage ceremonies. The use of *gajara* and *veni* is not limited to marriage only; these are also used to adornment for hair by our women, especially in South, every morning, evening, or even all through the day. Floral ornaments, bouquets, or flower arrangements also find place in social gatherings, birthday parties, welcoming home-coming friends or relatives, and honouring dignitaries. The arrival of new-born is rejoiced with flowers, the sick are wishes speedy recovery by offering flowers, while the dead people are bidden farewell with flowers along with tears of sorrow.

SCOPE FOR FLORICULTURE

In India, floriculture is only a developing subject which offers much scope for improvement. This problem can be tackled from several angles such as conservation, domestication and introduction. India is rich in its plant resources, many of which are of ornamental value and some are potentially ornamental. Much of this wealth is wasted as a result of rapid urbanization, industrialization, and unscrupulous collection. For example, some unscrupulous nurserymen are selling one beautiful *Paphiopedilum insigne orchid* plant for the price of a single flower in foreign markets. To conserve such rare orchids, the ICAR has now started some orchid sanctuaries, which is a correct step in this direction.

Domestication of wild plants with potential ornamental value is another way of improving garden wealth. In the process of domestication, possibly in an altogether different climate, the wild plants generally pass through many changes, which itself may cause some chance improvement. We have some very good plants in the wild with potential ornamental value, especially ferns, which can be acclimatized and domesticated under quite different climates. In this regard, the National Botanical Research Institute (formerly the National Botanic Gardens), Lucknow, has done some good work in acclimatizing the Himalayan ferns in the sub-tropical climate of Lucknow.

Introduction of plants either from the wild with potential ornamental value or from abroad offers a good scope for enriching ornamental plants. Initially, we should introduce wild plants with potential ornamental value, which can be improved upon by systematic breeding. Simultaneously, plants of proven quality can be introduced from abroad and acclimatized in our country. The process of introduction has improved our ornamental horticulture to a great extent. The introduction of *Mussaenda philippica,* the double-bracted mussaenda with white, pink, and red colours, from Thailand have acclimatized very well in the humid and mild climates of Kolkata, Bangalore, and Kerala. The introduction of many beautiful bougainvilleas from abroad, e.g. 'Lady Mary Baring', 'Golden Glow', and the multi- bracted cultivars such as 'Mahara', 'Cherry Blossom', etc. has enriched our ornamental horticulture to a great extent. A great variety of the so-called Hawaian Hibiscus introduced by Lal bagh, Bangalore, has completely changed the complexion of many gardens in and around Bangalore.

PROSPECTS FOR IMPROVEMENT

Hybridization

Acclimatization and introduction are not enough for improving the plant wealth. The tastes of the people change very frequently, and there is always a craze for new things. One of the best ways to improve is through intervarietal hybridization or interspecific hybridization or intergeneric hybridization. For example, in orchid, hybrids involving three genera *Cattleya, Brassavola,* and *Laelia* i.e. trigeneric hybrids are available. The hybridization work done in India, especially on roses, has enriched our floriculture to a great extent. Similarly, new hibiscus cultivars released by the Indian Institute of Horticultural Research, Bangalore, and others also enriched our collection of ornamental plants. Our efforts in this regard should be directed towards developing new hybrids suiting the different agro-climatic conditions prevailing in the country.

Mutation

Another important way of developing ornamental wealth is by mutation breeding. The natural mutant bougainvillea 'Mary Palmer' evolved spontaneously in a Kolkata garden has been acclaimed all over the world. But since natural mutants develop only by chance, other physical and chemical mutagens could also be employed to get new attractive mutants. Mutation can also be combined with hybridization to further enrich the floricultural wealth.

Polyploidy

Polyploidy is another method of plant improvement. Polyploidy can be induced by colchicine and other chemicals. Polyploids generally have larger flowers and intense-coloured petals sometimes with ruffling at the edges. Polyploidy combined with hybridization may result in remarkable improvement.

Propagation

Easy and rapid propagation of ornamentals will go a long way in spreading floriculture in India. The use of mist propagation units along with the application of root-promoting hormones has enabled many difficult-to-root trees and shrubs to root from cuttings. This method has improved the scope of supplying rare plants to garden lovers at comparatively cheap rates. Another field where not much work has been done is the production of disease-free plants. The tissue culture method offers the production of virus-free plant material. This method should be employed increasingly in ornamental plants not only for getting disease-free stocks but also to have rapid multiplication.

Dwarfing of plants

Dwarfing of ornamentals by growth-retardant sprays is being exploited commercially in advanced countries. In India, growth regulators have also been used to dwarf ornamentals. With the help of growth retardants it is possible to dwarf large plants to manageable sizes, so that the flat dwellers in cities can grow them in their limited spaces. Plants sprayed with growth retardants become tolerant to adverse growing conditions, the leaves become darker in shade and shining and on many occasions early flowering is induced. In chrysanthemum the growth-retardant spray can obviate the process of pinching. The commonly used growth retardants are B-Nine, Phosphone, and Cycocel. Maleic hydrazide (MH) also acts as an effective retardant. This method should be increasingly employed by the nurseries to encourage flat dwellers to take to gardening.

Extending Blooming Period

Some of the commercial flowers bloom only for a short period of the year irrespective of the planting date. For example, in North India, chrysanthemum starts blooming by November 15 and completes flowering by the first week of January. This causes a glut in the flower market. Therefore, staggering of the blooming period of such crops will go a long way in solving the marketing problem for the growers. The blooming of chrysanthemum can be altered by manipulating the photoperiod. This crop needs longer photoperiods for vegetative growth but shorter photoperiods for flowering. It is possible to extend the blooming period of chrysanthemum from the usual 45 days to five months under Lucknow conditions.

LANDSCAPE GARDENING

The importance of gardening is also not understood in India. The people should be educated to realize the importance of gardening, by providing good parks and gardens in cities for a large population to relax and enjoy the beauty of nature.

Bio-aesthetic Planning

The term bio-aesthetic planning, means the proper utilization of the available flora and fauna in the beautification of the surroundings. This concept was given by Prof. Lancelot Hogben. In India, the theme of bio-aesthetic planning was propagated by Dr. M.S. Randhawa who gave a practical shape to it in planning Chandigarh along with the famous architects Le Corbusier and Pierre Jeanneret. The aim behind this concept is to plant ornamental flowering trees along roads, in parks, house compounds, public places and also to develop national parks where non-carnivorous animals and beautiful birds will find sanctuary along with beautiful flora. The bio-aesthetic planner can be described as a master artist who uses the whole country as his canvas and his paints are the rich colours of red, blue, orange, and white of the different flowers. It is said that the untouched nature is quite monotonous. It is only with a touch of bio-aesthetic planning that the countryside and other places will look not only natural but pleasing too to the eye.

Bio-aesthetic planning should run hand-in-hand with town planning. The roads in towns and cities should be broad, planted with flowering and shade trees, and there should be spacious parks along with conservatories for harmless animals and birds.

Air Pollution

Air pollution, one of the most-talked-about problems in the present age, has reached disturbing proportions in some of the largest cities of the world and also in some of the metropolitan cities in India. The unplanned growth of the cities has resulted in congestion of houses, factories in residential areas, and proliferation of motor vehicles. The smoke from the coal ovens *(chulas)* of the residential houses, the dust and the smoke from the grinding mills and chimneys of the factories, and the exhaust fumes from the motor vehicles all add to the pollution of our cities. Pollution is causing an increase in the diseases of the respiratory tract, cancer, and many other ailments. Unless something is urgently done the health of our citizens may deteriorate rapidly.

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

The role of landscape gardening in human welfare cannot be overlooked. It is a great tragedy that most of our children in big cities do not have any open space to play and to see colourful flowers, birds, and

butterflies. 1t is the moral duty of our government, through the municipalities, corporations, and such other bodies, to provide the citizens with spacious parks having beautiful trees and flowers where they can relax, find peace of mind, and breathe fresh air after a day's hard work. The children will also be able to play freely in such parks. It is a common sight in congested cities that groups of youngsters play football, cricket, or hockey in the by-lanes in the absence of playgrounds and parks. Such a state of affairs should not be allowed to go on indefinitely. The wealth of any nation is linked with the health of its people. Unless we can ensure the healthy development of our citizens, especially the younger generation, by providing for them open breathing places through bio-aesthetic planning and landscape gardening, we cannot expect to build up a healthy society and a prosperous nation.

ACTIVITY/EXERCISE

1. Collect recent data regarding floriculture in India and all over the world from various websites.

CHECK YOUR PROGRESS

A} Subjective Questions

1. What is the significance of floriculture in our culture?
2. Write short note on

   Bio aesthetic planning

   Prospects for improvement
3. Explain the national scenario of floriculture in brief?
4. Explain in scope of floriculture and landscape gardening in India?

B} Objective Questions

a) Fill in the blanks

I. The area under floriculture in India during 2010-11 was————————.

II. The total production of loose flowers in India during 2010-11 was————————.

III. The total production of cut flowers in India during 2010-11 was————————.

IV. Three major loose flower growing states are ————————, ————————and————————.

V. Three major cut flower growing states are ————————, ————————and————————.

b) Multiple choice questions

i. Multi bracted cultivar of bougainvillea is

a) Lady Mary Baring b) Golden Glow

c) Cherry Blossom d) All of these

ii. Bougainvillea cultivar 'Mary Palmer was developed from

a) Hybridization b) Mutation

c) Introduction d) None of above

iii. Polyploidy is induced using

a) Colchicine b) Maleic Hydrazide

c) GA_3 d) NAA

iv. Dwarfing in ornamentals is induced by growth retardant like

a) B-Nine b) Phosphone

c) Cycocel d) All of these

v. The concept of bio-aesthetic planning was given by

a) M. S. Randhawa b) Lancelot Hogben

c) Julius d) All of these

c) Write true (T) or false (F) for the following statements

I. The export of flowers contributes 50% global floriculture trade.

II. India exports about $ 66 million flower produce to different countries.

III. United state is the major importer of flower from India.

IV. Mussaenda philippica was introduced from America.

V. Mahara is a single bracted cultivar of bougainvillea.

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Chapter 2

History of Gardening in India

OBJECTIVES

After going through this chapter, students will be able to know:

historical facts of gardening in India

trees, shrubs and climbers associated with Lord

the importance of gardening in various eras

INTRODUCTION

Whenever you visit any garden or park, you might have thought about the existence of garden, its history such as who has developed it, what is its importance in the history, etc. Is it right about your thoughts when you enter in a garden? Besides, you may have several other queries about gardening in your mind. In this chapter, we will discuss about the history of gardening in India.

HISTORY OF GARDENING IN INDIA

The history of gardening in India is as old as its civilization. The first evidence of ornamental tree, the pipal (*Ficus religiosa*), comes from a seal from Mohen-Jo-Daro, of third millennium B.C. Another seal from Harappa of the same period depicts a tree similar to that of weeping willow (*Salix babylonica*).

Gardening during Epic Era

The Aryans of the *vedic* period were great lovers of flowering plants. The lotus has been mentioned frequently in Sanskrit scriptures of *Vedic* times. The *Atharva* and *Rig Veda* mentions the pipal (Asvatha) tree with fair foliage. The epics of the Aryans, the *Ramayana* and the *Mahabharata*, mention about gardens, trees and flowers. In Ramayana, it has been narrated that the palaces had nice gardens with numerous flowers and shady groves and lakes were full of lotuses. The grove, Ashokavana where Sita was held in captivity by Ravana, was composed of Asoka (*Saraca indica*) trees. In the sabhaparva of *Mahabharata* epic, Vyasa described the pleasure gardens, parks and lakes around the palaces of Indraprastha. The following trees and creepers have been mentioned in both the epics.

Banyan tree (*Ficus benghalensis*)

Asoka tree (*Saraca indica*)

Weeping willow (*Salix babylonica*).

Pipal (*Ficus religiosa*)

Badi Champa (*Michelia champaca*)

Arjun tree (*Terminalia arjuna*)

Palash (*Butea monosperma*)

Nagkesara (*Mesua ferrea*)

Amaltas (*Cassia fistula*)

Sal (*Shorea robusta*)

Palmyra palm (*Borassus flabellifer*)

Screwpine (*Pandanus* sp.)

Bignonia sp.

Oleander *(Nerium oleander)*

Special mention has been given to tree Kadamba (*Anthocephalus cadamba*) because of its close association with the life of Lord Krishna. The lotus was very popular flower which was regarded by both the Hindus and the Buddhists as a symbol of purity. The lotus flower is like a sacred and virtuous man who remains unaffected even in the filthiest surroundings. During the later Aryan period the Aryans developed wishful thinking in the form of *Kalpavriksha*, the wish granting tree and *kalpalata*, a similar creeper. The faith goes that anybody, standing under these creepers or trees, wishing anything from jewellery, beautiful clothing, good food or even beautiful maidens, would get the same. A tree dating back to the third century B.C. was identified as banyan tree which is now preserved in the Kolkata Museum.

The association of different trees with the life of Lord Buddha is well known. His birth took place under the Asoka tree (*Saraca indica*) and other trees like Sal (*Shorea robusta*) and Plaksha (*Butea monosperma*) were also there. The Buddha attained his enlightenment under a pipal tree, spread his teachings under the shade of Banyan and mango trees and finally, breathed his last in a *Sal* grove. The great emperor Asoka adopted arboriculture and encouraged the planting of avenue trees. The Atharva Veda says that the Gods of the third heaven used to sit under the Asvatha (Pipal) tree.

The sculptures found at Mathura of the Kushan period (78-200 A. D.) had many trees inscribed on them and theses are identified as Asoka tree, Kadamba, Ixora, Swarna champa and Nagkesara. The poet Asvaghosha mentioned a number of plants in his Sundara Nanda including Nagkesara, Kadamba and lotus. During the rule of Chandragupta II, Kalidasa mentioned various trees like; Asoka tree, kadamba tree, Arjuna tree, Palash, Parijata, Kachnar, Siris and screwpine in most of his plays. He has mentioned about the creeper Madhavi and gardens in his play 'Sakuntala'.

Merriest festival of this period was 'Basant Panchami' which is celebrated in the memory of Lord Kamadeva-God of Love. People used to greet each other with exchange of flowers. Competitions of poetry, songs, drama and sports are organized by state and prizes distributed to the best. During the Gupta era, Vatsayana (300-400 A.D.) narrated four kinds of gardens in his book 'Kamasutra': **Pramododyan** meant for the enjoyment of the royal couples; **Udyan** where the kings played chess, enjoyed the dances of the maids and jokes of the court jesters; **Vrikshavatika** where high placed persons in the King's court enjoyed life with courtesans; **Nandanvan** which was dedicated to Lord Indra.

Famous poet Bana Bhatta described the number of flowering plants in '**The Harsh Charita'.** The flowering plants were grown in the vicinity of Palaces. Water pools were studded with red lotus and blue water lilies. Trees like; Arjun tree, Banyan tree, Sal, Champaka, Flame of Forest, Vakula, Karanj, Kadamba, Ashoka,

Indian coral tree, shrubs like; Malati, Gurhal, Harshringar, Rukmani and climbers like; Madhavi Lata have been described in the book.

Gardening during Mughal Era

A long gap in the history of gardening in India is evident before Babur attacked India, with the exception of the contribution of Firoz Tughlaq (1351-1388 A.D.). As many as about 1200 fruit gardens are said to have been laid out near Delhi and many more at other places by him. The foundation of Mughal empire in India was laid by Babur in the year 1526 A.D. when he defeated Ibrahim Lodi at Panipat. After his victory, he laid out a garden at Panipat and another at Agra wich is now known as Rambagh. The names of ornamental plants like; Oleander, Hibiscus, Jasmine and Screwpine in 'Babur Nama'- the memoirs of Babur, indicate his love for flowers. He is credited with the introduction of Persian rose in India. Akbar (1556-1605 A. D.) built a capital at Fatehpur Sikri, complete with gardens, trees, and flowers. He was the first Mughal to enter Kashmir and established a garden, Nasim Bagh, near to Dal Lake. Jehangir (1605-1627 A. D.) was also a great admirer of gardens and flowers and he has created gardens at Shalimar, Achhabal and Verinag in Kashmir. Shah Jahan (1627-1658 A. D.) also established several beautiful gardens such as Red Fort in Delhi, Taj Mahal in Agra, Shalimar garden in Lahore, etc. Aurangzeb made a garden at Aurangabad. Fadai Khan, a general of Aurangeb made a beautiful garden at Pinjore near Kalka (Haryana). Sher Shah Suri (1540-1544 A. D.) constructed the famous Grand Trunk Road from Lahore to Kolkata and planted avenue trees on both sides. Nawab Wajid Ali Shah (1847-1856 A.D.) established Sikandar Bagh, which is now the National Botanical Research Institute. During Mughal era (1526-1858 A.D.), Rajput kings also established several gardens in India.

The garden at Amber fort near Jaipur was started by Man Singh (1590-1615 A. D.) and completed by Jai Singh (1699-1743 A.D.). The Mandor garden near Jodhpur was built by Raja Abhai Singh (1724-1749 A.D.). Jai Singh II (1727 A.D.) founded the city of Jaipur and constructed beautiful garden & palace in the heart of the city. Another palace garden having water courses, fountains and many other features was made by Raja Suraj Mal at deeg in Bharatpur which was the best garden created by ay Rajput King.

Gardening during British Era

During British era, there was a lot of activity in gardening by Britishers and Indian kings. The arrival of britishers in India changed the whole pattern of gardening. The Mughal gardens in India were laid out in symmetrical patterns but the English changed the patterns into informal by laying out parks and gardens. King Hyder Ali and his son Tipu Sultan were famous amateur horticulturists of South India. King Hyder Ali established the most famous Lal Bagh garden in Bangalore. With the fall of Tipu Sultan it was managed by the British. In North India, Maharaja Ranjit Singh made an impressive garden at Amritsar. Famous Baradari garden at Patiala and fruit orchard at Chail were established by King Bhupinder Singh and his son Yadvindra Singh of Patiala. Britishers gave a beautiful gift to Indian gardens in the form of herbaceous border and lawn. During this period, a number of botanical gardens were established in different parts of the country. These are Royal Agri-Horticulture Society Garden, Kolkata; Botanical Garden, Saharanpur; National Botanical Gardens, Lucknow; Botanical Gardens of the Forest Research Institute, Dehradoon; Lal Bagh Botanical Garden, Bangalore; Government Botanical Garden , Ootacamund, TN, etc.

Post-Independence Period

The radical changes have been made in the field of ornamental gardening during post-independence period. Remarkable achievements have been made for three important areas like; conscious planning for improving environment, commercial floriculture and teaching and research of ornamental horticulture at

graduate and post graduate level. Several gardens in different cities like; Budha Jayanti Park, Delhi; Rose Garden, Chandigarh and Ludhiana have been laid out to provide recreational facilities and to improve the environment. State departments like urban departments, Archeological and tourism, etc. have taken initiatives in improving total environment of buildings by conscious planning and planting.

Keeping the immense scope of commercial floriculture in view, much attention is being given to exploit it fully. The cut flower trade in India has developed tremendously and hence, farmers earn more income by growing flowers around big cities. Till 1971, no university was providing education up to M.Sc level in Floriculture and Landscaping. Punjab Agricultural University, Ludhiana was the first Indian University to start imparting education in the subject. Strengthening of the facilities is essential to make floriculture industry prosperous.

ACTIVITY/EXERCISE

1. Visit any garden or park in your surrounding area and find out the history, and importance of the garden in our history.

CHECK YOUR PROGRESS

A} Subjective Questions

1. Explain in brief the history of gardening in India?
2. Write down the name of trees and creepers mentioned in both *'Mahabharata'* and *'Ramayana'* epics?

B} Objective Questions

a) Fill in the blanks

I. Tree _____ is closely associated with the life of Lord Krishna.

II. The birth of Lord Buddha took place under the tree_____.

III. The grove, Ashokavana was composed of tree_____.

IV. Nandanavana garden is dedicated to Lord _____.

V. As per Atharva Veda, the goods of the third heaven used to sit under _____tree.

b) Multiple choice questions

i. The Buddha attained his enlightenment under

a) Pipal tree b) Kadamba tree

c) Ashoka tree d) None of above

ii. Who has established the Red Fort in Delhi and Taj Mahal in Agra.

a) Akbar b) Jehangir

c) Shahjahan d) Sher Shah Suri

iii. Which of the following is a kind of garden mentioned in Kamasutra

a) Pramododyan b) Udyan

c) Brikshavatika d) All of above

iv. The Harsh Charita was written by

a) Bana Bhatta b) Vatsayana

c) Asvaghosha d) None of above

v. The first evidence of which ornamental tree comes from a seal from Mohen-Jo-Daro.

a) Banyan tree b) Ashoka tree

c) Arjun tree d) Pipal tree

c) Write true (T) or false (F) for the following statements

I. Budha Jayanti park was established during Post-Independence Perod.

II. The Kalpavriksha is the wish granting tree.

III. *Shorea robusta* is commonly known as Ashoka tree.

IV. The famous Grand Trunk Road was constructed by Sher Shah Suri

V. The famous "Lal Bagh" was established by the king Hyder Ali.

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Chapter 3

Types and Styles of Gardens

OBJECTIVES

After going through this chapter, students will be able to know:

types of gardens in India

various styles of gardens present in our country

INTRODUCTION

Whenever you visit any garden or park, you might have thought about the existence of garden including its type & style. Besides, you may have several other queries in your mind. In this chapter, we will discuss about the types and styles of gardens in India. In the history of garden making, initially threre have been two types, the formal and the informal. Thereafter, the third type is also described as wild garden.

TYPES AND STYLES OF GARDENS

Formal Gardens

The idea of formal gardening is as old as primitive man when he started construction of houses for living. The houses were built in square, rectangular or sometimes in circular shapes. The geometrical formalism brought orderliness to his immediate surroundings. Symmetry is the main characteristic of this type. The Persian gardens, the Mughal gardens and Italian gardens were formal in design. Geometrical formalism also influenced the French and British gardens of the pre-Industrial Revolution.

In the formal design, the land is forced to fit in the plan. In this type, an axis in drawn in the centre of the garden which divide whole of the garden in two equal halves, one half being the exact replica of the other, for every feature, element or adornment. Geometrically designed landscapes with trimmed hedges, paired flower beds, straight line planting and equal length of the sides of the area are the main features of formal or symmetrical gardening. The outline of the whole garden as well as the outline of different parts like flower beds, paths, hedges and lawns are of geometrical shape. These shapes are normally square, rectangular or circular. Formal gardens are generally enclosed. Attractive focal points at the terminals and intersections of paths and roads are essential to make such formal gardens more attractive.

Informal Gardens

This type of gardening is aimed to imitate nature and strives to produce a natural effect in a closed area. In the informal gardens, geometrical designs are employed without insisting on symmetry. Here, the garden plan is made to fit the land. The early Hindu and Buddhist gardens laid no emphasis on formalism. In Chinese and Japanese gardens, the art of asymmetrical balance was amply demonstrated.

A completely informal type provides a natural appearance but such gardens are not usually suited to very small sites. Planting is often of a mixed nature and there is a complete absence of set lines. Smooth, curvaceous outlines are more appropriate in this design rather than rigid lines. Informal gardens are laid out with open large lawns, bordered by clumps of shady trees or shrubs. The shape of the garden may not be square, rectangular or circular. Straight paths are avoided and irregular beds are introduced instead.

Shrubbery and herbaceous borders are so designed as to fit the periphery of the lawn. In this gardening design, nature is preserved in an artificial way.

Wild Gardens

The concept of wild garden, expounded by William Robinson, is against formalism. Such gardens are laid out for more agreeable communication with nature. It enables the growing of many plants that have never yet found a place in a trimmed garden. In this type, grass should remain unmoved as in nature and bulbous plants should be grown scattered in the grass to create a wild effect. Ornamental trees and shrubs are planted in forest flora and creepers are allowed to grow over the trees. Hundreds of the finest hardy flowers thrive much better in rough places than they ever did in the old-fashioned beds. Here, fine-leafed plants, ferns, flowers, climbers, grasses and trailing shrubs relieve each other in delightful ways. The passage to the garden is generally opened in woodland. In small gardens, every inch of space is needed to grow choice plants while the wild garden style is attempted only where a vast area is available. This type of garden combines a pleasing blend of beauty and utility with ecological and environmental needs.

STYLES OF GARDENS

Egyptian Garden

The Egyptians were great lover of flowers and gardens at national level and the gardeners of this country were the most honoured men. In this country, many temples were erected having shade trees with sacred groves. The private gardens also had ponds. The gardens were planted in regular rectangles with trees, vegetables and grape vines. Gardens were enclosed first by thorny fences and later by brick walls. The temples were the centre of horticulture, where garden designs improved with new plants. The introduction of trees from abroad particularly, influenced the temple gardens. Thus, Egyptian gardening added to the art of garden making a new species of formal and architectural styles.

Persian Garden

The Persian garden style is one of the oldest. The Persian styles were strictly formal and symmetrical. Unlike the Moghul gardens, the Persian gardens have no high boundary walls. They used crafted materials such as masonry, carved marble stones and highly polished stones. The Persian gardens were laid out by cutting terraces on the hill stopes. Natural springs were tapped to create straight water courses through the gardens. These water-courses were manipulated to undertake different movements along its run. These natural springs were available in same parts of Persia (now Iran) particularly in the North. If there was no natural source of water, this was created artificially by diverting some rivulet or a stream. So, the main stay of a Persian garden design was nahars (flowing canals) of water-the concept of Persian Paradise, “where cooling water flows”. The Persian gardens were having magnificent gateways.

The selection of plant material and their placement in the garden was very judicious. In the garden, cypress, white poplar and weeping willows were grown on the canal banks. Other favourite trees were chenar, pine, ash, pistachio, walnut, chestnut and myrtle. Among fruits; orange, lemon, pear, almond, mulberry, plum, cherry, apple, peach, apricot, fig and pomegranate trees occupied an important place in the garden. To them, fruit trees represented the symbol of life while the cypress symbolized death and eternity. Numerous varieties of roses, tulips, marigolds, violets, daffodils, poppies and all flowering annuals, iris, anemones, gladiolus, cyclamen & lilies etc. beautified the gardens.

The gardens also had scented plants, such as rosemary, sage, lavender, jasmine and roses.

French Garden

The style of gardening now known as French style is largely due to the efforts of Le Notre who served in the Royal Garden of Louis XIV from 1643 to 1715. He evolved a new style of greatest significance, profoundly architectural and formal in character. The main features of his mode of gardening rest upon long and wide avenues and vistas. Rectangle, squares and circles gave an orderly appearance to the garden. It is, in fact, a perfect example of the application of geometry to garden design, clipped hedges, framed walls and greenrooms. Trees were clipped into the shape of spheres, cubes and cones. Against the background of the foliage were displayed marble statues of Greek gods, nymphs and horses. The moral of the French garden style of Le Notre seems to teach the lesson "how to think big". His style dominated the gardens of civilized Europe for a long time.

Hindu-Buddhist Garden

The Aryans of Vedic times were lovers of nature. In the plains of northern Indian, the scorching heat of the sun burns all herbaceous vegetation, and wild flowering annual herbs are very rare. This climatic factor considerably influenced Indian gardening in the Hindu-Buddhist periods, so that their gardens were predominantly devoted to the growth of ornamental flowering trees, to the exclusion of flowering winter season annuals which could be grown only with the aid of artificial irrigation in winter the only flowering annuals which they grew were gainda (marigold), amarnath and tulsi. The Buddhist priests planted groves of flowering trees around their temples. In fact, the evolution of gardening is intimately associated with the temples and the monastery. The buddhist monks of India grew groves of flowering asoka and kadamba trees while the Chinese monks preserved trees like the cryptomeria and Ginkgo. The other sacred trees which find place in Hindu-Buddhist gardens were pipal, champaka, sal, palash, dhak, silk cotton tree, kachnar, blue lotus & amaltas. They considered tree as symbol of fertility. Most of the flowering trees which grow in India were sanctified by Aryans.Trees like Asoka, Sal and Palash are associated with the birth of Lord Buddha. The Kadamba tree is associated with Lord Sri Krishna while the silk cotton tree is associated with Lord Siva. Kachnar and Semul are associated with Goddess Laxmi and amaranth with Goddess Kali. The ponds and lakes of these gardens were filled with white and pink lotus.

Sculptures were another important feature in these gardens. A woman sculpture under a flowering ashoka, sal and palash tree is the symbol of the mother of the Buddha. Likewise; sculptures depicted the motherhood, beauty, affection and services of women. Statues of wild animals and birds were also placed in the garden.

Various kinds of deer and domestic animals were an integral part of the gardens which were laid out in such a naturalistic manner that different types of attractive and beautiful birds, including peacocks, were attracted to the gardens. In the lakes and ponds ducks, sarus, cranes and other water fowl were also found in abundance. The gardens were kept alive with parrots, mynas, and chikors swinging in cages from the branches of trees.

English Garden

Due to high rainfall, the natural groundcover in the English countryside is grass. British garden architects Repton and Capability brown advocated the concept that British garden should look like countryside. The idea was merge with countryside without any barrier. But it is only in the 18th century that they along with kent brought the touch of nature to the garden although the history of gardening in England dates back to 14th century when monks and priests conceived the idea of gardening and they started with kitchen gardens. Gradually, the spirit of gardening was imbibed among the people who realized the value of residing in pleasant surroundings. English gardens saw flower beds, topiary and terrace gardens by the

middle of the 16th century. In the middle of the 18th centuary, the gardens were laid out with more emphasis on architectural features. The main features of the gardens of this period were; curved paths, informal groups of trees, rivulets or streams, waterfalls and clipped hedges. The flowering annuals which subdued the architectural features, came into prominence during the 19th century. The main feature of English gardens as we know in India are; lawn, herbaceous border and rockery. Most of the flowering annuals that we see today in the Indian gardens, with the few exceptions of amaranthus, balsam, gomphrena, marigold etc., were brought here by the British.

Mughal Garden

In India, a garden in a sense of enclosed space grown with plants for the sake of the beauty of their flowers is a gift of the Mughals and their Persian soldiers. The gardens of Mughal periods are known as Mughal gardens and are famous till today for their own architecture and beauty. From 1494 to 1707 A.D. quite a few famous gardens were created by Mughals in different parts of the country. A Mughal garden is not a mere garden but serves the purpose of a fort, residence and a place of recreation. The main features of the Mughal gardens are site & design, running water, terrace, baradari, and flowers & trees.

(i) **Site and design :** Mughals gave a prime importance to the site for the construction of their gardens. On account of their love for running water, they selected sites centring round hill side, a river bank or having a perennial rivulet. As far as the design of the garden is concerned, a typical Mughal garden is a squarish or rectangular in shape. Its architecture is influenced by the climate of the place, its political, social and economic conditions. Garden is surrounded by a high wall adorned with serrated battlements and there is a stately entrance gate with huge wooden doors studded with heavy iron nails and spikes. The garden is divided into two or more terraces and provided with brick paved canal and tanks fitted with fountains. The purposed of the high walls was protection against enemies and hot summer winds.

(ii) **Running water :** Water is life and soul of the garden. The idea of constructing canals and tanks to keep the water brimming to the level of the path on either side was borrowed from the Persians. Water channels were paved with tiles of brilliant blue colour to reflect the sky and give impression of depth. Various patterns were used for paving the marble stones and tiles so that running water is thrown up and broken into ripples. These white waters shawls (Chadars) are characteristic features of the Mughal garden. Even the slightest slopes are utilized to create waterfall. At dusk, tiny lamps placed in the niches behind the waterfalls were lighted, and the diffusion of light through the water created a very pleasant sight.

(iii) **Terrace :** As the Mughals came from hilly country, the idea of building a garden in terraces come to them naturally. Sometimes, there are eight terraces corresponding with the eight divisions of the paradise according to Moslem faith, or seven to symbolize the seven planets.

(iv) **Baradari :** Baradari is evolved by Hindus to sit and enjoy fresh breeze and to watch the dark, clouds during the rainy season. But Mughals used these baradaries to sit with their slaves and listen to the songs of the dancing girls and watch pillars of baradari with their favourite design of bouquets of flowers in the vases and furnished them with thick carpets and cushions. Baradari is provided with twelve or sometimes more open doors on all sides.

(v) **Flowers & Trees :** Mixed avenues of cypresses and flowering trees like *Bauhinia variegata*, orange and lemon were planted. Oranges and pomegranate were used to border the square plots. For them every plant had some symbolic background and the selection was done accordingly. For example; oranges, pomegranate, almond, plums and white kachnars are the symbols of youth & life, while

cypresses symbolize death and eternity. Usually, the permanently built flower beds were of geometrical patterns. Beds of flowers were constructed near the main building or along the built up water channels and paths. The shady trees, such as the mango, chinar and tamarind were planted right across the whole area till their spreading branches swung over the walls. The Mughals mostly planted spring flowering trees, shrubs & herbs in their gardens. They grew white, purple & mauve iris near lilac bushes, daffodils and narcissus under apple and quince trees and tulips under pear and plum trees in their kashmir gardens. in summers, they grew roses, carnations, jasmines, hollyhocks, peonies and delphiniums.

Japanese Gardens

The origin of Japanese style of gardening goes back to the era of the empress Suiko (592-628 A.D.). Their style was influenced by Korean and Chinese taste during different periods. One of the most admirable features of the Japanese garden is that while other major styles of gardening of the world changed radically or fallen into disfavour, the Japanese continued, the same style for centuries but still remained popular. This can be attributed to the special relations of the Japanese gardens to nature. The most important teaching of the Japanese garden is that, “unless a garden has an air of peace it is not worth a place visiting. It should be a place where the mind finds rest and relaxation."

The Japanese gardens, though, very well planned, appear so casual to the people that they do not appeal to many. Except for some seasonal changes in the deciduous trees, these gardens hardly goes through any strong changes during different seasons. The immutability in Japanese gardens is achieved also because rather than a grand mixture of flowers, shrubs and trees, more emphasis is placed on natural elements such as a simple path, a group of rocks, stepping stones, streams, waterfalls, bridges, stone lanterns, and so on. A Japanese garden tries to capture a natural scenery. The three elements most important to achieve these are; water, stone and plants. Hence, before laying out a Japanese style garden, one must have the knowledge of following important features :

(i) **Water :** It is an essential feature and can be had in the form of a pond, waterfall, small stream, well or fountain.

(ii) **Island :** Another important feature is the island in the middle of the pond. Island may be connected by a bridge or left isolated.

(iii) **Bridges :** The incorporation of this feature bring more attraction to the garden. These may be of different material and different forms. Semicircular form of bridges to permit the passage of a boat under it, are constructed over large ponds.

(iv) **Stone :** Stones are used in groups. These are selected according to their shape and colour.

(v) **Stone lantern :** Stone lanterns may be for ornamental purposes or for light. It may be used to light the footpath, at a boat landing, path over a hill side or near waterfall to give the feeling of depth.

(vi) **Trees :** Trees are selected very carefully to maintain the equality of appearance in all seasons. The selection of trees depend upon climate and place. Low sculptured bushes and dwarfed trained trees look very attractive in Japanese gardens.

A Japanese garden may either be in the form of a large public park or a small family garden. It is further classified based on position, shape and purpose. There are five important types of gardens: hill garden, flat garden, tea garden, passage garden and sand garden.

In the **hill garden**, the most important feature is the hill with which is combined a pond and a stream. Rock arrangements are combined with plantings along the shore of the pond and the banks of the stream. A pair

of massive tall stones stands on each side of the waterfall. Planting of evergreen material is preferred here in hill garden.

A **flat garden** is laid out on level ground which comprises of raked sand or gravel, prostate growing trees, stones, stone lanterns, water basins and wells, which form the various features, are introduced into the scheme so as to lend scenic beauty to the environment.

The **tea garden** is generally attached to a tea house and presents a view of the beautiful scene around. There is an outdoor and an indoor garden. A water basin in which people wash their hands and stone lanterns for illumination are also provided.

Some gardens are laid out in narrow passages which are known as **passage gardens.** The layout of this type of garden is simple and is not over-crowded. Hardly any ornaments are placed in the garden. The important features in the garden are a few key rocks, slabs of stone and a few plants with open form and slender shape.

A **sand garden** is the simplest style and is totally devoid of plants. The only features in these gardens are gravel and stones. These vertical & prostrate stones are arranged in groups of 2 or 3. The gap between these stones is filled with fine white gravel. The gravel is raked in very simple patterns to simulate the rippling of flowing water.

Japanese use flowering plants sparingly in their gardens as too many colours go counter to unity. The flowering plants when used, are planted between the evergreens. The Japanese use both needle leaved and broad-leaved trees in their gardens. The examples of some of the plants used in these gardens are : maple, cotoneaster, *Cryptomeria japonica, Terminalia catappa, Lagerstroemia flosreginae, Ficus religiosa, Magnolia grandiflora, Pranus spp,* Poplars, Mulberry, Willow, Pines, Abies, *Podocarpus macrophylla, Juniperus chinesis among trees & shrubs.* Among vines; Clematis, *Lonicera Japonica, Ipomoea hederaceae, Ipomoea purpurea, Trachelospermum jasminoides & Wisteria sinensis* are common. The flower, Japanese most commonly use are chrysanthemum, asters, carnation, lilies, lotus, peonies & orchids.

ACTIVITY/EXERCISE

1. Visit any garden or park in your surrounding area and find out the history, style and type.

CHECK YOUR PROGRESS

A} Subjective Questions

1. Explain in brief the various styles of gardens present in India.
2. Explain different types of gardens.

B} Objective Questions

a) Fill in the blanks

I. The type of Japanese garden which is completely devoid of plants is_____.

II. Flowering annuals is a common feature of _____ style gardens.

III. In Persian Gardens, three scented plants grown are_____, _____ and _____.

IV. French garden art was developed by_____.

V. In Hindu-Buddhist gardens, a woman sculpture under a flowering ashoka tree is the symbol of _____.

b) Multiple choice questions

i. Which of the following is not a type of Japanese Garden

a) Hill Garden b) Sand Garden

c) Tea Garden d) Hindu Garden

ii. Which one of the following is associated with Lord Buddha.

a) Ashoka tree b) Jasmine

c) Silk Cotton tree d) Narcissus

iii. Which one of the following is a formal style of garden

a) Hindu-Buddhist Garden b) Japanese Garden

c) Mughal Garden d) English Garden

iv. Baradari is an important feature of

a) English Garden b) Hindu-Buddhist Garden

c) Mughal Garden d) Japanese garden

v. The tree associated with Lord Shiva is

a) Jasmine tree b) Kadamba tree

c) Silk cotton tree d) None of above

c) Write true (T) or false (F) for the following statements

I. The concept of a wild gardens is against formalism.

II. Hill garden is a part of English garden.

III. In informal gardens, nature is preserved in an artificial way.

IV. The concept of wild garden was given by Le Notre.

V. Lawn is the main feature of English Gardens.

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Chapter 4

Principles and Elements of Landscape Gardening

OBJECTIVES

After going through this chapter, students will be able to:

understand various principles of landscape gardening

learn about different elements used in landscape gardening

know the factors which affect the landscape designs

know about terminology used in landscape gardening

INTRODUCTION

In previous chapters, you have learnt about the history of gardening in various eras and styles and types of gardens. Now in this chapter, you will come to know about principles and elements of landscaping, terminology used in landscaping and factors which affect the landscape designs. It is imperative to know at the outset what is meant by landscape gardening. It is a very fascinating and interesting subject. It is an aesthetic branch of horticulture which deals with planting of ornamental plants in such a way that it creates a picturesque effect. There are several definitions and expressions to define these subjects. According to Bailey, landscape gardening is the application of garden forms, methods and materials to the improvement of any area. It can also be defined as the beautification of a tract of land having a house or other objects of interest on it. Before the execution of any landscape design in a particular area, it is important to understand the principles and elements.

PRINCIPLES OF LANDSCAPE GARDENING

The landscape gardening is making of pictures with plant material and hence, its principles are similar to those of art principles. Therefore, the understanding of such principles will help in using them properly. The various principles are as follows:

A) **Unity :** Unity in any garden is very important as it improves the artistic look. If has to be achieved from various angles. Different components of a garden should merge harmoniously with each other. Unity is created in a design when all the parts of the design blend together to form a single idea or impression. The design should present a pleasant picture from several angles. Unity is obtained by the effective use of components in a design to express a main idea through consistent style. Unity is emphasized by consistency of character between units in the landscape. Unity can be achieved by using mass planting and repetition. A natural feeling evolves when each activity area belongs to and blends with the entire landscape. Everything selected for a landscape must complement the central scheme and must, above all, serve some functional purpose.

B) **Balance :** It refers to visual equilibrium of any landscape design. This principles mainly focus on maintaining the balance on the both the sides of central axis of landscape. Balanced design gives stability to the overall garden otherwise unbalanced design will result in messy and disorganized situation. It is just like that of See-Saw game, according to which, equal weights can be balanced only

when they are equidistant from the centre. If weights are unequal, the heavier must move towards the centre for making balance. The balance may be of two types.

Formal balance: In this type, both the sides around central axis are exact replica of each other. Here, both the sides of landscape design were similar in all aspects like planting material, features, styles, etc. For example, trees planted on one side will balance with the same trees planted on other side.

Informal balance: In this type, both the sides around central axis are likely to balance each other side but not exact replica. For example, small trees in one side will balance with the shrubs on other side.

While maintaining balance, colour, form and texture of planting material should also be taken into consideration. Making balance with colour is difficult until and unless used properly. Red, Orange and Yellow colours are grouped into heavy and warm colours. However, White, Green and Blue colours are light and cool colours. Deeper shade is heavier than its lighter counterpart. Proper balance by selecting appropriate colours should be done to create the desired effect. Texture of leaves may be rough, coarse, fine or smooth and hence, proper balance is achieved between different types of texture. The consideration of plant form, bark colour and pattern should also be kept in mind to make the balance.

C) **Rhythm :** It refers to repetition of same objects at equal distance. It creates movement to the eye. Through this principle eye moves in continuation manner from one part of landscape design to other without any discontinuity. Rhythm can be created through progression of sizes, the shapes, a continuous line movement, etc. In gardens, generally trees of equal size, shape and height are planted in order to maintain the continuous movement. In Mughal gardens, fountain and water canals have also been extensively used to create such effect. Now-a-days other objects like lights are also used to create the effect of rhythm.

D) **Accent or Emphasis :** Accent or Emphasis is created in any garden to avoid monotonous view. This is mainly emphasized on the most important thing in any landscape design. It is also referred as focal point and serve as centre of attraction. Landscape designer should know what to emphasize, where to emphasize, how and how much to emphasize. Mostly unusual objects like statues, fountains and specimen trees are used to create the effect of focal point or accent or emphasis. In English gardens, statues have been used extensively to create such effects.

E) **Proportion :** It refers to definite relationship among the masses or it is the relation of one thing to another in magnitude. When two or more objects are put together, the proportions are established. It helps in space organization that means the space provided for garden features like roads, lawn, paths, shrubbery, border, trees, buildings, etc, should be in a right proportion. One feature should not dominate on other in terms of space management. The proportionate design created the harmonious effect and looks better. Such effects can be noticed in Persian and Mughal gardens.

F) **Harmony :** It is an overall effect of various features, styles and colour schemes of the total scene. The degree of harmony or unity of various elements of landscape is a measure induced in us and is called as beauty. Therefore, beauty can be defined as the evident relationship of all parts of a thing observed. When different parts of landscape are correctly placed in right way, it produces a harmonious and picturesque effect which attracts the visitor's attention. However, without harmony design lost its unity and do not have any appealing effect. The overall plan of the landscape should be harmonious and functional.

G) **Contrast :** This principle is the most useful in emphasizing the best features of an object. It can be very easily understood by following contrast colour theory. A fleck of scarlet colour against a green

background will make a contrast and scarlet colour will become prominent. In nature, this contrast is very common. Similarly, weeping growth habit against upright growth, dwarf against tall, rough texture against soft texture, etc. are few examples which can be used to create contrast. It is also very important that one of the two contrasting objects must clearly dominate each other. In this way, one becomes feature whereas other act as supporting background.

H) **Scale :** Scale is a relative dimension. The height and spread of trees and shrubs and the spread of the water garden are determined by adopting a scale, as one might adopt a scale in preparing a map. To make it clear, it may be noted that a small reflecting pool underneath a large tree will be dominated by the tree and render the pool ineffective, owing to the difference in their dimensions. Scale even takes into consideration the plant volume as well as size of both foliage and blossom. Many large trees having large leaves should be out of scale in a small garden as would large and heavy looking flowers. In a landscape composition, the scale of the object is established by the introduction of anything that shows a person's height, such as steps, doors, seats and hand rails etc.

ELEMENTS OF LANDSCAPE GARDENING

The elements of design are the visual and physical features of the plant & hardscape components that make up a landscape design. These elements are never independent of each other. A successful landscape design is created by the use of principles. The elements of design are used to achieve these principles much like building blocks are used to make a structure. The principles of design are similar to a recipe, with the elements of design being the ingredients. In order that we must make successful designs, through the use of design principles, following design elements must be understood.

A) **Line :** The landscape designer can create or control patterns by using line. A well planned group of lines in a landscape composition will direct the attention of the viewer to a focal point or particular area of interest in the composition. Lines have crucial role in controlling movement either visual or physical, in straight or curved directions. Hedges (row of plants) are one example of use of lines. Rows of trees also create a line but different from hedges due to size and character of trees. These lines can also be emphasized with edges, fences and walls. In a design, a straight line indicates direct movement without breaks. Interconnecting straight lines create the point at intersections for stopping, sitting, change of views and reflections back to the point of beginning. Curved lines invite slower movement and are useful in areas which should appear as natural as possible such as a path through a wild garden.

B) **Form :** Form is the two or three dimensional shape and structure of an object or space. It plays an important role in creating a particular design. In a tree, trunk, branches and leaves together create a form. Tall and slender tree have vertical form. Low and spreading trees have a horizontal form. A group of vertical plant form, if grouped together in sufficient quantity so that the length of group is greater than the height, appears to have a horizontal form. Some of the more common forms of landscape plant include round, conical, oval, weeping, horizontal and upright.

C) **Texture :** Texture describes the surface quality of an object or plant material. The different kinds of textures are emphasized through the use of plants and other landscape materials. In plants, texture is expressed in gradation form from fine to medium to coarse. Texture becomes significant if plants are placed near a building for contrast. Texture is used to minimize or emphasize architectural line. Small needle shaped leaves provide fine texture whereas broad, large leaves provide a coarse texture.

D) **Colour :** This is the most important elements of design. It can be used to create focal point in the design very well. Its use in the design to be more pleasant can be done more accurately by using

colour wheel. Colours are classified as primary, secondary and tertiary. The primary colours are red, blue and yellow. By different combinations of these colours, all other colours can be produced. Secondary colours are those composed of two primary colours and are green, orange and violet. Tertiary colours are formed by mixing one primary & one secondary colours. Red, orange and yellow are considered as warm colours and seems to advance towards the viewer. Green and blue are cool colours and tend to recede in a composition. Grey, being neutral, is the best of all as a background when bright colours are used in foreground.

E) **Variety :** It is a critical element in landscape design. A little variety causes monotony whereas too much of the variety brings confusion. Using several of each kind will be more appropriate to result in the unity of design. A unique balance between extremes produces a pleasant sense of unity in landscape composition. A variety of lines, forms, textures and colours are needed to create an orderly, interesting landscape. But it does not mean that each and every plant must be different with in the design.

F) **Fragrance :** One of the greatest delights of a garden is the fragrance which is recognized only in a chance manner. The scent of roses, carnations, tuberose, jasmine, marigolds, lilies, etc. are easy to recognize and well known to all. It is not only flowers; various kinds of grasses, aromatic plants, shrubs, trees also induce an exhilarating aroma in the garden.

G) **Pattern or character :** Many plants impart pattern to a garden setting. Pattern is a model which can be found in the natural arrangement of plant parts, e.g. weeping plants add delicacy, oats and bottle palms are stately, bulbous plants look exotic, cedars have a somber air, etc. Mixing of plants of divergent character could add up to a confused composition. Then there would be lack of unity in the overall garden design.

FACTORS AFFECTING LANDSCAPE DESIGNS

There are several factors which affect the making of suitable design for particular site. These factors are:

Human Choice: Human being's desire is to make his living comfortable. His dominance in making designs and selection of plant material is very well evident. Therefore, various styles of gardening have come into existence.

The site: It is an important factor and according to site, suitable design is made. In formal style, the site is selected according to plan. Topography of the site also affects the design.

Heritage: One inherits the knowledge of botany and aesthetic sense and uses accordingly. Our rich heritage teaches us to use flowers and fragrant trees to improve the surroundings.

Soil: Planting material should be selected according to the characteristics of soil types.

Climate: The climate of particular place affects the selection of plant material. Therefore, select plants suitable to the climate.

Views: Distant views of mountains, hills, woods, valley, etc. are preferred from site of the garden

IMPORTANT TERMS

Axis : It is an imaginary line which divides garden into two parts. It also connects two or more points. Axis is presented in the form of a path, line of fountains or trees, etc. If axis divides gardens

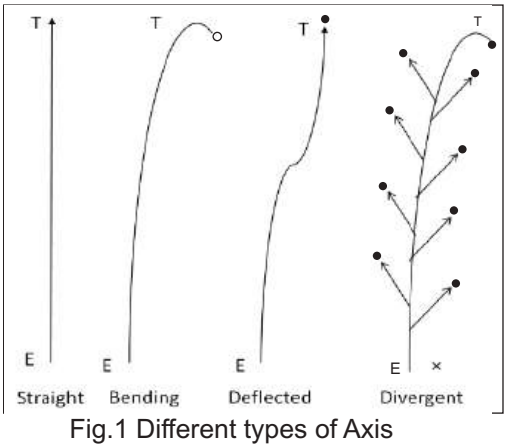

Fig.1 Different types of Axis

into two equal parts, it is called central axis. In formal garden, axis is central whereas in informal style, it is oblique. An axis in a garden is directional, orderly or dominating. An axis may be straight, bent, deflected but never divergent Fig. 1.

A powerful axis require a powerful terminus e.g. Mughal gardens. When an axis terminates in a structure having entrance, one or three openings are better than two since they provide a receptive element rather than an obstruction Fig.2. The axis is an unifying element Fig.3.

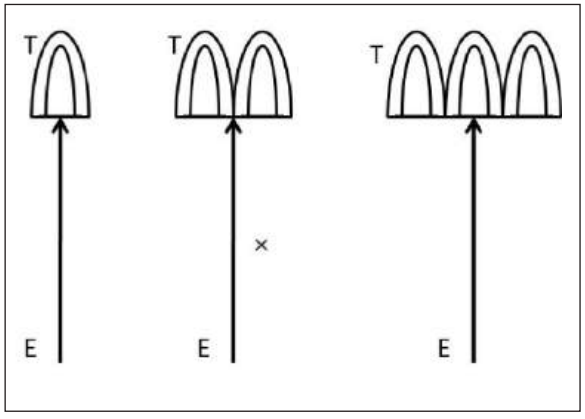

Fig. 2 Requirement of Axis

E-Entrance

T- Terminus

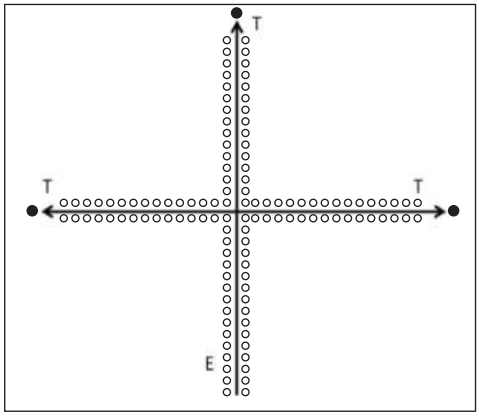

Fig. 3. Axis of unifying.

Circulations

In landscape gardening, it means a pathway from entrance to terminal point. Circulation varies with the type of gardening and topography. The more of circulation patterns, it has more points of views and attraction. Common circulation patterns are depicted in fig. 4.

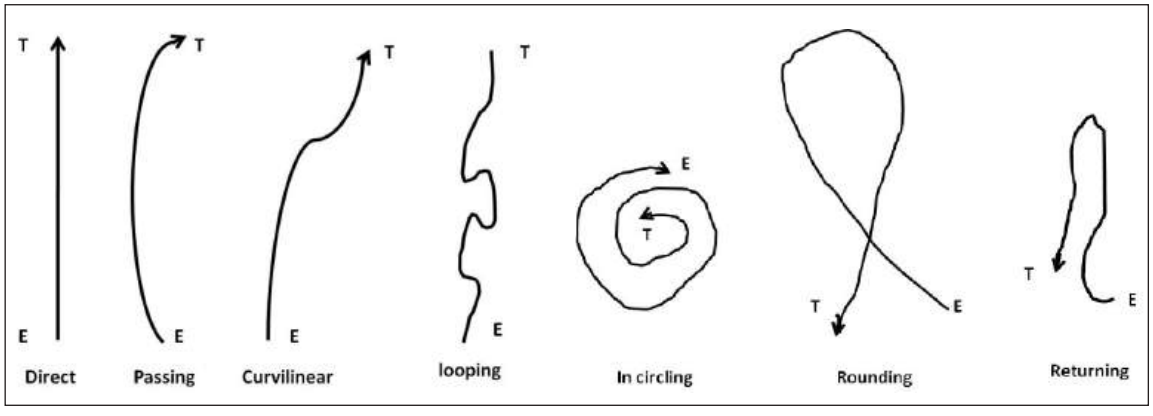

Fig. 4. Common types of circulation. E - Entrance, T- Terminus

Vista

Vista is a three dimensional confined view of terminal building or dominant element of feature. It may be natural or man-made. Natural vistas are common around mountains and snowy peaks. The more suitable example of man-made vista is a view of main building of Taj Mahal from the entrance gate. The overall effect of vista may be calm or induced motion. There are three different parts of a vista viz., 1) it should be subject to close control; 2) it should have a viewing station to see object or objects; 3) it should have intermediate ground. These should be satisfactorily united and thus result into an effect of totality.

ACTIVITY/EXERCISE

1. Prepare a landscape design for a garden by keeping the principles and elements in view

CHECK YOUR PROGRESS

A} Subjective Questions

1. Explain in brief the principles of landscape gardening?
2. Explain in brief the various elements of landscape gardening?
3. Write a short note on

   Axis

   Circulations in landscaping

   Vista
4. Explain the factors which affect the landscape design?

B} Objective Questions

a) Fill in the blanks

I. Visual equilibrium of any landscape design is known as————————————————.

II. Repetition of same object at equal distance is known as ————————————————.

III. ———————— is created in any garden to avoid monotonous view.

IV. The overall effect of various features, styles and colour schemes of the total scene is called ————————————————.

V. The total mass of any object or plant in landscape design is termed as————————.

b) Multiple choice questions

i. Which of the following is a circulation in landscape gardening

a) Divergent b) Rounding

c) Looping d) Both b & c

ii. A three dimensional confined view of terminal building or dominant element of feature, is known as

a) Axis b) Vista

c) Circulation d) None of above

iii. Which of the following is an element of landscape gardening

a) Pattern b) Form

c) Colour d) All of above

iv. Which of the following is a neutral colour in colour scheme

a) White b) Grey

c) Red d) Both a & b

v. Tertiary colour are formed by mixing of

a) Red and white b) Green and orange

c) Red and Blue d) None of above

c) Write true (T) or false (F) for the following statements

I. Straight lines invite faster movement whereas curved lines bring slower movement.

II. Proportion and harmony are the elements of a landscape gardening.

III. The imaginary line which divides garden into two parts is known as vista.

IV. Red, blue and yellow colours are primary colours.

V. Circulation is a pathway from entrance to terminal point.

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Chapter 5

Annual and Perennial Ornamentals

OBJECTIVES

After going through this chapter, students will be able to:

know different annual flowers

know different perennial ornamental plants such as trees, climbers and shrubs

know uses of these ornamentals

INTRODUCTION

Whenever you visit any garden, you come across different flowers. A number of questions related to their life cycle, whether they are permanent or short lived arise in your mind. Dear students, in any garden both annual and perennial ornamental plants are used to enhance the beauty. In this chapter, you will read about annual and perennial ornamentals which are used in any landscape to make different designs.

Proper introduction of annual flowering plants in the garden adds immensely to the decorative value of the garden. Similarly, any garden seems incomplete without the inclusion of trees shrubs & climbers.

ANNUAL FLOWER CROPS

Annual flowers or annuals are the group of plants which complete their life cycle in one season or in one year. In such a limited period, they complete the process of life like germination, growth, flowering, seed formation and after this plants wither out. They are easily grown plants. They vary widely in form, habit of growth, flower colour and flower size. They beautify the surroundings and exhibit a good show of blooms at low cost and labour. They bring a change in the look of garden with the change in the season and keep gardeners busy in raising them throughout the year. The annuals are grown for various situations and purposes in the garden.

IMPORTANT CHARACTERSTICS

Annual flowers –

are easily grown plants

vary in growth habit, form, Flower-colour, size, shape, and season of flowering

exhibit profuse flowering

bring change in outlook of garden with the changing season

provide mass effect

are grown for various situations with varied uses

bring variety of colour to place within short span of time

USES

Bedding purpose: Marigold, Phlox, Pansy, Dahlia, Verbena, Zinnia, Sweet William, Sweet Sultan, Petunia, Ice plant, Portulaca, Candytuft, Gomphrena, etc.

Cut flowers: Antirrhinum, Carnation, Aster, Sweet William, Sweet Sultan, Sweet Pea, Lupin, Helichrysum, Corn flower, Larkspur, etc.

Fragrant flowers: Phlox, Wallflower, Stock, Sweet William, Sweet Alyssum, Sweet Pea, Sweet Sultan, etc.

Loose flowers: Marigold, Zinnia, Gomphrena, Gaillardia, Annual chrysanthemum, Aster, Sunflower, etc.

Cut greens: Amaranthus, Kochia, Coleus, Cineraria, Celosia, etc.

Dry flower: Helichrysum, Acroclinum, Gomphrena, Marigold, Daisy, etc.

For pots: Marigold, Antirrhinum, Petunia, Aster, Salvia, Kochia, etc.

Hanging Basket: Nasturtium, Verbena, Sweet alyssum, Ice plant, Portulaca, Daisy, Phlox, etc.

Edging: Marigold, Pansy, Phlox, Petunia, Ageratum, Portulaca, Lobelia, Candytuft, etc.

Screening: Hollyhock, Sweet pea, Quamoclit, etc.

Rockery: Nasturtium, Verbena, Phlox, Dimorphotheca, Ice plant, Stock, Nemesia, Venidium, etc.

Shady Situation: Salvia and Cineraria, etc.

CLASSIFICATION

The annuals are classified on the basis of growing season, hardiness in temperate areas, photoperiodic requirement, earliness, etc.

Based on Growing Season

Annuals are divided into three groups according to their growing season.

Summer season annuals

They exhibit luxuriant growth as well as produce flowers under high temperature. In north Indian plains these are sown in February-March whereas in hills they are sown in March-April. e.g. Cosmos, Zinnia, Kochia, Sunflower, Tithonia, Gaillardia, Portulaca, etc.

Rainy season annuals

These annuls can withstand heavy rains and high humidity coupled with high temperature. They are sown during May –June. e.g. Amaranthus, Balsam, Celosia, Gomphrena, Zinnia, etc.

Winter season annuals

These annuals are able to tolerate low temperature and hence comfortably grown in winter season and bloom best during the season. Winter annuals are available in wide range of flower form, size and colour. They are sown in September-October in plains whereas in hills these planted in February- March and July-August.

Based on Hardiness in Temperate Areas

Hardy annuals: They need no artificial aid for their growth and flower freely in the open e.g. Digitalis, Rudbeckia, Viola, etc.

Half-hardy annuals: These need sowing under glass but are later planted out in beds e.g. Antirrhinum, stock, etc.

Tender annuals: They are cultivated under the glass protected from the vagaries of adverse weather conditions e.g. Pansy, etc.

Based on Earliness

Early blooming annuals: Ageratum, Alyssum, Amaranthus, Browallia, Celosia, Coreopsis, Cosmos, Gomhrena, Balsam, Salvia, etc.

Late blooming annuals: Abronia, Hollyhock, Anchusa, Antirrhinum, Arctotis, Centauria, Cheiranthus, Chrysanthemum, Dianthus, Mathiola, Salvia, etc.

Based on Photoperiodic Requirement

i. Short Day : Amaranthus, Salvia, Cosmos.
ii. Long Day : Rudbeckia, Antirrhinum, Petunia.
iii. Day Neutral : Gomphrena, Impatiens.

PERENNIAL ORNAMENTAL PLANTS

Perennial flowers or perennials are the group of plants which complete their life cycle in more than two years. They vary widely in form, habit of growth, flower colour and flower size. They beautify the surroundings and exhibit a good show of blooms at low cost and labour. They bring a change in the look of garden if planted with proper planning. The perennials are grown for various situations and purposes in the garden. The perennial flowers or ornamental plants include various shrubs, climbers, trees, bulbous plants, ferns, etc. In this chapter you will read various shrubs, climbers and trees.

i. SHRUBS

Shrub may be defined as perennial plants having many woody branches arising from the base of the plants. The plant whose basal portion is woody and the upper shoots are soft is called a sub-shrub. A shrub is erect and bushy, attaining a height of 0.5-4.0 meters. A garden or a landscape, without shrubs, will lose much of its charm, attraction, and beauty. Availability of large number of species and cultivars, a wide range of variation in shape and size of plants, diversified leaves and growth habits, remarkable range of sizes, shapes, forms and different colours and fragrance have made the shrubs important garden plants.

Uses

In small gardens where planting of trees is not possible, some selected shrubs always find a place. If a proper selection is made the shrubs will provide flowers in the garden throughout the year.

Most of the shrubs are quick-growing and flower within a year after planting and hence, add beauty to the area.

The shrubs are available in various heights from dwarf to tall and thus can be put to various uses in the garden. They can be planted in the shrubbery, border or as specimens in lawns and in a landscape.

Prostrate or trailing shrubs such as *Lantana sellowiana* and *Juniperus horizontalis* are suitable for planting in rock gardens.

Shrubs with ornamental berries: Many shrubs such as *Duranta plumieri*, some species of *Cotoneaster*, *Carissa carandas*, *Ochna squarrosa*, and *Rauwolfia canescens* bear most ornamental-looking berries. The shrub *Fortunella japonica* gets covered with small orange-like fruits and looks beautiful.

Shrubs with ornamental foliage: There are shrubs such as Crotons, *Eranthemum*, and *Acalypha* with beautiful coloured foliage.

Shrubs with ornamental variegated foliage: Varieties of some shrubs such as *Duranta plumieri*, *Citrus limonia*, *Nerium oleander, Manihot,* etc. have attractive variegated leaves.

Shrubs with fragrant flowers: Many shrubs such as *Cestrum nocturnum*, Jasmines, *Portlandia grandiflora*, *Cananga kirkii*, *Citharexylum fruiticosum*, *Nyctanthes arbor-tristis*, and *Oncoba spinosa* bear fragrant flowers.

Shrubs can effectively break the monotony of a large open space or lawn or can separate one part of a garden from another.

Shrubs for edges: The low-growing shrubs such as *Lantana sellowiana*, *Sanchezia nobilis*, and some species of *Eranthemum* can be used for edging the lawns.

Shrubs for hedges: The shrubs such as *Bougainvillea*, *Duranta plumieri*, *Clerodendron inerme*, *Malpighia glabra*, *Murraya exotica*, etc. are used as hedges.

Classification

From the practical point of view, shrubs are classified into three groups according to their requirement of sunlight under tropical conditions.

Shrubs require full sun for normal growth and flowering: Majority of the shrubs grown under full sunlight for their normal growth and flowering.

Shrubs require semi shade for normal growth and flowering: *Beloperone amherstiae, B. guttata, Calliandra brevipes, C. houstonii, C. inaequilatera, Magnolia fuscata, Nandina domestica, Olea fragrans, etc.*

Shrubs of intermediate group which grow well in both semi-shade and sun: *Acalypha, Brunfelsia americana, Cerbera fruiticosa, Cestrum, Crossendra, Eranthemum laxiflorum, Jatropha pandurifolia, Lemonia spectabilis, Mussaenda frondosa, Plumbago capensis,* etc.

ii. CLIMBERS

Climbers are an important group of ornamental plants. A climber is defined as a plant which possesses special structures to climb over a support. These special structures may be hook-like thorns (*Bougainvillea*), tendrils (*Antigonon leptopus* and *Bignonia*), rootlets (*Ficus repens*), or modified leaf stalks. The climbing plants which do not have any such structure but climb over a support by twining themselves spirally around such supports are called twiners. Such plants belong to the genera *Echitis*, *Hiptage*, *Lonicera*, etc.

There are still other plants which fail in their attempt to climb but somehow manage to support themselves over the trunks, stems, or branches of other plants; these are termed as ramblers and stragglers.

Quisqualis indica (Rangoon Creeper) is a good example of such plants. Creepers are those plants which are unable to climb vertically on their own because of their weak stems. Morning Glory is an example of such plants. Trailers are similar to creepers, the only difference being that they do not form any roots at their nodes.

Uses

Climbers viz., *Vernonia elaeagnifolia, Antigonon leptopus, Clerodendron splendens, Derris scandens, Pyrostegia venusta*, etc. can be used for the purpose of screening to maintain privacy from the adjacent houses.

The climbers such as *Quisqualis indica, Thunbergia mysorensis, Wisteria sinensis,* etc. are also grown to be trained on trellises, over specially constructed pergolas, arches, arbours and against pillars or similar structures.

Climbers like Bougainvillea and Morning Glory can be trained along slopes.

Climbers are also trained to climb over net houses, lath houses or conservatories where shade-loving foliage plants are displayed.

Climbers are useful for topiary works.

Climbers are most suitable for roof gardens, where vertical growth is preferred because of lack of space.

Climbers are helpful in reducing various types of pollution if used properly.

Classification

Climbers can be classified according to their growth habit and the purpose for which they are grown.

Showy flowering climbers: Climbers of this group generally display a show of colour with their flowers at a certain time of the year and are more appealing to the common man.

Climbers with scented flowers: A climber may be attractive because of its beautiful flowers and foliage or the scent of its flowers. But some climbers may possess both these virtues. Some of the climbing jasmines, *Trachelospermum jasminoids*, Honeysuckle, etc., possess sweet scents. These are generally grown near the houses.

Climbers with attractive foliage: Certain climbers are mainly grown for their foliage and the flowers of such plants are insignificant or inconspicuous. *Monstera deliciosa*, certain species of *Asparagus*, *Ficus repens*, etc., are grown for their foliage only.

Shade-loving climbers: Though, most of the climbers thrive best under the full sun, there are a few that grow well under light or partial shade. Besides, the foliage-type climbers such as *Pothos*, *Asparagus*,and *Hedera helix* which grow in partial shade, the flowering climbers such as *Trachelospermum jasminoids* with their sweet-scented flowers thrive well in full of partial shade. *Clerodendron splendens*, *Jacquemontia pentantha*, *Thunbergia grandiflora*, etc., can grow well in places receiving partial shade.

Heavy climbers: *Quisqualis indica*, *Wisteria sinensis*, and most of the other species of *Wisteria* are heavy climbers.

Light climbers: *Jacquemontia violacea, Clitoria ternatia, Quamoclit pinnata*, etc. are some light climbers. Though under favourable climate conditions *Pyrostegia venusta* becomes a prolific climber, it is also possible to grow them in limited space by pruning and trimming them. *Petrea volubilis* is another light climber with beautiful flowers.

iii. TREES

A tree is a perennial plant having distinct trunk and crown at the top. Trees are an essential feature of a garden, for roadside planting, public parks, along railway lines, in schools and colleges, etc. These provide shade or bear flowers or does both and also play a significant role in controlling air pollution in cities and towns. It is very difficult to draw a line of demarcation and to specify which an ornamental tree is and which is not.

Classification

From the floricultural point of view, trees are classified into two groups, namely, Foliage trees and flowering trees.

Foliage trees: The trees planted for their showy ornamental foliage are known as foliage trees. *Adansonia digitata, Ailanthus excelsa, Albizzia lebbek, Alstonia scholaris, Anthocephalus cadamba, Araucaria cookii, Azadirachta indica, Dalbergia sisoo, Eucalyptus, Ficus bengalensis, Ficus elastica, F. religiosa, Juniperus sp., Melia azedarach, Pinus sp., Pongamia glabra, Putranjiva roxburghii, Salix babylonica, Terminalia arjuna, Thuja orientalis, etc.* are the examples of foliage trees.

Flowering trees: The trees planted for their showy ornamental flowers are known as flowering trees. *Amherstia nobilis, Bauhinia sp., Bignonia megapotamica, Butea monosperma, Callistemon lanceolatus, Cassia fistula, Cassia grandis, Cassia nodosa, Chorisia speciosa, Erythrina indica, Jacaranda mimosaefolia, Lagerstroemia indica, Plumeria alba, Peltophorum ferrugineum, Rhododendron sp., Saraca indica, Tabebuia rosea, etc.* are the examples of flowering trees.

ACTIVITY/EXERCISE

1. Identify various annuals, trees, shrubs and climbers which can be utilized to enhance the beauty of garden.

CHECK YOUR PROGRESS

A} Subjective Questions

1. What do you understand by annuals. Explain in brief the uses and their classification?
2. Write down a short note on ornamental trees?
3. Define shrubs? Explain in brief the uses and their classification?
4. Define climbers? Explain in brief the uses and their classification?

B} Objective Questions

a) Fill in the blanks

I. Three annuals like————, ————————, and———————— are used as cut flowers.

II. ————, ————————, and———————— annuals are used for making dry flower products.

III. Amaranthus is classified as ——————day plant on the basis of photoperiodic requirement.

IV. Bougainvillea climbs with the help of special structure called ——————-.

V. An example of rambler is ——————————————.

b) Multiple choice questions

i. Which of the following climber has fragrant flowers

a) Jasmine b) Honey suckle

c) Both a&b d) None of above

ii. Which of the following climber can grow under shade

a) *Clerodendron splendens* b) *Thunbergia grandiflora*

c) *Jacquemontia pentantha* d) All of above

iii. Which of the following is a climber

a) *Ficus elastica* b) *Ficus infectoria*

c) *Ficus repens* d) *Ficus religiosa*

iv. Gomphrena is a

a) Long day plant b) Short long day plant

c) Intermediate plant d) Day neutral plant

v. Which of the following annual is used for screening purpose

a) Hollyhock b) Sweet Pea

c) Moon flower d) All of above

c) Write true (T) or false (F) for the following statements.

I. Petunia is a short long day plant.

II. Plants attain a height of 0.5 -4.0 meter are known as shrubs.

III. *Ochna squarrosa* is known for its ornamental berries.

IV. *Antigonon leptopus* has thorns to climb up.

V. Climber *Vernonia elaegnifolia* is used to trained over pergola, arches, etc.

SUGGESTED FURTHER READINGS

i. Randhawa G. S., and Mukhopadhyay A., (2007). Floriculture in India. Allied Publisher Pvt. Ltd., New Delhi.

ii. Jindal S. L., (1970). Flowering Shrubs in India. Ministry of Information and Broadcasting, Govt. of India, New Delhi.

iii. Randhawa M.S., (1957). Flowering Trees in India. Indian Council of Agricultural Research, New Delhi.

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Chapter 6

Principles and Methods of Propagation of Ornamental Crops

OBJECTIVES

After studying this unit, students will be able to understand:

principles of propagation of ornamental crops

methods of propagation in ornamental crops

general production technology of ornamental crops

INTRODUCTION

Floriculture is the cultivation of flower crops that gives knowledge about crop propagation, production technology that includes soil preparation, sowing/planting, vegetative growth of plants, manuring, weeding, irrigation, reproductive phase of plants and protection from insect-pest and diseases. We grow various types of flower crops. There are different methods of raising these crops. Some are directly propagated through seeds and many others are raised through different vegetative parts of the plant. Have you ever tried to know how different flower crops grow? Which flower is raised through seed or other plant parts? At what stage, vegetative parts can be planted and how it is prepared for growing flowers? This chapter will make you aware about diverse propagation methods which are employed to raise different flower crops.

PROPAGATION

Plant propagation is the process of creating new plants from a variety of sources. There are, in general, two modes of plant propagation.

1. Sexual or seed propagation
2. Asexual or vegetative propagation

Sexual Propagation

It refers to the use of seed or spore that is separated from the parent plant. A seed is a small embryonic plant enclosed in a covering called seed coat, usually with some stored food material and is formed from ripened ovule of gymnosperm and angiosperm plants after fertilization. The seed formation completes the process of reproduction in seed plants with the embryo developed from the zygote and the seed coat from the integuments of the ovule. Seeds size, shape and colour may vary from species to species. Actually, a spore is an asexual body but when this falls on a moist surface it produces small plant bodies (prothallia) which develops the sex organs (*Archegonia* and *Antheridia*) and these in due course develop the gametes which fuse and the resulting body develops into the fern plant. In general, plants raised from seeds are more vigorous in growth than those raised by vegetative methods.

Propagation of plants from seeds is very common and inexpensive method. Almost all ornamental trees are propagated from seeds. Seeds are collected from mature fruits/pods and are stored or sown immediately. The seasonal flowering annuals (winter, summer and rainy season), few shrubs and climbers are also propagated from seed.

Advantages

It is only the method of producing new varieties or cultivars.

It is often the cheapest and easiest method of producing large numbers of plants.

It can be done to avoid certain diseases.

It may be the only way to propagate some species.

Disadvantages

Plant characteristics are not genetically true to type to that of their mother plant.

Through this method, seedlings may take years together to produce flowers e.g. an orchid seedling may take 6-8 years to produce flowers but a plant raised through vegetative propagation from another mature plant flowers with in a season or between 1-2 years.

Asexual Propagation

It is a process where a plant can reproduce asexually, with the use of a vegetative part of the mother plant. This process can occur naturally and can also be done manually. Vegetative propagation results in the production of clones that are genetically identical to the parent plant and can be used to reproduce plants that are difficult or impossible to reproduce from seed.

Advantages

Unlike sexual propagation, only one parent is involved in this process.

It is faster means of propagation.

This method of propagation is beneficial to floriculturist, as they can raise various flower crops without the requirement of buying seeds.

The offspring produced are generally identical and thus more beneficial characteristics can be preserved.

Disadvantages

Extra labour and space are required to maintain the plants

Plants produced by vegetative means are more prone to diseases which are specific to the species of the plant.

METHODS OF VEGETATIVE PROPAGATION

There are a number of methods which are used for propagation of flower crops. Some commonly used methods in flowers are as under:

Cuttings

It is a process by which a plant is produced by taking a vegetative portion from the plant and rooting it in a favourable medium under optimum conditions. The plant parts used for cuttings are stems, leaves, roots and modified stems like tubers, corms, rhizomes, runners and bulbs. In general, propagation by cuttings is the most convenient method and hence, it is used popularly to raise new plant.

The propagation through cuttings depends upon the principle of rooting of cuttings.

The proper development of root and shoot system is essential in propagation through cuttings. In fact, regeneration of a plant part (cutting) into an entire plant structure basically depends on two fundamental properties of a plant cell. One is totipotency, which means the ability of an individual living plant cell to reconstitute all plant functions and the second is dedifferentiation, i.e. the capability of mature cells to return to a meristematic condition and develop into a new growing point. Therefore, for transformation of a plant part into a full-fledged plant, a plant propagator has to do some manipulations for inducing root and shoot system in the cuttings. In general, there is an existence of greater variability amongst plant species in the ability to root in their cuttings. In some of the flower species, cuttings root very easily as in coleus, bougainvillea, hibiscus, etc. However, in some of the species, rooting takes place only after suitable treatment and others do not root at all. Hence, it becomes mandatory to study the anatomical and physiological basis involved in the process of rooting of cuttings. Rooting of cuttings also depend upon the type of the cutting.

1. **Stem cuttings:** These are of various types: a) Soft wood or herbaceous cuttings, b) Semi hard wood cuttings, c) Hard wood cuttings, d) Terminal cuttings, e) Heel cuttings, f) Node cuttings.. The cuttings having few leaves at the top, root better than leafless cuttings.

   a) Soft wood or herbaceous cuttings: These are taken from below a node and the bottom leaves are removed. These may further be divided into two categories i.e. those taken from herbaceous plants such as carnation, chrysanthemum, coleus, dahlias, delphiniums, petunia, etc. and those taken from unripe tips of woody plants such as ornamental shrubs and trees. These are generally 2.5-10 cm long.

   b) Semi hard wood cuttings: The portions of stem which has passed the soft wood stage but are not yet mature are known as semi hard wood cuttings. These are used in propagation of jasmine and hydrangeas.

   c) Hard wood cuttings: The cuttings of shrubs and trees taken from mature current year's growth are known as hard wood cuttings. The length of cuttings varies with type of plant and weather conditions. Generally, the length of cutting is 15-20 cm.

   d) Terminal cuttings: These are obtained from the tip portion of the shoots. The lower leaves are removed by tearing off and only four terminal leaves are left in such cuttings e.g. carnation, chrysanthemum, etc.

   e) Heel cuttings: The lateral shoots which are pulled off from the stem and contain a portion of the stem are known as heel cuttings. These cuttings root easily and fast as compared to terminal cuttings.

   f) Node cuttings: These (single or multiple) cuttings are also obtained from the plants such as Dieffenbachia and Dracaena and are inserted horizontally in sand.

2. **Root cuttings:** A large number of plants are propagated through root cuttings. The plants which readily produce suckers can be propagated through root cuttings. These should be taken from young roots and length of the cuttings varies from 2.5-15 cm with one or few buds. In case of root cuttings, the phenomenon of polarity should be taken into consideration. The examples of herbaceous ornamental plants produced from root cuttings are Achillea, Anemone, Gypsophila, Gaillardia, Phlox, Salvia, etc. The woody plants produced by this method are Aralia, Campsis, Clerodendron, Rose, Wisteria, etc.

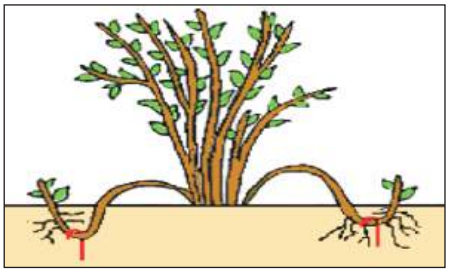
3. **Leaf cuttings:** Propagation through leaf cuttings is followed in plants such as Peperomia, Rex Begonia, Saintpaulia, Gloxinia, Bryophyllum, Kalanchoe, etc. In some plants viz., Peperomia and Saintpaulia, the leaf stalk is inserted in moist sand or compost with the leaf blade above.

LAYERING

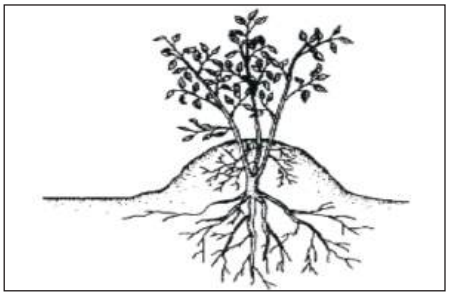
The method of inducing roots in a stem which is still attached to the plant and then detaching it after the root is formed for transplanting is known as layering. It is one of the oldest techniques used by the nurserymen to propagate many flower crops. After rooting, stem is detached from the parent plant and planted in the nursery to become a new plant, growing on its own roots. It is a reliable means of plant propagation and is adopted for species which are difficult or impossible to root from the cutting or large number of plants. Therefore, nurserymen use it only for difficult-to-root plant species.

Mostly shrubs, climbers and trees are raised by this method. There are different types of layering by which various plants are propagated.

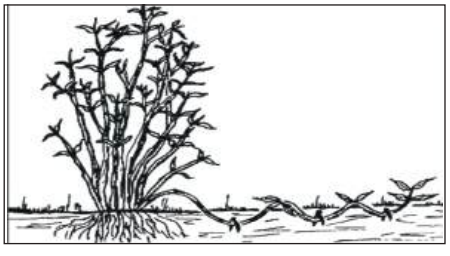
1. **Simple layering:** It requires just bending down a flexible branch to the ground and covering a portion of it with 6-12 cm deep soil at the back of the tip, leaving 10-30 cm of the tip above ground. The main aim of bending and holding in that position using heavy stone is to hinder sap flow at the bend to accelerate root formation. This method is adopted in various ornamentals e.g. jasmine, oleander, etc.



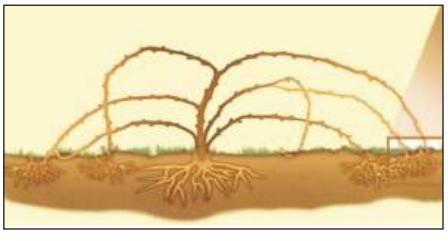
2. **Mound or stool layering:** Short stemmed or stiff branched shrubs which do not bend easily are raised by this method. Such plants are encouraged to produce many shoots from the ground level by cutting back the main stem the previous dormant season. Then the soil or other medium is mounded around the base of newly developed shoots. This treatment encourage root formation on the stem. This method is used in Deutzias, Cestrum, etc.



3. **Compound or serpentine layering:** In this method, the stem is covered at several points with soil, alternating with other points which are not covered. The stem is injured at the lower part and covered thereafter. The ornamented plants with flexible shoots like *Lonicera japonica* (Honey suckle) & wisteria etc. can be propagated by this method.

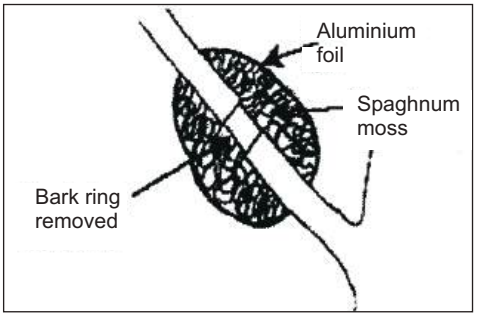


4. **Tip layering:** This is similar to simple layering where tip must remain above the ground whereas in tip layering, the tip is buried in the ground. Low growing trailing type of ornamentals in which rooting takes place in current year's growth are propagated by this method.



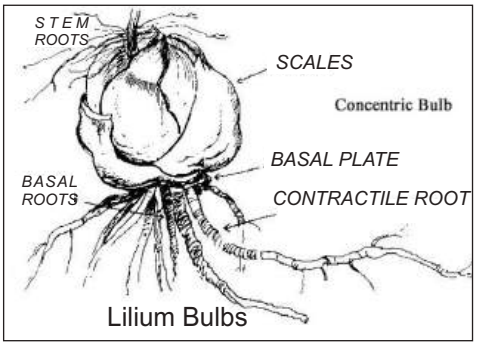
5. **Continuous layering:** In this method, a long branch close to the ground or stock plants having single stems only is used. The entire branch is placed horizontally and completely covered with soil except the tip. This is also known as trench layering. *Hydrangea arborescens*, Dianthus, Sedum and few other plants are raised through this method.

6. **Air layering:** The plants whose branches cannot be bent to ground level for layering are propagated by air layering. This is generally done on one year old shoot. The selected shoot is girdled in a band of about 3-4 cm. The girdling must be done below 20-30 cm from the tip. The girlded portion is covered with moist moss and tied tightly with transparent polythene sheet or aluminium foil. After rooting, the shoot is cut removed below the girdle. This is practiced in many ornamentals including climbers.



Bulbs

A true bulb consists of fleshy layers of scales that store food for the developing plant. In bulbs, the stem is reduced extremely to a disc around which fleshy leaf scales remain attached. These scales may be in continuous layer around axis or loosely arranged around the axis. The root development takes place from basal parts and new shoot arises from axils of the scales e.g. *Amaryllis*, *Tulip*, *Narcissus*, *Lily*, *Hyacinth*, etc. Outer scales can also be used for propagation in lilies after detaching it from bulbs.



Lilium Bulbs


Gladiolus Corm

Corms

It is an underground stem with short fleshy vertical axis covered with dry leaf bases. Vegetative buds are present over the surface. At the time of lifting the old corms get exhausted while the new corms are formed along with numerous cormels. Cormels will become flowering grade corms after 2-3 years depending upon size. Pieces of corms having growing buds can also be used for propagation. e.g. Gladiolus, *Crocus*, Freesia, etc.

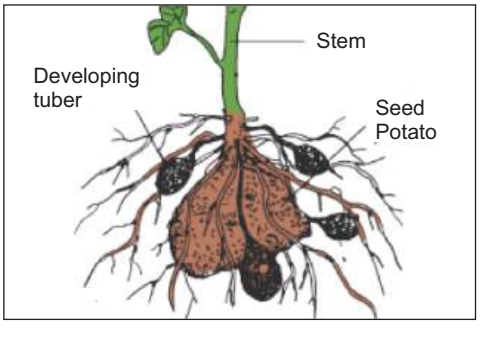
Rhizomes

The fleshy portion at the roots is called a rhizome, which is related to stem that grows horizontally. It is a sub-terranean stem that arises from the lateral buds from the main stem at ground level and extends underground in horizontal manner bears scaly leaves and axillary buds. *e.g. Iris*, Bamboo, *Canna*, etc.


Iris Rhizome

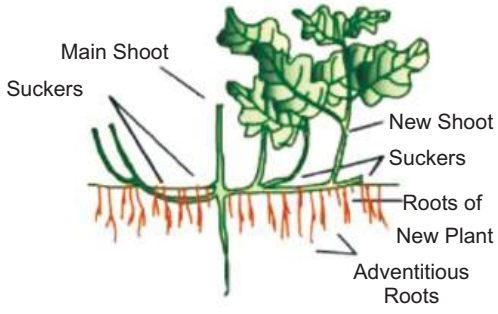
Tubers

These are the swollen underground stems modified for food storage bearing nodes and buds. It is similar to corms except for lateral orientation *e.g. Caladium*, etc. Some species of Begonia produce tubers but they do not reproduce naturally like potato tubers. Dahlia roots are not true tubers and cannot reproduce unless a portion of the stem is attached to it with present or adventitious buds.



Suckers

Some plants have the capacity to produce new stems from the adventitious buds formed on their roots. Such new growth is called sucker. These are produced from the base of the stem from below the ground level. These develop healthy root system and are carefully separated and transplanted. Trees like *Millingtonia hortensis* and *Holarrhena antidysenterica* and shrubs viz., Ixora and Jasminum produce root suckers.



Chrysanthemum (Guldaudi)

Stolon

A stolon is a slender branch which naturally produces roots and bears a bud at its extreme, thus forming a new plant. A stolon may be produced above ground or underground as in some ornamental grasses e.g. Chlorophytum

Bulbils

Lilies produce tiny buds or small bulbs in the axils of the leaves which when planted in the ground develop into bulbs. These structures are called bulbils. Some other plants such as the fern *Asplenium bulbiferum* and *Begonia evansiana* also produce similar structures for propagation.

Grafting

The operation of inserting one part of a plant in another in such a manner that a union takes place between the two parts is called grafting. The plant or the part of the plant on which the grafting is done is known as rootstock or stock and the part which is united with the stock is called scion. There are several methods of grafting which are employed for propagating fruit trees. Except budding, grafting is not widely used in ornamental horticulture. The grafting technique is based upon the principle of graft union.

Graft union

The basis of the successful graftage is graft union. In the process of grafting, the stock and scion are placed in close contact with each other and held together firmly, until they unite to form a composite plant.

The formation of graft union is basically a process of healing of wounds. In this process, the parts of graft that are originally prepared and placed in close contact to grow together. The union is accomplished entirely by cells that grow and develop after the actual grafting operation has been done. Further, in a graft union there is no intermingling of the cell contents of both stock and scion and cells maintain their own identity.

Formation of a graft union

The principal steps involved in the healing process and formation of the graft union are as under:

1. **Establishment of a direct contact between the cambial region of both stock and scion**

   Establishment of a direct contact between the cambial layers of both stock and scion is the foremost step in healing process of graftage i.e. the cambial layers of stock and scion must be matched closely so that the parenchymatous cells produced in this region can become interlocked. Mismatched cambial layers may prevent the formation of a successful graft union. Hence, it is essential that the two components of a graftage (stock and scion) must be tied firmly with wrapping material so that they do not dislodge. For this, both the stock and scion should be of same thickness, the cut should be smooth

and uniform on stock and scion to avoid any free passage between them. In this way, both stock and scion will match each other firmly and lead to the formation of a successful union.

2. Production and interlocking of parenchymatous cells

The living cells of both the stock and the scion are damaged by knife during the grafting operation, resulting in the formation of necrotic plate which separates the stock and scion from each other. However, under the damaged cells, some living cells also exist which initiate the formation of callus from the parenchymatous cells of phloem and xylem tissues. These cells mainly comprise of spongy tissue which penetrates the thin necrotic layer and soon fill up the gap between the stock and scion and become intimately interlocked. This interlocking of the cells provides a mechanical support to the graftage and also allows the passage of nutrients and water between the stock and scion. Initially, there is development of a brown line between the callus of stock and scion but it disappears gradually. Similarly, the old vascular tissue of both the components is sealed off with a deposit of gum and thereby, accelerates the healing process.

3. New cambial cells Production

In the callus bridge of the stock and scion, there are certain parenchymatous cells which differentiate into new cambial cells after 2-3 weeks of grafting. The development of these cells results in the formation of continuous cambial connections between the stock and scion. This is a good indication of formation of successful graftage.

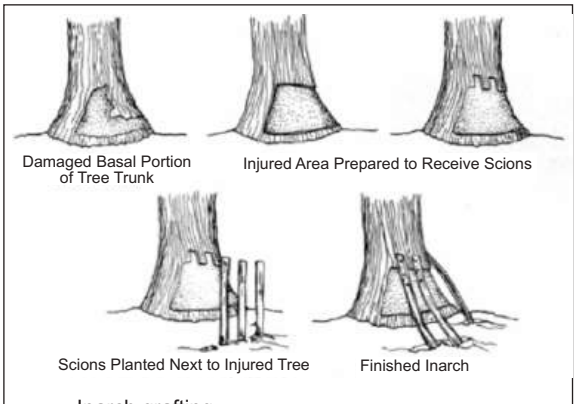
4. Formation of new vascular tissues

After the formation of continuous connection between the stock and scion through the callus bridge, new cambial activity results in the formation of new xylem towards inside and phloem outside the original vascular cambium of the stock and scion. The new xylem tissues generally originate from the activities of the scion tissues rather than from the stock. Hence, the production of new xylem and phloem tissues permits vascular connection between the stock and scion, continuing throughout the life of a grafted plant.

The types of grafting which are used in ornamental or flower crops are limited to inarching, side grafting, splice grafting, saddle grafting, flat grafting and cleft grafting.

1. Approach or inarch grafting

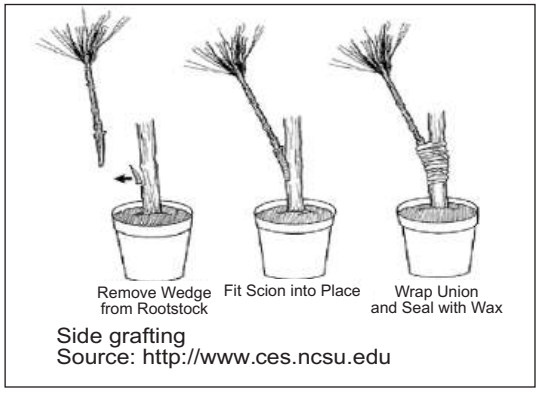
In case of approach grafting, two independent self-sustaining plants are grafted together and after succesful union the respective portions are detached. This method is followed in the propagation of roses in West Bengal and Bihar. Some other shrubs (*Allamanda violacea* is grafted on vigorous growing species of *A. cathartica* var. *schottii*) which do not grow well on their own root are inarched on cuttings of a vigorous species. Similarly, shrubs *(Petrea arborea* is grafted on *P. volubilis)* which are difficult to propagate by other methods are grafted on some easy-to-root varieties.



Inarch grafting
Source: http://www.ces.ncsu.edu

2. Side grafting

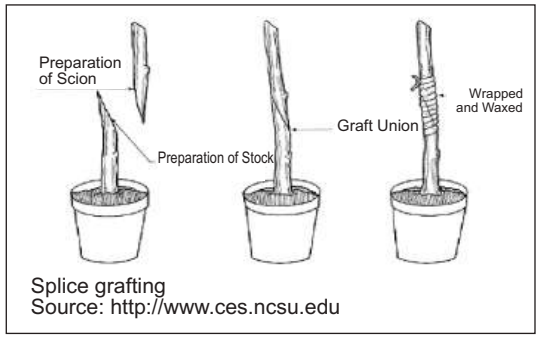
This method is followed in roses, camellias, etc. In this method a single oblique or angular cut is made with the help of a knife on one side of a branch, intended to be the stock. A slanting cut of 5-7 cm long is made into the scion wood having not more than 4-5 buds. Another slanting cut is also made on the opposite side to make the scion double-tapered. The cut in the stock is opened up by pressure and the double tapered scion is just inserted between the bark and cambium and as soon as pressure is released the scion tightens up.



Side grafting
Source: http://www.ces.ncsu.edu

3. Splice grafting

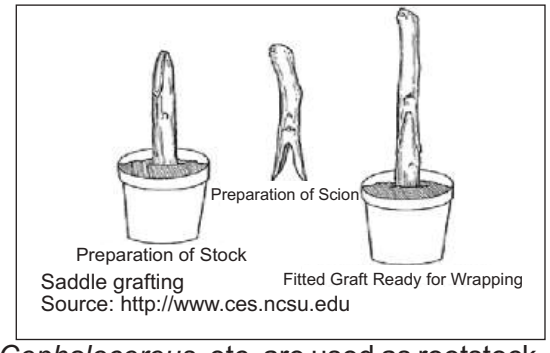
This method consists of putting a long slanting cut at the base of scion wood and a similar cut at the top of the stock. The two are united and tied with the help of polythene tapes. The stalk is cut close to the ground and the scion is obtained from a flowering wood.



Splice grafting
Source: http://www.ces.ncsu.edu

4. Saddle grafting

This method is used generally to propagate Rhododendron and lilac (*Syringa* sp.). In this, the stock is cut in the form of an inverted wedge with one side more slanting than the other. A similar cut in the reverse direction is inflicted on the scion and this is fitted over the inverted wedge of the stock. The jointed portion is tied with raffia or polythene tape.



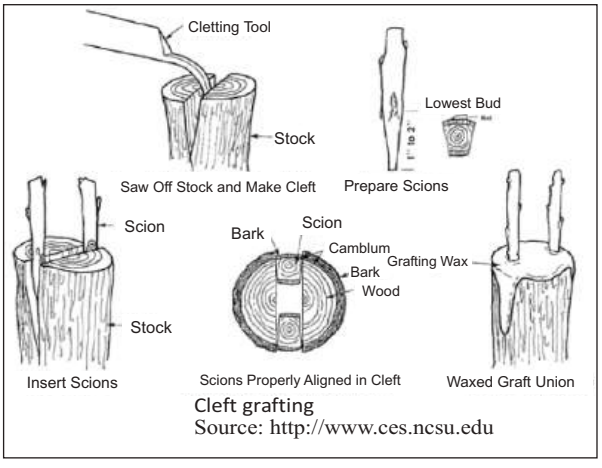
Saddle grafting
Source: http://www.ces.ncsu.edu

5. Flat grafting:

This method of grafting is suitable for cacti where *Cereus, Cephalocereus*, etc. are used as rootstock. Different species of *Mammillaria, Echinocactus* and *Gymnocalycium* which are usually globular-shaped are grafted in this manner.

6. Cleft grafting

This method is mainly used for grafting of fruit trees but in floriculture, mainly used for propagating cacti particularly having finger like stems. Plug grafting similar to cleft grafting also practiced in cacti.



Cleft grafting
Source: http://www.ces.ncsu.edu

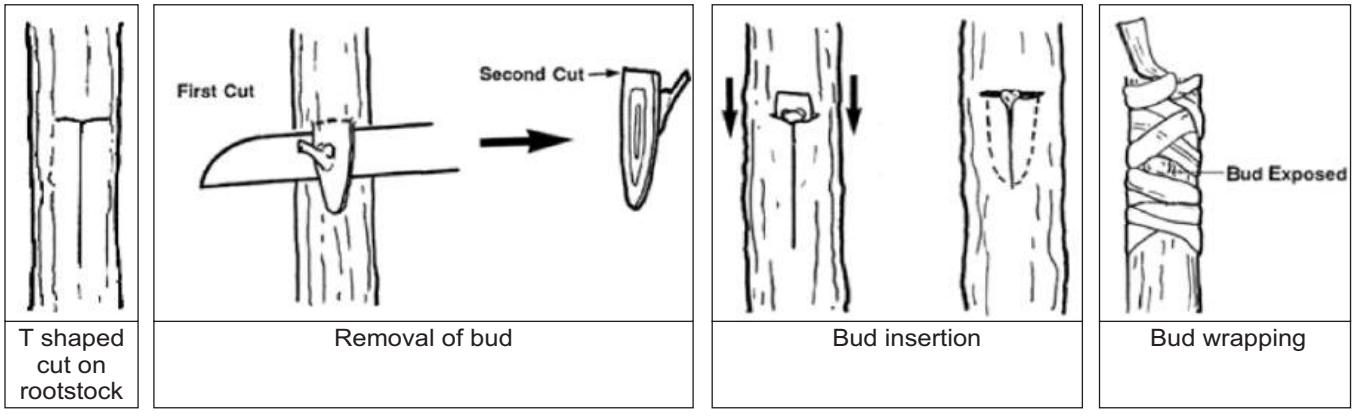
Budding

This is a form of grafting, the only difference is that instead of grafting a scion twig only a single bud is inserted in the stock. Some precautions should be taken while performing budding in flower crops. Select the right type of bud and perform the operation in the right season. In flower crops like rose, mostly **T or shield budding** is

employed for propagation. **Patch budding** is not generally used in India to propagate flower crops. However, there is possibility to use this method to multiply hibiscus hybrids which fail to grow on their own roots and to propagate some flowering trees which do not propagate by cutting or layering e.g. Gulmohar (*Delonix regia*). Patch budding is done in plants having thick barks.

Micropropagation/Tissue Culture

This method is practiced to multiply a plant at a rapid rate, to produce a large number of progeny plants using the modern plant culture methods in the laboratory. Such plants are free from all types of diseases and they are more healthy. The propagation of orchid through meristem culture was the first commercially successful venture in tissue culture. The ornamental plants in which potential for multiplication has demonstrated are Alstroemeria, Amaryllis, Narcissus, Chrysanthemum, Gerbera, Begonia, Dianthus, Pelargonium, Petunia, Antirrhinum Freesia, Gladiolus, Iris, etc.



T-Budding Source:http://www.ces.ncsu.edu

Main ornamental crops and plant parts used for their propagation

S.No.	Crop	Plant part for regeneration
1	Rose	Axillary buds
2	Marigold	Seeds and cuttings
3	Chrysanthemum	Terminal cuttings or suckers
4	Gladiolus	Corms and cormels
5	Dahlia	Tubers
6	Gerbera	Cuttings or suckers
7	Seasonal or annual flowers	Seeds
8	Trees	Seeds/cuttings
9	Shrubs	Seeds/cuttings
10	Climbers	Seeds/cuttings
11	Bougainvillea	Cuttings
12	Lilium	Bulbs
13	Ornamental and turf grasses	Rhizomes/runners/stolons
14	Tuberose	Bulbs
15	Foliage plants	Cuttings/ tissue culture

PRODUCTION TECHNOLOGY OF ORNAMENTAL CROPS

Annuals or Seasonal Flowers

Annuals are the plants which complete their life cycle in one season or one year. The annuals or seasonal flowers are propagated through seeds.

Raising of Nursery

Most of the flowering annuals are grown as transplants and seedlings are raised in the nursery beds. Healthy and vigorous seedling should be transplanted in a right manner at right time. Depending upon the requirement, nursery can also be raised in earthen or wooden pans or pots. Some of the seeds are sown directly in the beds e.g. Sweet pea, Nasturtium, Balsam etc. The medium for sowing of flower seeds may consist of 1 part of soil (light textured), 1 part of leaf mould or burnt rice husk and1 part of farm yard manure (well rotten).

Seed sowing: Upper 2-3 cm of nursery bed must be incorporated with the above media and properly leveled after drenching. Flowers seeds are sown on the surface and covered lightly with the above media. Beds are kept moist by sprinkling water as and when required. Seedlings of most flowers become ready for transplanting between 18-21 days of sowing.

Preparation of beds and manuring: Preparation of the flower beds must start at least 15 to 20 days prior to transplanting. Beds must be dug deep enough to expose the soil for 15 days to sunlight. Well rotten farm yard manure at the rate of 5 kg per square meter along with 30g Calcium Ammonium Nitrate, 45g of super phosphate and 30g Murate of potash should be thoroughly incorporated in the upper 10-15 cm soil of the beds at least 7 days before transplanting. A light irrigation before transplanting the crop should be given for proper setting of the seedlings. Beds are leveled properly for uniform application of water. Carefully removed seedlings are firmly set into beds at particular distance. After completion of transplanting, which should be done in the late afternoon, a light irrigation is also given afterwards. A light irrigation is also given next day. Established seedlings start growing in a week's time and young plants require regular supply of nitrogenous fertilizer.

Potting medium: The medium consists of garden soil-2 parts, well rotten farmyard manure-l part, leaf mould or burnt rice husk-l part. Add 30g Calcium Ammonium Nitrate, 45g Super Phosphate and 30g of Murate of Potash per cubic meter of soil should be used for growing annuals in the pots.

Diseases and pests: Most commonly observed diseases on the flowering annuals are Alternaria blight, Botrytis blight and powdery mildew. Alternaria and Botrytis blights can be controlled by spray of 0.1% captan, whereas, powdery mildew is controlled by spraying of 0.2% kerathane.

Insects/pests: Common insects causing damage to the flowering annuals are aphids, thrips, mites, leaf minor and green caterpillar. Follow preventive sprays of rogor at the rate of 2ml/*l* of water which is helpful in keeping plants free of the insects.

TREES, CLIMBERS AND SHRUBS

Trees

Trees are propagated through **seeds (***Delonlx regia, Cassia fistula, Callistemon lanceolatus, etc.*), **cuttings (***Populus sp., Plumaria sp., Ficus sp*. etc.) and **air layering (***Magnolia grandiflora and Ficus elastica*).

Preparation of pits and planting of trees: Pits should be dug of 90 x 90 x 90 cm size. Soil should be mixed with 10-12 kg well rotten farm yard manure, 20-25g bone meal and chlorpyrephos @ 4-5 ml// in 10 litres of water per pit (against termites). Refilling of the pits should be done after exposing the soil for 2-3 days, followed by immediate watering to settle down the soil. The planting of trees is done in the centre of pit and staking is done to keep the plants erect. If required, the tree guards are fixed to protect the trees from the damage. During initial phases of growth, staking is done to keep the plants erect and to develop strong framework to protect them from strong wind and animals.

Shrubs

Any garden soil is suitable for growing shrubs. If the soil texture is not good, it should be improved by refilling with fertile and well-drained soil. If the soil is highly alkaline or acidic in nature, it should be reclaimed by using soil amendments. The shrubs, which can tolerate high pH of soil, are *Bougainvillea spp., Thevetia peruviana, Russelia juncea, Nerium indicum* and *Caesalpinia pulcherrima.* Salt sensitive shrubs are *Buddleia asiatica, Lagerstroemia indica, Barleria cristata* and *Hamelia patens.*

Shrubs are propagated through seeds (*Stenolobium stans, Thevitia peruviana, Caesalpinia pulcherrima, Calliandra sp.*, etc.). Seeds are collected when they are fully ripe, dried in the shade and stored in airtight bottles. These are sown in the month of June and the seedlings are transplanted in rainy season in the polythene bags. These shrubs are also propagated through **cuttings** (*Malvaviscus arboreus, Jasminum sambac, Hamelia patens, Bougainvillea, Cestrum diurnum, Cestrum nocturnum,* etc.). The best season for propagation by cuttings is rainy season. The cuttings can also be made in Feb-March, if water supply is available. The cuttings are made 15-20cm long and planted in sand beds. The plants raised from cutting develop roots within 4-6 weeks and are transplanted in the poly bags. The cuttings of winter deciduous shrubs like *Lagerstroemia indica* and *Lawsonia inermis* are made in the months of December-January.

The shrubs like *Bougainvillea, Ixora sp., Jasminum sambac* and *J. multiforum (*ground layering), etc. are propagated by layering. Layering is done by removing the bark (2.5-3.0 cm) and wrapping by sphagnum moss during rainy season.

Soil preparation and planting: Soil should be prepared thoroughly at least 15 days prior to planting. Prepare the pits of 60 x 60 x 60 cm size and expose the soil to the sun for at least 2 weeks. Refill the pits with the mixture of soil and farmyard manure (8-10 kg). Fill the pits 10-15 cm higher than the general level of the field to avoid the formation of a depression after the first irrigation. Chlorpyrephos @ 4-5 ml/l in 10 l of water per pit should also be mixed with the soil to prevent the damage by termites. The best planting season of shrubs is rainy season. Planting can also be done successfully in the month of February-March depending upon the water availability during summer months.

Climbers

The climbers thrive well in any garden soil. The soil should be fertile, deep and good in water holding capacity and water drainage should be proper. The pits measuring 60 x 60 x 60 cm should be dug for planting the climber and refilled with soil mixture comprising of 10-15 kg of well rotten farmyard manure. The pits should be drenched with chlorpyrephos @ 4-5 ml/l in 10 litres of water. The main planting season for evergreen climbers is July-August and February-March, whereas, winter deciduous climbers are planted during January-February. Regular watering should be done and proper support is provided at the time of planting. Training is necessary in first year to have the desired shape. After planting the climbers, regular watering, weeding and hoeing should be done. Pruning of climbers is essential during subsequent years for

desired shape. General pruning consists of removal of dead wood and excessive growth. Heavy climbers need heavy pruning, whereas, light climbers require light pruning. Care should be taken to keep the climbers healthy and free from insect-pests or diseases.

Ornamental Bulbous Plants

The most important prerequisite for growing bulbs is to have a proper drainage. If good drainage is assured, it is not very difficult to grow bulbs in any type of soil. **Sites for bulbs:** The bulbs can be planted in ground at many places. The advantages of growing bulbs in a natural way as these can be left in the ground for several years to flower there without lifting, dividing and replanting them, provided sufficient spacing is allowed initially. The bulbs are grown in borders and beds in a formal or informal style, shrubbery as a ground cover and for beauty, under spreading trees, etc. **Panting time:** It varies with type of bulb and the climate of the place. In Bangalore, these are planted during June and October-November. However, in Delhi, these are planted in the middle of September or by mid October. In hills, bulbs are planted in February when chances of frost are over. **Planting:** The ground should be thoroughly prepared and well rotted farm yard manure at the rate of 2-4 kg per sq. m. The depth of planting varies with type of bulbs and to some extent on the nature of soil. In general rule, the bulbs are planted at about twice or thrice their own depth. Dormant bulbs should never be planted as they may rot in the ground. Before planting, bulbs should be treated with fungicide solution. **Cultural hints:** Watering should be sparse till the bulbs sprout. Nitrogen at the rate of 5-15g, phosphate at 20-40g and potash at 20-40g per square meter are found beneficial. Half of nitrogen should be applied as basal dose and other half before the appearance of flower buds. **Lifting and storing:** A bulb has three phases in its life such as resting period, the growing period and flowering season. The bulb should be lifted when foliage turns yellow. After lifting and before storing, bulbs should be treated with fungicides. Both damp and dry storage conditions are not congenial for storing bulbs like gladiolus, dahlia and caladium.

ACTIVITY/EXERCISE

1. Procure some corms of gladiolus and seeds of marigold. Grow them in different pots/small beds. Then, see their growth pattern and write your experience.

CHECK YOUR PROGRESS

A} Subjective Questions

1. Differentiate between sexual and asexual methods of propagations. What are their advantages and disadvantages?
2. Enlist different methods of vegetative propagation and give one example of each where these can be employed?
3. Explain in detail the production technology of annual crops.

B} Objective Questions

a) Fill in the blanks

I. Marigold is propagated through———————————————.

II. Rose is commercially propagated through———————————————-

III. Patch budding is a propagation method of a ———————— tree.

IV. Dahlia is propagating by ——————————————cuttings.

V. ——————————— sp. is propagating by mound or stool layering.

b) Multiple choice questions

i. Which of the following flower crops are propagated through seed

a) Chrysanthemum b) Rose

c) Tuberose d) None of above

ii. Rhododendron is propagated through

a) Saddle grafting b) Inarch grafting

c) T-budding d) All of the above

iii. Flat grafting is most commonly used for propagation of

a) Bulbous plants b) Trees

c) Cacti and succulents d) Both a & c

iv. Which of the following is a summer annual

a) Salvia b) Sweet Pea

c) Kochia d) Sweet alyssum

v. *Magnolia grandiflora* is propagated through

a) Seeds b) Cutting

c) Air layering d) All of above

c) Write true (T) or false (F) for the following statements

I. The underground storage organ of gladiolus is known as tuber.

II. *Cestrum nocturnum* is raised through continuous layering.

III. The bulbous plants like canna and iris have rhizomes.

IV. Chrysanthemum produces stolons throughout the year.

V. Narcissus produces the small structures called bulbils.

SUGGESTED FURTHER READINGS

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iii. Hartman H. T., and Kester D. E., (2002). Plant propagation: principles and practices. Prentice Hall, Inc. Kate Kinsella.

Chapter 7

Commercial Seed Production in Flower Crops

OBJECTIVES

After studying this chapter, students will be able to:

know about the F_1 hybrids and brief history of hybrid seed production

understand the advantages of F_1 hybrids

know the essential requirements of seed production

know hybrid seed production in important annual flowers (marigold, petunia, pansy and antirrhinum)

INTRODUCTION

In previous chapter, you have studied about principles of propagation and production technology of ornamental crops. Now, you might be well equipped with all the technologies explained in that chapter. In this chapter, you will be studying the hybrid seed production of marigold**,** petunia, pansy and antirrhinum flower crops.

The Commercial F_1 hybrid and open pollinated flower seed production is considered a profitable venture and, hence, it is popular amongst farmers on large scale. Earlier, seed production was being done on limited scale in Sri Nagar and plains of North India and in other localities due to limited demand. Mr. Man Mohan Attawar of M/s Indo American Hybrid Seeds, (India) Pvt. Ltd., Bangalore has started producing F_1 hybrid seeds of Petunia for 100% export during mid sixties. However, production of seeds of open pollinated flower crops was revolutionized by Mr. Avtar Singh, M/s Beauscape Farms, Sangrur, Punjab who started flower seed production involving farmers on large scale. At present in India, the area under flower seed production is about 1000-1300 ha. The main areas of flower production in India are: Punjab (Sangrur, Patiala,Ludhiana); Haryana (Panipat, Sirsa); Karnatka (Banglore Rani Banur); Himachal Pradesh (Kullu Valley) ; J & K(Sri Nagar Valley); and West Bengal (Kalimpong). The cost of seed production per ha varies from Rs.10,000 to 15,000 and generate a net profit of Rs.25,000 to 75,000.

CLIMATIC REQUIREMENT FOR SEED PRODUCTION

Seasonal flowers are divided into three seasons-summer, rainy and winter. Summer and rainy seasonals in India are available in limited number whereas, winter annuals are available in large range of colours and height and bring riot of colours in the garden and, hence, very popular amongst gardener. Thus, from seed production view point also, winter annuals cover large area. Ideal climatic condition for seed production is long duration of cool and dry season which helps in good seed setting of bold size. Excessive hot and dry season hampers seed setting of summer annuals in north Indian plains. Excessive rain at the time of flowering washes away pollen grains resulting in poor seed set.

According to climatic requirements, the production of flower seed is divided in following climatic zones.

1. **Mild climate** (Kasshmir Valley, Kullu Valley, etc.) –Delphinium, Giant Pansy, Zinnia, etc.

2. **Sub- Tropical area**- Antirrhinum, Anchusa, Ageratum, Calendula, Brachycome, Lineria, California poppy, Candytuft, Carnation, Dianthus, Daisy, Dimorphotheca, Nasturtium, Petunia, Portulaca, etc.

3. **Tropical**-Marigold, Salvia, Ipomoea, etc.

MODE OF POLLINATION

For commercial seed production of flowers, it is necessary to know whether the flower crop is self, often cross or cross pollinated. To find out whether a particular flower is self or cross pollinated, very simple method of bagging or growing in complete isolation may be followed. A number of plants are grown in flower beds and when flowers are about to open some of them may be covered with muslin bags and tied properly at the base so that no insect can enter. If the plants or flowers which were covered with muslin bags produce seeds, then it is obvious that variety or species is self pollinated. If the bagged flowers do not produce seeds, it is an indication that flowers have to be hand pollinated. Sometime this is not true of certain species or varieties.

For production of pure seeds numerous devices are adopted for cross pollination. Most common method is to grow them in isolation. This means to grow two species/variety or strain of the same species at certain distance from one another.

Mode of pollination in few flower crops

Self Pollinated crops crops	Often Cross Pollinated crops	Cross Pollinated
Balsam	Antirrhinum	Alyssum
Clianthus	Aster	Arctotis
Lupin	Dahlia	Calendula
Sweet Pea	Salvia	Cineraria
	Wallflower	Gazania
	Linum	Stock
	Linaria	Zininia

TYPES OF FLOWER SEEDS

In the market different types of seeds are marketed depending upon the derivation of seeds. They are:

(i) Open pollinated variety

In India, more than 90% seed of open pollinated type is produced and exported. These are true breeding cultivars and can be used for all genetic improvement. However, among the flower crops, these are used for landscape design for main effects and creating colour patterns. These represent true self pollinated lines which produce genetically and phenotypically uniform plants, uniform colour and of equal size. The seed of often or cross pollinated type is produced by providing proper isolation distance to avoid threat of foreign pollen grains.

(ii) F_1 hybrid

The F_1 hybrid seeds are very popular amongst many flowers due to superior in plant vigour, earliness, increased flower size, and numbers of flowers. These are produced by crossing two inbred

lines/variety. Various method are adopted like hand pollination by following the procedure of emasculation and pollination or by use of male sterility. In petunia or pansy, emasculation and pollination method is used whereas in marigold, zinnia, male sterile system is used for producing hybrids. Upon selfing, these do not breed true to type and produce mixture of progeny due to genetic segregation and recombination.

(iii) F_2 seed

In some of flower crops like pansy, Antirrhinum, F_2 seeds are also very common in trade due to wide variation in flower colours, but flower size may be little reduced. It results from self fertilization of F_1hybrids.

(iv) Mixture

In flower seed trade, mixture of seed is sold by blending the seed of different colour in certain proportion so that field looks more colorful. It has been observed that in many flowers, certain flower colour tend to produce more seeds than others do. Therefore, such mixtures are preferred.

SEED PRODUCTION TECHNIQUES

Soil

For successful seed production, soil should be preferably loam. Other soils like sandy loam to clay are also good. The soil should be well fertile and free from water stagnation and have 6.5-7.5 pH. Since most the crops have tendency to shatter the seed in the field and hence, the same crop may not be selected to grown year after year to avoid contamination.

Raising of seedlings: Indirect sowing

Generally seeds of annuals are sown in controlled space for better handling owing to small size of seed. In general, 10-15 cm raised nursery seeds of 1m width and 2-3m long are prepared. The soil should be well prepared by mixing 10-15 kg/m^2 well rotten farm yard manure. To check the soil borne diseases in nursery, soil should be drenched with 0.2% bavistein or soil can be sterilized by drench with 2% formaline and covering with polythene. For better handling of small seeds, these are mixed with bulk material like sand or ash. Seeds are sown by hand in line 5-6 cm apart and 0.5 cm deep. The depth can be increased with the increase in size of seed. After sowing, seeds are covered with well sieved mixture of farm yard manure and soil. Watering should be done twice or thrice a day or use sprinkler system. The seeds are covered with newspapers or straw to create darkness which helps in better germination. The seeds start germination within 2-3 days and then covering is removed. It takes about 21 days to grow the seedling sufficiently and are ready for transplanting when seedlings have 3-4 true leaves. For raising one acre nursery 8-10 beds of 5x1 m are required. The seed rate of various flower crops is as follows: Marigold (African) -400-500 g, Petunia-200 g; Island Poppy-150 g; Oenothera-2000 g; Nempphylla-500g; *Eschscholtzia californica*-200 g; *Bellis perernins*-100 g.

Direct sowing

Many flowers like nasturtium, etc. are sown directly. For this 15-20 cm wide ridges are prepared by manually or using tractors. Three to 4 seeds are sown directly by hand at 15-20 cm apart. After complete sowing, light watering is done. Seeds start germinating after 4-5 days.

Land preparation and transplantation

Before laying out the field, the land should be well prepared by ploughing by harrowing and mixing 15-20 tone well rotten farm yard manure per acre. In general 50 kg urea, 250 kg of single super phosphate and 60 kg of Murate of potash should be well incorporated in the soil. The application of remaining 100 kg area should be applied in to two equal splits i.e. one and two months of transplanting of seedlings. It is advised that before transplanting light irrigation should be applied which helps in better establishment of seedlings. The distance for tall annuals like helichrysum; delphinium; gaillardia is kept 60x45 cm, whereas for medium annuals, (petunia, verbena, phlox, eschscholtzia, etc.) 45 x 45 cm and for dwarf annuals (pansy, Mesembryanthemum, alyssym, daisy) 25x 25 cm is kept. The seedling should be transplanted in cool hours of evening and should be watered lightly immediately.

Isolation requirement

For the production of genetically pure seeds, crop should be isolated with other varieties of same crop.

Isolation distance for flower crops

Self Pollinated	Often Cross Pollinated	Cross Pollinated
No distance	50-100 m	1000 m

Management of annuals

Annuals or seasonal flowers are quite tender and require proper attention throughout their life. Regular water supply is essential for successful raising which should be done according to the requirement of the crop. Sufficient moisture is required till harvesting of seed is done. Frequency of irrigation depends upon season and soil type. In rainy season generally irrigation is not required except during dry spell. During winter season, irrigation is required at 10-12 days whereas during summer season, it should be done at 4-5 days. Regular weeding and hoeing is essential for the development of seedling in to health plants.

Roguing

Seed producer should have detective eye to observe off type or improved type in the field. They should keep constant vigilance from the beginning of the crop to the maturity. Remove and destroy the off types whereas if any plant exhibits superior trait in terms of vigour earliness, colour, or size of flower, etc., the seed of such plant should be preserved for further testing and utilization.

Insects, pests and diseases

The annuals are commonly attacked by *Heliothis* sp, aphids, leaf miner, etc. Protective control measure should be taken well in advance to avoid any considerable loss. Aphids commonly attack alyssum, stock, calendula, etc. Spraying of 3- EC metasystox @ 1.2ml/l/acre is effective to control it. Seed dressing with Bavistein (1 g/kg) or captan (3 g/kg) or drenching the infected nursery beds with 0.2% Brassicol or Bavistan (0.1%) is quite effective.

Seed harvesting and storage

Pods are harvested individually before the splitting occurs. Whereas, in many cases to save labour single harvesting with sickle is done at the cost of seed yield *e.g.* nasturtium, ice plant, Coreopsis, Verbena, Phlox, Oenonenthra, Clarkia, etc. The harvested seeds are spread over the tarpaulin under shade or in ventilated room for week but reshuffled daily.

The stage of seed collection of different flowers

S.No.	Plant	Stage of seed
1.	*Alyssum maritimum* (Sweet Alyssum)	The seeds shatter easily. Remove pods when just about to dry.
2.	*Antirrhinum majus* (Snapdragon)	Cut when just about to dry. Spike/ lower branches are harvested first.
3.	*Calendula officinalis* (Pot marigold)	Seeds shatter when too dry. Collect heads when partially dry.
4.	*Celosia argentia var. Cristala* (Cock's Comb)	Collect the heads when dry on the plant. Protect drying heads from rains.
5.	*Chrysanthemum coronarium* (Annual chrysanthemum)	Cut when almost all the flower heads dry.
6.	*Dahlia variabilis* (Dahlia)	Collect heads of flowers as they dry. Take out tubers when plant almost dry. Store in fry and cool place.
7.	*Delphinium consolida* (Larkspur)	Cut the whole plant when the lower capsules begin to dry and dry in shade.
8.	*Gaillardia pulchella* (Blanket flower)	Cut the entire plant when the maximum amount of seed is mature and dry on canvas.
9.	*Gazania splendens* (Treasure flower)	Cut the entire plant when the maximum amount of seed is mature and dry on canvas.
10.	*Gompherena globosa*	When the heads dry, collect individually.
11.	*Gypsophilla elegans*	When the majority of capsules have turned brown, cut whole plant and dry on canvas.
12.	*Helichrysum bracteatum*	When the heads become fuzzy, collect individually.
13.	*Impatiens balsamina*	Cut pods burst at the slightest touch. Collect individually when turning brown. Place in a box the half matured seeds to dry.
14.	*Kochia scoparia*	Cut the entire plant when the maximum amount of seed is mature and dry on canvas.
15.	*Mathiola incana* (Stock)	Remove the plant when seed pods begin drying. Dry in sun or shade. Single flower seeds produce 50% or more double flowering plants.
16.	*Mesembryanthemum crinifolium*	Whole plant should be harvested and seed should be extracted.
17.	*Papaver roheas* (Poppy)	Remove seed pods when just about to open after drying.
18.	*Petunia hybrida*	Remove seed pods as they begin drying. Double flowers require hand pollination.
19.	*Phlox drummondii*	Remove seeds when just about to dry to prevent shattering.

The seeds are cleaned and sieved with different types of seed machine and seeds are finally cleaned by hand winnowing or using table fan to separate light seeds. The average yield per acre and number of seeds per gram of commonly grown annuals are given in following table.

Seed yield of annual flowers and approximate number of seeds per gram

Name	kg/acre	No. of seeds/g
Alyssum maritimum (Dwarf white)	70-80	350
Antirrhinum majus (Tall)	120-130	8000
Antirrhinum majus (Dwarf)	60-70	8000
Calendula officinalis (Pacifica mixed)	400-425	140
Callistephus chinenesis (Ostrich Plume)	100-110	568
Celosia plumosa (Tall)	150-160	1600
Celosia plumosa (dwarf to medium)	40-50	1900
Chrysanthemum paludosum	80-90	1800
Chrysanthemum multicaule	100-110	600
Delphinium consolida	250-260	450
Eschscholtzia californica	250-270	850
Gaillardia pulchella	150-200	535
Gompherena globosa (Tall)	150-160	359
Gompherena globosa (Dwarf)	30-40	359
Helichrysum bracteatum (Tall)	150-160	1560
Helichrysum bracteatum (Dwarf)	30-40	1560
Helianthus annus (Sun bruster type)	250-260	25
Impatiens balsamina	300-320	170
Mesembryanthemum crinifolium	150-160	6600
Papaver rhoeas	100-110	4563
Pansy- viola type	250-260	800
Petunia hybrida (Open pollinated)	60-70	11,000
Phlox drummondii	120-140	677
Tagetes erecta	80-100	350
Verbena hybrida (Ideal floristmix)	120-130	673

HYBRID SEED PRODUCTION IN IMPORTANT ANNUAL FLOWERS

The first flowers to be used for F_1 hybrid seed production were those in which parental lines and cultivars were homozygous or could be easily selfed and also gave large number of seeds from small number of hand pollinations. F_1 hybrids in ornamentals crops were known even before Shull in 1911 when he

propounded the classical theory of hybrid vigour in plant breeding for the first time. Way back in 1909, F_1 hybrid variety 'Prima Donna' in begonia (*Begonia semperflorens* Link et Otto) was released by Benary Seed Company in Germany. It was during World War II, in 1942, that Japan produced the first commercial F_1 hybrids in *Petunia.* From 1950 onwards, F_1 hybrids were produced in flower crops like *Ageratum, Anemone, Gerbera, Primula, Petunia, Tagetes*, *Cyclamen,* pansies, *Begonia, Geranium, Portulaca, Dianthus*, balsam, stock, wall flower, *Gazania,* hollyhock, *Calceolaria* and *Zinnia* by several seed companies in the USA, China, Japan, The Netherlands, Denmark, Germany, United kingdom and Israel.

Advantages of F_1 hybrids

Enhanced vigour and uniformity

Dwarf and compact plants

Abundant basal branching

Profuse free flowering

Earliness

Enhanced blooming season

Doubleness

Large sized flowers

Novelty in flower colour and shapes

Tolerance/ resistance to biotic and abiotic stresses

Methods of making the cross

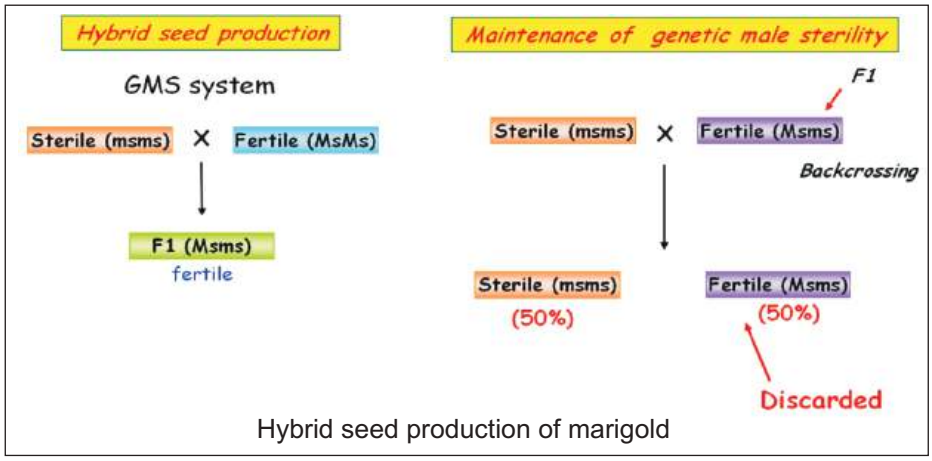
There must be some way to control pollination so that only the desired cross is obtained and selfing of the seed parent is eliminated. The method must be economically feasible. Various possibilities are as follows:

1. Hand emasculation and hand pollination
2. Hand emasculation and natural pollination
3. Hand emasculation of male plants
4. Genic male sterility as in marigold, *Zinnia*, *Ageratum* and *Calceolaria*
5. Cytoplasmic male sterility as in *Petunia*
6. Self-incompatibility as in *Petunia*, pansy, stocks and kale
7. Chemical emasculation- selective elimination of pollen production, that is, use of gameticides
8. Use of marker genes to identify the selfs so that they can be eliminated as seedlings

MARIGOLD

In marigold, genetic male sterility is being used for hybrid seed production. There are two types of male sterility involved in F_1 hybrid production of marigold, i.e. apetalous form (with no stamen) and true double form (produces no anther in the disc florets). Recently, United States has produced F_1 hybrid marigold,

mainly in open fields in California through insect pollination using these systems. However, apetalous types of male sterility have a greater reliability which is being used in Britain and is pollinated manually. The seeds of male sterile plants are produced by pollinating male sterile line heterozygous male fertile. The seeds give rise to 50% male sterile plants and 50% heterozygous male fertile plants. Such type of male fertile plants is rouged out from hybrid block as soon as possible before flowering on the basis of morphological markers. Although, ratio of male sterile line to male fertile line is dependent on the size of hybrid block, but a ratio of 3:1 (male sterile: male fertile) has proved to be optimum. Some of the important F_1 hybrids of marigold in African type are F_1 Gold Coin Series, F_1 Climax Series, Space Age Series, Galore Series, etc. while Tetraploid hybrid belongs to French marigold group. There are some interspecific hybrids also like Red and Gold hybrids, Nugget, Red Seven Star etc.



Hybrid seed production of marigold

PETUNIA

Although, gametophyte type of self-incompatibility is available in petunia, but commercial production of F1 hybrids is carried out by hand pollination rather than by insect. In fact, this is economic as single pollination gives about hundred seeds. Without emasculation, plants of one inbred line are pollinated by pollen collected from another line which carries a different S allele and *vice versa*. By this way, both the inbred lines are used as male as well as female parent and more quantity of seeds can be obtained.

Hand-emasculation in bud stage and hand-pollination is another way to produce F_1 hybrid by crossing two inbred lines. To economise, rapid emasculation and pollination are carried out at rate of at least 6 buds per minute, which give more than 1000 seeds. Some important F_1 hybrids in different groups are given below.

Single Grandiflora- Apple Blossom, Flamboyant, Pink Cascade, Red Cascade, Pink Show etc.

Single Multiflora- Commanche, Orange Bells, Coral Bells, Satellite, Polaris, Lollipop etc.

All Double Grandiflora- Blue Danube, Sonata, Allegro, Nocturne etc.

All Double Multiflora- Cherry Tart, Apricot Tart, Grape Tart, Apple Tart etc.

PANSY

Since, self-incompatibility exists in pansy, the hybrids are produced without emasculation. Like petunia, in pansy also F_1 seeds are obtained from the both the parents used.

ANTIRRHINUM

In 1953, first F_1 hybrid of antirrhinum was developed which was exclusively for greenhouse forcing. The outdoor types tall strong Rocket varieties were introduced only in 1960, which were developed through heterosis breeding. Since then, a number of F_1 hybrid varieties showing different growing habits have been developed. F_1 hybrids of double type have also been developed.

Recently, new development in flower forms has been carried out as a result of recombination of Peloric Julieva antirrhinum and strong normal flowered varieties which have been given the name "Bright Butterflies". Although, apetalous type of pollen sterility with thicker, fasciated pistil is available in genetic stock, but it has proved to be useless. Thus, hand emasculation and hand-pollination is used for F_1 hybrid production. Though, limited use of single gene pollen-sterile, either in segregating pollen- fertile, pollen-sterile population or in vegetatively multiplied clone has also been made.

ACTIVITY/EXERCISE

1. Identify the pollination behaviour of flower crops.

2. Perform hybrid seed production procedure in marigold

CHECK YOUR PROGRESS

A} Subjective Questions

1. Explain in brief the hybrid seed production in marigold and antirrhinum?
2. Explain in brief the seed production techniques of flower crops?
3. What are different advantages of F_1 hybrids in flower crops?

B} Objective Questions

a) Fill in the blanks

i. F_1 hybrid seed of petunia was first produced by————————————Pvt.Ltd.

ii. Three examples of self pollinated seasonal flowers are————,————— and ———.

iii. The pH of soil for seed production should be————————————.

iv. For seed production of often pollinated flower crops,————————m isolation distance is kept.

v. The open pollinated seed production of flower crops was revolutionized by————————.

b) Multiple choice questions

i. Which of the following has genetic male sterility

a) Marigold b) Zinnia

c) Ageratum d) All of above

ii. Which of the following has self incompatibility

a) Petunia b) Pansy

c) Both a and b d) None of above

iii. The first F1 hybrid of antirrhinum was developed during

a) 1953 b) 1975

c) 1997 d) None of above

iv. Apple Blossom is a variety of

a) Marigold b) Sweet alyssum

c) Petunia d) Pansy

v. Which of the following is an often cross pollinated flower crop

a) Antirrhinum b) Aster

c) Dahlia d) All of above

c) Write true (T) or false (F) for the following statements

i. No isolation distance is kept for pure seed production of cross pollinated flower crops.

ii. The seed yield of *Tagetes erecta* is 80-100 kg/acre.

iii. For hybrid production, a ratio of male sterile to male fertile is kept as 3:1.

iv. Prima Dona is a variety of petunia which was released by Benary Seed Company..

v. The number of seeds of petunia per gram is 11,000.

SUGGESTED FURTHER READINGS

i. Arora J. S., (1998). Introductory Ornamental Horticulture. Kalyani Publishers Pvt. Ltd., W. Bengal.

ii. Randhawa G. S, and Mukhopadhyay A. (2007). Floriculture in India. Allied Publishers Pvt. Ltd., New Delhi.

Chapter 8

Nutrition for Floricultural Crops

OBJECTIVES

After studying this unit, you will be able to:

To learn about elements, concentration and their role in plant metabolism

To know the Fertilizer recommendations for various flower crops

To find out the different deficiency symptoms and nutritional disorders in flower crops

Balanced nutrition is essential for the growth, development and flowering of crops. All the elements play an important role both in the vegetative and reproductive growth, and are indispensable for production of flower crops. In previous chapter, you have learned about seed production in flowers whereas in this chapter you will come to know about essential nutrients that are responsible for the proper growth. There may be certain questions arising in your mind. Why does plant need nutrients? How many nutrients are required for the growth and development of the crop? What are their functions and effects on plant growth and development? What will happen if there is occurrence of nutrient deficiency? How will we identify the deficiency symptoms of a particular nutrient in the soil and plant? You can face several questions of this category.

As nitrogen, phosphorus and potassium are required in large quantities and hence, affect plant growth more as compared to other mineral nutrients. In addition to these, secondary nutrients like calcium, sulphur and magnesium are also needed in fairly large quantities than the other essential elements such as iron, manganese, zinc, copper, boron, molybdenum and chlorine. Some of them viz., nitrogen, phosphorous and sulphur are consumed in building up the plant architecture while calcium, potassium and magnesium have both tissue building and metabolic functions. However, other essential elements such as boron, iron, manganese, copper, zinc and molybdenum have metabolic functions in the plant life. In general, the micro-nutrients are found naturally in the soil in sufficient quantities, whereas the macro-nutrients are deficient in the soil and needs continuous supply.

PLANT NUTRITION

Plant Nutrition is the study of the chemical elements and compounds that are necessary for plant growth, and also of their external supply and internal metabolism.

Criteria of Essentiality: Arnon & Stout proposed criteria of essentiality, which was refined by Arnon (1954). According to this criterion, an element is considered as essential when :-

1. A deficiency of the element makes it impossible for the plant to complete its life cycle.

2. Its deficiency can be corrected or prevented only by supplying this element.

3. The element is directly involved in the metabolism of the plant.

The metabolic function of all the elements required for the plant growth and development are described in Table 7.1.

Table 8. 1. Elements, concentration and their role in plant metabolism

Sr. No.	Elements	Quantity in whole plants	Available form	Function	Deficiency Symptoms
1.	Nitrogen	3-5%	Nitrate (NO_3^+) and Ammonium (NH_4^-)	• All living matter, amino acids, proteins.	• Appear first on older leaves and development of pale green colour which turns yellow green, yellow and ultimately chlorosis over entire leaf
2.	Potassium	1.5-3%	K^+	• Enzyme system in the change of sugar to starch, citric acid synthesis, in the change of amino acids to proteins, respiration, interaction with iron.	• Appear first on older leaves. • Necrosis begins at leaf tips and progresses towards the base.
3.	Calcium	0.1-3.5%	Ca^{2+}	• Cell wall, cell permeability, buffer.	• Appear first on terminal points • Terminal leaves become small, without a patterned chlorosis. • Older leaves become thick and brittle.
4.	Sulphur	0.05-1.5%	SO_4^-	• All living matter, proteins, nodulations in legumes, allyl oils of mustards, chlorophyll synthesis.	• Similar to N deficiency but appear first on younger leaves. • Yellowing of the entire leaves. • Not common in foliage plants.
5.	Phosphorous	0.25-0.5%	HPO_4^- and $H_2PO_4^-$	• All living matter, nucleo proteins, lipids, phosphorylation enzymes.	• Appear first on older leaves. • Loss of sheen. • Red , yellow and bluish pigments appear along the main vein s on underside of leaves and this "fall" coloration spreads to other portions of leaves.
6.	Magnesium	0.05-0.7%	Mg^{2+}	• A part of the chlorophyll molecule, enzyme activator of hexokinase, phosphorylase, carboxylase, dehydrogenase, peptidase, photosynthesis, buffer.	• Appear first on older leaves. Chlorosis begin at upper margins of leaves progressing inwards and downwards leaving a V shaped tip of green on the leaf tip e.g. *Philodendron scandens* subsp. *oxycondium.*

Sr. No.	Elements	Quantity in whole plants	Available form	Function	Deficiency Symptoms
7.	Chlorine	100-300 ppm	Cl^{2-}	• With Na and K it helps in maintaining cation anion balance.	• Wilting of plants, chlorosis, necrosis and unusual bronze discoloration of foliage and restricted growth.
8.	Iron	10-1500 ppm	Fe^{2+} and Fe^{3+}	• A part of the porphyrin compounds cytochrome enzyme system, chlorophyll synthesis.	• Appear first on younger leaves. • Marginal interveinal chlorosis with veins and veinlets remaining green.
9.	Maganese	5-1500 ppm	Mn^{2+}	• Chlorophyll synthesis, stabilisation of H- atoms split from H-OH by hydrogenation in photosynthesis, reduction of nitrates to nitrites, activator of arginase, carboxylases and dehydrogenases.	• Appear first on younger leaves • Similar to Iron deficiency ,except that a persistent band of green along veins and veinlets is broader
10.	Zinc	3-150 ppm	Zn^{2+}	• Tryptophan synthesis, phosphorylation enzymes, enzymes in chloroplasts.	• Zn deficiency have not been induced in foliage plants.
11.	Copper	2-75 ppm	Cu^{2+}	• Enzyme in synthesis of ascorbic acid, activator of polyphenoloxidase, laccase and oxidase.	• Terminal portion dies due to stunting • Multiple budding occurs below the dead portion giving a "Witches broom" appearance.
12.	Boron	2-75 ppm	$H_2BO_3^-$ and HBO_3^-	• Phosphorylation enzymes, glutamine synthesis, nodulation in legumes.	• Internodes become shorter. • Terminal leaves become small, puckered, blunt and have chlorotic areas interveinally. Vines develop characteristic curling at the nodes producing a "pigtail" appearance.
13.	Molybdenum	Very less	Mo^{2+}	• Nodulation in legumes, Tannin synthesis, reduction of nitrates to nitrites.	• Chlorotic internode mottling of the lower leaves followed by marginal necrosis and in folding of the leaves.

FERTILIZER REQUIREMENT OF COMMERCIAL FLOWER CROPS

Rose

Roses prefer farmyard manure (FYM), compost and leaf mould in addition to concentrated organic manures. The rate of application of organic manure depends upon the source and nature of the soil. The best time of manure application to the established plants is after pruning. Both organic and inorganic fertilization have beneficial effects on growth, development and flower production.

Fertilizer recommendation

Apply a mixture of urea, single superphosphate and potassium sulphate in the ratio of 1:3:2 at 50 g per plant or 10 kg per 100 sq. m. for three times i.e. first at pruning, second at the end of December when the first flush is over and third at the end of February when second flush of blooms is over.

Foliar feeding: Spray 3 gram mixture of urea, dihydrogen ammonium phosphate, potassium phosphate and potassium nitrate (2:1:1:1) along with 1.5 g of teepol at 10 days interval until last flush in March.

Gladiolus

Corms of gladiolus are rich in carbohydrates which is sufficient to sustain plant growth for initial few weeks. The cormels, however, require fairly good amount of fertilizers because of limited amount of stored food due to their small size. Gladiolus requires both macro as well as micro nutrients for good growth and flower production. Nitrogen is primarily required to promote vegetative growth. Healthy gladiolus plants should contain 2.5 to 3.0 per cent N on dry weight basis.

Fertilizer recommendation

N, P, K, each 200 kg/ha is recommended. Nitrogen may be applied in 3-4 split applications i.e. before planting, at 2-3 leaf stage, at spike emergence and after completion of flowering.

Chrysanthemum

The chrysanthemum is known to respond well to fertilizer application. Emphasis in the early stage should be on nitrogen and during bud appearance stage; proportion of potassium should be increased. The plants need phosphorous during their growth period and can be easily applied as it is released slowly. The recommended dose of NPK fertilization varies with the climatic condition of different regions of our country.

Fertilizer recommendation

After land preparation, apply 10-12 tonnes per acre of well decomposed farm yard manure and 50 kg of nitrogen, 160 kg P_2O_5 and 80 kg K_2O per acre as basal dose.

Top dress the crop with 50 kg nitrogen per acre at the time of first pinching.

Marigold

Although marigold responds to fertilization, information on its requirement of macro and micro nutrients is scanty.

Recommended dose

Apply 200 kg nitrogen/ha and 80 kg/ha each of phosphorous and potassium for good vegetative growth and flower yield.

Apply whole quantity of phosphorous and potassium at the time of land preparation. However, nitrogen should be applied in two split doses i.e. one at the time of land preparation and another after one month after transplanting.

China Aster

Application of manures and fertilizers in required quantities is important for proper growth, yield and quality of China aster flowers.

Recommended dose

Application of 120 kg N, 80 kg P_2O_5 and 120 kg K_2O per hectare at 10-12 leaf stage.

Tuberose

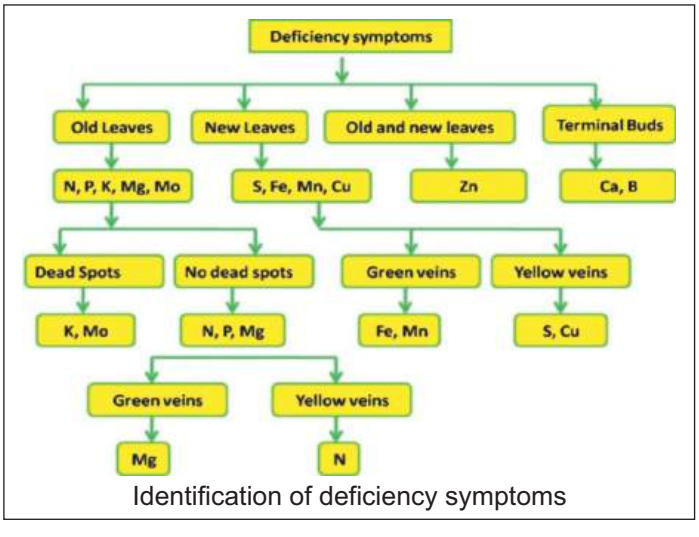
Tuberose has a high nutrient requirement and hence proper fertilization is essential for its cultivation. The requirement of manures and fertilizers for tuberose vary with climatic conditions and soil types. The application of organic matter is essential for promoting growth and higher production of spikes. FYM at the rate of 20 tonnes per hectare has been recommended during land preparation. For tuberose, nitrogen is much more vital element than phosphorous and potassium which influences yield and quality of flowers and bulb production.

Fertilizer recommendation

Application of 3-4 tonnes well rotten FYM per hectare prior to planting and Application of 100-250 kg Nitrogen, 100-150 kg P_2O_5 and 75-100 kg K_2O per hectare.

Nutrient deficiencies and disorders in flower crops

Deficiency leads to morphological variation, which results in low productivity of quality flowers. The deficiency symptoms of nutrients can be corrected through foliar feeding even after planting. The easy key for identification of deficiencies of macro and micro nutrients in general is summarised in following figure .



Identification of deficiency symptoms

Nutritional disorders are basically physiological disorders in the plants that affect the productivity as well as the quality of flowers. Disturbance in the plant metabolic activities resulting from an excess or deficit of environmental variables like temperature, light, aeration and nutritional imbalances result in disorders. Various disorders of flower crops, their symptoms and management are given in Table 7.2.

Table 8.2. Nutritional Disorders in commercial flower crops

Crop	Nutritional Disorder	Symptoms	Management
Rose	Iron deficiency	• Plants grow slow and show wilting symptoms. • Interveinal chlorosis in young leaves. • Thin leaves and stunted growth. • Necrosis at leaf margins. • Colour is dull and small flower size • Aborted flowering shoot.	• Soil should be slightly acidic (pH 6 to 6.5). • Use N fertilizers with higher NO_4 /NO_3 ratio. • Avoid calcareous soil and bicarbonate rich irrigation water. • Spray 0.5 % $FeSO_4$ at pH 4- 5 with surfactant Fe- EDTA chelate at 0.1 % • Control nematodes with appropriate nematicides.
	Boron deficiency	• Malformed flower buds and petals. • Decrease in number of flowers . • Die back of stem tip and flowering shoots. • Root growth affected. • Young leaves become scorched, thicken cup shapes and distorted. • Shoot become stiff and excessively branched.	• Foliar spray of 0.2 % Boric acid twice at 30 and 45 days after pruning.
	Magnesium deficiency	• Large necrotic white areas located. symmetrically on both sides of midribs of leaflets between larger veins. • Young leaves become mottled and Chlorotic. • Immediate drop of injured leaves. • Severe root injury.	• Adding Magnesium sulphate at 15-25 g/ plant immediately after pruning.
Chrysanthemum	Iron deficiency	• Interveinal chlorosis in young leaves during early stages and are yellowish in the severe stage. • Stunted growth of plants. • The leaves become small and thin.	• Use of iron tolerant cultivars is a practical way. The cultivar Indira released from IIHR, Bangalore is tolerant to iron deficiency. • Use of well decomposed FYM. • Use of acidic red soil while preparing growth media. • Foliar spray of 0.5 % Ferrous sulphate at ph 4.5 or Fe EDTA at 0.1 % twice once at 30 days and another at 45 days after pruning. • Maintaining growth media at pH 5.5 to 6. • Proper aeration is very important

Crop	Nutritional Disorder	Symptoms	Management
	Copper deficiency	• Few flower buds opened completely when copper is deficient. • Petals curve upwards. • In severe cases flower bud initiation is retarded. • Terminal leaf base Chlorotic initially. • Even veins are Chlorotic in later stages.	• Copper sulphate application at 10 kg/ha corrects copper deficiency.
	Boron deficiency	• 'Peripheral flowers lose turgidity before central flowers fully open. • The petals are twisted and cup shaped in severe deficiency.	• Soil application of Boron at 2 kg/ ha (15-20 kg borax/ha). • Foliar spray of 0.2 % Boric acid twice once in 3 week after planting and again at 25 % flower bud emergence.
	Boron toxicity	• Plant suffering due to boron toxicity are short and flower diameter is less.	• Boron concentration should be in safe range i.e. 25-125 ppm.
Gladiolus	Boron deficiency	• The youngest emerging leaves exhibit Interveinal chlorosis. • The spike size is reduced. • The flowers do not open fully.	• Applying acid forming fertilizers solubilise soil iron for the plant and increases iron vailability. • Foliar spray of 0.5 % $FeSO_4$ at pH 4-5 a surfactant and 0.2% urea.
	Manganese deficiency	• Interveinal chlorosis of young and physio-logically mature leaves. The leaves do not turn yellowish in severe conditions as in iron deficiency.	• Foliar spray of 0.5% $MnSO_4$ or 0.3 % $MnCl_2$ immediately after foliar symptoms appear. • Apply NPK fertilizers in band near the cormels to correct the disorder.
	Magnesium deficiency	• The older or lower leaves are Chlorotic with the base of the leaf remaining green while the tip is Chlorotic.	• Applying $MgSO_4$ to soil at 500kg/ha • If the pH is 7 or above and applying dolomite at same rate as basal dose if soil is acidic. • Foliar spray of 0.5 to 1.0 % $MgSO_4$ is recommended when soil application of Mg has not been done.

Crop	Nutritional Disorder	Symptoms	Management
Gerbera	Iron deficiency	• The young emerging leaves show interveinal chlorosis. • Size of the leaf is small. • Short flower stalks. • The young emerging laves are yellowish • The margins become necrotic. • The plant dies within a week or 10 days in severe deficiency.	• Foliar spray of 0.5 % $FeSO_4$ with 0.5 % urea with suitable surfactant. • Timely correction of root pathogens like fungus and nematode.
Carnation	Boron deficiency	• Young emerging leaf become curved and twisted. • The internodes of the upper part of the shoot is curved. • The meristem dies as the deficiency become severe.	• Spray 0.2 % Boric acid thrice, one at 15 days after planting , second 30 days after planting and third when 25 % of the plants have bloomed. • Boric acid or Borax can be applied to enhance the water soluble boron of the growth medium to be 0.6 -0.8 ppm.
	Iron deficiency	• The young emerging leaves exhibit interveinal chlorosis. • Leaf blade become thin.	• Correct the pH of the growth medium with gypsum at 0.5 -1.0 t/ha if the pH exceeds 7.5. • Spray of ferrous sulphate at 0.5 % with surfactant at 20 ml/100 litre.

ACTIVITY/EXERCISE

Identify the deficiency symptoms and disorders in various commercial flower crops.

CHECK YOUR PROGRESS

A} Subjective Questions

1. Explain in brief the various elements, concentration and their role in plant metabolism?
2. Explain in brief the various nutrient deficiency symptoms in flower crops.
3. What are different recommended doses of fertilizers for the following flower crops?

   Rose

   Gladiolus

   Chrysanthemum

   Tuberose

   China aster

   Marigold

B} Objective Questions

a) Fill in the blanks

i. ————————, ————————, and————————-elements are used in building up the plant architecture.

ii. ————————,———————— and————————-elements are used in both tissue building and metabolic functions.

iii. Iron, zinc and copper are available at ————pH.

iv. The criteria of essentiality for nutrient was proposed by ———————— and————— and redefined by————————.

v. ————————% nitrogen is found in whole plant.

b) Multiple choice questions

i. The interveinal chlorosis in carnation is a symptom of

   a) 'Fe' deficiency b) 'B' deficiency

   c) 'Mn' deficiency d) All of above

ii. In chrysanthemum, peripheral flowers loose turgidity before central flowers fully open, which is due to

   a) 'B' deficiency b) 'Cu' deficiency

   c) 'Fe' deficiency d) None of above

iii. Stiff shoots and excess branching in rose is a deficiency symptom of

a) Fe b) Mn

c) B d) Cu

iv. Phosphorous is available in which of the following form

a) HPO_4^- b) $H_2PO_4^-$

c) Both a&b d) None of above

v. The total quantity of boron in plants is found as

a) 2-75 ppm b) 10-1500 ppm

c) 3-150 ppm d) 5-1500 ppm

c) Write true (T) or false (F) for the following statements

i. Macro nutrients are found in soil in sufficient quantities whereas micronutrients are deficient in Indian soil.

ii. The availability of boron decreases at pH < 5 and >7.

iii. Magnesium is a part of chlorophyll molecule.

iv. Manganese have an important function in Tryptophan synthesis.

v. Nitrogen is primarily required to promote flowering.

SUGGESTED FURTHER READINGS

i. Arora J. S., (1998). Introductory Ornamental Horticulture. Kalyani Publishers Pvt. Ltd., W. Bengal.

ii. Randhawa G. S., and Mukhopadhyay A., (2007). Floriculture in India. Allied Publishers Pvt. Ltd., New Delhi.

Chapter 9

Applications of Plant Biotechnology in Flower Crops

OBJECTIVES

After going through this chapter, students will be able to :

To understand different techniques of plant tissue culture

To learn about Plant genetic engineering

To understand the role of biotechnology in flowers

INTRODUCTION

In previous chapter, you have studied about nutrient requirement, deficiency symptoms, etc. in flower crops. In this chapter, you will learn entirely a new technological application i.e. plant biotechnology in flower crops. You will learn different application of plant biotechnology in floriculture. Plant biotechnology may be defined as generation of useful products or services from plant cells, tissues and very often small organ explants. Previously, conventional breeding and selection, with mutation breeding and the selection of natural bud sports (spontaneous mutation) contributed in evolution of an array of flower cultivars which are currently available. However, these techniques are restricted by limited gene pool in any cultivated species or their wild relatives.

Various biotechnology tools especially, genetic engineering opens up a new era by widening the genetic base by operating at a transgenomic level. In this modern scenario, the demand for flower varieties with novel characters is increasing day by day. Therefore, there is need to create novelty and fortunately, the flower crops are ideal for improvement using biotechnology. Plant biotechnological approaches can be grouped into two categories viz. Plant tissue culture and Plant genetic engineering.

PLANT TISSUE CULTURE

Plant tissue culture denotes the *in-vitro* cultivation of plant cells in an unorganised mass. It is commonly used in a very wide sense to include *in-vitro* culture of plant cells, tissues as well as organs. Recent advances in tissue culture techniques have made it possible to culture and regenerate whole plant from cells, protoplasts, embryo and tissue *in-vitro* in a medium containing carbon source, required growth factors and growth regulators. The tissue culture techniques are based on principle of *totipotency*. *Totipotency* is the ability of a plant cell to perform all the functions of development, which are characteristic of zygote i.e. its ability to develop into a complete plant. Some of the important areas where tissue culture has been applied are as follows.

1. **Micropropagation**: The production of a large number of vegetative progeny through tissue culture is called as micropropagation. Micropropagation is perhaps the most widely used biotechnology tool for large scale propagation and for producing disease free planting material. The main advantage of this technique is that it produces large number of identical plants in much shorter time. It is a basic step for further application of other biotechnological tools for improvement of flower crops. Nearly 500 species

belonging 100 families comprising a wide number of genera are successfully micro propagated using apical or lateral meristems. The culture of short meristems has proven useful in eliminating virus from plants e.g. *Dahlia* sp. *Gladiolus* sp. *Lilium* sp. *Rosa* sp., *Antirrhinum majus*, *Gerbera jamesonii, etc*.

2. **Somaclonal variation**: Culture of plant cells *in-vitro*, generates genetic variation called somaclonal variation. The regeneration *via* callus intermediary can frequently results in plants that are physiologically and genetically different from their progenitor and called as somaclones. Somaclonal variation has been studied and utilized in number of important crops including carnation, *chrysanthemum, Lilium and Pelargonium.* In carnations, chimeral rearrangement and modified flower colour was obtained from somaclonal variation.

3. **Embryo culture:** Embryo culture has been one of the most useful tools in the hands of breeders and biotechnologists to develop interspecific hybrids by rescuing the embryo at right stage before it aborts. *In-vitro* fertilization or embryo rescue is a technique in which immature embryos are dissected out from the developing fruits and grown in a suitable medium. This is helpful in breeding programme because intra or interspecfic hybridisation often fail due to either failure of pollen tube to germinate on the stigma or an arrest of pollen tube growth in the pistil. Successful hybrids have been developed in carnation by *in-vitro* fertilization of *Dianthus serotinum* × *Melandrium album*, and Lilium- interspecific hybrids between *Lilium longiflorum* × *L. monadelphum.*

4. **Haploid culture:** The culture of anthers, ovules and individual microspore is of considerable value to breeders as it is possible to produce haploid plants which reveal recessive alleles. The haploid plants can be used for production of homozygous diploids and thus avoiding generation of inbreeding. Haploid culture resulted in development of specific traits in ornamental crops. In Gerbera, haploid plants from anthers or ovules possessed a variety of different colours. Haploid culture has been used in *Pelargonium* sp. to eliminate virus, in *Lilium* sp. to produce haploid plants and in gerbera, to obtain different flower colour.

PLANT GENETIC ENGINEERING

What are transgenics?

The most potent biotechnological approach is the transfer of specifically constructed gene assemblies through various transformation techniques. The plants obtained through genetic engineering contain a gene or genes usually from unrelated organisms; such genes are called transgenes, and the plants containing transgenes are known as transgenic plants.

Applications of transgenic plants

1. They have proved to be extremely valuable tools in the studies on plant molecular biology, regulation of gene action, identification of regulatory/ Promotory sequences, etc.

2. Specific genes have been transferred into plants to improve their agronomic and other features. Genes conferring resistance to abiotic stresses, e.g., herbicides, have been transferred in crop plants which enable the use of biodegradable herbicides like glyphosate in otherwise susceptible crops.

3. Genes for resistance to various biotic stresses have been engineered to generate transgenic plants resistant to insects, viruses, *etc.*

4. Several gene transfers have been aimed at improving the produce quality e.g protein or lipid quality etc., of transgenic plants

5. Transgenic plants are aimed to produce novel biochemicals like interferon, insulin, immunoglobulins etc or useful biopolymers like polyhydroxybutyrate which are not produced by normal plants.

6. Transgenic plants have been produced that express a gene encoding an antigenic protein from a pathogen. Therefore, use of transgenic plants as vaccines for immunization against pathogens is fast emerging as an important objective.

Plant genetic engineering complements plant breeding efforts by increasing the diversity of genes and germplasm available for incorporation into crops. For genetic engineering to be effective in developing more plants for floriculture use. three essential and interacting components are needed.

1. Suitable genes that have been characterized and cloned for favourable traits and their expression

2. An efficient transformation system to deliver foreign DNA to individual cells.

3. A suitable regeneration system to produce transgenic plants.

Transformation: It refers to the transfer of desired genes into other organisms, their stable integration and expression of foreign DNA in the that particular organisms Inspite of the various techniques available, *Agrobacterium* mediated gene transfer, protoplast based direct gene transfer and biolistic DNA transfer are the three major techniques that are widely used for the transformation of floricultural crops.

Vector mediated gene transfer method:

Using *Agrobacterium tumefaciens*

This method is commonly used to develop transgenic broadleaf plants like tomato and soybean, employs a plant bacterium called *Agrobacterium tumefaciens. Agrobacterium* contains a plasmid, called the Ti plasmid, part of which gets integrated into a plant cell's DNA upon infection. This bacterium, which is capable of inserting new DNA into the host plant cell, is a natural genetic engineer. Biotechnologists alter the Ti plasmid, to contain the gene they wish to be incorporated into the plant cell. Next, the plasmid is reintroduced into the bacterial cell. When this bacterium infects a plant cell, the new gene will be incorporated into the plant cell's genome. The altered plant cell can then grow into a complete plant, which will contain the new DNA in all of its cells.

Direct gene transfer method

1. **Particle gun method or biolistics**

   The **"Biolistic particle delivery system",** is sometimes referred to as a **gene gun.** The gene gun propels tiny gold or tungsten particles (1mm in diameter) coated with DNA into the plant tissue. The particles penetrate the rigid cell wall of many of the plant cells in the tissue, and deliver DNA containing the genes of interest inside. Those cells which incorporate the new DNA into their genome are selected and allowed to grow into full transgenic plants.

2. **Electroporation**

   Normally, incubating DNA in a solution with plant cells will not result in the plant cells taking up the DNA. This is because each plant cell is surrounded by a cell membrane and a cell wall, which are barriers to penetration by the DNA. However, when short, high intensity electrical pulses are applied to plant cell protoplasts (plant cells with their cell wall removed but which still have a cell membrane), small pores are formed in the cell membrane. These pores are large enough to allow the DNA in the solution to penetrate the cells. After the pulses, the pores close, trapping the new trapping the new DNA inside the

cell. A small number of the cells in the solution will not only take up the DNA, but will also incorporate the DNA into their genome. Those cells are selected and allowed to grow into transgenic plants expressing the desire gene.

3. Using Liposomes

This method is also employed in producing transgenic animal cells. The DNA is first incubated with liposomes. Liposomes are small, hollow spheres of fatty molecules that are capable of carrying DNA inside of them. When the liposomes are incubated with DNA under specific conditions, the DNA is absorbed. Liposomes containing plasmid DNA are called **lipoplexes**. The lipoplexes are subsequently injected into a plant cell, thus introducing the new DNA into that cell. If the new DNA is incorporated into the cell's genome, it is allowed to grow into the desired transgenic plant.

Target crops for transgenic improvement

For transgenics to make significant impact, it is necessary that the crops chosen are of national importance. Thus horticultural crops that contribute the most to our food and nutritional security (e.g. tomato, peas, cauliflower, banana, etc.) should be accorded high priority. Similarly, commercial crops that provide rural employment and occupy large area also deserve high priority. In view of strong opposition to transgenic produce in some major countries in Europe and in Japan, the international trade opportunities should be kept in mind while selecting crops for transgenic improvement.

Target traits for transgenic improvement

Target traits for genetic engineering would be automatically related to crop priorities and major breeding objectives. The transgenic approach is feasible to engineer traits that are controlled by one or a few major genes. Quantitative traits like yield are not easily amenable to improvement through transformation. Further, traits that can be routinely modified via conventional breeding need not be targetted for transformation.

The following traits where transgenic approach can be employed for further improvement.

Biotic stress such as insect and disease resistance.

Abiotic stress such as herbicide, salt and drought tolerance.

Quality improvement traits like nutritional quality, flower colour, and enhanced shelf life.

APPLICATIONS OF GENETIC ENGINEERING IN FLORICULTURE

1. Flower colour modification

It is one of the important trait in ornamental crops where consumer always desires for novel flower colour so genetic engineering helps a lot in developing this novel trait. The major colour pigments are classified into three groups namely; flavanoids, carotenoids and betalains. Therefore colour modification can be done by various ways. e.g. over expression of structural genes, use of sense or antisense enzyme construct, etc.

The first successful application of genetic engineering for modification of flower colour was with petunia to produce crimson coloured pelargonidin pigments by transferring AI gene from *Zea mays* which codes for a specific protection dihydroquencetin-4 reductase (DQR). Similarly the first antisense technology also has been used to genetically engineer petunia to incorporate antisense Chs gene (chalcone synthase gene).

World's first blue rose developed by Suntory Ltd in collaboration with Australian Firm Florigene Ltd and genetically engineered carnation Moonshadow produced by Florigene through the Introduction of a F3' 5'H gene together with a petunia DFR gene into DFR deficient white carnation

2. Enhanced post harvest attributes

Rapid deterioration of flower after harvest due to factors such as ethylene biosynthesis and physical blockage of the xylem is the major problem in the flower industry. The ethylene biosynthesis and its autocatalytic role of triggering senescence is well established. The pathway of biosynthesis is also well characterized and the crucial genes including 1-aminocyclopropane-1 carboxylate synthase (ACC synthase) and 1-aminocyclopropane-1 carboxylate oxidase have been cloned, sequenced and successfully incorporated into flower crops. Transgenic carnations having the antisense ACC synthase gene and ACC oxidase gene produced lower levels of ethylene and delayed senescence to retain langer vase life.

3. Virus resistance

Molecular approaches to virus cross protection proved effective in recent times. The expression of viral coat protein gene in transgenic plants can lead to protection against the invading virus. This approach has recently demonstrated in carnation mottle virus.

4. Insect resistance

Resistance to insects is generally lacking in many crops. Chemical control measures are hazardous and environmentally non-sustainable. At present, *Bt*-transgenics have proved to be highly effective in management of lepidopteran pests of several crops. Other genes such as lectins, protease inhibitors, etc. have also shown promise. In floricultural crops insect resistance transgenics have been developed. eg. transgenic chrysanthemum expressing cry 1C protein to control *Spodoptera exigua*.

5. Fungal disease resistance

In roses,black spot is caused by *Diplocarpon rosae* which deteriorate the flower quality so arises the need of developing transgenic roses against this disease. The gene Chitinase from Barley provides resistance against Black spot disease and transgenic roses can be produce. Similarly trangenic carnations having Chi a transgene provide resistance against *Fusarium* wilt

6. Altered flower and plant morphology

Flower and plant morphology is an important aspect wherein conventional breeding has given due considerations. In recent years, a number of regulatory genes have been identified, isolated and characterized that governs the determinations of floral meristems, organ primordia which are terms as MADS box genes and ABC genes. The floral binding protection (fbp) genes are now successfully incorporated to modify the flower shape and colour in Petunia.

MOLECULAR MARKERS AND MARKER ASSISTED SELECTION (MAS)

Molecular markers consist of specific molecules which show easily detectable differences among different strains of a species or among different species. These markers may be based on proteins i.e. isozyme or DNA. Molecular markers are based on analysis of restriction enzyme digests of genomic DNA or on that of amplification products generated by PCR; some markers combine both these strategies. Some of the common markers are RFLP (Restriction fragment length polymorphism), RAPD (Random amplified polymorphic RNAs), AFLP (amplified fragment length polymorphism), STS (Sequence tagged sites), SCAR (Sequence characterized amplified regions), etc.

Marker assisted selection is the breeding strategy in which selection for a gene is based on molecular markers closely linked to the gene of interest rather than the gene itself and the markers are used to monitor the incorporation of the desirable allele from the donor source.

ACTIVITY/EXERCISE

1. Visit plant biotechnology and tissue culture laboratory and understand the different techniques.

CHECK YOUR PROGRESS

A} Subjective Questions

1. **Define the following**
   - i. Plant tissue culture
   - ii. Totipotency
   - iii. Micropropagation
   - iv. Transgenic plants
   - v. Transformation
   - vi. Marker assisted selection
2. **Explain in brief the gene transfer methods to develop transgenics.**

B} Objective Questions

a) Fill in the blanks

I. RAPD stands for———————————————————————————————.

II. Black spot of Rose is caused by _____

III. The gene responsible for crimson coloured pelargonidin pigment in petunia was transferred from ———————————————.

IV. World's first blue rose was developed by ———————— in collaboration with ————————.

V. Bt transgenics are highly effective against ———————————————pests of several crops.

b) Multiple choice questions

i. Plant tissue culture is based on the principle of

a) Explant b) Organ

c) Totipotency d) None of above

ii. Chi trans-gene in carnation provide resistance against

a) Calyx splitting b) Viruses

c) Fusarium wilt d) Aphids

iii. Floral binding protection gene is incorporated to modify the flower shape and colour in

a) Rose b) Carnation

c) Petunia d) All of above

iv. Which of the following marker not a DNA based

a) RAPD b) STS

c) Isozyme d) CAPs

v. Which of the following method is direct gene transfer method?

a) *Agrobacterium* based method b) Particle gun method

c) Using liposome d) Both b & c

c) Write true (T) or false (F) for the following statements.

I. DQR stands for dihydro quencetin-4 reductase.

II. Colour modification of flower can be done by under expression of structural gene.

III. The first antisense technology has been used inpetunia to incorporate antisense chs gene.

IV. The genetically engineered Moon series of carnation was produced by Suntory Ltd.

V. Cry 1C protein in chrysanthemum control *Spodoptera exigua*.

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Chapter 10

Protected Cultivation of Commercial Flower Crops

OBJECTIVES

Students will be able to know about

advantages of protected cultivation

various protected structures for cultivation of flower crops

the production technology of commercial flower crops

INTRODUCTION

Protected cultivation can be defined as a cropping technique where the micro climate surrounding the plant body is controlled partially/ fully as per the requirement of the plant species grown during their period of growth. When we celebrate any festival or occasion, then we demand flowers. But sometimes, flowers are not available in the market due to season specific cultivation. Then several questions arise in our mind. How we can produce flowers throughout the year? Whether we can produce flowers under protected structures? What are the different protected structures and methods for cultivating flowers? Simple structures such as cold frames, hot beds, sash beds, etc. were commonly used by nurserymen and growers to modify the environment of limited area. These save the crop for limited period only i.e. few weeks to few months only. But now-a-days many permanent structures are also used for controlling the environmental conditions of plants.

PROTECTED STRUCTURES

A) Temporary Structures

Cold or storage pits : In early times, pits used to dig about 90 cm deep to store the pot plants or germinating seedlings, the top was covered with transparent material or glass in frame in slanting position keeping higher side in north side and slope on south side. Thus the plants were remained too much below of frost line so they were not damaged due to prevalence of low temperature.

Hot beds: In such beds, farmyard manure is spread on the ground ranging from 30-45 cm thick for mild climate and 60-70 cm thick for severe climatic conditions. On fermentation, manure provides heat for three to six weeks.

Sash beds: Under severe climatic conditions to save the crop from top, crop is covered with transparent glass fixed in frames. The frames are made up of wood. The length of frame is about 180 cm and 150 cm wide. These frames are made in such a way that one or more layers of glass can be accommodated. The usual height on one side is 30 cm and 15 cm on other side. Higher side is placed on north side so that sloppy side faces south side to get the maximum benefit of sun light.

Cold frames: When sash beds are not heated, these are called as cold frames. These are successful in mild climatic conditions.

Forcing boxes: These are small cold frame with a single glass or glass substitute like polythene, polyvinylchloride or rein forced plastic fiber which is over a single plant in the field during early spring.

B) Permanent Structures

Green house: Structures in which crops can be grown in partial or fully controlled climatic conditions

Glass house: It is a type of greenhouse in which cladding material used is of glass. This type of house is used in temperate conditions because the inside temperature rises to a greater levels.

Lath house: These are generally made up of wood or wood with a metal frame work. The degree of shade is determined by the distance between two laths which is generally kept about 5 cm. The width of individual lath is 5-7.5 cm and length is about 3.0-3.50 m. These structures are suitable for growing green foliage crops, ground covers or other crops which require partial shade or broken sun light.

Low tunnels: These tunnels are 1-1.6 m in height covered with clear polythene. Sometime, very low height tunnels of 30-60 cm height are made by keeping the height of crop and duration into consideration. These are very useful being simple and of low cost. These are mostly used when adverse weather conditions are limited to short duration.

Shade net house: In tropical climatic countries where sunlight is very bright and shading nets of different colour and density used to reduce light intensity as per requirement.

Greenhouse technology is the most practical way of achieving the goal of protected cultivation.

Advantages of protected cultivation

Crops could be grown under inclement climatic conditions when there is no possibility to grow in open fields.

Efficient utilization of precious inputs like irrigation, fertilizers, etc.

Early cropping with higher productivity or enhanced crop duration.

Able to get blemish free superior quality product.

Ensure the production of any plant at any place and throughout the year.

Easy to control insect pest and diseases.

Reduced water requirement

Less labour requirement.

Basic considerations for cultivation in greenhouses

Type of greenhouse

Feasibility study

Planting material

Growing system

Plant protection

Post harvest management

Supporting facilities for analyzing quality of water and growing media

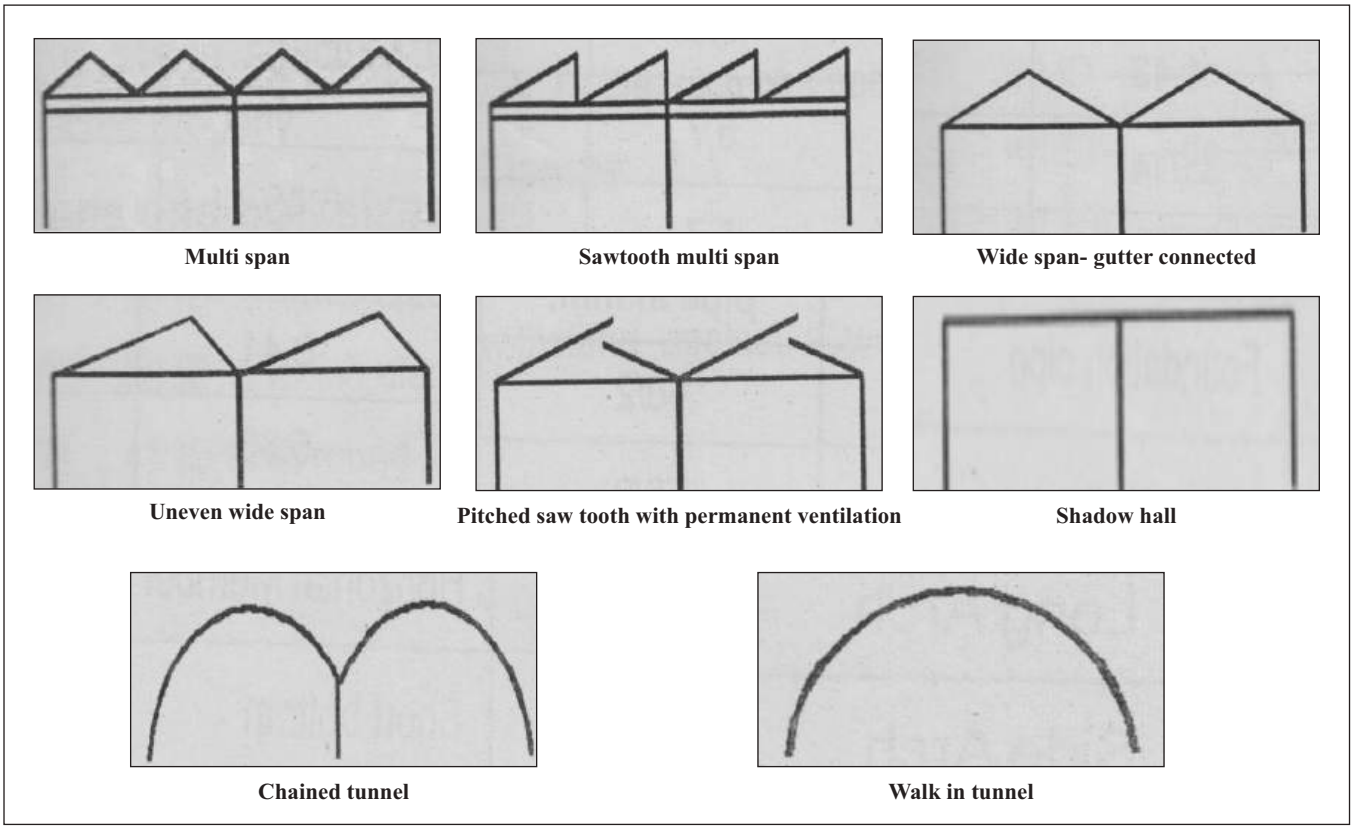
Management and coordination among themselves and with crop

GREEN HOUSE

Green houses can be defined as structures in which crops can be grown in partial or fully controlled climatic conditions. Greenhouses are frames of inflated structure covered with a transparent material in which crops are grown under controlled environment conditions. Greenhouse cultivation as well as other modes of controlled environment cultivation have been evolved to create favourable microclimates, which favours the crop production throughout the year.

Types of green houses

A) Green house with rigid cladding material



B) Green house with a flexible cladding

Arched saw tooth with permanent ventilation

Arched wide span

C) According to the material of structure

GI structure

Wooden structure

D) Classification based on number of spans

Free standing or single span

Multi span or ridge and furrow or gutter connected

E) Classification based on environmental control

Naturally ventilated

Passive ventilation

F) Based on suitability and cost

Low cost or low tech greenhouse – Cost involved in its construction is Rs. 300-500/m^2 . This greenhouse is without Fan and Pad cooling system.

Medium-tech greenhouse – Cost involved is Rs. 800-1100/m^2 . This greenhouse is with Fan and Pad cooling system but without automation.

Hi-tech greenhouse - Cost involved is Rs. 2000-3500/m^2. Expensive greenhouse with fully automation system.

CLIMATE CONTROL

Greenhouse heating

The need for greenhouse heating comes during winters when inside temperature falls down. There are many methods to raise the temperature inside a green house and some of them are described below:-

1. **Boiler:** One or more boilers are installed in a greenhouse and steam or hot water is piped to various locations of greenhouse.
2. **Unit heaters**: These are often referred to as forced-air heaters. A fan in the back of the unit heaters draws in greenhouse air, passing it over the exterior side of the tubes and then out from front of the heater to the greenhouse environment again. The cool air passing over the hot metal tubes is warmed. Thus, raise the temperature of the greenhouse.
3. **Convective heaters:** These heaters differ from unit heaters in that they do not have built-in heat exchanger. Fuel of any type including wood, coal, oil or gas is combusted in a fire box. The resulting hot fumes pass out through an exhaust pipe which is situated along the ground either between ground beds or beneath benches.

Greenhouse cooling

Most of the localities experience periods of heat which are adverse to greenhouse crops. Hence, there is a need to lower it. There are few following methods which lower the temperature inside the greenhouse during summers.

1. **Effective ventilation:** It involves removing air from inside the greenhouse and replacing it with outside air. It influences the heat, water vapour and CO_2 concentration inside the polyhouse. The ventilation can be
   - **a.** Natural – caused by wind and temperature forces.
   - **b.** Mechanical or induced – accomplished by using fans.

   The cold air enters from the side vents and hot air escapes from the top vent.
2. **Shading:** Shading with screen prevents an increase in temperature and reduce light intensity. Shading can be done in following ways:
   - **a.** Inside screen – horizontal screen below the roof e.g. Aluminium net
   - **b.** Outside screen – screen over the polyhouse e.g. shade net
   - **c.** White washing – white distemper or lime can be applied on the polythene so that the sun radiation can be reflected reducing the intensity.

3. **Fan-and-pad cooling systems:** Evaporative cooling is a process that reduces the temperature of air by the evaporation of water into the air system. In this system, on one wall of greenhouse water is passed through a pad which is placed vertically in wall. On the opposite wall exhaust fans are fixed. Warm air from outside of the greenhouse is passed through wet pad and pushed outside from the other side. During this process, water absorbs heat from surroundings and evaporates thus reducing the temperature of the greenhouse.

4. **Fog and misting systems**: The rate of cooling of air increases proportionally as water droplet size decreases. The droplet size of mist is 1000 microns whereas the size of droplet of fog is 40 microns. The droplets of this size remain suspended in air while they evaporate to cool the air which occurs without water condensation at surface of leaves.

Greenhouse lighting

Alterations in light quality affect plant quality but the effects vary significantly between species. Now-a-days, the use of light emitting diodes (LEDs) as a lighting system in greenhouse production is developed. The LED technology opens up possibilities to select specific parts of the light spectrum to study and control different processes.

Soil/media

Soil as a media: EC and pH of soil or media are the most important factors to be considered. Following are the standards of EC and pH for soil to be used as media in greenhouses.

EC of the soil should be less than 1mS/cm. EC estimates the amount of total dissolved salts.

Soil pH measures relative acidity or alkalinity. The availability of nutrients directly affected by soil pH. Plants require specific pH of soil for their normal growth. Under greenhouse conditions pH should be maintained in between 5.5 to 6.5 for normal growth and availability of nutrients.

Irrigation water

The optimum pH of water required for plant growth is 5.4 - 6.8. The acidity of irrigation water is estimated by the concentration of bicarbonates, which can be neutralized by nitric acid and phosphoric acid.

EC of water means capacity of water to conduct electricity. Water EC should be between 0.3 to 0.5 mS/cm and water containing fertilizers should be around 1.2 to 1.5 mS/cm.

At high pH the micronutrients (Fe, Mn, B, Zn, Cu) become less available. At low pH, they become too available

Some basic Requirements of major cut flowers crops:

Name of crop	Commercial life cycle (Yrs)	Day temperature (°C)	Night temperature (°C)	Humidity (%)	Light intensity (Lux)	CO_2 Conc. (ppm)
Rose	6.5 – 7.0	24-28	18.5-20	65-70	60000-70000	800-1000
Gerbera	2.5 -3.0	20-24	18-21	60-65	40000-50000	800-1000
Carnation	1.5 – 2.0	16-20	10-12	60-65	40000-50000	800-1000
Lilium	1.0	20-25	10-15	60-65	30000-40000	–

PROTECTED CULTIVATION OF COMMERCIAL FLOWER CROPS

Rose

Rose belongs to family Rosaceae is the most popular cut flower ranked first in international market. It is cultivated commercially in India both for loose flowers and cut flowers. There are three basic group of rose given in the following table.

Sr. No	Type of roses	Stem length(cm)	No. of buds/stem	Flower size
1.	Hybrid tea	50-120	1	Large
2.	Floribunda	30-70	1	Smaller
3.	Spray (floribunda or polyantha)	40-70	>3	Smaller

Internationally Roses are classified as:

a) **Rose large –** These are Hybrid Tea types with more than 75 cm stem length and extra large bud.

b) **Rose sweet heart –** These are HT and Floribunda types but stem length varies from 45-60 cm and bud is small.

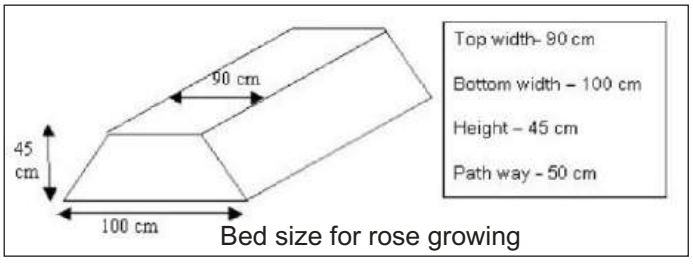
c) **Rose spray –** These are floribunda types with smaller stem length less than 45 cm and bud is also smaller. It has 5-6 flowers per stem.

Planting material:

Plants with their own roots can be used as planting material but budded or grafted plants are preferred. Budding is the best method in tropical conditions. The rootstocks used for budding or grafting should be disease free. The major rootstocks used are *Rosa multiflora*, *R. indica* var. *odorata* and Natal briar

Planting:

Raised beds are used having dimensions as given in the figure. Fumigation of beds should be done with formalin before planting.



Bed size for rose growing

Planting distance: The distance between the plants should be 17 X 45 cm

Planting density : 7.5 plants/m^2

Varieties: Grand Prix, Mercedez, Starlite, Grand Gala, Ravel, First Red, Vivaldi, Konfetti, Noblesse, etc.

Cultural practices in greenhouse

1. **Initial plant development/mother shoot bending:** First flower is pinched one month after that 2-3 eye buds will sprout on main branch, these sprouts will grow as branches and these branches in turn

will form buds. When the plant attains this stage of growth, the mother shoots is to be bend towards the direction of path. This cultural practice is done to initiate bottom breaks of ground shoots, to form main frame work of plant structure. The mother shoots bends nearer to the crown.

2. **Desuckering** – Removal of unwanted vegetative/ floral growth from axil of leaf below the terminal bud is termed as desuckering. The main aim is to improve the quality of flowers and stem.

3. **Disbudding -** Most large flowering greenhouse varieties produce few lateral auxiliary buds. Lateral buds which do develop must be pinched out regularly to obtain high quality production from single apical buds. Two or three disbudding per week may be needed during peak production. Remove the lateral buds as soon as they can be pinched out without causing damage to the stem or apical bud.

4. **Wild shoot removal –** As the plant grows the wild shoots also grow. So it is very important to remove these wild shoots from time to time.

5. **Support of the plants –** Generally, various varieties require support system. Without the support system, the stems bend into the path, which creates problem for intercultural operations and it can damage the bud.

6. **Pruning or under cutting –** pruning or under cut should be done in the month of October and November. In subsequent increasing higher mostly pruning is done on the wood that has grown as first harvest after the previous pruning.

7. **Weeding and loosening of the soil –** Every 15 days soil should be loosened with help of long handed weeding hook.

8. **Removal of Dieback** – If dieback appears then remove it immediately and then apply Bordeaux mixture over the cut.

9. **Harvesting**

S.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

Water management - Water requirement of rose is 5-7l/day/m^2. Water should be applied through drip irrigation system. If Tensiometers are used on sandy soils apply water when reading is between 10 and 15 kPa and in case of heavy soils apply water when reading is between 15 and 20 kPa.

Yield – The yield in case of HTs is 100-150 stems/M^2/year. In case of medium and small flowered varieties, it is 200-250 and 250-300 stems/m^2/year, respectively.

Effect of temperature on crop

Number of petals/flower and **Stem Length** decreases as the temperature increases.

Flower buds start to lose colour intensity at higher temperature.

Length of the "Neck" of the rose – The neck of the rose is described as the part of the stem between the bud and the upper leaf. Low temperature give short necks and high temperature give long necks. Short necks are preferred by importers.

Bullhead formation – Some varieties form bullheads easier than others. This type of malformation is mostly found on sites with very low temperature**.**

Blind shoots – Abortion of the initiated bud gives blind shoots. It is not only a temperature problem; it is also affected by the low light intensity. Low temperature and low light intensity increase the percentage of blind shoots.

Problems

Mite attack – Red spider mite cause serious damage to rose crop, particularly under greenhouse conditions. Low relative humidity and hot conditions favours the development of red spider mites. Both the flowers and foliage parts are seriously affected. To control this create humidity in the green house and Use systemic acaricides like dicofol 2ml/ l.

Aphid attack – Aphids suck out the plant sap producing large number of wounds. They excrete large quantities of sugar rich honey dew on which sooty mould fungus may grow. To control the aphid attack regular sprays (10-15 days interval) with 0.1% Rogor should be done.

GERBERA

Gerbera (*Gerbera jasmesonii* L.) is valued for its cut flowers due to its array of colours, keeping quality and extensive transportability.

Varieties for green house

Red – Julia, Natasha, Alcatraz

Yellow – Havana, Faith

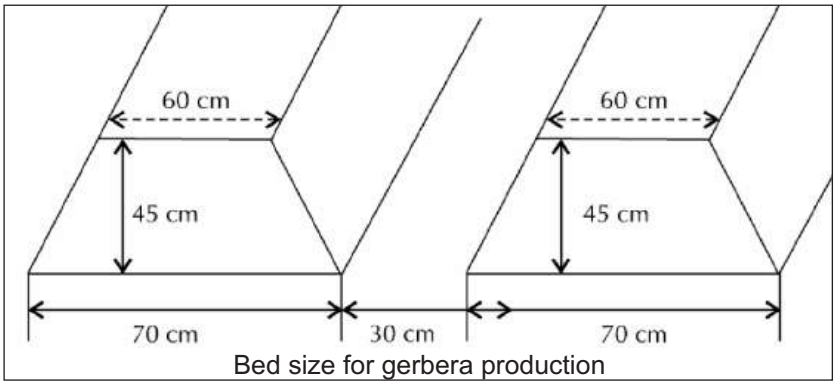
White – Dakota

Pink – Grizzly, Basic

Propagation – It is propagated through suckers and tissue culture techniqes.

Bed preparation – A raised bed is always preferred for planting of gerbera. After fumigation, the beds of following dimensions are prepared.

Bottom width – 70 cm; Top width – 60 cm; Path width – 30 cm; Height – 45 cm

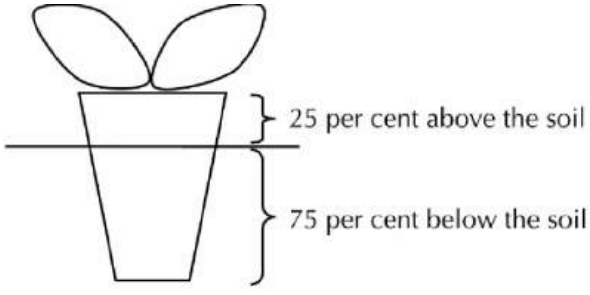


Bed size for gerbera production

Soil disinfection

The disinfection of the soil is absolutely necessary to minimize the infestation of soil borne pathogens like *Phytophthora*, *Fusarium* and *Pythium* which could otherwise destroy the crop completely. The beds should be drenched / fumigated with 2% formaldehyde (100 ml formalin in 5 litres of water / m^2 area) or methyl bromide (70 g / m^2) and then covered with a plastic sheet for a minimum period of 2- 3 days. The beds should be subsequently watered thoroughly to drain the chemicals before planting.

Planting: The crown of plants should be 1-2 cm above soil level during the planting of gerbera. Plant the seedlings without disturbing the root ball.



Planting of gerbera

Planting distance - Generally, two rows should be planted on one bed at 37.5 cm distance between the rows and 30 cm distance between the plants in one row.

Planting density - 6 plants/m^2

Planting Time - Planting can be done round the year but preferably during September-October. After plantation, maintain the humidity at 80-90% for 4-6 weeks to avoid desiccation of plants.

Irrigation- Immediately after planting, irrigate the plant with overhead micro sprinklers for four weeks to enable uniform root development. The pH of irrigation water should be 6.5-7.0 and EC should be less than 0.7 mS/cm. After four weeks drip irrigation is given at one dripper/plant.

Special cultural operations

1. **Disbudding** – up to first 8 weeks
2. **Removal of old leaves** – allows plant to produce new leaves
3. **Raking of soil** – done for sufficient aeration

Harvesting – Harvesting is done when outer 2-3 rows of disc florets are perpendicular to the stalk. The heel for the stalk should be cut about 2-3 cm above the base and kept in fresh chlorinated water.

Yield – The crop yields 2 stems/plant/month. Harvest starts from 3rd month of planting and continued up to two years. Under greenhouse condition, 175 - 200 flowers/m^2/year can be obtained.

Problems

Iron deficiency – It occurs as an interveinal chlorosis, primarily on the younger leaves. The veins and vein lets remain as thin green lines. Apply ferrous sulphate @ 0.5% till problem alleviates.

Aphid – cause deformed leaves, excrete some plants on which fungus grows.

Stem break- It is a common post harvest disorder in cut gerberas. This is mainly caused by water imbalances. It could be ethylene controlled and associated with early senescence caused by water stress.

CARNATION

Carnation is one of the most demanded cut flower in the world. Carnations are grown in almost every climate. However, the quality of carnation is better when grown in temperate conditions. It is categorized into following three types

Chabaud or Marguerite – These are seed propagated carnations bearing large single or double flowers with fringed petals.

Border – These are outdoor carnations, hardy and early flowering. Depending upon the flower colour, they are further classified as self (One colour only), bizarre (Clear ground colour, marked and flaked with 2 or 3 colours), flakes (Clear ground colour and flaked with one colour only), fancy (Yellow or white ground with mottled or flaked or spotted with various colours), picotees (Pale ground colour with an edge of a darker colour)

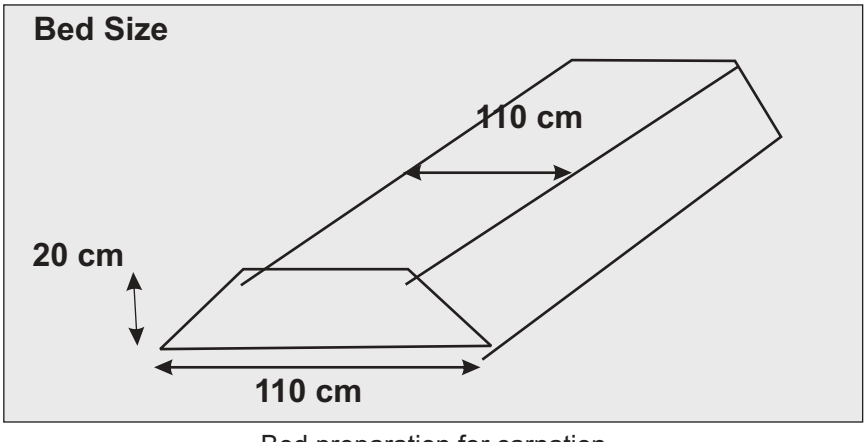
Perpetual – These are modern day varieties popular in the cut flower trade. These are grouped into two major classes i.e. standard carnations having large flower on an individual stem and spray carnations having several shorter branches with smaller flowers on each branch. Standard carnations are more in demand in the world market.

Varieties grown under green house

Standard types – Master, Tanga, Sonsara, Laurella, Solar, Dakar, Raggio di Sole, Cabaret and Isac are most promising.

Spray types - Bagatel, Cherrybag, Fantasia, Picaro, Ondelia, Sintonia and Macarena are spray types.

Soil and Bed preparation – The soils should be well drained and aerated. A rich sandy loam soil is considered to be best for planting carnations. Carnations are planted on raised beds up to 20-30 cm height from ground. The top and bottom width of bed should be 100 and 110 cm, respectively. The pathway between the two beds should be 50 cm wide. Sterilization of beds may be done with chloropicrin about 10-15 days before planting.



Bed preparation for carnation

Planting distance – The carnations should be planted at 15 cm from plant to plant and 15 cm from row to row.

Planting density - It is determined by planting pattern, cultivar, training and production programme, etc. Most growers use the planting density of 21- 32 plants per sq. meter.

Planting method – The cuttings are always planted at a shallow depth. Cuttings planted shallow establish faster due to increased aeration and are less susceptible to disease infections.

Nutrition – proper nutrition is essential for obtaining good growth and flowering in carnations. The three macronutrients: N, P and K, besides a few micronutrients Ca, Mg and B all play important role in carnation production. Nitrogen is a critical factor in nutrition of carnation and is needed for vegetative as well as reproductive stages of growth. Nutrition is generally given through irrigation system.

Irrigation – Both surface irrigation through drip lines and over head irrigation through sprinklers system are followed in carnations. Drip irrigation economizes the water use and also facilitates nutrient application. In initial stages, overhead sprinkler or misting helps in early establishment and growth of the rooted cuttings.

Special cultural practices

Support system – Carnation is a very fragile plant and growing stems tend to fall on the sides under their own weight. To avoid this, supporting nets are stretched one over the other. The first net of the size 7.5 X 7.5 cm mesh, is tied 10 cm above the ground surface and the subsequent nets of 15 X 15 cm mesh are tied 20-25cm height. The total number of nets layer required will be 4-6 which are tightly stretched on supports. The nets are usually led before planting. Rooted cuttings are planted within the netting and nets are successfully raised with the plant growth.

Topping (pinching) – It is an important cultural operation in the successful production of maximum number as well as quality carnations. Some cultivars do not require pinching but sim cultivars require pinching to encourage branching. Pinching should be done approximate 3-4 weeks after planting. Three types of pinching have been adopted in carnations.

Single pinch method - In this method, the top of the main or leader shoot is removed leaving 5 pairs of leaves from which 4-5 lateral shoots develop. These lateral shoots will produce flowers at the same time. This method is particularly applicable to cultivars which produce higher proportion of quality blooms like the hybrid standard carnations.

Pinch and a half method - This method is followed to regulate the supply of flowers throughout the year. It involves the removal of main stem tip to induce 4-5 lateral shoots. When these lateral shoots develop 5-6 pairs of leaves, only half of the lateral shoots are pinched. This method provides steady supply of flowers but reduces the quantity of the first crop.

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

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

Harvesting - Most of the carnation varieties will be ready for harvesting in about 105-120 days after planting. Carnation can be harvested at different stages and timings according the market demand. Bud size and petal growth are used to judge the stage of harvesting.

Harvesting stages based on market demand

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

Harvesting stages based on type of carnation

Type	Harvesting stage
Standard carnations	Paint brush stage, when petals have started to elongate outside the calyx
Spray carnations	With two flowers open and rest of them showing colour

Method of harvesting - The best time of harvesting is morning. The flowers are harvested by either snapping the stem off at a node or cutting off with a sharp knife or small shears. The cut given on the stem should be smooth to avoid injury to flower stem or to the mother plant. In the production period, flowers should be harvested at every two days interval. As soon as the flowers are harvested, the cut ends should be kept dipped in water or preservative solution (sodium hypochloride at 1 ml/10 l of water).

Yield

Standard types – 300-350 flowers/m^2

Spray types – 250 flowers/m^2

Problems

Calyx splitting - Calyx splitting is an important disorder in carnation. The cultivars with short and broad calyx are more susceptible than the ones with long and narrow calyx. Irregular or fluctuating temperature during flowering also induces calyx splitting. Low temperature below 10°C leads to the development of an extra whorl of petals inside the calyx. The calyx unable to hold these extra growing petals splits up. Low nitrogen, high ammonical nitrogen or low boron levels enhance calyx splitting. Closer spacing has also been reported to encourage calyx splitting. **Control:** Selection of cultivars that are less prone to calyx splitting, regulation of day (20-25°C) and night (12.5- 15.5°C) temperatures and maintenance of optimal levels of nitrogen (25- 40 ppm) and boron (20-25ppm) in the growing medium can minimize this disorder.

Fusarium wilt - Fusarium wilt (caused by *Fusarium oxysporum* f.sp. *dianthi*) is one of the most serious diseases in carnation. Poorly drained soil and abnormally high temperature are conducive for the

development of this disease. The affected plants show foliage wilting, often only on a few branches, followed by death. The best control measures are soil sterilization or chemical fumigation of the soil

Aphid - Aphids (*Myzus persicae*) suck the sap from the leaves of growing plants leading to reduce plant vigour. In severe conditions, they leave sticky deposits on the leaves and flower buds.

Mite - The red spider mite (*Tetranychus urticae*) is the most serious pest in carnation. The mites are minute red insects which live on the undersides the leaf and suck sap. The affected leaves turn pale and withered and show severe webbing. The affected plants become stunted and distorted. The quality, yield and vase life of flowers decline with increase in mite population. Mites usually cause severe damage in hot dry conditions. Proper ventilation and watering are the most important factors to prevent the mite attack.

Effect of temperature on carnation crop - Yield of carnations increases with increase in temperature whereas size of flower, stem strength and petals/flower decreases with increase in temperature. In case of growth of leaf, less curling of leaves occur with increased temperature. Calyx splitting also decreases with increase in temperature and increase with increased difference between maximum and minimum temperature.

LILIUM

The production of lilies as cut flowers in countries with a sub-tropical climate has considerably risen in the last few years. Lilium has following four divisions.

Asiatic lilies – These are most popular ones. They are 30-150 cm tall with deep blood-red, orange, rose, peach, bright yellow, cream or white flowers. Individual blooms are 15-20 cm in diameter facing up, outwards or down and are frequently streaked with purple or any other colour.

Oriental lilies – Oriental lilies are elegant, large flowered with fragrance. They are 60-180 cm tall having large, saucer shaped flowers, large leaves, long vase life (10-15 days). The 10-30 cm diameter blooms are primarily pure white, crimson, white blotched with red and pink shades.

***Longiflorum* cultivars** – These are the popular Easter lilies which have aromatic, magnificent white trumpet shaped flowers. Bulb globular, leaves horizontal, flowers are long (10-15 cm) usually white in color and green near the base, stout and smooth. In each plant, there are about 5-6 flowers.

LA cultivars – It is a group of new hybrids. The LA exhibits upward facing buds with large flower heads.

Varieties suitable for greenhouse cultivation

Asiatic - Connecticut King, Gran Paradiso, Elite, Pollyanna**,** Prato, Solemio

Orientals - Star Gazer, Marco Polo, Casablanca

Easter lily (*Lilium longiflorium*) var. Osant (white) is also grown under polyhouses.

Propagation – Lilies are propagated by a variety of vegetative means and also by seed. Vegetative propagation includes simple division of bulbs or bulb splitting usually done in fall. This includes propagation by stem bulblets, bulbils, stem cuttings and bulb scales. However, propagation is also being carried out by tissue culture method.

Bulb handling – Frozen bulbs (stored at 0-2°C) should be gently defrosted at a temperature of 10- 15°C with the plastic packaging opened up. Defrosting at higher temperature results in quality loss. Freshly harvested bulbs must be pre-cooled to 2-4° C for 6 weeks and then planted in beds. Bulbs have no covering

so handled properly. In case of light deficient periods slightly smaller bulbs are preferred whereas in case of high temperature period larger bulbs are used.

Soil preparation – Before planting, the soil should be sterilized to avoid incidence of diseases caused by soil borne pathogens.

Bed preparation – Fertilizers like CAN (@ 50 g/m^2), DAP (@ 25 g/ m^2) and Murate of potash (@ 50 g/ m^2) should be applied and mixed thoroughly in the upper layer of the beds and leveled before planting. Raised beds of 15 cm height should be used.

Planting time – Bulbs are usually planted in plains during Oct. – Nov. and in hilly areas during April – May. The flowering time is Jan – Feb in plains and July – August in hilly areas.

Planting density - Group wise bulb size and planting density of the bulbs is given in the following table.

Cultivar type	Bulb size(cm)	Planting density (bulb/m^2)
Asiatic	10-12	65-90
	12-14	55-80
	14-16	45-70
	>16	40-65
Oriental	16-18	40-50
	18-20	35-45
	20-22	30-40
	>22	25-35

Planting method – Lilies are usually grown on raised beds about 15 cm above the ground level and the maximum depth at which the bulb should be placed is 6-8cm during winter and 8-10cm during summer months.

Post planting care - When a lily bulb is planted, its water and food absorption during the first three weeks will be dependent on the bulb roots which are already developed on planting. Therefore, it is essential that lily has good and sound roots when planted. When the shoot of the lily emerges, the underground part of the stem just above the bulb will form so called stem roots. These stem roots will soon start to provide the plant with water and nutrients instead of the bulb roots. These should be protected from high soil temperatures with light mulch or low growing perennials.

Nutrition – During the first three weeks of cultivation, lilies do not need a high nutrient level. Three weeks after planting, nitrogen should be applied @ 1 kg of CAN and potassium nitrate @ 500 g per 500 liters of water on weekly basis. Lilies being susceptible to fluorides, fertilizers such as super and triple superphosphate and a number of compound fertilizers that retain fluorides should not be used. Fertilizer application should be stopped once the flower buds show colour.

Irrigation - Drip irrigation is suitable for this type of crop as this would avoid wetting of the foliage thereby reducing the chance of disease. Average water requirement is 8-10 l/m^2 during dry period. The salt level (EC) of irrigation water should be less than 0.5 mS/cm.

Plant support – Bamboo sticks are generally used for staking the plants having a height of more than 80 cm during the growth period.

Mulching – Mulching can be done with suitable substances viz. potting compost, rice chaff, straw etc. to prevent heat penetration, drying out and soil structure deterioration.

Weeding – Weeds should be removed before cultivation and soil should also be sterilized by steaming etc.

Harvesting – Harvesting is generally done when the first bud in a stem of less than 5 buds is just opening and showing colour. Stems having 5-10 buds are suitable for harvesting when 2 buds show colour whereas stems having more than 10 buds at least 3 of them must show colour. Harvesting at earlier stage results in miserable, pale flowers with some unopened buds. Stems are cut close to the ground instead of pulling. These spikes should be cut 15-20 cm above the ground level so that development of the bulbs continues in the soil.

Yield - Yield of flowers based on bulb size and planting density is described in the following table.

Bulb size(cm)	Number of flowers	Planting per m^2
12-14	1-3	40
14-16	2-4	35
16-18	3-5	35
18-20	5-7	28
20+	6-8	25

Problems – The major problem in case of lilies are aphid attack and botrytis.

Aphid – Deformation and curling of upper leaves at an early stage of development occurs while the lower leaves are intact. The aphids live on underside of leaves and suck the cell sap. The young buds get damaged. Control – Aphids can be prevented by covering the screen vents and doors with a mesh screening. Destroy the weeds which act as host for aphids or spray with suitable insecticides.

Botrytis - It is a fungal disease caused by *Botrytis elliptica* under excessive moisture and warm temperatures. Circular or oval and yellowish to dark brown spots appear on leaves. In severe conditions, it can lead to death and decay of the whole plant. Control - spraying with fungicides like captan/thiram during moist conditions when an infection is suspected and also before flowering helps in preventing the disease.

Nitrogen deficiency – Plant exhibit deficiency symptoms when they are about to bloom. Control – If nitrogen deficiency is diagnosed during cultivation, an additional application of rapid action nitrogen fertilizer is required as a corrective measure.

Storage of bulbs – The bulbs should be properly packed in perforated trays with peat moss or saw dust and stored in cold storage at 2-3°C and 70 % RH for two to three months during summers. The storage temperatures for the bulbs of Asiatic, Oriental, Longiflorum and LA hybrids are 2.5C, 1.5°C, 1.5°C and 2.5°C, respectively. Bulbs of Asiatic hybrids can be stored up to one year without any deterioration in quality. Bulbs stored for longer periods will develop more rapidly and the plants will be of short height with few buds developing into flowers. On an average, bulbs can be stored at 1°C for two weeks and at 5°C for 1 week only.

ACTIVITY/EXERCISE

Cultivate gerbera and lilium under protected structures?

CHECK YOUR PROGRESS

A} Subjective Questions

1. Explain in brief the various structures used for protected cultivation of flower crops**?**
2. Explain in brief the advantages and basic considerations of protected cultivation?
3. Enlist suitable varieties grown under protected structure for the following flower crops?

   Rose

   Carnation

   Lilium

   Gerbera

B} Objective Questions

a) Fill in the blanks

I. LED stands for————————————————————.

II. The EC of soil/media used in protected cultivation should be ————————————.

III. The optimum pH of irrigation water in protected cultivation should be ————————————.

IV. The planting density of rose in greenhouse is ————————————plants/m^2.

V. 'Grand Gala' is a variety of _____ and is suitable for greenhouse cultivation.

b) Multiple choice questions

i. Which of the following are temporary structure

a) Cold frames b) Sash beds

c) Hot beds d) All of above

ii. Mite is a most serious pest of

a) Lilium b) Carnation

c) Gerbera d) None of above

iii. Planting time of lilium in plains is

a) Feb-March b) May-June

c) Oct-Nov d) All of above

iv. 'Connecticut King' is a variety of

a) Rose b) Carnation

c) Asiatic lily d) Oriental lily

v. Which of the following greenhouse has rigid cladding material?

a) Multi Span b) Saw tooth Multi Span

c) Both a & b d) None of above

c) Write true (T) or false (F) for the following statements

I. Wild shoot removal is the special cultural operation of carnation.

II. Calyx splitting is a disorder of carnation.

III. Bull head formation in rose occurs due to high temperature conditions.

IV. Gerbera is harvested when outer 2-3 rows of disc florets are perpendicular to the stalk.

V. Fusarium wilt of carnation is caused by *Fasarium oxysporum* f.sp. *dianthi*.

SUGGESTED FURTHER READINGS

i. Arora J. S., (1998). Introductory Ornamental Horticulture. Kalyani Publishers Pvt. Ltd., W. Bengal.

ii. Randhawa G. S. and Mukhopadhyay A. (2007). Floriculture in India. Allied Publishers Pvt. Ltd., New Delhi.

Chapter 11
New Concepts of Landscape Gardening

OBJECTIVES

After studying this chapter, students will be able to:

understand xeriscaping and waterscaping

know the interiorscaping

understand the roof, terrace and vertical gardening

INRODUCTION

Students of class have read about the meaning of floriculture and its importance. During this process, you might have come across the question in mind what for we are reading this subject? After reading this chapter, you will come to know that this subject has most valuable business opportunities. For example, you can go for higher studies to become scientist, Landscape architecture, consultant, business manager, etc. There is a lot of scope for a floriculturist and landscaper than others. Read this chapter and decide yourself! In this chapter, we will deal with xeriscaping, waterscaping, interiorscaping, terrace gardening, roof gardening and vertical gardening.

XERISCAPING

The term xeriscape is derived from a combination of the words “xeri” and “scape”. The word “xeri” is derived from the Greek word “xeros” which means dry and “scape” means picture or a view of a type of scene. Truly speaking, xeriscaping is a water conservation concept that is based on theme to develop efficient landscape designs which has main objective of saving water and should also have aesthetic appeal. The concept of xeriscaping has its origin in Colorado. There is lot of misconceptions regarding the concept of xeriscaping.

People often perceive xeriscaping only to cover those places which have hot, hostile and dry scenery and where there is very less planting material and almost all rocky. Sometimes they correlate the xeriscape to barren, desert, arid, or any other form of plant material that might be associated with dry climates but actually, it is not so there are many plants that are compatible with the environment and are part of a well planned xeriscape and often are very attractive, quite lush and extremely colourful. The concept of xeriscaping was originally developed for those areas which are prone to droughts and have very less availability of water. But now a days it is not so, it is covering almost every sphere of landscape with the main emphasis on saving of water.

The xeriscaping is based on seven basic principles that are prerequisite for any xeriscape. The main idea of using these principles is to conserve the water. The concepts of xeriscape can be applied to any style of design. These principles are interlinked with each other and these principles when used in combinations it conserves more water as compared to using either one or two principles. The seven principles are as follows.

1. Planning and design

The foremost thing for the creation of xeriscape is proper planning of the xeriscape. The proper planning regarding the layout, design, input requirements should be made at the earliest. Proper planning in the initial phase of the creation of xeriscape will somewhat reduce the work load of the maintenance of the xeriscape.

2. Soil analysis and improvement

The soil of the particular location should be tested for nutrients and salts. If that soil is not so fit for growing plants then some amendments can be made at the earliest stages. Also make use of some amendments to improve the capacity of the soil to hold water and nutrients

3. Plant selection

The selection of planting material is also very important. Select those plants which have very less water requirements or those which uses water very efficiently because the main theme of xeriscaping is to conserve water.

4. Use of turf and groundcovers

Turf grasses are required to maintain the greenery of the xeriscape but it is not mandatory to cover all the empty spaces with turf grasses Put modest quantities of turf in areas where it will be used for cooling the environment, for play and recreation. Often, less water consumptive landscape materials such as groundcovers or mulches may be utilized in place of turf grasses which have more water requirements

5. Efficient irrigation

Irrigation methods, Irrigation frequency should also be taken care of. Utilize modern systems that are based on latest technology and are very efficient in saving water like drip irrigation and sprinklers. Bubblers or drip emitters are placed accordingly for trees and shrubs. Sprinklers are more commonly used in turf grasses.

6. Use of mulches

Mulch covers on the soil surface help to reduce erosion, retain moisture and minimize the fluctuation in soil temperature. Mulches are very efficient of conserving moisture.

7. Maintenance

Proper and timely maintenance is also required for successful xeriscape. One important principle is to avoid over planting. Too dense planting will give cluttered appearance and xeriscape will not gives aesthetic appeal.

The planting material suitable for xeriscaping is given in following table.

Acacia aneura	*Prosopis alba*
Acacia redolens	*Salvia clevelandii*
Agave americana	*Salvia greggii*
Baileya multiradiata	*Sambucus mexicana*
Caesalpinia gilliesii	*Simmondsia chinensis*

Caesalpinia pulcherrima	*Tagetes lemmonii*
Calliandra eriophylla	*Tecoma stans*
Cassia phyllodenia	*Vauquelinia corymbosa*
Cassia nemophylla	*Vitex agnus-castus*
Lantana montevidensis	*Vitis arizonica*
Leucaena retusa	*Yucca baccata*
Opuntia bigelovii	*Yucca brevifolia*
Parkinsonia aculeata	*Yucca elata*
Pinus halepensis	*Ziziphus jujuba*

INTERIORSCAPING

Interiorscaping is the practice of designing, arranging and caring for living plants in closed environments. It is also called as interior landscaping. Interiorscaping is an appropriate term because indoor environment contain plains, angles and horizons that are softened, accentuated or altered by the addition of plants and planters-thus landscaping the interior. Similar to outdoor landscape, interior-scape provide spaces with ornament, colour, sculptural elements, focal points and an overall pleasant.However, Interiorscapes are indoor landscapes such as planters filled with plants in shopping malls, museums and office spaces. Interiorscapers are people who care for the indoor plant displays.

Importance of interiorscaping

Improve indoor air quality

Improve work performance

Reduce stress levels

Reduce noise levels

Create positive image

Increase sales

Modes of interiorscaping

Pots

It is the common method of interior-scaping, seen in every house. Pots can be chosen to suit individual plants. Plastic nonporous pots are ideal for plants, which flourish, in moist compost. Watering is needed less frequently in plastic pots than in clay pots. All pots should have drainage hole at the bottom. Earthenware pots are most commonly used for growing interior plants. Earthenware pots are cheaper and being porous provide better aeration of soil. The pots can be plain and ornamented in design, depending upon the interior furnishings of the room with which these should hormonise in colour as well as in texture

Window garden

The most common place to keep-house plants in a room is the window-sill, window-ledge, or window box. The windows are best showcases for indoor gardens. A window where the light makes the colours grow

and helps in the growth of the plants. The plants can be placed on the window sill and shelves or on plant stands, tiered tables or plant trolley and planters. The plants can also kept in water light trays placed in the window-ledge.

The plants required plenty of sunshine should be placed on the south side as well as on east and west sides, while the shade loving plants can be placed on windows facing north and those needing light may be grown successfully on east and west-sides.

Gardening in hanging baskets

Hanging baskets with trailing or cascading plants are suitable for indoors. These can be hanged at the entrance of the house to welcome the visitor. Hanging baskets can also placed in the hall or the drawing room besides a well-lit window, or in the bathroom above a fluorescent light. Hanging baskets even decorate the kitchen walls.

Table garden

For Interiorscaping the table garden is most rewarding with suitable arrangement of appropriate types of small house plants in a dish, bowl, trough, aquarium, terrarium (glass cases) or bottle, it is possible to create delightful manure land scape for interior- scaping. The table garden provides an opportunity to give expression to one's aesthetic and artistic aptitude.

Terrariums

The terrarium has a glass cover at the top, which is removed occasionally to provide ventilation, which is necessary for the growth of the plant. Since the terrarium is enclosed, plants do not need frequent watering, as the moisture from the transpiration of leaves and soil evaporation condenses on the glass, returns to the soil and become again available to plants.

The arrangement of plants in the terrarium should be planned before planting. The young and small plants should be firmly planted and watered carefully very fast and vigorous-growing plants should not be included for planting.

Bowl and dish gardens

Large glass-bowls are also used for growing plants. The mouth of the bowl can be closed by putting a glass-cover over it. The planting in a bowl is done in the same way as in terrarium. **In dish**, the plants are grown without being covered by a glass as in a terrarium or in a bowl garden. Cacti and succulents are ideal for the shallow bowl or dish garden.

Bottle garden

Plant grown in a large bottle as in a terrarium is known as bottle garden. A carboy is ideal for this purpose. A bottle may be thoroughly cleaned with soap and water and make to sparkle by rubbing it with a clean cloth. Small plants can be introduced with a fork or dessert-spoon tied to thin bamboo cane with wire or tape. A bottle garden is displayed in semi-shade.

Vertical garden

A Vertical Garden is a green wall which is either a free-standing wall or part of a building that is partially or completely covered with vegetation. The concept of the green wall dates back to 600 BC with hanging gardens of Babylon. This new concept of gardening is not normally found in Indian gardens. This consists of a wooden frame of thickness varying from 15 cm to 30 cm depending upon convenience. The height and

breadth of the frame varies according to available space. The border paces are enclosed with wire frame which serves as the growing medium. It is possible to grow many dwarf flowering and foliage plants in such frames provided the medium is supplied with nutrient and watered regularly. Shallow rooted plants requiring very little anchorage will grow well.

Recently, the larger green walls concept has been utilized with the latest in-built irrigation technology. It works as living ecosystem that can be grown on external walls. It is also used in interior designing especially in hotel lobbies and high rise buildings. It also provides an additional thermal insulation effect during summer and winter and is an effective way to increase clean air. Vertical garden is becoming a popular gardening concept these days due to the lesser availability of outdoor spaces. A blank wall or a fence can be made green with the concept of vertical gardening.

Selection of plants for interiorscaping: Plants are selected based on their utility such as easy to manage for beginners, for dark corner, for north window, for south window, for east and west window, trailing and hanging plants, climbing and trellis plants, for terrarium, bowl and bottle plants and tough evergreen plan.

Utility	**Plants for Interiorscaping**		
Easy to manage for beginners	Ficus	Araucaria	Maranta
	Tradescantia	Aspidistra	Monstera
	Dracaena	Chlorophytum	Philodendron
	Scindapsus	Dieffenbachia	Sansevieria
For dark corner	Tradescantia	Araucaria	Sansevieria
	Philodendron	Aspidistra	Zebrina
	Maranta	Monstera	Selaginella
For north window	Tradescantia	Aglaonema	Araucaria
	Begonia	Monstera	Dieffenbachia
	Chlorophytum	Sansevieria	Chlorophytum
	Hedera	Aspidistra	Philodendron
For south window	Cacti	Acalypha	Lantana
	Amaryllis	Zephyranthus	Daffodils
	Pelargonium	Tulip	Euphorbia
	Chrysanthemum	Succulents	Coleus
	Poinsettia	Ciccus	–
For east and west window	*Zebrina pendula*	Anthurium	Palms
	Eucharis	Araucaria	Hedera
	Tradescantia	Begonia	Beloperone
	Dracaena	Impatiens	Bromeliads
	Cissus	Dieffenbachia	–

Trailing and hanging plants	Asparagus	Portulaca	Begonia
	Zebrina	–	–
Climbing and trellis plants	Ficus	Philodendron	Hedera
	Scindapsus	–	–
For terrarium, bowl and bottle plants	Aglaonema	*Ficus sp.*	Begonia
	Rex begonia	Maranta	Asparagus
Tough evergreen plants	Chlorophylum	Monstera	Chamaerops
	Philodendron	Aspidistra	Scindapsus
	Dieffenbachia	Phoenix sp.	Dracaena

ROOF GARDENING

A roof garden refers to any garden which is planted on the roof of a building. It is also known as green roofs. Humans have grown plants in top structures since antiquity. Roof garden plays a dominant role in improvement of urban landscapes especially in areas which are over polluted. Roof gardens achieved maximum importance in big cities where the people are unable to maintain their own home gardens at ground levels. Besides the decorative benefit, roof plantings may provide food, temperature control, architectural enhancement, and recreational opportunities.

Benefits of roof gardening

Improve air quality and cleans the environment

Helps protect rooftops from damaging UV light.

Can act as insulation from heat, cold and sound

Creates novelty in gardening

Conservation of energy

Reduce urban heat island effect, which ultimately lowers the temparatures.

Adds value to properties

Types of roof garden

There are two basic types of green roofs

Intensive green roofs: These types of gardens require strong foundation. A minimum of one foot of soil depth is the basic and essential requirement and thus adding more load to the building. Here planting with trees and large can be undertaken. They are multi-layer constructions with elaborate irrigation and drainage systems. Genrally, they require more maintenance.

Extensive green roofs: They require about 1 to 5 inches soil depth. Extensive green roof systems generally require less maintenance than intensive systems.

Limitations

Since the garden is at a high level from the ground, the cost of establishment is very high.

The depth of soil in roof garden is very limited. It is shallow not exceeding 90 cm.

The drainage is good in roof garden, hence water has to be replenished constantly by frequent watering.

Large trees and shrubs are generally not grown on the roof as the growth of tap root is limited by the roof below.

Plant food in the soil leaches off very rapidly due to shallow depth, good drainage and frequent watering and hence, there is need to provide nutrition frequently.

Plants for roof gardens

It is possible to grow a wide range of plants in a roof gardenexcluding large trees, shrubs and climbers. Depending upon the sun and shade, the climate, the size of the roof, etc. the following plants are recommended for growing in the roof garden.

Flowering annuals: Antirrhinum, stocks, dwarf sweet peas, pansy, dahlia, chrysanthemum, marigold, sweet alyssum, phlox, pinks and verbena.

Herbaceous perennials: Pelargonium, Michaelmas daisy, canna, mirabilis, portulaca, solidago, vinca and perennial verbena.

Shrubs: Many of medium and dwarf shrubs can be grown.

Trees: *Plumeria sp., Callistemon lanceolatus* (Bottle bush) and *Gliricidia maculate*

Creepers: *Cobaea scandens*, railway creeper, *Vernonia elaegnifolia*, passion flower, *Thunbergia alata*.

Bulbs: A variety of bulbous plants of annual or perennial nature can be grown.

Climbers: Bougainvillea, *Clerodendron splendens, Bignonia venusta*, climbing rose.

Native grasses: Buffalo grass, bluestem, blue grama, perennial ryegrass, blue fescue

TERRACE GARDENING

A terrace is a raised space of ground constructed around a dwelling house or at the corner of a garden or on the sides of a hill. When this terrace is used for some gardening, is known as terrace gardening. These gardens are basically meant for a place of leisure and pleasure. It is constructed just in front of the house from where a view of the whole garden can be obtained.

In hilly areas, it is not possible to have a large piece of land in one plane for laying a garden and hence, gardens are laid in terraces, where it is a natural phenomenon. But, in the plains areas, the land for gardening may not have any natural undulation for terracing. In such places, it is worthwhile to have a terracing to break the monotony and bring novelty into the garden.

Construction of terrace garden

In European weather, where sunshine is in great demand, the terrace is best situated in front of the house where the inhabitants can bask in the sun and enjoy the full view of the garden. Under our climatic conditions in the plains also, the same principle may be followed, but the terrace should not be preferably

situated on the western side as it will prevent the inhabitants from relaxing in the afternoon because of the hot sun.

A terrace may also be constructed in other parts of the garden, say in front of boundary wall or a dry wall. A terrace should not look out of the place but form a natural link between the two and should give a full view of the garden. It is advisable to make the terrace about 45cm above the general level of the garden supported by a retaining wall or a blank, preferably made of stone blocks. It is not necessary to have a straight outline or to locate the steps in the centre. Ample space should be provided to utilize it as a sitting place. The major portion of the terrace may be paved with stone or brick, and small space should be left for flower beds or for creepers to climb on the house walls. The soil in these areas should be dug to a depth of 45cm and add bone meal and FYM. A slope of 1:60 should be allowed towards the house to prevent the runoff water from the house flowing on the terrace.

Planting material

Planting in the terrace should be done after much thought and planning. A few low growing creeping plants such *as Portulaca, Lantana sellowiana* for tropics and *Thymus serpyllum* and *Veronica repens* for the temperate regions may be used in terrace gardens.

ACTIVITY/EXERCISE

1. Visit to various gardens and famous buildings to see the concept of xeriscaping, Interiorscaping, roof, vertical and terrace gardening.

CHECK YOUR PROGRESS

A} Subjective Questions

1 What do you understand by xeriscaping and write down the principles of xeriscaping?

2. Write down a short note on

   Vertical gardening

   Roof gardening

   Terrace gardening

3. What do you understand by Interiorscaping and explain in detail the importance and modes of Interiorscaping?

5. Explain in detail the planting material for xeriscaping, Interiorscaping and roof gardening?

B} Objective Questions

a) Fill in the blanks

I. The word 'xeri' is derived from greek word———which means———and 'scape' means——.

II. Three plants used for xeriscaping are————,———— and ————.

III. Interiorscaping is defined as————————————————————————.

IV. The garden where plants grown in a large bottle as in a terrarium is known as————————.

V. Vertical garden is defined as————————————————————————.

b) Multiple choice questions

i. Flowering annual suitable for roof gardening is

a) Antirrhinum b) Pansy

c) Dahlia d) All of above

ii. The plant suitable for xeriscaping is

a) *Calliandra eriophylla* b) *Tagetes lemmonii*

c) Both a and b d) None of above

iii. Which of the following is suitable for terrace gardening

a) Portulaca b) *Lantana sp*.

c) *Thymus sp.* d) All of above

iv. Xeriscaping is based upon the following principle

a) Soil analysis and improvement b) Plant selection

c) Efficient irrigation d) All of above

v. Interiorscaping improves

a) Indoor air quality b) Work performance

c) Stress levels d) All of above

c) Write true (T) or false (F) for the following statements

I. *Ziziphus jujuba* is used for interiorscaping.

II. Interiorscaping improve air quality and reduce noise levels.

III. Begonia is used for south window whereas pelargonium for north window.

IV. Rex begonia is suitable plant for terrarium, bowl and bottle garden.

V. Deep rooted shrubs and climbers are suitable for roof gardens.

SUGGESTED FURTHER READINGS

i. Randhawa G. S., and Mukhopadhyay A., (2007). Floriculture in India. Allied Publishers Pvt. Ltd., New Delhi.

Chapter 12

Insect-Pests and Diseases of Commercial Flower Crops & their Management

OBJECTIVES

After studying this chapter, students will be able to:

understand about harmful effect of insect, pest and diseases infestation in flower crops

identify the major insect, pest and diseases of flower crops

identify the symptom of insect, pest and disease infestation and their management practices

understand integrated pest management in flower crops

INTRODUCTION

In human being, we found many diseases like typhoid, malareia, etc. Similarly plants also affected by many pests and diseases which affect normal growth and development. Infestation by pest and diseases in flower crops causes massive loss as it affect yield and quality of produce. Hence, identification of various diseases and pests in early stage and immediate management becomes very necessary. There are various categories of pests and diseases that flower crops. Pests includes – insects, mites, rodents, animals, birds etc. insects are major and important pest and causes damage by sucking sap from plants; biting plant parts; boring into the twigs and leaves; attacking roots and flowers. Fungus, bacteria, viruses and mycoplasmas are major organism which causes various diseases in vegetable crops. Disease infested plants shows particular symptom on plants e.g. powdery mildew, downey mildew, rust, etc.

Another group of microorganisms that causes significant loss to flower crops are nematodes. Nematodes are thread like microorganism. They are sub-terranean in habit and damages roots of various crops leading to the development of nutrient deficiency like symptom. The nematode damage symptom like swelling of roots is most prominent in flower crops.

In this chapter students will learn about various insects, pests and diseases of flower crops and their management practices. Different types of insects and pathogens attack flower crops causes reduction in yield and quality of produce. To overcome the harmful effect of insects and pathogens, there are broadly two types of management practices – preventive and protective measures. Preventive measures are use before the attack of pest/pathogen and protective measures are used after the pest/pathogens attack. In general, pests and diseases can be managed by following methods:

1. **Mechanical method**
   - **a.** Manual picking and destroying the pests, larvae and diseased parts
   - **b.** Removal of infested plants or plant parts and complete destruction
2. **Cultural method**
   - **a.** Crop rotation i.e. growing a series of different / dissimilar types of crops in the same area in sequential season.
   - **b.** Deep ploughing of fields, which results in destruction of pests.

c. Clean cultivation *i.e* weed / debris free cultivation.

d. Proper use of fertilizers and water

e. Growing resistant varieties

f. Timely or late sowing and proper harvesting

3. Chemical method

The chemicals which kills insect are called insecticide, kills fungus are called fungicide, kills mites are called acaricide, kills nematodes are called nematicide and so on. Chemical control method is used as curative method. This method should be used carefully because improper use is hazardous to environment and causes resistance development in insect pest / pathogens against that chemical and causing heavy out-break.

4. Biological methods

Use of bio-control agents to control pest and pathogen are called biological method. Bio-control agents are generally predators, parasites or beneficial microorganisms eg *Bacillus (Bt),* Trichogramma, NPV, neem / castor formulations etc

5. Integrated pest and disease management (IP &DM)

Integrated pest and disease management **(**IP &DM) means careful combination of all available pest and disease control techniques and subsequent integration of appropriate measures to manage and control pest and pathogen population. IP &DM is not a single pest control method but, rather, a series of pest management evaluations, decisions and controls. In practicing IP &DM, growers who are aware of the potential for pest infestation follow a four-tiered approach. The four steps include:

1. Before taking any pest control action, IP &DM first sets an action threshold, a point at which pest populations or environmental conditions indicate that pest control action must be taken.
2. Monitor and identify pests which create problems to flower crops.
3. As a first line of pest control, IP&DM programs work to manage the crop, lawn, or indoor space to prevent pests from becoming a threat. These control methods can be very effective and cost-efficient and present very less, risk to people or the environment.
4. Once monitoring, identification, and action thresholds indicate that pest control is required, and preventive methods are no longer effective or available, IP &DM programs then evaluate the proper control method both for effectiveness and risk.

MAJOR INSECT- PEST OF COMMERCIAL FLOWERS

Usually the larvae or the nymph of the insects cause the damage. The insects can cause damage in two ways: Chewing and sucking. The most common chewing insects are beetles, grasshoppers and caterpillars on leaves; bollworms, fruit fly larvae and codling moths on fruits; termites, borers on stems and roots; cutworms on seedling, stem and weevils on seeds. The most common sucking insects are aphids on leaves; mites and stinkbugs on leaves and fruits; thrips and red spider mites on leaves and fruits; scale insects on fruits, shoots and branches; and fruit piercing moths on fruits.

It is very important to identify the insect and their life cycle for better management practices. Different types of insect pest attacks. The major insects of commercial flower crops and their identification/symptom of damage are summarized here under.

ROSE

There are a wide variety of insects that affect roses. Insect pests degrade the ornamental value of roses in the garden and decrease productivity in commercial rose ventures. In case of severe infestation, they can even cause death of plants. The following are the important insect pests of rose.

Aphids : These are small, slow-moving, soft-bodied insects with piercing-sucking mouthparts. Aphids cause damage by sucking plant sap. These insects grow early in the season on tender parts like shoots, buds and flowers. The infested flowers become malformed. The aphids secrete sweet honeydew on which fungi grow to produce black sooty mold which also degrades the ornamental value of rose. The honey dew also attracts ants. The aphid population is kept under control by natural enemies like lady bird beetles. Severe infestations can be controlled by spraying insecticides like monocrotophos, acephate, imidacloprid, malathion and dimethoate.

Thrips : These are one of the most important insect-pests of roses. There are several species, but flower thrips and western flower thrips are two of the most common. Thrips are tiny, insects. Immature thrips are usually light yellow to lemon colored and are spindle-shaped. Thrips cause damage mainly by feeding on flowers in same fashion as aphids do. Thrips can be effectively controlled by spraying insecticides like acephate, malathion, imidacloprid, Dimethoate and spinosad. Spinosad is one of the most important insecticides that provides very good control of thrips

Red spider mites : These are minute insects not visible to the naked eye and feed on the underside of the leaves. They feed by sucking the fluid from plant cells. When mite populations are heavy, leaves give a bleached or bronzed appearance and mites produce webbing on the top of leaves. Severely injured leaves may curl and drop from the plant. Foliar applications of carbaryl, acephate, or pyrethroid insecticides have a tendency to trigger mite outbreaks. Mites are favoured by hot dry weather, especially if accompanied by dusty conditions. Keeping plants well watered during periods of drought helps reduce the potential for mite outbreaks. Washing foliage with a water spray can also help control or prevent mites, especially if you spray the undersides of leaves. Mites can be controlled by spraying miticides like dicofol, milbemectin, malathion, bifenzate and dimethoate.

Scale insects : They can be easily detected by the reddish encrustations on the shoots. Their bodies are covered with a hard, scale-like covering that may be round, elliptical, tear-shaped, or oyster shaped, depending on species. These scale covers often blend in with the bark of the plant, making the scale difficult to see. Scale damage plants by sucking sap from the plant with their thread-like sucking mouthparts. Heavy infestations also cause tissue damage as they probe and feed on plant cells. Scale infestations can reduce plant vigor and growth. Heavy infestations can cause the death of shoots or even whole plants. The infested parts can be pruned to prevent further spread. They can be effectively controlled by spraying insecticides like malathion and dimethoate.

Chafer beetles : Rose chafers are beetles that feed on the growing points, making irregular holes and punches on the leaves. The grubs feed on the roots. The insecticides like carbaryl, acephate, and chlorpyriphos control these beetles.

Termites

Termites cause damage to the rose plants even before they are fully established. They destroy the underground parts. They are very difficult to control as they colonize under the soil. One of the most difficult things with termites is that by the time they are evident much of the damage would have been done to a plant. They can be controlled by soil application of chlopyriphos and application of granules of carbofuran.

Whiteflies

Adult whiteflies are small insects that are covered with a white waxy powder. They most often occur on the undersides of leaves, but clouds of adults will fly around infested plants when disturbed. Like aphids, whiteflies suck plant sap through piercing-sucking mouthparts. They can be effectively controlled by spraying imidacloprid, acephate, malathion and neem oil.

Digger wasps : They damage the plants after pruning. They dig into the pruned stem through cut end. Their digging also facilitates the entry of weak pathogens that cause die back. The pruned ends should be effectively sealed with a proprietary fungicidal paste to prevent the damage. In case of small gardens a few drops of insecticides like dimethoate may be dropped into the tunnel.

Mealy bugs : These are small insects with white cottony filamentous growth on the exterior. They damage the plants by sucking sap from the shoots. They can be effectively controlled by spraying monocrotophos and dimethoate.

GLADIOLUS

Seed corn maggot : The adults are slender, grayish with large winged flies. The maggots are small and white in colour. Maggots feed on the seeds of gladioli by entering the capsules in the field or webbing the seeds in the storage. Spray with 4% wettable chlordane powder. Dip the corms for one hour in thiram and insecticide solution for 24 hrs before planting.

Aphids : Aphids **s**uck saps from young plants and transmit viral diseases. Spray metasystox, rogor, etc. at the rate of 2 ml/l of water to control aphids.

Thrips : Adults emerged are milky white but soon turn brown except for the third segment which is light brown. The wings have a light transverse band near the base. They feed on flowers and floral sheeths. It causes deformities and discoloration of gladiolus flowers and corms become soft and prone to decay. It causes silvering and whitish streaks on spikes because the cells in drying out become filled with air and so reflect the light. Thrips also thrive on corms in storage. The buds and flowers remain closed or open irregularly due to thrips attack. Spray metasystox, rogor etc. at the rate of 2 ml/l of water before the bud initiation and at the time of flower emergence.

Cut worms : These feed on different parts of the plants and sever the plants at the base. Spray metasystox, rogor etc. at the rate of 2 ml/l of water to control cut worms.

Mites : They feed on leaves under warm and shady locations. White specks appear on leaves, which later turn into bronzing or silvering. Spray miticides to protect the plant from mite attack. Various kinds of miticides are available in the market.

Nematodes : They attack on gladiolus corms and roots. Treat dormant corms in hot water (35°C) for 30 minutes before planting

CHRYSANTHEMUM

Around 35 pests are known for the production of unsaleable blossoms and low quality pot plants. The important pests of the chrysanthemum and their management are given hereunder.

Aphids : Adults of Aphids are yellowish green to black in colour, with 3 mm long eyes. Nymphs are globular, yellowish green or brown in colour.

Aphids on the terminal shoot and on under side of the leaves cause damage by sucking the sap. Feeding

results in stunting, leaf curling, withering of flowers and severe infestation resulting in death of the entire plant.

Provide screens on vent and doors to prevent aphids from getting into greenhouse. Remove the weeds all around the crop. Use natural enemies like green lacewing, syrphids and ladybird beetles to keep aphid population very low. Spray monocrotophos (2ml/l) or malathion (1ml/l) for reduction of aphid population.

Thrips : These are very small insects and always hide in flowers, buds and leaf axils. They go unnoticed until damage appears. They are slender and white to black in colour. Thrips feed on growing points causing mottling and distortion of leaves and also leaf silvering due to separation of the upper epidermal tissue from the rest of the leaf. These aphids also damage flowers of summer blooming. The affected flowers look as if dried due to separation of the upper epidermal tissue from the rest of the leaf. Remove weeds in and around the crop and greenhouse in which crop has been raised. Use yellow or blue sticky traps for mass trapping of thrips. Release of nymphs and adults of the predatory minute pirate bug reduce the thrips population. Spray dimethoate (1ml/l) to control thrips.

Leaf miner : This is a major pest of commercially grown chrysanthemums throughout the world. The maggots of this pest make tunnels within the leaves between the upper and lower surfaces and pupate at the end leaving the characteristic trails behind. Avoid over fertilizer application because high N content are associated with leaf miner problem. Use yellow sticky traps for mass trapping of leaf miner. Provide a 40 mesh insect proof net to prevent the entry of leaf miner into greenhouse.

The other pests of chrysanthemum are The American worm, Caterpillar, red spider mite, Yellow mite, Bihar hairy caterpillar, gall midge, etc.

CARNATION

Red spider mite : It is the most serious pest of carnation which feeds on the under sides of leaves, suck the sap and eventually the leaves turn pale and have a dusty coating and fine webs. In severe attack, plants become stunted and flowers are invaded. Plant growth, crop quality, yield and vase life of flowers decreases with increasing mite populations. Use varieties having straight and flat leaves which are proved to be resistant. Clean and eliminate the weeds to reduce the mite incidence. Apply proper water and ventilation to prevent attach. Spray wettable surface (3g/l).

Aphids : They feed on flower buds, leaves and terminal shoots by sucking the sap and also transmits mottle virus. aphids suck the sap from the leaves and disfigures the young growth. Spray monocrotophos (2ml/l) or malathion (1ml/l) for reduction of aphid population.

Thrips : These are very small insects and always hide in flowers, buds and leaf axils. They go unnoticed until damage appears. They are slender and white to black in colour. Thrips suck the sap from the leaves, causing them to turn yellow and patchy with black specks and slight crinkling. A severe attack adversely affects the growth. They also cause streaks in the flowers, making them unmarketable. Flowers show brown abrasions. Remove weeds in and around the crop and greenhouse in which crop has been raised. Use yellow or blue sticky traps for mass trapping of thrips. Release of nymphs and adults of the predatory minute pirate bug reduce the thrips population. Spray dimethoate (1ml/l) or malathion (2ml/l) to control thrips.

The other insects of carnation are leaf beetle, cotton boll worm, carnation tortrix moth, carnation fly, etc.

MARIGOLD

Two spotted spider mite : It becomes a pest late in the crop cycle primarily it spins webs over the flowers

which interfere with pollination. Spray Dicofol 18.5 EC (2ml/l) of the water. Spot application of dienochlor mixed with insecticidal soap also controls the mite.

Leaf hoppers : Both nymphs and adults suck the sap and cause cupping or rolling of leaves, wilting of shoot tips and leaflets. French marigold is more damage by hoppers. Spray Dimethoate 30 EC or Malathion 50 EC (2ml/l of water) to control leaf hoppers.

Leaf miner : Larval feeding in the leaf mesophyll causes serpentine mines. Severe damage may reduce seed production due to reduced photosynthesis or severe stunting. The young plants may die. Release parasitic wasp in greenhouse which reduce the leaf miner population in greenhouse marigolds grown for seed within 8 weeks of first release.

Aphids : They feeds on flower buds, leaves and terminal shoots by sucking the sap and also transmits mottle virus. Aphids suck the sap from the leaves and disfigures the young growth. Spray monocrotophos (2ml/l) or malathion (1ml/l) for reduction of aphid population.

Greenhouse white fly : Sooty mould fungus grows on the honeydew excreted by whiteflies. Fungal growth on leaves can interface with photosynthesis or hinder pollination when it covers the flowers reproductive parts. Insecticidal soap can be used to reduce whitefly populations with no residual effects on natural enemies.

LILY

Leaf caterpillars : The larvae feed on green matter of leaves and cause defoliation. The moth is stout with a mosaic patteren of yellow, red and black on the forewings and black hind wings. In severe infestation, the whole plant is defoliated. Spray Malathion 50 EC (2ml/l of water) to manage leaf caterpillars.

Aphids : They suck sap from shoots and floral buds which results in withering of tender shoots and premature falling of buds. The affected plants lose their elegance. Spray monocrotophos (2ml/l) or malathion (1ml/l) for reduction of aphid population.

Lily bulb mites : The bulb mites feed on the bulbs and roots and destroy them. Afterwards they infest the scales and burrow into stems. The stem and leaves of infested plants become yellow. In *Lilium longiflorum*, typical symptoms include resetting, cessation of growth at a height of 3-6 inches, chlorosis and occasional death. Grow bulbs in properly drained soil. Follow crop rotation with non host crops. Store bulbs at 1.6°C to prevent mite attack. Hot water treatment is also effective against them.

Thrips : Thrips are serious pests of lily bulbs and produce rust coloured sunken areas at the base of the outer scales which become sft and break off easily. Plants grown from infested bulbs are stunted. Spray dimethoate (1ml/l) to control thrips. Hot water treatment is also effective against them.

The other pests of lily are lily beetle, lily weevil, stem borer, leaf caterpillar, etc.

GERBERA

Cotton white fly : The nymphs and adults suck sap from the underside of the leaves. Use yellow-orange sticky traps to control them. Application of methamidophos at 1ml/l effectively controls whitefly in greenhouses. Spray monocrotophos (2ml/l of water) or neem oil (3ml/l of water).

Leaf miner : The insects bore into the leaf and make irregularly shaped tunnels or blotches which are generally light yellowish tan to brown in colour. As larvae mature, they fold the leaf together with threads and feed on the inner surface. The combination of yellow trap against adults and aqueous sprays of pyrazophos against the larvae within the leaf mines is also effective. Spray dimethoate 30 EC (1ml/l of water) and chloropyriphos 20 EC (2ml/l of water).

The other insects of gerbera are mites (*Polyphagotarsonemus latus* Banks. and *Steneotarsonemus pallidus* Banks.), aphids (*Myzus persicae* Sulz. and *Aphis fabae* Scopoli.), *Helicoverpa armigera*, *Memestra brassicae* and *Spodoptera littoralis* Boisd.

DISEASES

Diseases include four main groups such as fungal, bacterial, viral diseases and biological disorders. The diseases receive their name from the symptoms rather than from the agents which cause them.

COMMON SYMPTOMS OF FUNGAL DISEASES

Rot: Different parts of the plant decay and rot. Soft plant tissue and bad smell characterize the process.

Leaf spot: Spots of different colors and increasing size appear on the leaf surrounded by a yellow border.

Rust: Rust or metal like spots on the underside of the leaves.

Blight: From brown to black colored circular spots on the leaves. They can also appear on the fruit.

Powdery mildew: Light colored powder on the upper surface of the leaves.

Downy mildew: Soft, grey growth on the lower surface of the leaves cause dead spots on the upper surface.

Damping-off: Seedling's disease. The bottom of the stem dries out and the seedlings fall over.

Anthracnose: Brown to black colour spots appears on leaves and fruits.

COMMON SYMPTOMS OF BACTERIAL DISEASES

Canker: Bumps and cankers appear on the branches, releasing gum onto the bark. It is usually accompanied with small brown spots on the leaves.

Blight: Brown areas and spots on the leaves grow from the edge of the leaf inwards.

Spot: Light colored areas on the leaves that turn to black. The spots on the fruit dry and crack.

COMMON SYMPTOMS OF VIRAL DISEASES

Mosaic: Leaves are covered in small, alternate yellow and green patches, accompanied by dwarf syndrome.

Leaf curl: Leaves curl upside, most common in solanaceous vegetable. Plants become unproductive.

Ring spot: Green and brown rings on the fruit. The plant stops growing

MAJOR DISEASES OF COMMERCIAL FLOWERS

The major diseases of important flower crops and their identification/symptom of damage are summarized here under.

ROSE

Die-Back (Casual organism: *Diplodia rosarum***) :** This is the most common disease of rose. The disease causes death of the plant top downwards. Initially, it is evident by blackening of the stem from the pruned end. Severe infestation leads to the death of the plant. As it is a weak pathogen it gains entry into the plant through wounds, injuries and pruning cuts. The affected parts should be cut away and burnt. The pruning cut should be oblique to prevent accumulation water. The pruned end should be sealed with proprietary fungicide like Bourdeaux paste or copper oxy chloride. The disease can also be effectively controlled by spray of carbendazim.

Powdery mildew (Casual organism: *Sphaerotheca pannosa***) :** This disease is the major fungal pathogen of roses grown in greenhouses and also an important disease on field grown roses. The disease is evident by powdery growth of the fungus, particularly on the lower side of the leaves. The disease appears when days are warm and nights are cool. Flower buds infected fail to open. Sanitation is very important to prevent the spread of the disease. All the infected debris hould be burnt. The disease can be effectively controlled by sprays of bavistin, benlate, karathane, bayleton and calixin.

Powdery mildew

Black spot (Casual organism: *Diplocarpon rosae***) :** The disease is evident by dark brown, circular spots with fringed borders. The spots expand and coalesce. The leaves turn brown and fall. The infested debris should be burnt. The diseases can be controlled with chlorothalonil, fenarimol and benlate. *R. wichuriana, R. rugosa, R. laevigata, R. multiflora, R. virginiana* and *R. roxburghii* were highly resistant to black spot.

Black spot

Downy mildew (Casual organism: *Peronospora sparsa***) :** Downy mildew is more common in greenhouse grown roses. Infections occur on young plants during extended periods of cool, humid weather in early to mid spring. Infected leaves develop purplish red to dark irregular spots. Later leaves drop prematurely resulting in complete defoliation of the plant. Downy mildew is effectively controlled by spraying chlorothalonil, Fosetyl-aluminum and Ridomil.

Downy mildew

Rust (Casual organism: *Phragmidium sp.***) :** The disease is evident by reddish orange pustules on leaflets and petioles. Later the colour changes to black. In case of severe infection, defoliation occurs. The disease can be controlled by sulphur and oxycarboxin.

GLADIOLUS

Fusarium wilt (Causal organism: *Fusarium oxysporium* f. sp. *gladioli) :*

The main symptom is inter-veinal leaf tip yellowing which extends down the leaf and the whole leaf gradually turns brown and becomes narrow. This disease also results in curving, bending, arching, stunting, drying of leaves. The leaf infection is also associated with root and corm rots in field as well as in storage. Dark colour streaks develop on corm base. Use resistant varieties together with soil drench

Rust

of Carbendazim for days after planting and three times at 10 day interval is recommended. Crop rotation, sanitation, early lifting and proper curing of corms at 29.5 - 30°C for about one week and hot water treatment of corms and cormels at 53-55°C for 30 minutes reduce the disease. Thiram, Captan sprays can be reduce the incidence.

Curvularia blight/ leaf spots (Causal organism: *Curvularia trifolii* f. sp. *gladioli):*

Yellowing and browning of leaf tips occur. Small to medium red spots which are dark brown in colour, rounded, elongated or irregularly shaped surrounded by a reddish brown ring, mostly shallow. This disease attacks young leaves, survives in corms and in soil and is carried on seed. It is also destructive to cormel planting and may develop on flowers during warm humid weather. As soon as the disease appears, sprays should be applied every other day, especially during wet weather. Spray 0.2% Dithane M-45 and miltox (Copper oxychloride +zineb) each at fortnightly intervals

Bacterial leaf spot (Causal organism: *Xanthomonas germisudans):*

They may damage leaves in warm rainy season. Crowded plants grown from cormels are mostly affected. Rotting of leaf sheath and stem at soil level. Cut the flowers for use or break out old flower heads only when foliage is dry. Also avoid working among wet plants. Avoid use of excess N fertilizer which results in lush growth. Hot water treatment of corms and cormels at 53-55°C for 30 minutes can reduce the disease.

Botrytis blight and flower rot (Causal organism: *Botrytis gladioli):*

It is destructive to leaves and flowers. Botrytis survives in corms, soil and in plant debris. Disease develops during cool wet weather conditions. Leaves are more susceptible to infection after frost injury. Small circular reddish brown sunken spots and results in spongy tissue during rot. Keep the relative humidity low (< 80%) and maintain good air circulation. Do not plant too densely. Roughing of affected plants and removal of all infected debris can reduce disease incidence. Hot water treatment of corms and cormels at 53-55°C for 30 minutes can reduce the disease. Application of mancozeb may check the disease.

Storage rot (Causal organism: *Penicillium gladioli*. Other fungi responsible for storage rot are the species of *Aspergillus, Rhizopus, Alternaria*, etc.):

It appears in the form of black, brown greenish or yellowish mouldy growth or the corms may rot and emit a foul smell. Wounding of corms at the time of digging or during handling should be avoided. Hot water treatment of corms and cormels at 53-55°C for 30 minutes can reduce the disease. Avoid damp storage conditions. The high temperature should be avoided as it may cause rapid rotting of corms under humid conditions.

CHRYSANTHEMUM

Basal stem rots (Causal organism: *Pythium* and *Rhizoctonia* sp.):

Rot due to *Pythium sp.:* Decay start near the soil surface rather than in the root system. Diseased area has brown colouration. Fungus form a brown coloured web over the crowded plants.

Rot due to *Rhizoctonia sp.:* Rotting start at the root tips. Roots become brown and blackdepending upon the stage of decomposition. It may destroy the root system and cause a slow retardation in growth.

Pre planting sterilization of soil with formalin (0.2%) and regular drenching with thiram controls the spread of infection to neighbouring cuttings.

Stem rot and wilt (Causal organism: *Fusarium oxysporum):*

Disease appears only after the appearance of flower buds although infection might have occurred even in rooting beds. Stem near soil becomes dark brown and dries. Lower leaves turn yellow and plant wilt permanently afterwards. Soil application of dithane M-45 (0.2%) controls the disease.

Grey mould (Causal organism: *Botrytis cinerea):*

The fungus can attack the plant at any stage from rooting bed to flowers in transit. I causes girdling of stem which results in death of upper part. Leaf infection starts from margin and proceeds towards centre and base, showing semi-circular bands. Flower infection starts with brown water soaked spots on lower petals. Proper aeration, more planting distance and spraying captaf (1g/l) or thiram (3g/l) provides good control.

Chrysanthemum ray blight (Causal organism: *Didymella chrysanthemi):*

It affects all plant parts but most severely affect the shoots and flowers which develop reddish petal spots on light coloured cultivars and brownish spots on darker coloured types. The disease often begins with the rotting of terminal buds while the leaves are affected by patches of brown black decay. When large lesions form at the base of stem, the plants may develop small yellow and often shriveled leaves. Destroy diseased plants and avoid high humidity in greenhouse. After the appearance of symptoms, spray at least three times at weekly intervals with Zeneb or Thiram (0.2%).

Chrysanthemum stunt (Causal organism: Chrysanthemum stunt virus):

Reduce flower size. Pale foliage with margins falling to enlarge giving stiff appearance. Red and bronze flowers, often bleached, may open prematurely. As the virus is transmitted through the wounds the tools used to cut or pinch affected plants should not be used on healthy plants without proper sterilization. Use cuttings from healthy plants.

CARNATION

Wilt (Causal organism: *Fusarium oxysporum* f. sp. dianthi):

It is favoured by warm temperature and can cause very high percentage of mortality. Chief symptoms are abnormal growth and stunting of young shoots. Leaves become yellowish and the stems are soft so as to easily crushed. The entire plant wilts and collapses in a short time after the attack. The part of the stem in contact with the soil shows shredding of bark while the wood beneath remains firm. If pulled, the plant breaks off easily. Since the Fusarium pathogen occurs in the vascular elements it may be already infected when removed from parent. Clean vegetative propagules can be obtained through the cultured cuttings, apical meristems, single cell cultures and indexing procedures. Always use pathogen free stock. Soil should be kept free from pathogens by clean cultivation, soil treatment with fumigants, steam sterilization, etc. This disease can be prevented by drenching of soil around the plants base with carbendazim (0.1%) or Bavistein (0.2%).

Alternaria leaf spot and blight (Causal organism: *Alternaria dianthi* Stevens and Hall):

This is most serious foliar disease of carnation. Small and purple coloured spots appear on the leaves. Under moist conditions these enlarge to form leaf spots up to one cm in diameter. The margins of the lesions are usually purple in colour and the centre is grey-brown and black spores may be present in this area. In severe cases, leaves get dry and become dead. This also affects the stems at nodes where it enters through the wounds or growth cracks producing black lesions. Destruction of diseased debris and Dithane M 45 (0.2%) spraying are recommended.

MARIGOLD

Leaf Spot (Causal organism: *Alternaria tagetica* and *Alternaria zinnia):*

It produces small, blackish-brown, circular spots initially which spread fast and become irregular later and cover large areas. Marigold is also attacked by *Alternaria zinnia* Pape which produces leaf blight or marginal-blight symptoms. The infection appears as minute spots which later enlarge to form large irregular spots or blotches that are amphigenous and light brown to dark brown. Dithane M-45 (0.2%) or copper oxichloride (0.2%) spray may reduce the infection.

Flower bud rot (Causal organism: *Alternaria alternate* and *Alternaria dianthi):*

This disease is serious in humid climate. The infection appears on young unopened buds as dark brown spots. Buds do not open properly and the flower quality is adversely affected. Dithane M-45 (0.2%) or copper oxichloride (0.2%) spray may reduce the infection.

Septoria leaf spot (Causal organism: *Septoria tageticola):*

Oval to irregular, smoky-grey to black spots, interspersed with minute, black fruiting bodies appear. Infection starts from the lower leaves and progresses upwards. Dithane M-45 (0.2%) or Bavistein (0.1%) spray may reduce the infection.

TUBEROSE

Foot and tuber rot (Causal organism: *Sclerotium rolfsii):*

Disease appears in patches and cause wilt and stems rot. A fan shaped mycelid strand of the fungus appears at the base of the infected plants and in later stages brown and round sclerotia develop on the mycelia growth. This fungus initially attacks the roots and later spreads to the tubers and petioles which induce rooting. Soil application of thiram (0.2%) or bavistein (0.5%) three times at 20 days interval may control the disease. Soil drenching with fumigants is also effective against this fungus.

Blossom blight (Causal organism: *Fusarium equiseti):*

Light brown lesions devlop on petals which soon darken and result in the drying of the tissue. The blighted blossom drops off from the plants. Tips of the florets become brown under humid conditions on which brown spore masses develop. Application of benomyl (0.2%) as a foliar spray reduces the disease.

GERBERA

Foot rot and root rot (Causal organism: *Phytophthora* sp. *Pythium* sp.; *Rhizoctonia solani):*

The plants killed in the nursery stage known as damping off and also at various stages of crop growth. These pathogens are favoured by water logged conditions and high humidity. Seed treatment with Captan, use of healthy seeds so as to get healthy nursery, avoidance of water logged conditions, good sanitation and proper application of fertilizers are general control measures.

Anthracnose (Causal organism: *Colletotrichum gloeosporiodes):*

It produces circular, scattered, reddish brown spots which collapse with one another in moist weather and involve large areas, thereby resulting in withering rolling and drying of leaves. Spraying with Bavistein (0.1%) gives an effective control. Excess water or overcrowding of plants should be avoided. Infected debris should be burnt in time.

Blossom blight (Causal organism: *Botrytis cinerea):*

Light brown irregular water soaked areas appear on flower stalks which enlarge and coalesce producing distinct depressed lesions. The infection spreads on the entire flower. The stalk of the base is girdled which causes drooping and death of plants. Deep planting, bad drainage and poor ventilation predispose the plants to infection and should be avoided. Infected plants should be removed and destroyed. Seed treatment with benlate (0.1%) or thiram (0.2%) helps in preventing the disease.

LILIUM

Foot rot (Causal organism: *Phytophthora cactorum):*

Infected plants turn violet brown at the base of the stem and then the infection moves upwards. The leaves become yellow acropetally. In severety, plants fall over due to collapse of the stem. Provide proper

drainage. Avoid cultivation in wet weather. Remove affected plants from the site and destroy them. Hot water treatment of bulbs for 2 hours at 39°C followed by a 30 minute dip in 0.2% benomyl eliminates infection and stimulates plant growth.

Fusarium Scale Rot (Causal organism: *Fusarium oxysporum* f.sp. *Liliae*):

Yellowing of foliage and wilting are the initial symptoms. Bulbs appear healthy but roots develop a reddish coloured decay at their tips. The plants remain stunted with yellow foliage and extensively rotted scales. The infected scales later fall away or shatter from the basal plate. Use resistant cultivars. Removal of infected plants and soil treatment with formalin or steam sterilization also helpful in controlling disease. Hot water treatment of bulbs for 2 hours at 39°C followed by a 30 minute dip in 0.2% benomyl eliminates infection and stimulates plant growth.

Botrytis blight (Causal organism: *Botrytis elliptica* and *Botrytis cinerea*):

The first symptoms of the disease initially appears as small, circular or elongated, sunken spots or water soaked. The centre becomes reddish brown at first and is gradually surrounded by a yellowish zone and becomes pale brown on enlargement. Flower buds thus produced are shrivelled, distorted or disfigured depending on the severity. Use disease free stock and resistant plant material for healthy flower production. Removal of all old foliage and flowers from field is necessary to eliminate the inoculums potential.

Bacterial Soft rot (Causal organism: *Bacillus lilii*, *Pectobacterium carotovorum*):

The bulbs become soft and wet decay occurs. All diseased bulbs should be discarded. Healthy bulbs should be planted in well drained soil. Avoid any injury to the bulbs while lifting from soil.

Viral diseases of lily are caused by tulip breaking virus, lily symptomless virus, cucumber mosaic virus, etc.

ACTIVITY/EXERCISE

1. Visit different fields of your area and collect samples of flower crops infested with insect-pests. Try to identify the pest and record it.

2. Visit different fields of your area and collect samples of flower crops affected by various diseases. Try to identify the causal organism (Virus, bacteria, fungi, etc.) and record it.

CHECK YOUR PROGRESS

A} Subjective Questions

1 Explain in brief cultural practices to control insect-pests of flower crops?

2. Explain in detail the various insects of rose and gladiolus and their management?

3. Write down the common symptoms of fungal, bacterial and viral diseases?

4. Explain in detail the various diseases of rose, gladiolus, chrysanthemum, carnation and Lilium and their management?

B} Objective Questions

a) Fill in the blanks

i. To overcome the harmful effect of insects and pathogens, there are broadly two types of management practices ———————and ——————— measures.

ii. Growing a series of different / dissimilar types of crops in the same area in sequential season is called ————————-

iii. A point at which pest populations or environmental conditions indicate that pest control action must be taken is known as————————

iv. The most important insect pests of rose is ————————

v. Causal organism of powdery mildew in rose is ———————— and can be controlled by ————————(fungicide)

b) Multiple choice questions

i. Which of the following is resistant to black spot

a) *Rosa laevigata* b) *R. multiflora*

c) *R. roxburghii* d) All of above

ii. The serious disease of gladiolus is

a) Fusarium wilt b) Die back

c) Powdery mildew d) None of above

iii. Foot and tuber rot of tuberose is caused by

a) *Sclerotium rolfsii* b) *Fusarium equiseti*

c) *Pythium sp.* d) None of above

iv. Anthracnose is a disease of

a) Rose b) Gladiolus

c) Gerbera d) Chrysanthemum

v. Bacterial soft rot of Lilium is caused by

a) *Bacillus sp.* b) *Pseudomonas sp.*

c) *Pectobacterium sp.* d) Both a) and c)

c) Write true (T) or false (F) for the following statements

I. *Die back* of rose is caused by *Diplodia rosarum*.

II. *Rosa wichuriana* and *R. rugosa* are susceptible to black spot.

III. The casual organism of Fusarium wilt is *Curvularia trifolii*.

IV. Chrysanthemum ray blight is caused by viruses.

V. Flower bud rot of marigold is caused by *Alternaria alternate*.

SUGGESTED FURTHER READINGS

i. Randhawa G. S. and Mukhopadhyay A.(2007). Floriculture in India. Allied Publishers Pvt. Ltd., New Delhi.

ii. Arora J. S., (1998). Introductory onamental Horticulture. Kalyani Publishers Pvt. Ltd. West Bengal.

Chapter 13
Post Harvest Management of Flower Crops

OBJECTIVES

After studying this chapter, students will be able to:

understand harvesting of flowers

know handling of harvested flowers

learn the post harvest management of different commercial crops

INTRODUCTION

Post harvest management can be defined as after harvest care of the plant or cut or loose flower. The term cut flower is defined as the flower which is harvested along with the portion of the stem. The demand for cut flowers in the global market is increasing at the rate of 10-15 percent each year. The major flowers which dominate the global trade are rose, carnation, chrysanthemum, orchids, tulips, gerbera, anthurium, lilies, gypsophila, bird of paradise, alstroemeria, etc.

The flowers are highly perishable in nature and prone to postharvest losses. Nearly 30 per cent flowers perish during handling. Postharvest management involves harvesting, pre cooling, pulsing, holding, dry and wet storage along with the postharvest package technology for commercial crops like rose, gladiolus, carnation, chrysanthemum, gerbera, anthurium, orchids, tuberose, etc. In this chapter, students will learn about harvesting of flowers, immediate handling of harvested flowers, packaging and storage of the commercial flowers.

HARVESTING OF FLOWERS

Proper stage, method and time of harvest is one of the important aspect to ensure long vase and shelf life of cut and loose flowers.

Harvesting time

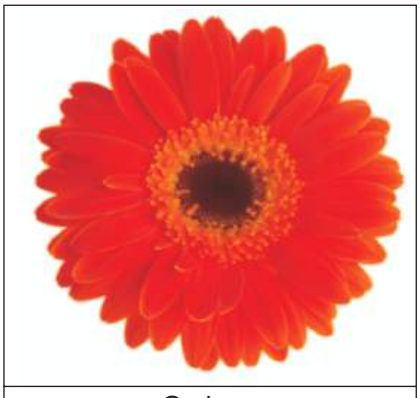
Flowers should always be harvested when temperatures are moderate because high temperatures lead to faster respiration and excessive water loss. Flowers should therefore, be harvested either in the morning or in the evening. In the morning, flowers are fully turgid due to low transpiration loss of water during night. Flowers such as rose, chrysanthemum and gerbera which are highly prone to water stress should preferably be harvested in the morning. Before packing the flowers, it should be ensured that there are no dew drops on the flowers because high moisture conditions favour the growth of pathogens. Evening harvest is also advised due to high sugar level in the stem which is again because of increased activity of photosynthesis during day time. After harvest, the cut stems should be immediately placed in water or preservative solutions.

Harvesting method

The stems should always be cut with sharp knives or secateurs. While harvesting, care should be taken not to crush the stem. Hardwood stems should always be given slanting cut so as to expose the maximum

surface area to ensure rapid water absorption. The nature of the cut, however, does not matter much in case of the herbaceous stems because such stems have ability to absorb water through epidermal tissue too.


Rose


Gerbera


Gladiolus

Stage of harvesting of different flowers

Specific flowers such as, stems of chrysanthemum should be harvested at least 10 cm above the ground level. The stem close to the soil is harder and lignified which results in lesser water uptake by the stem. The rose stems should be harvested leaving at least two 5 leaflet leaves on the stem. This ensures sufficient leaf area on the plant for sustained production of flowers for a longer duration. Some flowers such as dahlia, poinsettia and papaver release latex upon cutting that can be overcome by hot water (80-90^{0}C) treatment for few seconds.

Harvesting stage

Flowers should always be harvested at an optimum maturity stage. Too immature buds do not open properly whereas over mature ones also wither quickly. The stage of harvest varies with the species and even with the cultivar, prevailing temperature conditions, distance to the market place and requirement of the consumer. In general, for transport to the distant markets, the flower should be harvested at bud stage whereas for the local market, the flower can be harvested at relatively open stage.

Many flowers like rose, gladiolus, carnations, daffodils, lilies, iris, freesia and tulip can be harvested at bud stage as the buds of these flowers possess the ability to open in water. However, flowers like orchids, dahlia, gerbera, calendula etc. are harvested when fully open. The optimum stages of harvest for some important flowers are mentioned in the following table:

Optimum stages of harvest for important flowers

Flower Name	Stage of harvest
Antirrhinum majus (snapdragon)	1/3 florets open
Calendula officinalis	Fully open flowers
Cattleya sp. (orchid)	4-5 days after opening
Chrysanthemum morifolium (Florist's chrysanthemum)	Standard :When outer florets fully expanded Spray: Flowers open but before shedding of pollens Pompons and decorative :Centre of the oldest flower filly open Anemones: Open but before central disc florets begin to elongate

Dahlia variabilis	Fully open flowers
Dendrobium sp. (orchid)	Fully open flowers
Dianthus caryophyllus (carnation)	Standard: Paint brush stage when flowers are half open Spray: At least 2 flowers fully open
Freesia hybrids	Coloured buds
Gerbera jasmesonii	Flowers open but outer 2 rows show shedding of pollens
Gladiolus sp.	1-5 florets show colour
Gypsophila paniculata	Flowers just open
Iris germanica	Coloured buds
Lilium sp. (lily)	Coloured buds
Narcissus sp. (daffodil)	Goose neck stage
Polianthes tuberosa (tuberose)	Single : Buds fully developed but unopened Double: Maximum florets open
Rosa× hyrida (Rose)	1-2 petals beginning to unfold
Strelitzia reginae (bird of paradise)	First floret opens
Tulipa sp. (Tulip)	Half coloured buds
Zinnia elegans	Fully open flowers

Harvesting of flowers at bud stage is always advantageous as the buds continue to open over a long time and hence, possess long vase life. Besides, the buds are less sensitive to ethylene, easy to handle during storage and transport, economical to transport and are less prone to damage by diseases and pests.

HANDLING OF HARVESTED FLOWERS

Pre -cooling of flowers

Most of the cut flowers are pre- cooled either by simply placing them packed or unpacked in cold chambers or by forced air cooling. Forced air cooling involves forcing cool air in the packed boxes. The system is efficient and the flowers can be cooled in 6 to10 hours. Cold chain linkage from farm to the market is necessarily required to maintain quality of the cut flower. Optimum temperature to which the flowers are cooled varies with different flower species. Flowers are generally cooled at 2-3°C but those originating in tropical and sub-tropical climates are prone to chilling injury and hence, pre-cooled at higher range of temperatures.

Floral preservatives

The term 'Floral Preservative' is used for any chemical formulation which is used for extending the vase life of flowers. Besides increasing vase life, floral preservatives help to improve flower opening, flower size, shape and colour. Many commercial formulations are now available in liquid or powder forms in many countries like U.K., U.S.A. and Holland for extending flower vase life. These formulations are to be used as per the guidelines provided by the manufacturer.

Types of floral preservatives

Floral preservatives can be applied as (i) pulsing solutions, (ii) bud opening solutions and (iii) holding or vase solutions.

Pulsing solution: "Pulsing" refers to short duration (16-24 h) pre-shipment or pre-storage treatment. The effect of such a treatment lasts throughout the entire vase life of the flower. Sugar (sucrose) is a main component of the pulsing solution. Since pulsing involves short duration treatment, relatively higher levels of sucrose are used.

Bud opening solution: Immature buds of many flowers can be made to open in chemical solutions, referred to as "bud opening solutions" The components of bud opening solutions are essentially the same as those of pulsing solutions, but in case of bud opening solutions, lower concentrations (2 to 5 per cent) of sucrose are used.

Holding or vase solution: Holding or vase solutions are meant to hold flowers continuously, until the termination of vase life. The level of sucrose in vase solutions is, therefore, also kept very low (0.5 to 2 per cent), due to long durations for which flowers are kept in the solution. Many commercial vase preservatives are also available for use as holding solutions and are required to be used as per recommendations of the manufacturer.

Constituents of floral preservatives

The main constituents of floral preservatives are (i) Water, (ii) Sugar, and (iii) Biocides. Besides, mineral nutrients, acidifying agents, anti-ethylene compounds and growth regulators are also used in floral preservatives. The brief account of these constituents is given herewith:

Water: at is the most important component of floral preservatives. It affects vase life in terms of its quantity as well as quality. Tap water can be harmful due to its high pH (alkalinity), presence of total dissolved solutes (TDS) and toxic ions. High pH promotes the microbial growth and hence, reduces vase life. Therefore, acidifying water to low pH 3.0-3.5 is advantageous because it decreases microbial growth and considerably improves water uptake by the stem. Sensitivity of different flowers to the presence of TDS in vase water varies. Vase life of rose and chrysanthemum flowers shows decline even at low level of TDS (200 ppm) in water. Some flowers like gladiolus show decline in vase life when TDS in water is relatively high (more than 700 ppm).

The presence of sodium ions in vase water is detrimental for roses whereas fluorides are highly toxic to some flowers like gladiolus, gerbera, freesia, and chrysanthemum. In such cases, it is always advantageous to use deionized or distilled water. If tap is to be used, it should be boiled and decanted to remove the dissolved salts. In certain cases, tap water is also reported to increase vase life due to the presence of a combination of minerals like $CaCl_2$, $NaHCO_3$ and Cu^{2+}.

Sugar: This is the most widely used sugar in floral preservatives. Sugars acts as additional food source and also improve water balance of cut flowers. Besides, sugar also decreases sensitivity to ethylene. The optimum concentration of sugar required, however, varies from species to species and type of the treatment. Since sugar promotes microbial growth, it is usually combined with biocides before use.

Biocides: These are chemical compounds which are used to inhibit microbial growth in vase water as well as on the stem surface. Important biocides used for treating cut flowers are 8-hydroxyquinoline citrate, silver nitrate, aluminum sulphate, citric acid, slow release chlorine compounds and quaternary ammonium compounds.

8- hydroxyquinoline citrate (8-HQC) is very effective broad spectrum biocide. It acidifies water and also induces partial closure of stomata. This compound is used at the concentration of 200-600 ppm. Silver nitrate ($AgNO_3$) is also very effective biocide. $AgNO_3$ at the concentration of 25 ppm completely inhibits the microbial growth. High concentration (1000-1200 ppm) of $AgNO_3$ can also be used as short term (10 – 15 minutes) treatment. $AgNO_3$ has, however, very low mobility and remains concentrated at the cut surface of the stem where it inhibits microbial growth. A lot of concern is however, being voiced in the developed countries regarding the use of silver, as being a heavy metal, it is considered to be an environmental hazard.

Aluminium sulphate (100-300 ppm) has also been found very effective in increasing keeping quality of gladiolus, carnation and roses. It reduces pH of the solution, very effectively inhibits bacterial growth and also causes partial stomatal closure, thereby, increasing vase life. Aluminium sulphate is also reported to cause foliage wilting in chrysanthemum, and hence, must be used with caution.

Citric acid (50-100 ppm) improves vase life of roses, chrysanthemum, gladiolus and carnation. It acts as an acidifying agent, lowers pH of the solution and also prevents blockage of xylem vessels.

Several slow release chlorine compounds such as sodium dichloro isocyanurate (DICA) and 1,3-dichloro-5,5-dimethyl hydantion (DDMH) have also been found useful for many flowers and also form constituents part of many floral preservatives. Quaternary ammonium compounds have also been found very useful biocides for cut flowers.

Besides, some other compounds such as thiabendazol, dichlorophen, salts of nickel, cobalt and copper and benzoic acid have also been found to extend vase life of some flowers.

PACKAGING OF FLOWERS

Flowers are generally made in to bunches of 5, 10,12 or 20 stems, and loosely tied with rubber band. Bunches should be carefully put together to prevent any damage to the blooms and leaves and secured with the rubber band at the base and close to the bunched head. Flowers such as gerbera, orchids, anthurium and standard chrysanthemum are packed individually. The bases of some tropical flowers such as dendrobium and anthurium are kept moist by putting them in specially designed vials filled with water or in moist wool. Bunches are held in polyethylene sleeves or buds are wrapped in corrugated paper to protect them from mechanical damage. Polyethylene sleeves are generally employed for wrapping a wide range of flowers but such a wrap may tend to retain moisture and encourage fungal attack. Hence, many wholesalers prefer naked bunches. Hot-needle sleeves allow the bunches to breath and reduce the chance of fungal attack.


Packaging of cut rose stems in fibre board boxes

The flowers are generally packed in telescope types boxes made of corrugated fiberboard. The quality board (usually 4-5 ply boxes should be strong enough to hold the weight of at least eight such completely filled boxes) should be used. The dimensions of the packing boxes are worked out keeping in view the length of the stem, type of the flower to be packed and efficient utilization of the space in the cargo or in refrigerated trucks.

Gladioli, snapdragon and some other species which show geotropic bending during transport should be transported in vertical hampers. A new packaging system, **the 'Procona'** system which uses plastic container and a cardboard sleeve and allows transport of flowers upright in water is very useful to keep flowers fresh during transport, especially when they are not transported under proper temperature conditions.

Transportation of flowers

Flowers are usually transported by air and by refrigerated vans/trucks. But when the distances are short, non-refrigerated insulated trucks can also be put to use for transportation of flowers. Temperature management during transportation is very essential. The flowers should be pre-cooled before transport and also kept cool during transit. Therefore, flowers and boxes are essentially required to be cooled before transport. Postharvest problems of flowers mostly arise while loading the local vehicle and storage at the airport. Before loading, boxes or the truck or van is pre-cooled to the ideal temperature Loading should be carried out as quickly as possible.

STORAGE OF FLOWERS

Storage of flowers regulates the supply of the flowers in the markets to prevent gluts especially, during the periods of high production and low demand when the prices crash down. Storage is also useful to hold the flowers till sufficient quantities are available for shipment.

Factors affecting storage life

Important factors which determine the storage life of the flowers are

Quality of the flower to be stored: The flowers must also be cut at an optimum harvest maturity. Some flowers like gladioli, roses, lilies, narcissus and irises can be stored at bud stage as buds of these flowers possess the ability to open after storage.

Stage of harvest: The flowers must also be cut at an optimum harvest maturity. Some flowers like gladioli, roses, lilies, narcissus and irises can be stored at bud stage as buds of these flowers possess the ability to open after storage.

Temperature: Temperature management during storage is an important component which determines subsequent vase life of flowers. Temperature fluctuations in the cold room should be avoided.

Relative humidity during storage: Relative humidity inside the cold room should preferably be kept high (90-95 per cent). Low relative humidity causes excessive water loss from the flowers thereby stimulating their desiccation.

light

Ethylene production

Pathogens: Cold rooms should be kept clean to prevent the spread of pathogens as well as ethylene accumulation by the decaying plant tissues and microbes.

Storage Methods

There are three methods for the storage of flowers;

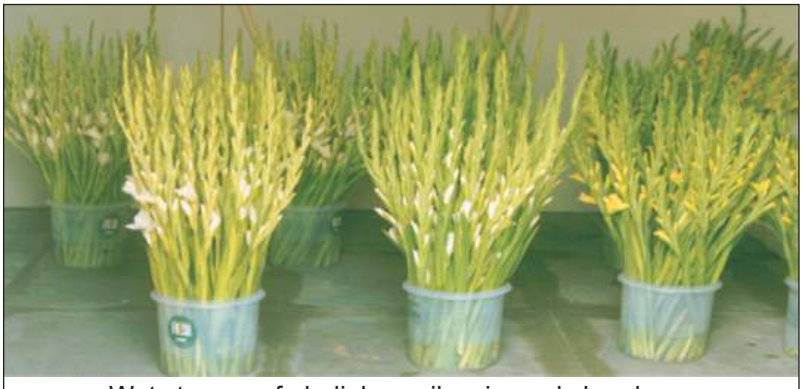
Simple Refrigerated Storage (which includes both wet and dry storage);

Controlled Atmosphere (CA) Storage;

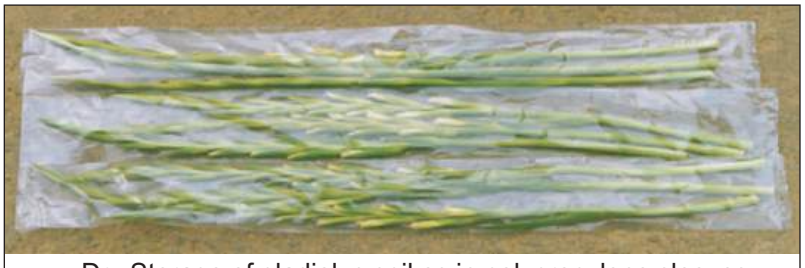
Hypobaric or Low Pressure Storage (LPS).

Simple Refrigerated Storage

Simple Refrigerated storage is the most widely used method for storage of cut flowers. It includes two types of storages viz. wet storage and dry storage. **In wet storage**, the stems are stored with their basal portions dipping in water or preservative solution. Wet storage is used to hold the flowers for short duration and for their day to day handling. The temperature in wet storage is kept at 2-4°C i.e. slightly higher than that in dry storage.



Wet storage of gladiolus spikes in cool chamber



Dry Storage of gladiolus spikes in polypropylene sleeves

In dry storage, flowers are sealed in plastic bags to prevent the loss of moisture. Dry storage is also referred to as Modified Atmosphere (MA) storage because sealing of flowers in plastic bags leads to reduction in O_2 and increase in CO_2 levels due to respiration of the tissue. Such conditions are suitable for storage of flowers. In general, 5-7 % CO_2 and 1- 2 % $O_2$is kept in storage. Build up of very high levels of CO_2 (beyond 4-5 %) or extremely low levels of O_2 (lower than 0.4 %) in the packages, however, may damage the flowers. Therefore, it is very important to identify the suitable films for optimum build up of both CO_2 and O_2 levels inside the packages. Dry storage is more laborious but can be used to hold the flowers for longer duration. Before dry storage, flowers should be pre-cooled to remove the field heat. Pulsing of flowers before storage also improves their storage life. Most flowers are prone to freezing injury below -2°C but since free water freezes at 0°C, water droplets condensing on the petals can also cause injury to the tissues. Therefore, the flowers should be stored at 0.5-1°C. The temperature range for tropical flowers like anthurium, cattleya and poinsettia is 10-15°C and for sub tropical flowers such as gladiolus, strelitzia and anemone is 2-8 °C.

Storage type	Crop	Storage Temperature	Maximal storage period
Dry storage	Carnation	0 - 1°C	16 - 24 weeks
	Chrysanthemum	1°C	3 weeks
		4°C	2 weeks
	Gerbera	2°C	2 days
	Gladiolus	4°C	2 -3 weeks
	Rose	0.5- 2°C	2 weeks

Wet storage	Anthurium	13°C	2 - 4 weeks
	Carnation	4°C	4 weeks
	Chrysanthemum	4°C	2 weeks
	Dendrobium	5 - 7°C	10 - 14 weeks
	Gerbera	4°C	3 - 4 weeks
	Gladiolus	4°C	9-12 days
	Tuberose	7 - 10°C	3-5 days
	Rose	2 - 5°C	5 days

Controlled atmosphere (CA) Storage

Controlled atmosphere (CA) storage refers to low temperature storage in gas tight chambers under decreased levels of O_2 and increased levels of CO_2. CO_2 levels higher than 4-5 per cent may produce anaerobic conditions. Major limitation in CA storage of flowers is that the optimum levels of O_2 and CO_2 required for storage vary for different flowers and hence, different flowers cannot be stored at the same time in the same chamber.

Hypobaric or low Pressure Storage (LPS)

Hypobaric or low Pressure storage (LPS) refers to storage at low atmosphere pressure i.e. 40-60mm Hg) under continuous ventilation and high relative humidity. Major disadvantage of LPS is that it causes rapid loss of water and faster removal of gases from the tissues. LPS, however, holds considerable promise for prolonged storage of flowers but due to high cost of installation, it is of limited use.

The optimum storage temperature and duration of storage varies with each individual flowers. As a general rule, flowers originating from temperate regions e.g. rose, carnation, lily, cymbidium and chrysanthemum are best stored at a temperature close to 0°C above the freezing point of plant tissues i.e. at above -2°C. Flowers originating from tropical regions e.g. anthurium, vanda, cattleya and bird of paradise are sensitive to chilling injury and hence, have to be stored at higher temperatures.

POST HARVEST HANDLING OF COMMERCIAL FLOWER CROPS

ROSE

Harvesting: Flowers should be harvested at the tight bud stage when the floral buds are fully matured and had developed full colour. If harvested earlier, the immature flower buds will not open properly. White, pink and yellow cultivars are harvested earlier to red as red may not open if harvested at tight bud stage. The flower stalk should be done with sharp secateurs. It is advisable to harvest in early morning hours as to obtain quality flowers.

Handling: The flowers after harvesting should be pre-cooled by keeping them in bucket containing water so as to remove field heat. This treatment lowers down the respiration rate and should be performed in polyhouse itself and immediately transferred to cold storage.

Grading and Packaging:

The popular grades of rose are

Large flower cultivars: Stem length 60-90 cm and bud size 3-3.5 cm

Small flower cultivars: Stem length 40-50 cm and bud size 2-2.5 cm

Roses are packed in the bundles of 10, 12, 20 and 25 in corrugated card board boxes of 100×32.5×20 cm (L×W×H) accommodates about 80-100 cut roses of 60-65 cm length. Bunches are wrapped in cellophane sleeves. Then, inline the boxes with tissue paper or newspaper.

Storage: The flowers can be stored at 2-4°C in cold storage for enhanced floral quality and vase life.

GLADIOLUS

Harvesting: The spikes of gladiolus should be harvested at tight bud stage with one or two pairs of leaves when the lower 1-3 flower buds shows colour for distant markets, whereas for local markets, spike should be harvested when lower flower has started opening. The spikes should be harvested by making a slant cut with sharp knife at base of the spike and it is advisable to harvest the spikes during morning or evening hours.

Handling: After harvesting, spikes should be immediately kept in bucket containing cold water for removal of field heat. The pulsing treatment is given before packing with 400 ppm 8-HQC + 3% sucrose for 3 hours

Grading and Packaging: The spikes are graded into four grades depending upon their stem length and number of florets per spike. The International grades for gladiolus is as follows.

Grade	Spike Length (cm)	Minimum number of florets
Fancy	>107	16
Special	96-107	15
Standard	81-96	12
Utility	<81	10

Packaging

The spikes should be grouped into bunches, each bunch should contain 12 spikes and then fastened with rubber bands. In order to avoid bruising and desiccation, the bunched spikes should be packed in corrugated paper and then finally packaged into cardboard boxes. For local markets, Tube light boxes are also used for packaging.

Storage: The spikes can be stored at a temperature of 4-8°C in cold storage. To prevent them from geotropic bending, they are always transported in upright position.

CARNATION

Harvesting

Standard cultivars for local market are harvested when flowers are half opened or at painting brush or outer petal is perpendicular to stem, whereas foe distant market cross is developed on buds and colour is visible.

Spray cultivars are harvested for local market when two flowers have opened and others have shown colour, while for distant market when 50% flowers have shown colour. For loose flowers, fully open flowers are harvested.

Grading

The various grades of carnation cut flowers suggested by Society of American Florists are based on minimum flower diameter and stem length.

Parameters	Grades		
Bud diameter (mm)	**Blue or fancy**	**Red or Standard**	**Green or Short**
Tight	50	44	None
Fairly tight	62	56	None
Open	75	60	None
Stem length (cm)	55	43	30

Other local grades of carnation are based on minimum stem length (cm) are A-Over 45 cm;A: 30-45 cm; C: Less than 30 cm.

Packaging

Carnations are packed in the bundles of 10, 12, 20 and 25 in corrugated card board boxes of 120×60×30 cm (L×W×H) accommodates about 800-1000 flowers. Bunches are wrapped in cellophane sleeves.

Storage: The flowers can be stored at 0-4°C in cold storage for enhanced floral quality and vase life.

CHRYSANTHEMUM

Harvesting

For cut flower purpose, mainly there are two types, standards and sprays. Standards are harvested when outer rays florets started unfurling or reflexed whereas sprays are harvested when the lower 2-3 flowers are opened. The flower stem should be cut at 20 cm from the ground level with sharp knife. However, for loose flower purpose, the fully developed and opened flowers are harvested. The harvesting of flowers in the morning is generally recommended for obtaining superior quality.

Handling

It is recommended to keep the flowers immediately in a bucket containing water and preservatives. Sometimes chrysanthemum is harvested at bud stage for distant markets and then bud opening solutions are recommended for uniform opening of flowers. The bud opening solution containing 200 ppm 8 HQC+ 2-5% sucrose for 24 hours at 21°C in continuous light is generally recommended.

Grading

Chrysanthemums are graded based on various parameters like Stem length, number of flowers, colour, appearance and freshness of flowers. Standard chrysanthemums are grouped into 4 grades i.e. Blue, Red, Green and Yellow whereas spray types grouped into three grades i.e. Gold, Silver and Bronze. The leaves are striped of 15-20 cm from lower portion of the stem.

Parameters	Grades			
	Blue	**Red**	**Green**	**Yellow**
Stem length (cm)	75	75	60	60
Flower diameter (cm)	15	12.5	10.0	——
Stem strength	strong	———	———	——

Packaging

The stems are bunched in five and fastened with rubber bands at the lower portion of the stem and further packed in polythene sleeves. These polythene sleeves are then packed in cartons of having measurement of 91 x 43 x 15 cm. Generally cushioning material is provided to avoid bruising of flowers.

Storage: Chrysanthemum can be stored for 3-6 weeks period at 0-3°C.

MARIGOLD

Harvesting

The flowers are harvested when they are fully developed and matured but before they are fully opened. It is advisable to harvest the flowers in the evening. Before harvesting flowers, a day before, the field should be well irrigated because by doing so the flowers will retain its freshness and keeping quality for long time.

Handling: The harvested flowers are graded according to size, colour, appearance etc.

Grading and Packaging: Generally for local markets, the flowers are packed in bamboo baskets and gunny bags. For export purpose flowers are packed in corrugated fibre board boxes with vents for air exchange.

TUBEROSE

Harvesting

For marketing of flower spikes, the tuberose is harvested by cutting the spikes from the base when 1-2 pairs of flowers open on the spike. Individual flowers which grow at the horizontal position on flowers stalk are picked in the early morning. The spikes are clipped by using a sharp knife/secateur that gives a clean cut, leaving about 4-6 basal portion of the scape so as not to damage the growing bulb.

Grading

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

Packaging

Loose flowers of single-flowered tuberose are packed in bamboo baskets covered with wet gunny bags. About 10-15 kg fresh flowers are packed in each basket and transported to the nearby wholesale market where they are sold by weight.

The spikes are packed by wrapping them first in wet newsprint sheets and subsequently in corrugated sheets, making bundles of convenient sizes. Such bundles are finally packed in strong card boxes, which are quite handy.

ACTIVITY/EXERCISE

1. Harvest the various flowers at appropriate stages and follow the post harvest procedures to maintain flower quality.

CHECK YOUR PROGRESS

A} Subjective Questions

1 What do you understand by post harvest management?

2. Write down a short note on harvesting?

3. What are the various components of floral preservatives?

4. What are the methods of storage of flowers?

5. Write down the post harvest management of rose, carnation, chrysanthemum and marigold?

B} Objective Questions

a) Fill in the blanks

I. Gladiolus is harvested when_____.

II. The main constituents of floral preservatives are_____,_____ and _____.

III. The sodium ions are detrimental to_____flowers whereas fluorides are highly toxic to_____flower.

IV. Flowers are generally made into bunches_____,_____,_____ and_____ stems.

V. In dry storage,_____% CO_2 and _____% O_2 is kept to get good quality flowers.

b) Multiple choice questions

i. Short duration pre-shipment or pre storage treatment with solution is known as

a) Holding b) Pulsing

c) Pre-cooling d) All of above

ii. Microbial growth in vase water is decreases at pH

a) 3.0-3.5 b) 8-8.5

c) 7.0 d) None of above

iii. Which of the following is act as biocide

a) Sugar b) Citric acid

c) 8-HQC d) Both b and C

iv. The relative humidity inside the cold room is kept around

a) 40-50 % b) 60-70 %

c) 90-95 % d) None of above

v. Dry storage is also known as

a) Modified atmosphere storage

b) Controlled atmosphere storage

c) Low pressure storage

d) All of above

c) Write true (T) or false (F) for the following statements

I. Harvesting should be done when temperature is high.

II. Snapdragons are harvested when 1/3 florets are open.

III. High pH promotes microbial growth and reduces vase life.

IV. Sugars in floral preservatives act as anti-ethylene compound.

V. Anthurium is stored at 13 °C for 2-4 weeks.

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Chapter 14

Value Addition in Flower Crops

OBJECTIVES

After studying this chapter, students will be able to:

know the importance of value addition

understand the benefits and ways of value addition

familiar with different value added products

know the major challenges in value addition industry

INTRODUCTION

Whenever you go to market, shopping malls, etc., always find some value added products made from flowers through value addition. Value addition is a process of increasing the economic value as well as consumer attraction of any floral products through diverse ways i.e. changes in genetics, processing or diversification. Value-addition is any step taken to increase the value of a raw product anytime between harvesting and sales of the final product. Value added products constitute nearly 15% of the global floriculture business and form the major share in Indian floricultural exports as well. Availability of raw materials, cost effectiveness and usefulness of the product are the important considerations for commercial production of value added products. Any product can be considered value-added if it is originally grown by the farmer and increased in value "by labour and creativity." By adding value means to generate a value added product for which consumers are willing to pay more than they would like to pay for a raw product.

India has high scope for value addition in floricultural crops because of its rich bio diversity. Many regions in India are still unexploited as far as floral wealth is concerned. They are rich in many wild floras that can exploit for value addition with minimum expenses.

India is one the leading country in loose flower production like rose, tuberose, jasmine, marigold etc. and all these crops have unique quality of having the essential oils. Value added products from these crops like perfume, various nutraceutical and pharmaceutical compounds have great demand in International market. Thus, India can lead in export of these products if proper planning can be taken. It requires collaborative effort of both government and private enterprise. The government should frame policies and should take some initiatives for the promotion of the value addition industry.

BENEFITS OF VALUE ADDITION

Value-addition ensures more acceptable quality products for the domestic and export market.

It creates novelty and diversification.

Elimination of waste and utilization of excess produce.

Additional profit and stabilize farm income.

Value-added products offer creativity.

VALUE ADDED SERVICES IN FLORICULTURE

The floriculture trade comprises of only the fresh flowers and pot plants but also many value added products are enlisted hereunder:

1. Tinting : Artificial colouring of the flowers to create novelty
2. Aqua packing for better presentation and attraction
3. Three dimensional window packing of flowers for greater visibility
4. Garlands, venis, bouquets, flower arrangements etc.
5. Petal embedded craft papers for making greeting cards
6. Dry flowers and pot pourries
7. Special sleeve for packing of the pot plants

VALUE ADDED PRODUCTS FROM FLOWER CROPS

1. Essential oils
2. Dry flower
3. Pharmaceutical and nutraceutical compounds
4. Insecticidal and nematicidal compounds.

1. **Essential oils:** Essential oils may be defined as chemical compounds of odoriferous nature, highly volatile, obtained from herbs, flowers, woods and seeds. Essential oils are used mainly in perfumery, flavor, cosmetic industries and aromatherapy. Aromatherapy refers to use of essential oils for various therapeutic purposes. The scent of essential oils is conveyed by the olfactory nerve to areas of brain that can influence emotions and hormonal response. Pure essential oils are blended for harmonious, combined effect and fragrance. Essential oils blends are being utilized for various purposes like emotional and hormonal balance, stress relief, rejuvenation, calmness etc. The concept of aromatherapy is also gaining importance in India as well and scope exists for diversifying in to cultivation, extraction of aromatic principles with known therapeutic values.

Flower crops used for essential oils extraction

Crop	Recovery (%)
Rosa damascena	0.05
Rosa bourboniana	0.04
Rosa centifolia	0.01
Jasminum grandiflorum	0.25-0.30
Jasminum auriculatum	0.29
Jasminum sambac	0.14
Polianthes tuberosa	0.08-0.11

Value added commercial fragrant products

Rose


Rose water

Rose water: It is prepared by boiling the rose flowers in water and condensing the steam. Rose water is used as sherbets, eye lotions and eye drops.

Rose oil, Otto or attar of roses: Out of dozen constituents that have been identified in roses, only one is soluble in water which gives us rose water. The attar constitutes the remaining eleven essential oils, together with the wax from the surface of the petals and other minor impurities. It is the costliest among the natural essential oils used in high grade perfumery products all over the world.

Itra of roses: Indian roses itra is in fact a type of oil produced by distilling rose flowers and absorbing the vapours in oil of sandalwood in receiver.

Gulkand: Preserving the rose petals in sugar is known as Gulkand. It is prepared by mixing rose petals and sugar in ratio of 1:2 and mashing and drying the mixture in the sun. It is laxative and is commonly used for flavouring and sweetening purpose.

Agarbatties and Dhoopbatties: In crude distillation methods the flowers cannot be exhausted completely. The petals left after distillation contain some odour. The petals are dried in shade and used for manufacturing agabatties and dhoopbatties. These petals are also used for flavouring of snuffs, chewing tobacco etc.

Rose vinegar: Rose petals ere used for preparation of rose vinegar. It is digestive, refreshing and cooling.

Pankhuri: It is prepared by drying the rose petals in shade and used in preparation of cool summer drinks and incense

Jasmine

Jasmine Oil

Burners and vaporizers: It can be useful for treating depression and nervous disorders. It acts as a relaxant

Blended massage oil or in the bath: It helps to promote relaxation, reduces tension, stress. It is also useful as a soothing agent in muscle pains.

Lotion and creams: It is useful for removing scars and creams and lotion best suited for dry skin.

Blended with other oils like Sandalwood, Rose, bergamot and all citrus oils.

2. Dry Flowers

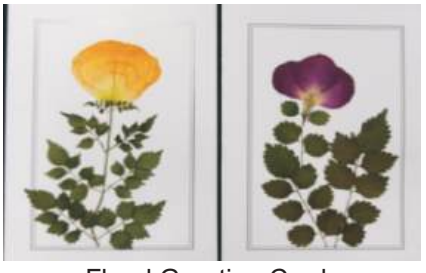
Dry flowers may be arranged in dry vases just as fresh cut flowers are arranged. Dried flowers, grasses, seed heads and pods are used mainly by florists to make semi-permanent, maintenance-free flower arrangements. They are found both in homes and in commercial locations throughout the world. India is one of the major exporters of dry flower.

Top ten genera of dried ornamentals in the global market are *Helichrysum, Helipterum, Limonium, Nigella, Gypsophila, Delphinium, Amaranthus, Papaver, Carthamus, Rosa.*

Dried flower products


Potpourri

Potpourri: It is special dried floral arrangement that is the mixture of sweet smeling leaves, spices, seeds, roots and distilled essential oils which is filled in pillows or sachets. The basis of a potpourri is the aromatic oils found within the plant. The important plants used for making pot pourri are roses, lilacs, lavender, pinks, hyacinth, lilies, violets, wall flowers, marigold and many other which are associated with perfume *viz.* geranium, daisy bush, bergamont, sage, savory, thyme, angelica and sweet cicely.


Floral Greeting Cards

Corsage: A flower or small arrangement of flowers worn by a person as a personal ornament. Typically worn by women on special occasions (like anniversary celebration, wedding), a corsage may be worn pinned to the chest, or tied to the wrist. It is usually larger or more elaborate than a buttonhole.

Wreath : It is a band of flowers or foliage inter-twined into a ring, usually placed on a grave as a memorial or worn on the head as a garland or a mark of honour. The dry flowers utilized for making wreath are roses, lavender, pansy, hydrangea, forsythia etc.


Floral wall hangings and frames

Floral greeting cards : Greeting cards can be made easily by drying the flowers by press drying. The press dried flowers are pasted on craft paper with the help of glue.

Buttonhole : A small flower or bunch of flowers worn in a buttonhole or pinned to the lapel of a coat/jacket is known as buttonhole.

Wedding dried flower buttonholes arrangement available in market

Wedding dried flower buttonholes with wheat, dried lavender stems or a mixture. Each simple button hole is approximately 9 cm long and tied with a pretty 3mm wide ivory ribbon.

Lavender buttonhole - 9 stems of dark blue lavender.

Wheat buttonhole - 4 stems wheat.

Lavender & wheat - 3 stems of each

Floral wall hangings and frames : Wall hangings and floral frames are prepared by dry flowers. They add charm to place where they are kept. Generally pressed dried flowers are used for this purpose.

Petal embedded handmade paper and product : Recently recycling of paper waste in making handmade paper is gaining popularity due to its biodegradable and eco-friendly nature. The surplus flower petal waste can be added to the pulp during the process of making the petal embedded handmade paper to create some of the exquisite stationery items like notepads, letter pads, pen stands, diaries, calendars, bags etc. These products give unique look and attract the customer to buy.


Petal Embedded Handmade Paper

3. Pharmaceutical and Nutraceutical Compounds

Some of the flower crops are rich sources of pharmaceutical compounds like catharanthin, Vincristine (from *Catharanthus roseus*) used for cancer treatment. Similarly, Vitamin C is isolated from rose fruits (rose hips) and is marketed as rose hip vitamin C for the cure of scurvy disease and used extensively to boost immune system to fight diseases. Nutraceutical is a blend of two words "nutrition" and "pharmaceutical". It is a food or food product that provides health and medical benefits, including the prevention and treatment of diseases. e.g. Rose tea prepared from rose petals and rose hips contains other vitamins and compounds that may help to cure stomach problems, such as bladder infections and diarrhea. Rose petals contain an astringent, tannin, and can be used to control bleeding. Besides rose, marigold and calendula flowers are some of the richest sources of lutein which prevents blindness. The pigments extracted from the flowers are mixed in the poultry feed to intensify the yellow colour in egg yolk and flesh colour of broiler chicken. The pigments are also used in the food industry as natural colour. A number of flowers are rich in anthocyanins, flavonoids, carotenoids and xanthophyll pigments that are used in food, beverage and confectionery industries and they act as anti oxidants.

4. Insecticidal and Nematicidal Compounds

Various plant parts like leaves, flowers have insecticidal and nematicidal compounds that act against insects and nematodes. Leaves and flowers of marigold possess a good insect repelling properties and often seen hanging from native huts to deter swarms of flies and mosquitoes. Hence, marigold oil is valueable in keeping insects at bay. It has juvenile hormonal and insect repellent activities against flies, ants and mosquitoes. Therefore, marigold oil is being used on commercial scale for formulation of insect repellents. Besides, marigolds have been reported as nematode trap crop. It is a source of Thiophane compounds which are nematicidal.

Insecticidal compounds from flower crops

Crop	Species	Principal constituent	Effect
Marigold	*Tagetes minuta* *Tagetes patula*	Limonene	Repellent for flies and mosquitoes
Chrysanthemum	*Chrysanthemum cinerarifolium*	Pyrethrum	Knock down effect on Lepidoptera insects
Periwinkle	*Catharanthus roseus*	Rotenone type	Caterpillar and beetles
Sabadilla lily	*Schoenocaulon officinale*	——	Contact and stomach poison for caterpillars, leaf hoppers, thrips and bugs but toxic to honeybee

MAJOR CHALLENGES OF VALUE ADDITION INDUSTRY

Identification of suitable markets for value added products

Identification of suitable local raw materials

Requirement of the varieties according to market preferences

Standardization of technology for value added products

Proper knowledge of standards for products is required

Proper coordination is required at different functional areas i.e., research, finance, quality assurance and certification

ACTIVITY/EXERCISE

1. Dry the flowers and press dry them, make value added products greeting cards, wall hangings etc. Try the different methods of drying the flowers.

CHECK YOUR PROGRESS

A} Subjective Questions

1 What do you understand by value addition?

2. Write down benefits of value addition?

3. What are the value added commercial fragrant products of rose?

4. What are the main dried flower products?

5. What the major nutraceutical and pharmaceutical compounds obtained from flowers?

6. Who are the main major challenges in value addition industries.?

B} Objective Questions

a) Fill in the blanks

I. Value added products constitute nearly _____ of the global floriculture business

II. Artificial colouring of the flowers to create novelty is called as _____

III. Preserving the rose petals in sugar is known as _____

IV. Out of total floriculture exports, dry flower constitutes _____ share.

V. India leads in export of _____ oil accounting over _____ of total exports of jasmine oil in the world

b) Multiple choice questions

i. India is the_____largest producer of essential oil

a) 1st b) 2nd

c) 3rd d) None of above

ii. Which of the following country is the largest exporter of essential oil?

a) India b) USA

c) Australia d) Turkey

iii. Gulkand is made from

a) Rose b) Chrysanthemum

c) Periwinkle d) None of above

iv. Out of total floricultural export, dry flowers constitute

a) 20% b) 50%

c) 71% d) 89%

v) The limonene is the major constituent of

a) Jasmine b) Chrysanthemum

c) Marigold d) All of above

c) Write true (T) or false (F) for the following statements

I. *Helichrysum* is the top most ten genera of dried ornamentals in the global market.

II. The essential oil content of *Rosa damascena* is 1%.

III. Pharmaceutical compounds like catharanthin, Vincristine (from *Catharanthus roseus*) used for cancer treatment.

IV. Marigold is used as a trap crop against grass hopper.

V. Pyrethrum, an insecticide active ingredient is extracted from Periwinkle.

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