Practical Manual

Basic Horticulture-I

for

(Class XI)

Central Board of Secondary Education
2, Community Centre, Preet Vihar, Delhi-110092

नया आगाज़

आज समय की माँग पर
आगाज़ नया इक होगा
निरंतर योग्यता के निर्णय से
परिणाम आकलन होगा।

परिवर्तन नियम जीवन का
नियम अब नया बनेगा
अब परिणामों के भय से
नहीं बालक कोई डरेगा

निरंतर योग्यता के निर्णय से
परिणाम आकलन होगा।

बदले शिक्षा का स्वरूप
नई खिले आशा की धूप
अब किसी कोमल-से मन पर
कोई बोझ न होगा

निरंतर योग्यता के निर्णय से
परिणाम आकलन होगा।
नई राह पर चलकर मंज़िल को हमें पाना है
इस नए प्रयास को हमने सफल बनाना है
बेहतर शिक्षा से बदले देश, ऐसे इसे अपनाए
शिक्षक, शिक्षा और शिक्षित
बस आगे बढते जाएँ
बस आगे बढते जाएँ
बस आगे बढते जाएँ.....

Practical Manual

Basic Horticulture-I

For

Class-XI

Central Board of Secondary Education

2, Community Centre, Preet Vihar, Delhi-110092

Practical Manual Basic Horticulture - I
for Class XI

First Edition : October, 2013

No. of Copies : 1000

Paper Used :

Price : ₹ 450/-

Published by :
The Secretary, C.B.S.E. 'Shiksha Kendra', 2, Community Centre, Preet Vihar, Delhi-110 092

Designed and Printed by :
Akashdeep Printers, 20-Ansari Road, Darya Ganj, New Delhi-110 002
Ph. : 23275854, 23271561

PREFACE

This practical manual entitled **"Basic Horticulture-I"** provides information on different aspects of horticultural crops viz. visit to a garden/orchard/vegetable farm, identification of major fruit crops, vegetable crops, flower crops, ornamental plants for avenues, lawn grasses, hedges and edges plants, indoor and outdoor foliage ornamentals, cacti and succulents and bulbous plants of the country, propagation of horticultural crops through seeds and asexual/vegetative methods, preparation of pot for planting, media preparation and filling, identification of different fertilizers and organic manures, and preparation of model of a low cost storage structure for horticultural crops. There are total twelve practicals in this book to impart practical knowledge to the students and will also help in their skill development. The manuscript gives an overview of basics of various horticultural crops, their identification, propagation techniques, different manures and fertilizers and low cost storage structures. Educational visits to gardens, orchards, vegetable farms, nurseries of horticultural plants and progressive growers of the region may be arranged for the students for better understanding of the subject.

Vineet Joshi, IAS
Chairman, CBSE

ACKNOWLEDGEMENTS

Advisors

- *Dr. S. Ayyappan, Secretary, DARE and Director General (ICAR), Krishi Bhavan, New Delhi-110 001*
- *Sh. Vineet Joshi, IAS, Chairman, CBSE, Delhi-110 092*

Special Acknowledgements

- *Dr. Rameshawar Singh, Project Director (DKMA), Directorate of Knowledge Management in Agriculture, Krishi Anusandhan Bhavan, Pusa, New Delhi-110 012*
- *Dr. Jagdeep Saxena, Editor, ICAR, New Delhi-110 012*

Convener & Editor : Dr. S.K. Upadhyay

AUTHORS

- *Dr. S. K. Upadhyay, Professor, Department of Horticulture, CSKHPKV, Palampur-176062*
- *Dr. R. R. Sharma, Senior Scientist, Division of Post Harvest Technology, IARI, New Delhi-110 012*
- *Dr. Akhilesh Sharma, Associate Professor, Department of Vegetable Science & Floriculture, CSKHPKV, Palampur-176 062*
- *Dr. Desh Raj, Associate Professor, Department of Vegetable Science & Floriculture, CSKHPKV, Palampur-176 062*
- *Dr. Hare Krishna, Senior Scientist, CIAH, Beechwal, Bikaner (Rajasthan)-334 006*

Editing & Coordination

- *Dr. Biswajit Saha, Associate Professor & Programme Officer, (Vocational Education), CBSE, Delhi-110 092*
- *Shri Dharampal Singh, Former Director (EDUSAT & Vocational Education), and Consultant (Agriculture), CBSE, Delhi-110 092*

Practical Manual

Basic Horticulture-I

For

Class XI

Convener

Dr. S. K. Upadhyay

Contributors

Dr. S. K. Upadhyay
Dr. R. R. Sharma
Dr. Akhilesh Sharma
Dr. Desh Raj
Dr. Hare Krishna

भारत का संविधान

उद्देशिका

हम, भारत के लोग, भारत को एक [1]**[संपूर्ण प्रभुत्व-संपन्न, समाजवादी, पंथ-निरपेक्ष, 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 **सबमें** 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 नवंबर, 1949 ई. (मिति मार्गशीर्ष शुक्ला सप्तमी, संवत् दो हज़ार छह विक्रमी) को **एतद्द्वारा इस संविधान को अंगीकृत, अधिनियमित और आत्मार्पित करते हैं।**

भारत का संविधान

भाग 4क

नागरिकों के मूल कर्तव्य

अनुच्छेद 51क

मूल कर्तव्य- भारत के प्रत्येक नागरिक का यह कर्तव्य होगा कि वह -

(क) संविधान का पालन करे और उसके आदर्शों, संस्थाओं, राष्ट्रध्वजों 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 संप्रभुता, एकता और अखंडता की रक्षा करे और उसे अक्षुण्ण बनाए 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 हो, ऐसी प्रथाओं का त्याग करे जो महिलाओं के सम्मान के विरुद्ध हों;

(च) हमारी सामासिक संस्कृति की गौरवशाली परंपरा का महत्व 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 ऊँचाइयों को छू सके; और

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

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 51 A

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.

*(k) a parent or guardian to provide opportunities for education to his child or as the case may be ward between the age of six and fourteen years.

CONTENTS

Chapter No.	Name of the practical	Pages
1.	Visit to a garden/orchard/vegetable farm	1-14
2.	Identification of major fruit crops of our country	15-47
3.	Identification of major vegetable crops of our country	48-64
4.	Identification of major flower crops of our country	65-73
5.	Identification of ornamental plants for avenues and lawn- grasses, hedges, edges plants of our country	74-99
6.	Identification of indoor and outdoor foliage ornamentals, cacti-succulents and bulbous plants	100-120
7.	Propagation of horticultural crops through seeds	121-140
8.	Propagation through asexual methods-cuttings, layering, runners, suckers, grafting, and budding,	141-181
9.	Preparation of pot for planting, cleaning, media preparation and filling	182-186
10.	Identification of different fertilizers-NPK	187-190
11.	Identification of organic manures-FYM, vermicompost, cakes, bonemeal	191-195
12.	Preparation of model of a low cost storage structure for horticultural produce	196-200

PRACTICAL MANUAL:
BASIC HORTICULTURE - I
CLASS XI

MM: 40

S. No.	Exercise	Marks	No. of sessions
1.	• Visit to a garden • Visit to an orchard • Visit to a vegetable farm	3	3
2.	• Identification of major fruit crops of our country	3	3
3.	• Identification of major vegetable crops of our country	3	3
4.	• Identification of major flower crops of our country	3	3
5.	• Identification of ornamental plants for avenues and lawn- grasses, hedges, edges plants of our country	3	4
6.	• Identification of indoor and outdoor foliage ornamentals, cacti-succulents and bulbous plants	4	3
7.	• Propagation of vegetable crops through seeds • Propagation of flower crops through seeds • Propagation of fruit crops through seeds	4	3
8.	• Propagation through cuttings • Propagation through layering (air and ground), runners and suckers • Propagation through grafting • Propagation through budding	5	3
9.	• Preparation of pot for planting, cleaning, media preparation and filling	3	1
10.	• Identification of different fertilizers-NPK	3	2
11.	• Identification of organic manures-FYM, vermicompost, cakes, bonemeal	3	2
12.	• Preparation of model of a low cost storage structure for horticultural produce	3	2

MODULE OBJECTIVES

Sl. No.	Practical topic	Duration	Key Learning outcomes The students will be able to understand:
1.	Visit to a garden	2 hours	• Different styles of gardening • Ornamental plants for use in different gardens • Developing different features in garden
	Visit to an orchard	2 hours	• Features of an orchard • Different fruit crops grown in an orchard • Points to be remembered while establishing an orchard.
	Visit to a vegetable farm	2 hours	• Features of vegetable farm • Different vegetables crops grown in a vegetable garden • Cultivation practices adopted to grow vegetables
2.	Identification of major fruit crops of our country	6hours	• Different characteristic features of major fruit crops for their easy identification.
3.	Identification of major vegetable crops of our country	6 hours	• Different characteristic features of different vegetable crops for their easy identifications
4.	Identification of major flower crops of our country	6 hours	• Different cut and loose flower crops grown in India
5.	Identification of ornamental plants for avenues and lawn-grasses, hedges, edges plants of our country	8 hours	• Different ornamental trees and shrubs for avenues, lawn grasses, hedges and edges plants grown in India
6.	Identification of indoor and outdoor foliage ornamentals, cacti-succulents and bulbous plants	6 hours	• Various foliage/ house plants, cacti and succulents plants and bulbous flower crops based on primary morphological characters.

Sl. No.	Practical topic	Duration	Key Learning outcomes The students will be able to understand:
7.	Propagation of flower crops through seeds	2 hours	• To raise the seedlings of ornamental annual flowers and plants • To raise the new hybrids developed through crossing different ornamental plants • To prepare ideal type of growing medium for seed sowing
	Propagation of vegetable crops through seeds	2 hours	• Importance of nursery raising in vegetable crops • Location for raising healthy seedlings • Method for preparation of nursery seed bed • Sowing methods for vegetable cultivation
	Propagation of fruit crops through seeds	2 hours	• Importance of multiplication of fruit plants through seed • Pre-sowing seed treatments to overcome dormancy • Techniques of propagation of fruit plants and rootstocks through seed
8.	Propagation through asexual methods-cuttings, layering, runners, suckers, grafting and budding	6 hours	• Basic techniques used in propagating horticultural plants through asexual methods • To develop skill in the art of cuttings, layering, grafting and budding.

Sl. No.	Practical topic	Duration	Key Learning outcomes The students will be able to understand:
9.	Preparation of pot for planting, cleaning, media preparation and filling	2 hours	• Different types of pots/ containers used for growing ornamental plants • To prepare pots for planting of ornamental plants • To prepare soil based and soil-less growing medium • The procedure for potting, de-potting and re-potting of ornamental plants
10.	Identification of different fertilizers-NPK	4 hours	• The characteristic features of different fertilizers for their easy identification
11.	Identification of organic manures-FYM, vermicompost, cakes, bonemeal	4 hours	• The characteristic features of different organic manures for their easy identification
12.	Preparation of model of a low cost storage structure for horticultural produce	4 hours	• To prepare model of low cost storage structure for horticultural produce.

LEARNING PLAN

Exercise	Aims	Material required
1.	• To get acquaint with different styles and types of gardens developed • To get knowledge about different types of ornamental plants used in different gardens.	Paper sheet and pen to note down the instructions, transport facility for visiting different gardens.
	• Acquaintance with features of an orchard and different aspects of orchard establishment.	Paper sheet and pen to note down the instructions and pictures of different fruit plants.

Exercise	Aims	Material required
	• Acquaintance with different aspects of vegetable farm, raising of different vegetables, their cultural practices and identification	Paper sheet and pen to note down the instructions, forceps, hand lens, and pictures of different vegetables.
2.	• Imparting knowledge for the identification of major fruit crops on the basis of different morphological characters at different plant growth stages	Paper sheet, pen to note down the instructions, forceps, hand lens and pictures of different fruit crops.
3.	• Imparting knowledge for the identification of different vegetable crops on the basis of different morphological characters at different plant growth stage	Paper sheet, pen to note down the instructions, forceps, hand lens and pictures of different vegetables.
4.	• To identify various cut and loose flower crops based on primary morphological characters.	Paper sheet, pen to note down the instructions, flower crops, hand lens and standard encyclopedia and books on Floriculture
5.	• To demonstrate different ornamental trees and shrubs for avenues, lawn grasses, hedges and edges plants grown in India	Paper sheet, pen to note down the instructions, ornamental trees and shrubs for avenues, lawn grasses, hedges and edges plants, hand lens and standard encyclopedia and books on Floriculture
6.	• To identify various foliage/ house plants, cacti and succulents and bulbous flower crops based on primary morphological characters.	Paper sheet, pen to note down the instructions, foliage/house plants, hand lens and standard encyclopedia and books on Floriculture
7.	• To recognize the importance and methodology to raise healthy seedlings of ornamental flowers and plants.	Spade, Khutti, Hand shovel, soil leveler, measuring tape, rope, watering can with fine rose head, leaf mould/ FYM, SSP, sand, soil disinfectant chemical, black

Exercise	Aims	Material required
		polythene/ tarpaulin, fungicide (Bavistin/ Dithane- M. 45/ Captan/ Ridomil), insecticide (Fenvalerate dust/ chloropyriphos), seed material, dry grass/ thatch, flexible stick, transparent polythene sheet, etc.
	• To impart knowledge of innovative nursery raising techniques and growing of direct seeded crops	Paper sheet and pen to note down the instructions, different tools for land preparation, farmyard manure, fertilizers, seeds of vegetable crop, bavistin, herbicide, etc.
	• To multiply those fruit plants through seed, that can not be multiplied by other means of propagation • To raise rootstocks for various grafting/budding purposes • To overcome seed germination barriers such as hard seed coat, dormancy	Paper sheet and pen to note down the instructions, different tools for land preparation, farmyard manure, fertilizers, seeds of fruit plants, File, wooden boxes, tin boxes, plastic containers, refrigerator, sterilized sand, sphagnum moss, mercuric chloride, gibberellins, thiourea, sulphuric acid, labels, hammer, nut cracker, bavistin, herbicide, etc.
8.	• Basic techniques used in propagating horticultural plants through asexual methods • To develop skill in the art of cuttings, layering, grafting and budding.	Appropriate plant material, Propagation media, Secateur and grafting/budding knives, Labels and marking pens. Rooting hormones (IBA, NAA), and Tying material (polythene sheet-150gauge/ paraffin wax etc.)
9.	• To recognize the importance of preparing pot for potting and repotting • To understand the steps for preparing ideal growing media for plants growing in pots/ containers	Soil (Clay/ Loam/ Sandy loam), FYM, Leaf mould, Sand, Peat moss, Perlite, Vermiculite, Lime, Gypsum, inorganic fertilizers, etc. Containers (Pots), crocks (broken pieces of pots), pebbles, coarse sand, growing

Exercise	Aims	Material required
		medium, plant material (seed/ bulb/ seedling/ sapling), secateur, pruning knife, hand trowel, dibbler, Khutti, watering can, fungicide and insecticide
10.	• The characteristic features of different fertilizers for their easy identification	Paper sheet and pen to note down the instructions, samples of fertilizers, petri-dishes etc
11.	• The characteristic features of different manures for their easy identification	Paper sheet and pen to note down the instructions, samples of manures, petri-dishes etc
12.	• To study the principle and working of low cost structures for storage of fruits and vegetables. • To prepare model of low cost storage structure for horticultural produce.	• Locally available materials like bricks, sand, bamboo, khaskhas/ straw, gunny bags, etc., with a source of water.

Practical 1

EXERCISE 1.1:
VISIT TO ORNAMENTAL GARDENS

Objective :

- To get acquaint with different styles and types of gardens developed
- To get knowledge about different types of ornamental plants used in different gardens.

Delivery schedule : 01 period

Student's expectations/ Learning objectives:

- To study different styles of gardening
- To acquire knowledge of ornamental plants for use in different gardens
- To get knowledge of developing different features in garden

Pre-learning required: Knowledge about different types of gardens and ornamental plants.

Handouts/material required/equipment's & tools: Paper sheet and pen to note down the instructions, transport facility for visiting different gardens.

Introduction:

Several ornamental gardens have been developed in different parts of the country in cities and other places of historical importance during various regimes. Historical gardens developed had set different styles of gardening. These gardens have been influenced by the environmental factors, topography, vegetation, construction material, people, their customs and the purposes of using these gardens. Primarily these gardens are grouped into two styles as Formal and Informal gardens. The key features of such gardens are given below:

Formal gardens:

- First plan is made on paper and then land is selected accordingly
- Land is leveled
- Symmetrical design
- Geometrical: Square, rectangular, circular beds and borders

- Roads and paths cur at right angle
- Balance is symmetrical as same feature replicated on both sides of central axis
- Hedges, edges and topiary are trimmed
- Trees can be selected as individual feature
- Mughal, Persian, Italian, French, Chinese and American gardens
- The famous Mughal gardens developed in India are in Kashmir (Nasim bagh, Nishat garden, Shalimar garden, Chasma-e- Shahi, Achabal, Bijbehara, Verinag, etc.); Mughal garden Pinjore, Mughal garden at Rashtrapati Bhavan, New Delhi.

Informal gardens:

- Plan is forced to fit the land
- Main aim is to capture natural scenery
- Land is not leveled
- Asymmetrical design
- Non-geometrical beds and borders

- Untrimmed hedges, edges and topiary
- Individual plants are not selected as feature
- Japanese, Chinese, English gardens
- Informal gardens developed in India are at Brindavan, Mysore; Budhajayanti Park, New Delhi and Roshnara Park, New Delhi.

To get acquainted with the prevailing commercial floriculture activities in the state in general and region in particular, the important flower nurseries, commercial production units in government sector, progressive flower growers and florist wholesale and retail shops will be visited. The students will be exposed to the practical capsules for getting maximum quality and problems associated in commercial floriculture. The detailed information with reference to important cut flowers, pot plants, cut greens, planting material and seed production of ornamentals being grown will be given.

Procedure:

i) Students will be taken to the nearby or important gardens of the region/ state/ country for making them familiar with different styles and types of gardens.

ii) Important flowers and ornamental plants in the garden will be identified and their use in gardening will be explained.

iii) The use of infrastructure in gardens will be explained.

iv) Any insect-pests or diseases infesting flower crops and ornamental plants will be identified and their remedy will be suggested at the spot to the students and growers.

v) Development of different features in the garden will be explained on the spot.

Precautions:

i) Maintain the proper discipline during the visit.

ii) Don't argue on unnecessary point with the officers/ officials of the gardens.

iii) Avoid confrontation on any issue with your classmates, the gardeners, tourists visiting the garden.

Exercise: Prepare diary of all events of the tour. Take photographs of important garden features and paste on the tour report to be submitted.

EXERCISE 1.2: VISIT TO AN ORCHARD

Objective :

- Acquaintance with features of an orchard and different aspects of orchard establishment.

Delivery schedule : 01 period

Student's expectations/ Learning objectives:

- Studying the features of an orchard
- To know about different fruit crops grown in an orchard
- Points to be remembered while establishing an orchard.

Pre-learning required: Knowledge about establishment of an orchard

Handouts/material required/equipment's & tools: Paper sheet and pen to note down the instructions and pictures of different fruit plants.

Introduction:

Indian topography and agro climates are well suited for horticultural crops, which are considered ideal for achieving sustainability of smallholdings, increasing

employment, improving environment, providing an enormous export potential and above all achieving nutritional security. Furthermore, horticulture has the potential for improvement of wastelands as well as arid and semi-arid areas. Most of the horticultural crops need comparatively less water compared to field crops and provide higher employment opportunities, better nutritional security as well as healthy environment. Fruit production is profitable. Farmers involved in fruit production usually earn much higher income as compared to cereal producers. Cultivation of fruits allows for productive employment where the labour/ land ratio is high, since fruit production is usually labour intensive. Increasing fruit production contributes to commercialization of the rural economy and creates many off-farm jobs. It also provides ample opportunities for sustaining large number of agro-industries, which generate substantial employment opportunities. It is indeed important for students to know about different fruit crops, their nomenclature, at what time we plant them, how do we plant them, what are their important insect- pests and diseases and their management, what are the edible parts of different fruits and how do we harvest and market them.

Features of an ideal orchard

Orchard is a piece of land cultivated with fruit crops and related horticultural crops.

1. Store and office building: It should be in the centre of the orchard for easy and proper supervision of work by the manager. For easy approach of labours to take any implements and tools needed for their work, to take the inputs like herbicides, weedicides, pesticides, fungicides, fertilizers etc., to the field. In the store room, racks should be provided to keep the herbicide or weedicide, pesticide and fungicide. Wooden plank (flat piece of timber) is arranged on the floor to keep fertilizer bags. The garden implements and tools are arranged in the racks. Storage bins are also kept in stores for storing the seeds and produces.

In the office, racks are used to keep records and registers related to orchard management such as stock register, produce register, muster roll, attendance register, tree register etc.

2. Wells and water tanks: It should be located at convenient places in different parts of the orchard atleast one well for 2 to 4 hectares. Water tanks are used to store water. From the well the water is lifted and stored in the tank and used for irrigation. Wells and water tanks are connected with irrigation channels of concrete nature or pipes. From the tank, irrigation channels are used to take water to the field.

3. Separate blocks: For each fruit crop, a separate block should be allotted. Fruits ripening at the same time should be grouped together. In deciduous fruit trees (sheds leaves during winter such as apple, pear, plum, peach), there are certain varieties which need pollen from another variety to set fruits. The trees which provide pollen are called pollinizers. For example in apple, Golden Delicious, Tydeman Early Worcestor, Lord Lambourne and Granny Smith are pollinizers. Every third tree in third row should be planted with a pollinizer or every fourth tree in every fourth row should be planted with pollinizer.

4. Irrigation channels: Two types of channels viz., concrete and mud channels are laid out in the orchard. Concrete channel reduces water loss through seepage and maintenance is easy as compared to mud channel. Weed growth is very less or negligible in concrete channel. Channel should be laid along the gradients for most economical conduct of water. For every 30 m length of channel, 7.5 cm slope should be given.

5. Roads and foot paths: These two components should occupy minimum space for the economy of transport. The metal road in the main areas are advantageous because it is easier for the movement of vehicles like tractor or lorry to carry fertilizers, pesticides and harvested produces, planting materials like seedlings, layers, grafts, cuttings, etc. In the centre of road the height should be more than at the sides. There should be a gentle slope from the centre towards the edge of the road, so that there won't be any stagnation of water during rainy season.

6. Fruit trees: Short growing fruit trees should be planted at the front and tall at the back for easy watch and to improve the appearance of the orchard. Short growing fruit trees are guava, pomegranate, annona and aonla. Tall growing fruit trees are avocado, mango, sapota and litchi.

Evergreen trees such as papaya, sapota, mango and oranges should be in the front area and deciduous ones like apple, pear, peach, plum, apricot and almond behind the evergreen trees. Fruits attracting birds and animals should be close to the watchman shed, so that watchman can protect them to the extent possible.

7. Manure pit: Manure pit is essential to dump the waste plant materials after the harvest of the produce. This will enable to supply considerable quantity of organic manure to the farm. This should be located in a corner of the orchard.

8. Fencing: It may be live fence or artificial ones. Live fence is economical and cheaper compared to other. Suitable plants for fencing are *Agave, Prosopis juliflora, Pithecolobium dulce etc*. These crops are planted closely in 3 rows which serve as good fence. In artificial fencing, stones or concrete pillars are planted at regular spacing (4 or 5 feet) and they are connected by barbed wire. Trees used for fencing should be drought resistant, easy to propagate from seed, quick growing, have dense foliage, should withstand severe pruning and should be thorny.

9. Wind breaks: These are rows of tall trees planted close together around the orchard. These are essential to resist wind velocity which cause severe loss particularly moisture loss from the soil through evaporation and fruit drop. Wind breaks are efficient in reducing the velocity of wind thereby minimize the damage to the fruit crops by wind. Wind breaks are planted in area where there is heavy wind. Its effectiveness is maximum for a distance of about 4 times as great as its height but has some effect over twice about that distance. For effective control, wind break should be planted in double rows and the trees are alternately placed. Wind break should be of tall growing nature. The spacing between wind break and first row of fruit tree should be similar to that of the space between fruit trees. It is advantageous to dig a trench of 90 cm deep at a distance of 3 m from the wind break trees and prune and cut the roots of wind break exposed and again fill up the trenches. This has to be repeated for every 3 or 4 years in order to avoid the competition between wind break and fruit trees for moisture and nutrition. Some specific characters of wind break are erect nature, tall and quick growing, hardy and drought resistant, mechanically strong framework and dense nature to offer maximum resistance to wind. Some of the common windbreaks are *Casuarina equisetifolia, Polyalthia longifolia, Eucalyptus globules, Grevillea robusta* and *Azadirachta indica* etc.

10. Layout of an orchard: Arrangement of plants in a particular system of planting depending upon its vigour, growth habit and spacing requirement is known as layout. While laying out an orchard, the factors to be considered are system of planting, tree vigour, spacing, water requirement, cultural operations like training/pruning etc. Proper layout of the orchard would facilitate easy supervision, management and planning for future expansion. Cultivation of perennial and annual crops of fruits, vegetables and to some extent flowers should also be taken into account while making layout.

Points to be remembered while establishing an orchard

- The orchard should be established in such a location where the soil, climate and other physical facilities required for successful growing of crops and marketing of the produce are available.
- The selected site, if uncultivated, should be cleaned by uprooting the existing trees and bushes and leveled properly after deep tillage. If the land or site is in a hill area, the prepared land should be divided into terraces depending upon the topography of the land and then leveled within the terraces.
- The leveled land should be divided proportionately for growing crops and for roads, paths, building etc. Minimum / optimum space should be allotted for each feature. Roads & Paths should occupy only 10% of the total area, provided with convenience, economy in transport and supervision. The farm office should be located at the center of an orchard, which should be easily approachable by road.
- Drainage and irrigation channels should be kept concealed as much as possible which could save water from seepage and evaporation. Irrigation channels should be well spaced so that it could cover all the plots.
- While planting the fruit trees, evergreen fruits should be planted in the front and deciduous trees at the back.
- Trees should be grouped according to their height, irrigation requirement and nature of growth.
- Fruit trees that attract birds should be planted near watch and ward.
- Self-sterile or self-incompatible fruit trees requiring pollinizer should be planted mixed with pollinizer variety or the same should be side grafted on the fruit trees themselves to ensure optimum fruit set.
- While planting the trees, proper spacing should be adopted to accommodate inter-crops. Apart from this, vigour of tree and fertility of the soil should also be considered.
- Under semi-arid conditions, in-situ planting of rootstock can be taken up which facilitates grafting of desired scion at later stage of crop growth.
- Windbreaks should be planted at the rear end of the orchard. Trees suitable for this purpose should be tall growing, amenable for pruning and evergreen in growth. For example, *Eucalyptus*, *Casuarina*, Silver ok etc.

- Fencing the orchard with barbed wire or concrete wall or live-fence should be done well in advance to the planting of fruit trees.
- Nursery area should be located under shade, near water source and office building and should be easily accessible for transport of seedlings and raw materials like potting mixture, sand etc.

Observe about the features existing in the orchard visited by you and compare with the features of an ideal orchard. Record your observations in the data sheet. Ask the caretaker of orchard about the cultural practices being following to establish and maintain orchard of a particular fruit crop, fertilizers and plant protection measures being adopted and the problems faced in maintaining the orchard. Record your observations in the data sheet.

Exercise 1: Visit a model orchard and study its features. Record your observations and prepare a check list of features present in the orchard.

Exercise 2: Study of different aspects of orchard establishment and record your observations in the given data sheet.

Datasheet-1

Information about fruit plants growing in an orchard

Particulars	Fruit crops in orchard				
	1	2	3	4	5
Name of the variety					
Spacing and No. of plants/ha					
Layout system adopted					
Training system adopted					
Fertilizer application : Name(s) of fertilizer used , Dose applied, Time and method of application					
Blooming period initiation, Proportion of pollinizers, Peak flowering time i.e. full bloom)					

Time of harvesting					
Weed control: weedicide and dose used					
Nutrient deficiencies observed, if any					
Disease and insect-pest management,					
Any other particular cultural practice followed					
Constraints in orchard management, if any					

EXERCISE 1.3:
VISIT TO A VEGETABLE FARM

Objective :

- Acquaintance with different aspects of vegetable farm, raising of different vegetables, their cultural practices and identification

Delivery schedule : 01 period

Student's expectations/ Learning objectives:

- Studying the features of vegetable farm
- To know about different vegetables crops grown in a vegetable garden
- Cultivation practices adopted to grow vegetables

Pre-learning required: Knowledge about different vegetable crops

Handouts/material required/equipment's & tools: Paper sheet and pen to note down the instructions, forceps, hand lens, and pictures of different vegetables.

Introduction:

Cultivation of vegetables occupies an important place in agricultural development and economy of the country. Vegetable farming gives higher yield per unit area within the shortest possible time which ultimately increases the income. Several vegetables

are exported to foreign countries which provide an opportunity for earning foreign exchange. In addition, vegetables play an important role in the balanced diet of human beings by providing not only the energy-rich food but also promise supply of vital protective nutrients like minerals and vitamins that is why the vegetables have been reckoned as a protective food. It is indeed important for children to know about different vegetable crops, their nomenclature, at what time we grow them, how do we grow them, what are their important insect- pests and their control measures, what are the consumable parts of different vegetables and how do we harvest and market them.

Features of an ideal vegetable garden

1. **Proper sunlight:** Vegetables are sun loving crops and grow their best with 6-8 hours or more of direct sunlight. Leafy greens can manage to grow under less sun light while lettuce prefers cool weather and continue to grow throughout the summer if shaded by taller plants.

2. **Assured irrigation facility:** Ideal vegetable garden should be close to the source of water. Vegetables need water at regular intervals. If there is erratic water supply, vegetable crops exhibit various kinds of problems like poor crop stand, poor growth, cracking of fruits, improper fruit setting or prone to cultural problems like blossom end rot.

3. **Soil with good fertility status:** Soil is the most important factor in any garden and perhaps more so in a vegetable garden. Vegetables are short duration crops and have very high yield potential. They complete their entire life cycle by producing flowers and fruits and hence, they are very heavy feeders. A rich soil not only supports them to grow strong but also protect them from disease and pest problems. Therefore, the soil in the vegetable garden should be rich in organic matter and fertility status. Compost and composted manure can be added in spring and/or fall.

4. **Proper drainage:** One final consideration while selecting land for vegetable garden is that the area should have provision of proper drainage and run-off. Vegetables do not sustain under water logging conditions.

5. **Manure pit:** Manure pit is essential to dump the waste plant materials after the harvest of the produce and converting it to vermicompost or any other compost. This enables to supply considerable quantity of organic manure to the farm. This should be located in a corner of the vegetable garden.

6. **Protection from stray animals:** Proper fencing of the vegetable garden is essentially required to protect the crops from stray animals and also from theft.

7. **Store and packing house:** The store house and packing house should be in the centre of the vegetable garden for easy approach to the workers. They can take the implements, tools or inputs like herbicides, pesticides, fungicides, fertilizers etc., to the field and also bring backthe harvested produce for hydrocooling, sorting and packing to the market. In the store room, racks should be provided to keep the chemicals. Wooden plank (flat piece of timber) is arranged on the floor to keep fertilizer bags. The garden implements, tools and packing material etc. are arranged in the rack.

8. **Roads and foot paths:** These two components should occupy minimum space for the economy of transport. The metal road in the main areas is advantageous because it facilitates the movement of vehicles like tractor or lorry to carry fertilizers, pesticides and harvested produce etc.

9. **Cropping plan:** A comprehensive plan of different vegetables to be grown in the vegetable garden should be made well in advance keeping in view the principle that early the crop more shall be the price.

A planned vegetable garden

Ideal agronomic practices to be followed in vegetable garden:

You know the importance and necessity of different agronomic practices which are adopted to raise a healthy vegetable crop. So, it is imperative to understand the cultural practices which have been adopted to raise different vegetable crops in the

vegetable garden. You should have curiosity to inquire about the following aspects which determine the success of vegetable cultivation.

- Suitable variety/hybrids of different vegetable crops
- Reliable source for the procurement of vegetable seed
- **Optimum sowing or planting time:** It determines the environmental conditions at planting, flowering and fruit development stage and thus has direct impact on the successful cultivation of vegetable crops.
- **Proper spacing:** The closer planting results in overcrowding which ultimately hinder the access to proper sunlight and aeration and plants become more vulnerable to the attack of diseases and insect-pests.
- **Nutrient management:** The balance use of organic and chemical fertilizers enhances soil fertility and crop productivity.
- **Management of weeds , diseases and insect-pests at appropriate growth stages:** It is very essential as either of these may cause losses to crop yield to the tune of 30-60 per cent
- **Optimum irrigation at critical growth stage:** Irrigation at critical growth stages like flower initiation, fruit set and fruit development etc. are very crucial to exploit maximum production potential of different vegetable crops as they cannot withstand prolonged dry conditions.
- **Harvesting at proper stage:** Appearance, colour, tenderness and crispness determines the harvesting stage of a particular vegetable crop to fetch high premium in the market.
- Post-harvest handling of vegetable crops.

Ask the gardener about the cultural practices he is following to raise a particular vegetable crop, chemical fertilizers and plant protection measures he is adopting and the problems he is facing in managing the garden. Make your observations in the data sheet.

Exercise 1: Visiting vegetable farm and studying various agronomic practices to raise vegetable crops in data sheet.

Data sheet

1. Date of visit:

2. Cropping Season:

Name of the crop	Area sown under a particular crop	Date of sowing/ trans-planting	Name of the variety/ hybrid	Spacing	Growth stage	Insect-pest & disease incidence	Expected harvesting duration (days)	Expected yield	Remarks

Practical 2

IDENTIFICATION OF MAJOR FRUIT CROPS OF OUR COUNTRY

Objective :

- Imparting knowledge for the identification of major fruit crops on the basis of different morphological characters at different plant growth stages

Delivery schedule : 03 period

Student expectations/Learning objective:

- To demonstrate different characteristic features of major fruit crops for their easy identifications

Pre-learning required: Names of major fruit crops and knowledge about classification of fruit crops

Handouts/material required/equipment's & tools: Forceps, hand lens, paper sheet, pen to note down the instructions and pictures of different fruit crops.

Introduction:

Most fruit crops are perennial trees, shrubs, or vines. Trees are large woody plants which generally produce a single main stem or trunk, where the renewal growth occurs at the shoot tips in the canopy. The latter is an important distinction between trees and shrubs, since large shrubs can be trained to a single stem, but tends to produce new growth from the base or crown. Vines are woody plants that are trained to have a single trunk at the base, but use twining stems or tendrils to support the canopy. Vines rarely have large trunks like trees since they support themselves by climbing on taller plants in nature, or on trellises in cultivation. As a result, vines spend little of their energy on supportive wood, while growing very tall and maximizing leaf exposure to sunlight.

Fruit plants can be identified by observing certain distinguishing morphological characteristics. The keen and frequent observations on vegetative and reproductive parts of plant help in easy and clear identification. It is essential to know the different parts of the plants before undertaking the identification as these forms the basis of distinguishing characters. In this practical you will learn how to identify a fruit crop

keeping in mind their characteristic morphological features. The important distinguishing characters of major fruit crops have been discussed here under which may help the students in distinguishing them even at early stages of their growth. It takes time and exposure to learn to identify fruit plants.

Procedure:

Step 1: Critically observe the morphological characteristics of the specimen. To identify plants, look for morphological features such as leaves, flowers and fruits.

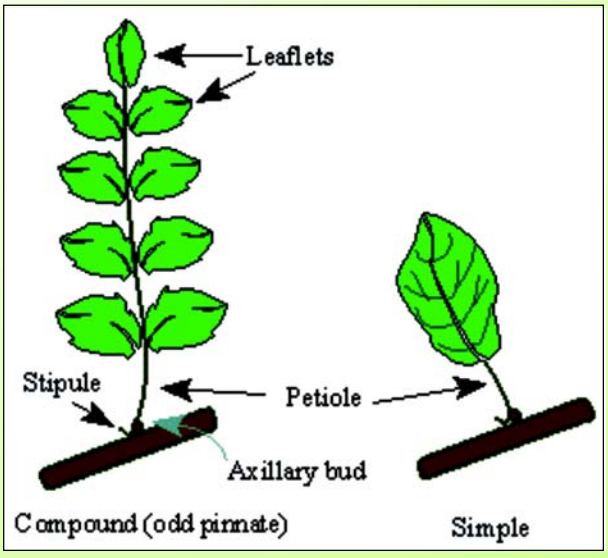
i) Plant:

- Tree
- Shrub
- Vine

ii) Leaf characteristics:

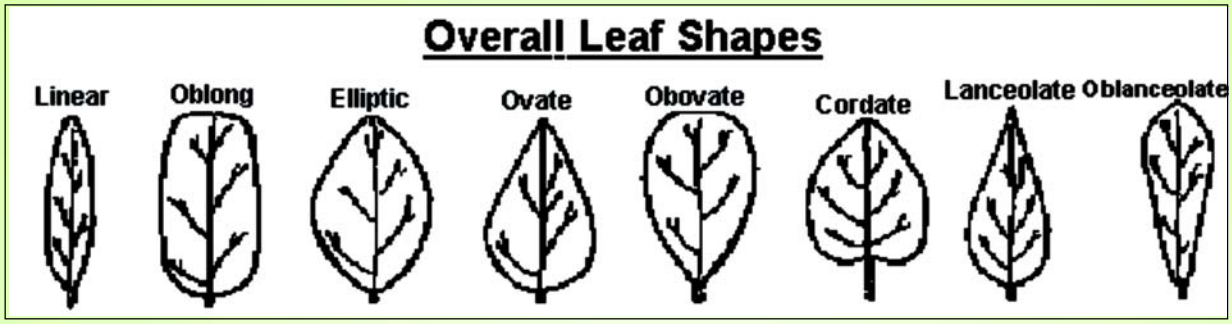
- Shape of leaf- long narrow or ovate or lanceolate
- Presence or absence of pubescence
- Type of leaf - simple or compound leaf, petiolated or sessile
- Presence or absence of leaf sheath
- Leaf margins: serrated or smooth
- Texture of leaf- smooth or rough.

Leaves take many forms, being compound if composed of two or more leaflets or simple if just a single leaf blade. The compound leaf having a single terminal leaflet, and an uneven number of leaflets is termed "odd pinnate", whereas compound leaves lacking the single terminal leaflet are "even pinnate".



Compound and simple leaves and their associated parts.

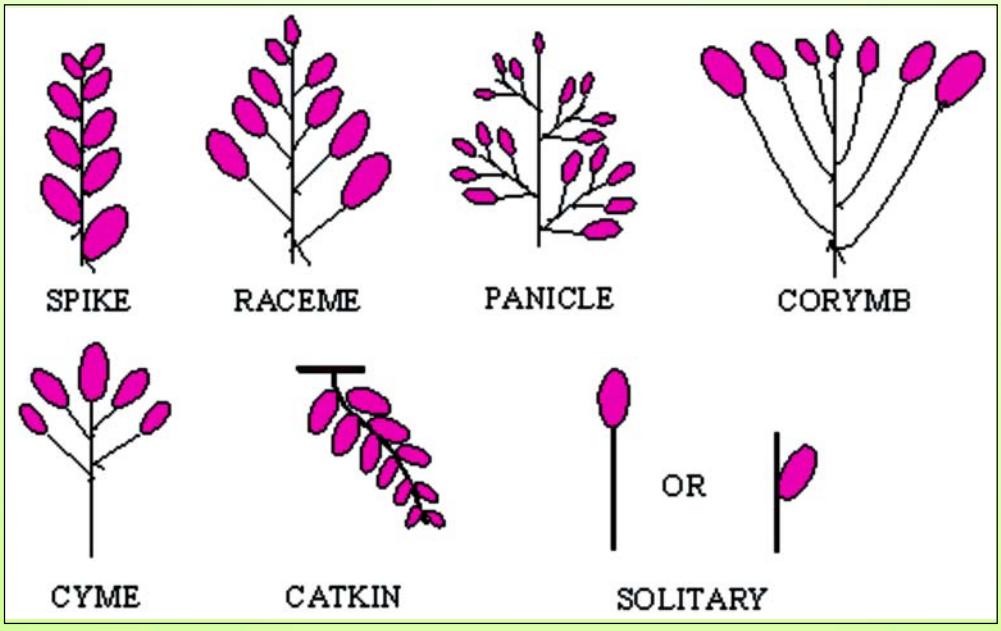
Characterizing the foliage is a great way to start the process of identifying a plant. Several terms are used to describe the overall shape, tip, and margins of leaves or leaflets.



Pictures for leaf margins & leaf tips

iii) Flower:

- An inflorescence is a cluster of flowers, and there are several terms for specific inflorescences.
- Generally, there are two types of inflorescences, determinate and indeterminate. In a determinate inflorescence, the top-most flower is the most mature, and generally opens first, whereas the top-most flower in an indeterminate inflorescence is the least mature and last to appear. The most common inflorescence types in fruit crops are indeterminate (spikes, racemes, panicles, umbels, corymbs), with the cyme being the most common determinate inflorescence.



Different inflorescence types commonly found in fruit crops

iv) Fruit

- Colour
- Size
- Shape

Step 2. Draw the sketch of each plant.

Step 3. Record the observations with respect to plant, leaf, inflorescence and fruit characteristics in the data sheet.

Step 4: Use chart of morphological features of fruit crops

EXERCISE 2.1: IDENTIFICATION OF TROPICAL FRUIT CROPS OF OUR COUNTRY

Tropical fruits are the fruits grown in tropical areas /zone i.e. the zone which comprises regions having hot and humid climate in summer and mild in winter. The most commercial fruits are mango, banana, cashew nut, sapota, pineapple, papaya, pomegranate, grapes etc. This zone includes the regions of Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Kerala, southern districts of Madhya Pradesh and West Bengal. The distinguished morphological characters of sub-tropical and tropical fruits are described below:

Mango *(Mangifera indica)*

Family: Anacardiaceae

- The tree is medium to large, evergreen, with an open or dense symmetrical canopy.
- Leaves are simple, Lanceolate shaped and leathery in texture with prominent mid and lateral veins.
- The inflorescence is a much branched panicle bearing both male and hermaphrodite flowers
- The fruit is a fleshy drupe with variable shape (nearly round, oval or ovoid-oblong), size (60 g to 2.3 kg) and colour (greenish-yellow, yellow with a red or purple blush or completely red.
- The skin is tight, thick and smooth. The flesh is yellow to orange with few to many fibers.
- The single seed is large, flat and in a woody, fibrous husk.

Banana *(Musa acuminate x M. balbisiana)*

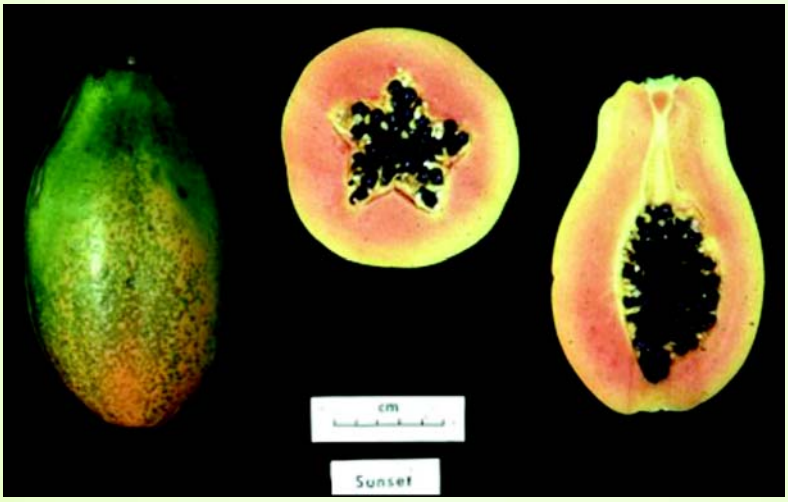
Family: Musaceae

- Pseudostem is composed of tightly clasping leaf sheaths, slightly swollen at base; suckers freely produced.
- The leaves of banana plant are very large, blunt, wide and long, arranged in a spiral, and sometimes tattered along the edges.
- Bracts and flowers are inserted independently on peduncle. Basal flowers are generally female only and male flowers are on distal hands. The flower bud is reddish-purple, large and pointed.
- Fruits are long, finger-like, and slightly curved, with a smooth, yellow skin and soft, creamy-white pulp. There are no seeds in edible types. The fruit are arranged in clusters, called hands, of 6-25 or more bananas.

Papaya (Carica papaya)

Family: Caricaceae

- Papaya is a small, single-stemmed, evergreen, quick growing plant.
- Trunk is erect, unbranched (generally) with hollow soft wood.
- Pal-like leaves are large, deeply lobed margins with long petioles.
- Flowers are borne singly (usually female and hermaphrodite) or in large clusters (male) in leaf axils and colour ranges from yellow to white.
- Fruits are spherical to oblong in shape, fleshy berry with central cavity.
- The skin is thin and yellow or yellowish-green at maturity.
- The flesh is yellow, deep orange, pinkish or deep red depending on cultivars.
- The center of the fruit is a large cavity lined with soft, black, pea-sized seeds.



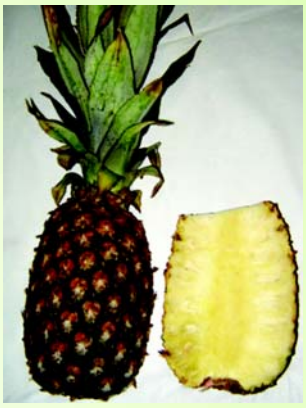
Pineapple *(Ananas comosus)*

Family: Bromeliaceae

- Pineapple plants are herbaceous and perennial with dense rosette leaves. The stem is short and thick, 15-25 cm long, narrow at the base and wider at the top with short internodes.
- The leaves are long and narrow and are arranged in aright-or-left-handed spiral on a short stem, forming a rosette. The number of leaves ranges from 35 to 60, and there is a bud in every leaf axil. The leaves either have smooth edges with a few spines just below the tip or have spines all along the margins. The tip is elongated, ending in a finer point. The upper leaf surface is green and the lower is silvery-white.

- The pineapple fruit grows on a stalk in the center of the rosette of leaves. The pineapple is a multiple fruit. (i.e. Fruits formed when a cluster of flowers produces numerous fruit that mature into a single mass.) The pineapple is oval to cylindrical in shape, topped by a leafy crown.
- The skin is golden yellow at maturity and has numerous scales.
- The flesh is whitish-yellow, juicy and sweet, around a central fibrous core. Seeds are absent.





Grapes *(Vitis vinifera)*

Family: Vitaceae

- Grape is a woody vine that uses tendrils to attach to supports.
- Leaf shapes vary with type and cultivar but are usually large, roundish to heart-shaped, often lobed, with serrate margins.
- Grapes grow in bunches or clusters.
- Fruit may be green, red, purple, or yellow when ripe.
- Individual grapes are round or oval, thin-skinned and juicy. Seeds are few or absent, small, round and often pointed at one end.


Sapota *(Achras zapota)*

Family: Sapotaceae

- It is evergreen tropical fruit plant. The branches appear in whorls.
- Leaves are elliptic to obovate and light to deep green.
- Flowers are solitary appear in leaf axils.
- Fruit is a drupe, egg or round shaped. The skin of the fruit is slightly tough resembling potato skin in appearance. Each fruit contains 3 to 5 or more black shinning seeds.

EXERCISE 2.2: IDENTIFICATION OF SUB-TROPICAL FRUIT CROPS OF OUR COUNTRY

Sub-tropical fruits are the fruits which are commercially successful in sub-tropical zones i.e. where the temperate occasionally goes below freezing points but not as a rule below 25° F. The overall climate is hot and comparatively dry, whereas, the

winters are less cold. The chief fruits are sweet orange, mandarin, grapefruit, lime, lemon, litchi, grape, guava, phalsa, fig, pomegranate, avocado etc. The tropical fruits like Mango and Banana can also be grown in this zone whereas, the low chilling cultivars of Pear, Peach, Plum, and Almond of temperate zones can also be grown in sub-mountainous tracts of sub-tropical zone. The chief regions of sub-tropical zone are Punjab, Haryana, Uttar Pradesh., north districts of Bihar, West Bengal, Madhya Pradesh, Rajasthan, and Assam.

Mandarin *(Citrus reticulata)*

Family: Rutaceae

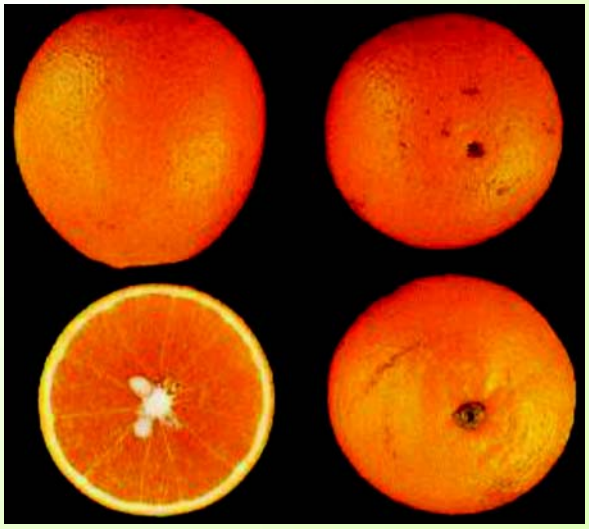
- Trees are medium-sized and upright in growth.
- Leaves are lanceolate in shape with narrowly-winged petiole.
- Fruits are medium-sized, globose in shape, sweet in taste, segments easily separable, core open at maturity, loose skinned, orange in colour, rind thin, rind and segments easily separable, usually 10-14 segments in each fruit. Seeds are pointed with light green cotyledons.

Sweet Orange *(Citrus sinensis)*

Family: Rutaceae

- Sweet orange is a medium-large evergreen citrus tree.
- Leaves are ovate with blunt-pointed leaf apex and have rather narrowly winged petiole.

- Fruit are subglobose to oval in shape, orange-coloured, tight skinned with solid central core and have a somewhat coarse rind.
- The flesh colour is usually orange and sweet.
- Seeds are with whitish cotyledons.

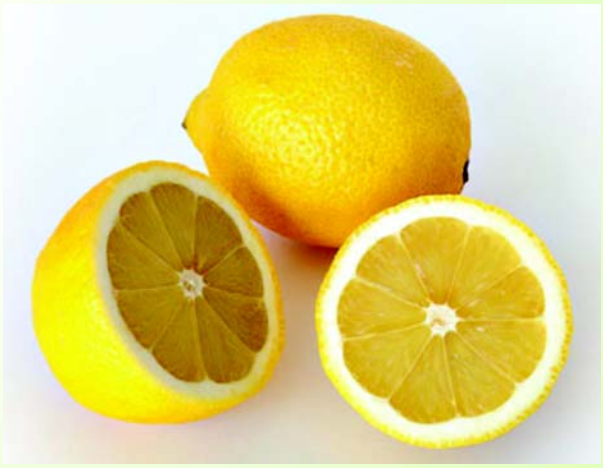


Lemon *(Citrus limon)*

Family: Rutaceae

- Lemons are medium-sized spreading thorny citrus trees. The new flushes are pigmented.
- Leaves are not dark green and leaf margins are subserrated. Petioles are medium-sized and narrowly winged.
- Flower buds are pigmented and the pistil is densely dotted with oil glands.

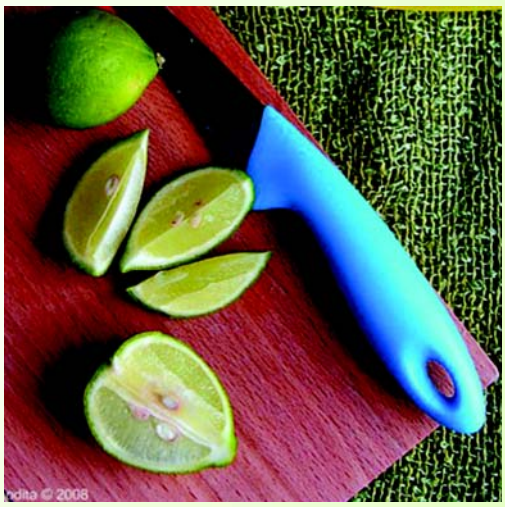
- Fruits are oval to elliptic with pointed nipple. Fruit surface is smooth, light yellow and core solid; juice abundant and acidic. Seed cotyledons are white.



Kagzi Lime *(Citrus aurantifolia)*

Family: Rutaceae

- Tree is small, bushy with small but sharp spines.
- The leaves are small with narrowly-winged petioles.
- The flowers are yellowish white with a light purple tinge on the edges. Flowers and fruits are small.
- Fruits round to oval, maturing irregularly throughout the year, greenish yellow in colour and thin skinned. Core solid at maturity, flesh greenish in colour and juice highly acidic.
- Seeds are small, smooth and cotyledons whitish.



Grapefruit *(Citrus paradisi)*

Family: Rutaceae

- The grapefruit tree is round-topped spreading citrus tree.
- Leaves are large with winged petioles.
- The flowers of grapefruit are white and fragrant.
- The fruit is large but subglobose in shape. Rind surface and fruit flesh are yellowish in colour. Fruits are highly juicy, sweet with bitter aftertaste. The central core opens at full maturity. Seeds big but smooth-surfaced and white inside.





Pummelo *(Citrus grandis / C. maxima)*

Family: Rutaceae

- The pummelo tree is spreading, round-topped, almost thornless citrus tree.
- Leaves are large with broadly-winged petioles. Lower surface of leaves is pubescent, particularly the main vein.
- The flowers of pummelo are very large, crowded in short axillary racemes.
- The fruits are large-sized, subglobose to pyriform in shape, with thick and spongy rind. Fruits are sweet and moderately juicy. Rind thick, smooth with large oil glands. Seeds are very large, coarsely veined and white within.


Guava *(Psidium guajava L.)*

Family: Myrtaceae

- The guava is a large shrub or a small spreading tree that may grow up to 10 m in height with a fairly thin trunk. The bark of the trunk is attractive with smooth, greenish or reddish brown or multi-coloured bark peeling annually in thin flakes.
- The leaves are simple, opposite, oval almost and light green in colour. Veins are prominent on soft under surface and markedly depressed on upper surface.
- Guava flowers are white borne in leaf axils of new growth.
- Guava is a berry with few to many small brown seeds. The fruit is very variable in size and other characteristics depending on cultivar. Fruit shape ranges from round, ovoid to pear-shaped.
- The peel color ranges from green to yellow and flesh color may be white, yellow, pink or red. Fruit peel thickness may be thin or thick and depends upon cultivar.
- There is a wide range in flavor and aroma, ranging from sweet to highly acid and strong and penetrating aroma to mild and pleasant.

Litchi *(Litchi chinensis)*

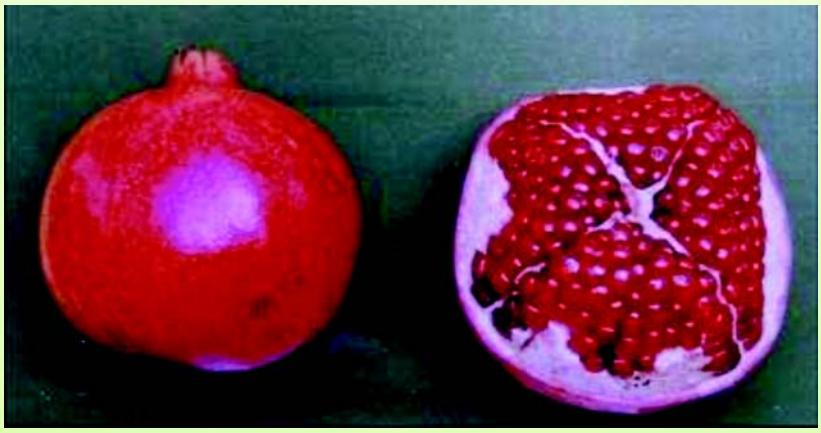
Family: Sapindaceae

- Trees are medium to large, much branched, round topped, evergreen reaching up to 10m or more in height with short stocky trunk. Bark is grayish brown and rough.
- Leaves are compound, alternate consisting of 4-7 oblong leaflets, glossy dark green above and grayish brown under surface. New leaves are a bronze red.
- Flowers are greenish-white to yellow panicles borne in terminal clusters.
- Litchi fruits are one-seeded nuts, usually develop in bunches and vary in shape and size. The fruits are usually oval in shape. The fruits have a thin leathery shell (pericarp) which turns bright-red when the fruit is ripe.
- The sweet, juicy flesh is white, translucent and surrounds a large, oval, dark, shiny seed.

Pomegranate *(Punica granatum)*

Family: Punicaceae

- It is a deciduous shrub or tree. Branches are slender and somewhat thorny.
- Leaves are dark green, glossy, simple, opposite or in whorls, small and somewhat narrow, oblong to oval, clustered on short branchlets.
- Blooms are a flaming orange-red, to 2.5 inches in diameter with crinkled petals and numerous stamens. Flowers are borne solitary or in small clusters.
- Pomegranate fruits are berries, brownish red to purple-black, to 5 inches, with a protruding calyx at the blossom end. The skin is leathery.
- The flesh is a juicy, edible, reddish pulp surrounding numerous, small, dark seeds.



Ber *(Zizyphus mauritiana)*

Family: Rhamnaceae

- Indian jujube is thorny shrub or small tree. It sheds its leaves in summer after the harvest of the fruits.

- Leaves are alternate, simple, obtuse, broadly oval to rounded-elliptical, slightly equal to the base, densely tomentose underside and have stipular thorns.
- Flowers are small, greenish -cream, fragrant, and borne in the leaf axils.
- Fruit is drupaceous, persistent lower part of calyx often evident, ellipsoid to subglobose, greenish yellow to golden yellow in colour.



Fig *(Ficus carica)*

Family: Moraceae

- Leaves are simple, large, thick, bright to dark green, with three to five lobes; shiny above but dull or fuzzy below.
- The fruit are somewhat "pear-shaped," with a wide, flat bottom narrowing to a pointed top. When the fruit ripens, the top may bend, forming a "neck."
- Figs can be brown, purple, green, yellow or black, and vary in size.
- The fruit is fleshy with an "eye" leading to a cavity inside. The skin is slightly wrinkled and leathery.

- The fig flowers develop inside the fruit and cannot be seen. Seeds are either absent or inconspicuous.

Loquat *(Eriobotrya japonica)*

Family: Rosaceae

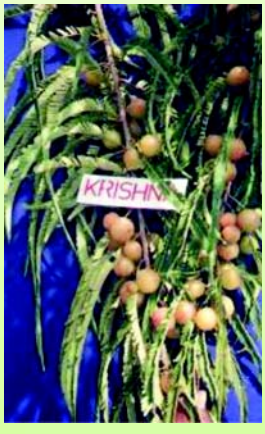
- The tree is symmetrical, evergreen and has a hairy dense crown.
- The ten to twelve inch long leaves are alternate, simple, oblong, leathery, and dark glossy green on the upper surface, rusty-coloured beneath.
- The flowers are white, with five petals, and are produced in stiff panicles of three to ten flowers. The flowers have a sweet aroma that can be smelled from a distance.
- The fruits are borne in clusters, commonly round, oval or pyriform, golden yellow and fuzzy skinned. The fruit skin thick but slightly tougher. The dried flower can often be seen on the bottom of the fruit. There are a few large, shiny, dark seeds in the soft, tart, yellowish flesh.



Aonla *(Emblica officinalis)*

Family: Euphorbiaceae

- A deciduous tree, small to medium in size; its bark is usually light brown to black, coming off in thin strips or flakes, exposing the fresh surface of a different colour underneath the older bark; in most cases, the main trunk is divided into 2 to 7 scaffolds very near the base.
- Leaves are small sized, simple, closely set in pinnate fashion, making the branches feathery in general appearance. The leaves develop on the determinate shoots after the fruit-set.
- Flowers appear on newly emerged determinate shoots. Male flowers appear first in the form of clusters at the basal part of determinate shoots followed by female flowers in the axil of leaves at the distal end of same shoot
- Fruits, fleshy, almost depressed to globose, primrose yellow in colour.
- The stone of the fruit, six-ribbed, splitting into three segments, each containing usually two seeds; citron green in colour.

EXERCISE 2.3: IDENTIFICATION OF TEMPERATE FRUITS OF OUR COUNTRY

Temperate fruits are the fruits growing in the temperate regions. Temperate regions are the regions where the temperature falls below freezing point during the winter. The temperate trees shed their leaves during the cold season and enter the rest period. A definite chilling temperature is required to break the rest period or dormancy. In general, the temperate fruits are grown in the states of Jammu & Kashmir, Himachal Pradesh, Uttarakhand and North -Eastern states.

Apple *(Malus domestica)*

Family: Rosaceae

- Apple plant is deciduous without spiny branches. The growth habit of plants which may be with an upright to slightly spreading growth habit. Tree size varies greatly but is usually relatively small.
- Leaves are oblong to oval, alternate, pointed, with serrate margins, soft textured with fine fuzz giving a dull appearance.
- Floral buds are mixed buds borne terminally on spurs and terminally or laterally on long shoot, depending upon the cultivar, age and vigour of tree.
- The inflorescence is determinate having five flowers. Flowers are white or pink or carmine in cymes.
- Apple fruits are round to slightly elongated and red, yellow or green in color. The flesh is crisp, white, and juicy. They are often borne on short stems known as spurs. The blossom end of the fruit may have 4 (sometimes 2 or 3) distinct lobes. The skin is smooth with prominent lenticels, or may be covered with tan corky tissue known as russett. Seed are hard, small, ovoid, pointed at one end, black or brown and shiny. Papery membranes surround the seeds.

Pear *(Pyrus communis; Pyrus pyrifolia)*

Family: Rosaceae

- Pear trees have a very upright growth habit.
- Leaves are alternate, with serrate margins.
- Showy white flowers appear in spring either before or when leaves emerge.
- Pears may be oblong or nearly round. Typically the stem end is narrow, broadening at the base or blossom end.
- Fruit may be green, yellow, yellow with a red blush, or red.
- Like apples, the fruit are usually borne on short stems called spurs.
- The flesh is white, juicy and soft, with slightly gritty stone cells.
- The seeds and leaves are very similar to apple except that they lack fuzz and are smooth and shiny in appearance.

Peach *(Prunus persica)*

Family: Rosaceae

- The tree is deciduous, moderately small with a dense upright growth habit except when pruned to encourage spreading growth.
- Leaves are alternate, narrow and 4-8 inches long with finely serrated margins. They point downward and curve inward.
- Peaches are roundish, sometimes pointed at the blossom end, with a suture along one side. Peaches vary in size but are usually about the size of a tennis ball.
- The skin is fuzzy and its color ranges from yellow to red.
- Flesh color is yellow, or sometimes white.
- The stone or pit is large, deeply pitted, oval or pointed, and tan to brown in color.

Nectarine *(Prunus persica var. nucipersica)*

Family: Rosaceae

- Tree is deciduous, small to medium in size to 20 feet, similar to peach.
- Leaves are bright green, glossy, alternate, and long with toothed margins.
- Nectarines are generally the same size, shape, and color as peaches, just a peach without fuzz. Like peaches, they have a suture or crease. However, they may be a little smaller and slightly tarter than peaches.
- Skin color is mostly red with some yellow.
- Flesh is yellow to white, redder near the center. The stone or pit is oval and deeply pitted.

Plum *(Prunus domestica; Prunus salicina)*

Family: Rosaceae

- Tree medium to large, upright growth and deciduous.
- Leaves are alternate, serrate, sharp pointed, medium sized and glabrous.
- Flowers are produced three in a bud on one year shoot or on spur. Flowers perfect, solitary or raceme, usually white in colour.
- Plums closely resemble small nectarines in shape, although some may be oval instead of round. Like nectarines, they have a crease on one side.
- The flesh and skin colour vary greatly with cultivar (yellow, green, red, blue or purple) and unlike nectarines, the color is not mottled.
- The skin is smooth and thin; the stone is usually oval, pointed at one end, and slightly rough.



Apricot *(Prunus armeniaca)*

Family: Rosaceae

- The leaves are alternate, heart-shaped and sharp pointed with finely serrated margins. The new growth often has a reddish tint.
- Flowers are solitary, produced in clusters, on short spurs, with 5 petals and 5 sepals and erect stamens.
- Apricot fruits resemble small peaches in shape and appearance, usually being yellow or orange with a vertical dent along one side. The skin is smoother than a peach, but is finely fuzzy. The stone is oval, flat, and smooth with ridges along one edge.




Sweet Cherry *(Prunus avium)*

Family: Rosaceae

- Sweet cherry is a tall tree and branches are erect.
- Leaves are large, thin, pubescent beneath and serrated. The petioles are long having two or more swollen glands.
- The floral buds are borne on 2 year old shoot or at the base of 1 year old shoot and found only on lateral, simple flower buds. Flowers are white in colour, raceme on long pedicels and produced in clusters.
- The fruit is cordate in shape, has deep cavity and apex is rounded or pointed. The fruit colour of cherry varies with varieties and may be yellow, red or purplish black.
- The texture of the flesh is tender or firm, sweet and yellow or red or dark purple in colour.

Kiwi Fruit *(Actinidia deliciosa)*

Family: Actinidiaceae

- Kiwi fruit grows on a vigorous, woody, twining vine or climbing shrub reaching 30 feet.
- Its alternate, deciduous leaves are oval to nearly circular with long petioles. Young leaves and shoots are coated with red hairs. Mature leaves are dark-green and hairless on the upper surface, with prominent, light-colored veins below.
- The fragrant flowers have five to six petals, white at first, changing to buff-yellow.
- The oval fruit, about the size of a large hen's egg, has russet-brown skin densely covered with short, stiff brown hairs. The fruit has a soft texture, green flesh, edible black seeds and a unique flavor.

Pecan *(Carya illinoinensis)*

Family: Juglandaceae

- Pecan trees grow seventy to 100 feet in height. Bark becomes gray, rough, and somewhat scaly on older trees.
- Leaves are odd-pinnately compound, with 11 to 17 leaflets, lanceolate, with serrate margins.
- Male and female flowers are on the same tree. The male flowers are in hanging catkins and the female flowers in spikes.
- Pecans develop inside a rough green husk that turns black and splits open at maturity.
- The nut is oblong, brown or tan with black streaks, smooth, thin-shelled, pointed and one to two inches long.
- The kernel is distinctively ridged.





Walnut *(Juglans regia)*

Family: Juglandaceae

- The trees are very large, ranging from 50 to 75 feet in height and width
- The leaves are 12 to 24 inches, alternate, and pinnately compound, having 15 or more lanceolate leaflets with serrate margins.
- Fruits develop in clusters inside a rough, green husk about the size of a tennis ball. The shell of the nut is nearly round, black, very hard, rough and deeply ridged. The nut (kernel) is contained inside the shell.



Strawberry *(Fragaria x annanasa)*

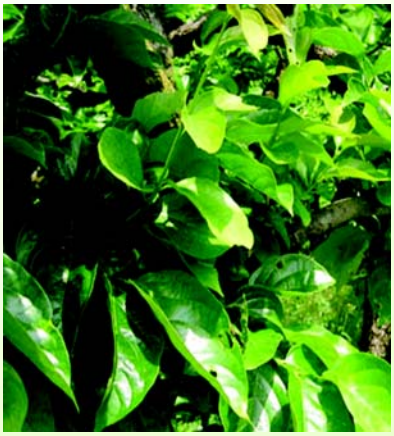
Family: Rosaceae

- The strawberry is a nearly stemless small plant. It forms stolons on which new plants develop.
- Leaves are compound, consisting of three rounded leaflets with deeply serrated margins.
- The strawberry flower is about an inch in diameter with five white petals and a yellow center.
- The fruit is bright red at maturity, somewhat cone-shaped or flattened cone-shaped, with numerous small, hard, brown seeds scattered on the outside surface in shallow depressions.
- The fruit is fleshy, with a prominent, green calyx at the stem end.

Persimmon *(Diospyros kaki)*

Family: Ebenaceae

- This deciduous tree can grow to about 30 feet when mature.
- The broad, stiff leaves are alternate, ovate, dark green and shiny above, lighter below, and leaf margins are often curled.
- The inconspicuous flowers surrounded by a green calyx, and may be white, cream-colored or pink-tinged.
- The persimmon fruit are round to oval, yellowish-green to orange or red in color, and may reach the size of a peach.
- Notice the dried calyx at the top of the fruit. This can help distinguish persimmons from apricots or tomatoes.
- They are sweet, slightly tart fruits with a soft to occasionally fibrous texture. Seeds are large, flat, dark and shiny, if present.


Exercise 1: Prepare a scrap book by collecting leaf samples of various fruit plants available in your region.

Exercise 2: Record your observations on morphological features of fruit crops of your region as per the data sheet given below.

Data sheet (Exercise 2)

Plant Identification Key of Fruit Plants

Fruit plant	Plant/Stem characteristics	Leaf characteristics (arrangement, type, margins, tip, size, shape, colour, *etc*)	Flower/ inflores cence characteristics (Type colour, size,)	Fruit characteristics (size, shape, colour)	Other characteristics

Practical 3

EXERCISE 3.1: IDENTIFICATION OF MAJOR VEGETABLE CROPS OF OUR COUNTRY

Objective :

- Imparting knowledge for the identification of different vegetable crops on the basis of different morphological characters at different plant growth stages

Delivery schedule : 03 periods

Student expectations/learning objective:

- To demonstrate different characteristic features of different vegetable crops for their easy identifications

Pre-learning required : Names of different vegetable crops and knowledge about classification of vegetable crops

Handouts/material required/equipment's & tools: Forceps, hand lens, paper sheet, pen to note down the instructions and pictures of different vegetables.

Introduction:

Vegetables are the products of herbaceous plants which are annuals, biennial and perennials (mostly annual) whose plant parts such as fruits, leaves roots, stems, petiole, flower etc. are used for culinary or consumed as raw. As discussed in Practical 1 that it is important to identify different vegetable crop plants at different growth stages. The vegetable plants differ with respect to each other in their morphological characters. The keen and frequent observations on vegetative and reproductive parts of plant help in easy and clear identification. It is essential to know the different parts of the plants before undertaking the identification as these forms the basis of distinguishing characters. In this practical you will learn how to identify a vegetable keeping in mind their characteristic morphological features. The important distinguishing characters of important vegetable crops have been discussed here under which may help the students in distinguishing them even at early stages of their growth. It takes time and exposure to learn to identify vegetable plants.

Procedure:

Step 1: Critically observe the morphological characteristics of the specimen. To identify plants in garden, look for morphological features such as size, shape and color of the leaves as well as unusual characteristics like scent or hair.

i) Root system:

- Adventitious
- Tap root system.

ii) Stem characteristics:

- Hollow or pithy
- Number and length of internodes
- Branched or single stem
- Smooth or ridged
- Leaf arrangement on the stem- alternate or paired
- Presence or absence of any specific characters like tendrils, spines etc.

iii) Leaf characteristics:

- Shape of leaf- long narrow or ovate or lanceolate
- Presence or absence of pubescenc
- Type of leaf - simple or compound leaf, petiolated or sessile
- Presence or absence of leaf sheath
- Leaf margins: serrated or smooth
- Texture of leaf- smooth or rough.

iv) Inflorescence:

- Colour of flowers
- Type of inflorescence.

v) **Economic part**

- Colour
- Size
- Shape

Step 2: Draw the sketch of each plant.

Step 3: Record the observations with respect to root, stem, leaf, inflorescence and fruit characteristics in the data sheet.

Step 4: Use chart of morphological features

IDENTIFICATION CHARACTERISTICS OF DIFFERENT VEGETABLE CROPS

Summer vegetables

Tomato *(Solanum lycopersicum)*

Family : Solanaceae

- Examine the stems of the plant. They have short, fine, white hair on them i.e. slightly fuzzy. Observe the growth habit of plants which may be determinate or indeterminate. Indeterminate type bears inflorescence cluster at every third internode.
- Notice the leaves on the tomato plant. Tomato bears compound leaves with multiple leaflets (5-9) growing along a common stem (called rachis). Leaves are green, hairy, serrated/oval/pointed, and have visible veins.
- Sniff your fingers after touching a tomato plant leaf. Tomato leaves have a pungent scent that remain on the skin.
- Observe the flowers on the plant. Tomato flowers are bright yellow with pointed petals.
- Notice the fruits growing on the plant. After pollination, a flower of tomato grows as a single small, round, green fruit. Colour of the fruit changes with the onset of maturity.
- Cut open the fruit you will see the locules filled with jelly like substance containing seeds.

Tomato

Brinjal (*Solanum melongena*)

Family : Solanaceae

- See the stem of the plants. They are branched, erect, have fine hairs and in some varieties may have spines.
- Notice the leaves which are usually large, lobed, ovate, thin and relatively hairy on the under surface. Leaves also bear sharp spines. Petiole is about one fourth as long as the leaf blade.
- Observe the flowers of the plant. Flowers are violet in colour, borne solitary and forms cluster of two or more in lateral cymes. Flowers are deeply lobed with toothed calyx. Calyx is five lobed and covers the base of the fruit on enlargement. Fruit is berry with numerous seeds.

Brinjal

Bell pepper *(Capsicum annuum)*

Family : Solanaceae

- Observe the plants. They have straight main stem which bear secondary branches forming 'V'. Flowers are white in colour and star shaped. Fruits are juiceless berries which vary in shape and size.
- Observe the shape of the peppers. A standard bell pepper form blocky fruits in shape with three or four lobes at the bottom of the fruit. Skin of fruit (pericarp) is thick and glossy in appearance.

Bell pepper

- Check color of the fruits. Bell peppers are usually green in colour and change color to red, orange or yellow on maturity.

Cucumber *(Cucumis sativus)*

Family : Cucurbitaceae

- Observe the growth habit of the plant in question. Summer and winter squash plants grow very fast in the early days of summer while cucumber plants take a few days more to grow.

- Cucumber plants along with its leaves are usually smaller than squash plants and the stems are not as thick as squash plant.
- A cucumber vines grow vertically with the help of strong tendrils that make grip with staking material and provide upward growth.
- Cucumber leaves are triangular in shape with pointed lobes. The leaves are large, dark green and have a slightly rough texture.
- See the stem of cucumber, it is delicate and has tender spines.
- Cucumber bears male and female flowers separately on the same plant (monoecious flowers). Flowers are small and yellowish coloured. Cucumbers usually form long thin fruits.

Cucumber

Bitter gourd *(Momordica charantia)*

Family : Cururbitaceae

- Observe the growth habit of the plant. Plant vine may grow upto the height of 15 feet. The stems have twining tendrils and are slender, green and hairy.
- The leaves are green, hairy, alternate, deeply palmate and lobed with 5 coarsely toothed lobes.
- The flowers are monoecious and yellow in colour.
- The fruits may be egg-shaped to oblong, green, tapering at the ends and covered with blunt tubercles (swellings).
- Taste the fruit. It is bitter in taste.

Bitter gourd

Bottle gourd: *(Lagenaria siceraria)*

Family : Cucurbitaceae

Bottle gourd

- Observe the plant habit. The bottle gourd is a vigorous, annual, running or climbing vine with large leaves and lush in appearance. The vine is branched and climb by means of tendrils along the stem. The foliage is covered with soft hair and has a foul musky odour when crushed.
- Look at the leaves. The leaves are circular in overall shape with smooth margins, a few of them may have broad lobes or undulating margins. Leaves have a velvety texture because of the fine hair, especially on the undersurface.
- Look at the flower of bottle gourd. The bottle gourd flowers are borne singly on the axils of the leaves, the males on long peduncles and the females on short peduncles. The flowers are white and attractive with spreading petals.
- It bears two types of fruits namely, long and round.

Summer squash:

Family : Cucurbitaceae

Summer squash

- The summer squash plant has bush type growth and no vine formation.
- The plant has separate male and female flowers on the same plant. The female flowers can be easily identified as they bear miniature fruit (ovary) at the base. Flowers are showy and yellow in colour.
- Feel the outside skin of summer squash fruit which is tender (not hard).
- Look at the color of the squash. It looks bright green and has a shiny gloss.

Musk melon *(Cucumis melo)*

Family : Cucurbitaceae

- A muskmelon plant has trailing prostrate stems generally upto 10 m in length and often forming large mats. Stems are viny, herbaceous, slender, angled in cross-section, branched near the base and rough in texture with short stiff hair.

- Observe the leaves of the plants. Leaves are alternate more or less palmate, angled or shallowly 3-7 lobed and covered with very short stiff hairs (scabrous). Tendrils are unbranched and borne singly per node from the base of the leaf petioles.

Musk melon

- Flowers are axillary, monoecious, with 1 or more male flowers per node and single female flowers at few different nodes.
- The fruits of the muskmelon are oblong to round. Surfaces are net-veined or covered with minute stiff hairs and lack prickles. Immature fruits are green, but become mottled or striped with yellow or orange, or are solid yellow or orange at maturity.

Watermelon *(Citrullus lunatus)*

Family : Cucurbitaceae

- Watermelon grows on vines which usually sprawl across the ground in a sunny location. At maturity, each vine is 10 to 15 feet in length and has tiny tendrils or thread-like curling stems at leaf bases.
- Look at the vine's foliage and feel its texture. Watermelon leaves are light green with silvery white tinge. The leaves are deeply lobed having three to five finger-like lobes that have coarse rounded teeth.
- The flowers are yellow and occur singly. Flowers appear on the young vines, usually at the tips. Fruits are large in size, green, smooth and round.
- Cut open a fruit. The flesh of a watermelon fruit is easily recognizable both at mature and immature stages. Mature or near ripening fruits have red flesh and black seeds while the flesh of young developing fruits is pale green to white with small white seeds.

Water melon

French bean *(Phaseolus vulgaris)*

Family : Fabaceae

French bean

- Observe the plant of the French bean. It is erect or twine annual herb.
- Look at the leaves of the plant. The leaves are trifoliate, compound. The edge of the leaf blade is entire (has no teeth or lobes).
- Study the flower of French bean. Flowers white to violet-purple. Flowers are bilaterally symmetrical.
- Look at the pods of the French beans. Pods are slender, straight or slightly curved, the surface glabrous or faintly pubescent with prominent beak.

Cowpea *(Vigna unguiculata)*

Family : Fabiceae

Cow pea

- Observe the growth habit of the plant. Plants are herbaceous annual with twining stems varying in erectness and bushiness.
- Study the leaves of the plant. Leaves are alternate and trifoliolate. The lateral leaflets are opposite and asymmetrical, while the central leaflet is symmetrical and ovate.
- Look at the flower of the plant. Flowers are white, cream, yellow, mauve or purple in colour.
- Look at the pods of the cowpea. Pod pendulous, smooth, with a thick decurved beak and contains10- 15seeds.

Guar or cluster bean *(Cyamopsis tetragonoloba)*

Family : Fabaceae

- Study the growth habit of the plant. Plant grows upright, reaching a maximum height of up to 2-3 m. It has a main single stem with either basal branching or fine branching along the stem.

- Look at the leaves of the plant. Leaves are elongated oval in shape and borne on alternate position. The leaves and stems are mostly hairy.
- Check the flowers of the plant. Clusters of flowers grow in the plant axil and are white to bluish in color.
- Look at the pods of the cluster bean. The developing pods are rather flat and slim containing 5 to 12 small oval seeds.

Cluster bean

Okra *(Abelmoschus esculentus)*

Family : Malvaceae

- Observe the growth habit of the plant. The plant is erect herb up to 2 m tall. Stems are succulent with scattered stiff hair.
- Study the leaves. Leaves are 50 cm wide and 35 cm long, deeply lobed, with toothed margins, hairy on both surfaces, especially on the nerves. Each leaf is borne on a petiole.
- Look at the flower of the okra. Flowers are showy, usually yellow with a dark red, purple or mauve centre, borne on a stout peduncle.

Okra

- The fruits of okra are 6-20 cm long (at harvesting stage), roughly circular in cross-section with a pointed end, usually 5-ribbed, borne at the leaf axils. Immature fruit dark green or pale green.

Amaranthus *(Amaranthus tricolor or Amaranthus bicolor)*

Family : Amaranthaceae

- Observe the plant of amaranthus. They are erect-growing plants.
- Its stems are vigorous, cylindrical and fibrous. On maturity stems becomes hollow inside. The plant has the stripes on the stem and shades of green, red, pink, brown or purple depending upon the variety.

- Look at the leaves of the amaranthus plant. The leaves are stalked, compound, alternate, long or oval and green or dark red at the base and bright yellow, orange or florescent pink at the top.
- You will find tiny green, red or purple flowers clustered densely together, sometimes slightly drooping at the head of the plant. The flowers last for a long time.

Amaranth

Winter Season vegetables

Potato *(Solanum tuberosum)*

Family : Solanaceae

- The potato plant is leafy, herbaceous and spreading type. The leaves are compound with 7-15 leaflets.
- Study the flower of the potato. Potato flowers are star-shaped, white, lavender, pink or light blue with yellow centers and borne in clusters.
- Look at the fruits of the potato plant. The fruits are like small green tomatoes, about an inch in diameter and contain several hundred seeds.

Potato plant

- Dig out the potato plant; you will see tubers growing underground which are round to oval in shape and in general light brown in colour.

Cauliflower *(Brassica oleracea var. botrytis)*

Family : Brassicaceae

- Look at the cauliflower plant. The stem/stalk varies from short to medium in length. Leaves are produced close to the ground, which are longer, narrower and brighter green in color than cabbage and broccoli leaves. The leaf petiole is long and broad that looks flat on the upper surface and is little raised on the lower side.

Cauliflower

- The edible portion of cauliflower is called curd which is formed in the centre of the leaves. The inner leaves curve inwards to cover the curd in mid and late group varieties and keep curd blanched (white).
- Curd is white to creamish in colour and compact.

Cabbage *(Brassica oleracea var. capitata):*

Family : Brassicaceae

- Cabbages have very short stem joints and in some varieties the heads are practically coreless. It grows rosette on a short stalk with the broad outside leaves close to the ground and the "wrapper" leaves form the heads. The leaves have wavy edges. Upper leaves are sessile while those on the base are much more fleshy, petiolated with lobules.

Cabbage

- As the plant grows, the leaves increase in number and form a ball-shaped "head" in the center of the plant.
- The leaves of cabbages can range from smooth to crinkled, green to red. They are usually very broad and cupped, with a network of veins that connect to a large central mid-vein.
- Observe the head of the plant. The head of the cabbage plant is made up of several layers of overlapping leaves. Head cabbage and head lettuce are similar in appearance, but cabbage leaves are usually more tightly wrapped on the head. The head is very solid. The cabbage heads are glossy light green in colour. The red cabbage is purple in colour.
- Flowers are yellow in colour, grouped in loose racemes.

Broccoli *(Brassica oleracea var. italica)*

Family : Brassicaceae

- Broccoli leaves have elongated petiole, somewhat round in shape. Leaves are green grey in colour with very curly deep lobes. Broccoli leaves are also broader than cauliflower leaves and have a lobe-like structure(s) at the base of the leaf.

- It has succulent, loose, leafy edible stem, which support large and compact heads of thickly clustered flower buds which are green in colour.
- The main group of florets or "head" grows in the center of the leaves. After the harvest of the main head, shoots may arise from the stem which is called as spears.

Broccoli

Garden pea *(Pisum sativum)*

Family : Fabaceae

- Observe the plant. Garden pea plant may be dwarf or vining/ tall types.
- Stem of pea plant is round and hollow covered with a waxy bloom.
- Observe the leaves of garden pea. The leaves are compound (made up of two or more discrete leaflets). The edge of leaf blade has teeth. Leaves consist of one or more pairs of opposite leaflets borne on petioles together with several pairs of tendrils (which are essentially modified leaves) and a single or compound terminal tendril.

Garden pea

- Leaflets are broad and ovate with distinct ribs which may be slightly toothed or entire.
- The two (pseudo) stipules at the base of the leaf are also ovate but much larger than the leaflets.
- Study the flower of the plant. Flower is white coloured which develops into a pod.
- Study the pods of the pea. Pods containing several seeds, flattened when young but becoming roundish at later stages and are dehiscent along two sides.

Onion *(Allium cepa)*:

Family : Amarylidaceae

- Observe the leaves of the onion. Leaves arise from underground part of the stem. The leaves are bluish-green and grow alternately in a flattened fan-shaped swathe.
- Leaves are fleshy, hollow and cylindrical, with one flattened side. The base of each leaf is a flattened usually white sheath that grows out of a basal disc.

Bulb plant ***Seed umbel***

Onion

- From the underside of the disc, a bundle of fibrous roots extends to a shallow depth.
- Look at the inflorescence of the onion. Inflorescence of onion is called cyme.
- Onion bulbs are pungent when chopped and contain certain chemical substances which irritate the eyes.
- At maturity the foliage dries up and the outer layers of the bulb become dry and brittle.

Garlic *(Allium sativum)*

Family : Amarylidaceae

- Observe the garlic plant. The leaves are long, narrow and flat like grass. This plant has narrow foliage with long, narrow and flat grass like leaves.
- Taste the plant parts. All parts of this vegetable have a very strong taste and it is widely used for culinary purposes.

Garlic

- Look at the bulb of the plant. The bulb is of a compound nature, consisting of numerous 'cloves,' which are grouped together between the membraneous scales and enclosed within a whitish skin, which holds them as in a sac.

Carrot *(Daucus carota)*

Family : Umbelliferae

Carrots

- Note the stem of the plant. The stem at its vegetative state is just above ground and is greatly compressed as result internodes are not visible. The stem apex is slightly convex.
- Observe the leaves. Leaves are dark green and shiny, the lowest being broadly linear-lanceolate toothed leaflets. Leaf blades are two to three pinnate, the leaflets being repeatedly divided - pinnatifid. Leaves and the basal rosette are alternate and compound.
- Generally carrot flowers are perfect, small or white or occasionally greenish white or light yellow. Flowers usually open first at the periphery of the primary umbel. The primary umbel is produced at the terminal end of the main floral stem.
- Uproot the plant and observe the roots. The root length of most of the cultivars ranges between 10 and 25 cm. Roots are orange, yellow, red, purple and white - fleshed. Root shape of many carrot cultivars is conical, but the extent of tapering varies as per cultivars.

Radish *(Raphanus sativus)*

Family : Brassicaceae

Radish

- The plant of the radish is erect, herbaceous that grow up to 40 inches.
- Leaves are arranged in a rosette, with sizes ranging from 10-15 cm in small cultivars to up to 45 cm in large cultivars. Leaves have a lyrate shape i.e. divide pinnately with an enlarged terminal lobe and smaller lateral lobes.
- Radishes make the swollen part of the roots which is edible. Roots are round to cylindrical with a color ranging from white to red.

- The white flowers are borne on a racemose inflorescence. The flower of the radish has four white petals with rose, purple, or yellowish veins. The flower are usually bisexual.
- The fruit of the radish is a round pod-like structure called as siliqua.

Turnip *(Brassica rapa)*

Family : Brassicaceae

- The leaves grow directly from the above-ground shoulder of the root, with little or no visible crown or neck. The edge of leaf blade has lobes. Leaves are light to medium green, hairy or bristly and lyrate-pinnatifid.
- Turnip root is mostly white-skinned apart from the upper portion which protrudes above the ground and are purple, red, or greenish wherever sunlight has fallen. This above-ground part develops from stem tissue, but is fused with the root. The root is roughly conical to globular with interior white flesh

Turnip

- Flowers are yellow in colour. Sex form is similar as that of radish.
- Fruit bearing seed is called as siliqua with long tapering beak.

Fenugreek- Trigonella foenum-graecum (Common methi) and Trigonella corniculata (Kasuri methi)

Family : Fabaceae

- Fenugreek is of two types viz., common methi and kasuri methi. The common methi has quick growing upright plants whereas kasuri methi is slow growing and remains in rosette condition.
- Carefully observe the leaves they are alternate, trifoliate, and lanceolate and leaflets are shortly stalked blunt and oblong.

Common methi ***Kasuri methi***

- Leaves of common methi are light green in colour and that of kasuri methi are dark green in colour.
- Observe the flowers of the fenugreek. Flowers are sessile, solitary in the axils of the leaves. Flowers of kasuri methi are yellow in colour and that of common methi are white or light violet.
- Taste of the leaves is bitter with peculiar odour.
- The pods of common methi are straight, long and slender with a prominent beak and that of kasuri methi are sickle shaped.

Spinach *(Spinacia oleracea)*

Family : Chenopodiaceae

Spinach beet

- Observe the plant of the spinach. It forms clumps of long-stemmed leaves that can grow up to 12 inches long and 18 inches wide at maturity.
- Look at the leaves of the spinach. The edible leaves are arranged in a rosette from which a seed-stalk emerges. The leaves are alternate, simple, ovate to triangular-based with very variable in size
- Observe the flowers of the spinach. The flowers are inconspicuous, yellow-green, maturing into a small, hard, dry, lumpy fruit cluster containing several seeds.

Exercises

1. Identify the vegetable plants growing in the vegetable farm on the basis of morphological characters and record your observations in the data sheet.

2. Identify the following vegetable plants

1._____

2. _____

3. _____

4. _____

5. _____

Data sheet (Exercise 1)

Crop	Leaf characteristics (size, shape, colour, pubescence *etc*)	Stem characteristics	Flower/ inflorescence characteristics (Colour, size, type)	Fruit characteristics (size, shape, colour)
Summer Season vegetables				
Tomato				
Brinjal				
Okra				
Chilli				
Bell pepper				
Cow pea				
French bean				
Winter season vegetables				
Garden pea				
Cauliflower				
Cabbage				
Broccoli				
Spinach				
Radish				
Carrot				
Turnip				

Practical 4

IDENTIFICATION OF MAJOR FLOWER CROPS OF OUR COUNTRY

Introduction :

Different flowers and plants are identified based upon the knowledge of morphology and anatomy. For describing flower crops, every part of it is to be studied in detail and compared with similar structures of other plant. Every plant part has a name and its study is called as **Phytography**. It is a branch of taxonomy or plant systematic. It deals with the descriptions of plants and their organs (parts). The main plant parts used for description of flowering plants are given below:

- Roots (position and morphology)
- Stem (Branching pattern, texture, shape, bark-surface, form, modifications, etc.)
- Buds (position, protectiveness, time of sprouting, etc.)
- Foliage (Leaf-simple/ compound, insertion, arrangement, parts, stalk, base, apex, shape, serration/ margins, incision, venation, surface/ texture, sap, duration, etc.)
- Inflorescence (type, size and number of flowers, duration, etc.)
- Flowers (shape, symmetry, completeness, parts, arrangement, insertion, union of floral parts, calyx- sepals, corolla- petals/ tepals, colour, shape, size, androecium- stamens, anthers, gynoecium- stigma, style, ovary, fragrance, duration, etc.)
- Fruits (type, shape, size, colour, fragrance, duration, etc.)
- Ovule/ Seed (shape, size, colour, number, duration, etc.)

EXERCISE 4.1: IDENTIFICATION OF MAJOR CUT FLOWER CROPS

Objective :

- To identify various cut flower crops based on primary morphological characters.

Delivery schedule : 1 period

Student's expectations/ Learning objectives:

- To get acquaint with different cut flower crops grown in India

Pre-learning required : Knowledge about various cut flowers.

Handouts/material required/equipment's & tools: Flower crops, hand lens and standard encyclopedia and books on Floriculture

Introduction:

When flowers are harvested with long stem usually containing few or many leaves for various uses indoor and outdoor are called as cut flowers. The main cut flower crops grown in India are given below:

Description of cut flower

Photograph

Alstroemeria pelegrina (Alstroemeria)

Family: *Alstroemeriaceae*

It is a perennial, rhizomatous bulbous cut flower crop growing to over one meter. Shoots are leafy, light green and flowers borne in spike having 4 to 12 florets of various colours.

Anthurium andreanum (Anthurium)

Family: *Araceae*

Anthurium is a tropical cut flower, having dark green shining heart shaped foliage and brightly, heart shaped spathe of various colours.

Cymbidium spp. (Cymbidium)

Family: *Orchidaceae*

Cymbidium is the most popular genus grown for cut flowers. Plants are evergreen with fleshy roots and short pseudo-bulbs enclosed with linear leaves. Inflorescence is erect or pendulous, bearing long lasting flowers of varied colours. Lip is 3-lobed. Column is boat shaped.

Dendranthema grandiflora (Chrysanthemum)

Family: *Asteraceae*

Plants are semi-woody, perennial, leaves single, serrated, dark green and inflorescence capitulum having two types of florets (tubular and ray), varied flower form in different colours.

Dendrobium spp. (Dendrobium)

Family: *Orchidaceae*

Dendrobium is the second largest genus, but very popular cut flower after Cymbidium. Stem is elongate or with pseudo-bulbs. Leaves are one to several. Inflorescence is terminal or lateral with one to many flowers of varied colours.

Dianthus caryophylus (Carnation)

Family: *Caryophylaceae*

Plants are herbaceous, perennial, stem with swollen nodes, leaves thick, dark green grass like and flowers with smooth or fringed petals of various colours.

Gerbera jamesonii (Gerbera)

Family: *Asteraceae*

Plants are almost without stem, tender perennial herb. Leaves radical, with petiole, deeply lobed and dark green. Flower heads solitary, many flowered, daisy like in almost every colour.

Gladiolus x gandavensis (Gladiolus)

Family: *Iridaceae*

Gladiolus leaves resemble sword and 6-8 number. Flowers called as florets are borne in spike. Florets open acropetally and are of almost all colours. Under ground plant-part is called as corm, which distinct nodes and internodes and covered with thin papery covering.

Heliconia angustifolia (Heliconia)

Family: *Musaceae*

Dwarf plantain like plants with colourful foliage. Boat shaped bracts look very ornamental and available in red, yellow and orange colours.

Lilium spp. (Asiatic Lilium)

Family: *Liliaceae*

Leaves are mostly shining and upward growing. Flowers are mostly dark coloured and with no or slight fragrance. Flowering is for extended period. Bulbs are almost white and small size.

Lilium spp. (Oriental Lilium)

Family: *Liliaceae*

Leaves are less or no shining, broad shaped and growing almost parallel to ground. Flowers are mostly white or pink coloured with high fragrance. Flowering occurs during late autumn. Bulbs are yellowish tinged and of large size.

***Narcissus pseudonarcissus* (Daffodil)**

Family: *Amaryllidaceae*

Plants perennial, leaves linear and dark green. Flowers are borne on long stalk. Narrow perianth tube with six segments mainly of creamish white colour and a cup shaped corona in the centre of yellow, orange colour.

***Polianthes tuberosa* (Tuberose)**

Family: *Agavaceae*

Plants are leafy with long narrow, linear, grass like and mostly prickly. Flowering stalk called spike has single, semi-double and double flowers, creamy-white, tubular and highly fragrant.

***Ranunculus asiaticus* (Ranunculus)**

Family: *Ranunculaceae*

Plants are dwarf with finely cut dark green foliage. Flowers are turban shaped double in almost red, yellow, orange, white and scarlet colours. Tubers have claw shaped 3-5 flangs in dusty brown colour.

***Rosa hybrida* (Rose)**

Family: *Rosaceae*

Plants are erect to climbing, stem prickly, leaves oddly pinnate and prickly. Flowers in cut flower varieties are many and almost all colours.

***Strelitzia reginae* (Bird of Paradise)**

Family: *Strelitziaceae*

Plants are perennial, herbaceous, thick stalked dark green foliage and long contractile roots. Flowers are yellow-orange with violet-blue centre and with flying bird shaped.

***Tulipa* spp. (Tulip)**

Family: *Liliaceae*

Plants have 3-4 strapped shape to lanceolate green leaves. Flowers are solitary having six to many tepals borne on a scape in almost every colour.

Exercise: Visit the commercial Floriculture farms/ nurseries/ Florist shops and identify different cut flowers being grown or sold based upon their distinguishable morphological characters.

EXERCISE 4.2: IDENTIFICATION OF MAJOR LOOSE FLOWER CROPS

Objective :

- To identify various loose flower crops based on primary morphological characters.

Delivery schedule : 1 period

Student's expectations/ Learning objectives:

- To get acquaint with different loose flower crops grown in India

Pre-learning required : Knowledge about various loose flowers.

Handouts/material required/equipment's & tools: Flower crops, hand lens and standard encyclopedia and books on Floriculture

Introduction:

When flowers are harvested without stem usually with small or no petiole for various religious and social functions are called as loose flowers. The loose flowers are used to offer in temples, mosques, churches, gurudwaras, making garlands, veni, gajra, corsage, etc. The main loose flower crops grown in India are given below:

Loose flower crop

Photograph

Callistephus chinensis (China aster)

Family: *Asteraceae*

Plants are herbaceous, annual. Leaves are simple, serrated and light green. Flowers are single to double and in pink, purple, red, yellow and white colours

Chrysanthemum spp. (Annual chrysanthemum)

Family: *Asteraceae*

Plants are herbaceous with semi-woody base, annual, leaves simple, serrated/ lobed and flowers mainly in white and yellow tinge.

Crossandra undulaefolia (Crossandra)

Family: *Acanthaceae*

Dwarf evergreen shrub growing to two feet. Flowers are yellow to orange borne in dense bracted spikes.

Dendranthema grandiflora (Chrysanthemum)

Family: *Asteraceae*

Plants are semi-woody, perennial, leaves single, serrated, dark green and inflorescence capitulum having two types of florets (tubular and ray), globular to decorative flower form and mainly in white and yellow colours.

Jasminum sambac (Arabian Jasmine)

Family: *Oleaceae*

Plants are bushy to climbing. Leaves are sessile, opposite and light green. Flowers are single to double form, white and borne in clusters of 3-12 per cluster.

***Nelumbo nucifera* (Lotus)**

Family: *Nymphaeaceae*

Plants are growing in ponds. Leaves are overtopping. Flowers are pink to red about 20-30 cm across growing above water.

***Nerium indicum* (Red kaner)**

Family: *Oleaceae*

Plants are tall, multi-branched, erect growing. Leaves are simple, thick, dark green and shining. Flowers are single to double borne in corymbs in pink, white and red colours

***Polianthes tuberosa* (Tuberose)**

Family: *Agavaceae*

Plants are leafy with long narrow, linear, grass like and mostly prickly. Flowering stalk called spike has single, semi-double and double flowers, creamy-white, tubular and highly fragrant.

***Rosa hybrida* (Rose)**

Family: *Rosaceae*

Plants are erect to climbing; stem prickly, leaves oddly pinnate and prickly. Flowers in loose flower varieties are many, borne in clusters and mostly in red, pink and white colours.

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

Family: *Asteraceae*

Plants are tall, stem green, foliage oddly pinnate, light green and flowers large, yellow to orange tinged.

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

Family: *Asteraceae*

Plant is dwarf, stem bronze, foliage oddly pinnate, dark green and flowers small, mainly red tinged.

Exercise: Visit the commercial Floriculture farms/ nurseries/ Florist shops and identify different loose flowers being grown or sold based upon their distinguishable morphological characters.

Observations:

S.No.	Name of the flower	Cut flower or loose flower or both	Plant characteristics	Flowers and inflorescence	Remarks
1					
2					
3					

Precautions:

- Do not damage the flower crops during identification.
- Carefully note the most distinguishable characters of flower crops identified.

Practical 5

IDENTIFICATION OF ORNAMENTAL PLANTS FOR AVENUES AND LAWN- GRASSES, HEDGES, EDGES PLANTS OF OUR COUNTRY

Introduction:

Different flowers and plants are identified based upon the knowledge of morphology and anatomy. For describing flower crops, every part of it is to be studied in detail and compared with similar structures of other plant. Every plant part has a name and its study is called as **Phytography**. It is a branch of taxonomy or plant systematic. It deals with the descriptions of plants and their organs (parts). The main plant parts used for description of flowering plants are given below:

- Roots (position and morphology)
- Stem (Branching pattern, texture, shape, bark-surface, form, modifications, etc.)
- Buds (position, protectiveness, time of sprouting, etc.)
- Foliage (Leaf-simple/ compound, insertion, arrangement, parts, stalk, base, apex, shape, serration/ margins, incision, venation, surface/ texture, sap, duration, etc.)
- Inflorescence (type, size and number of flowers, duration, etc.)
- Flowers (shape, symmetry, completeness, parts, arrangement, insertion, union of floral parts, calyx- sepals, corolla- petals/ tepals, colour, shape, size, androecium- stamens, anthers, gynoecium- stigma, style, ovary, fragrance, duration, etc.)
- Fruits (type, shape, size, colour, fragrance, duration, etc.)
- Ovule/ Seed (shape, size, colour, number, duration, etc.)

EXERCISE 5.1:
IDENTIFICATION OF MAJOR ORNAMENTAL TREES FOR AVENUES

Objective :

- To identify various ornamental trees for avenues based on primary morphological characters.

Delivery schedule : 1 period

Student's expectations/ Learning objectives:

- To get acquaint with different ornamental trees for avenues grown in India

Pre-learning required : Knowledge about ornamental trees for avenues.

Handouts/material required/equipment's & tools: Ornamental trees for avenues, hand lens and standard encyclopedia and books on Floriculture

Introduction:

Tree is a perennial plant having distinct trunk and crown at the top. The important characteristics of trees used for avenue planting are given below:

- Good ornamental value all through the year
- Medium size (10-15m)
- Trunk straight to 5m
- Fast growing
- Unbreakable and non-drooping branches
- Non-thorny

Description of ornamental tree	Photograph

***Acacia auriculiformis* (Australian Acacia)**

Family: *Mimosaceae*

Dwarf to medium sized, evergreen tree with light yellow fragrant flowers year round.

***Acrocarpus fraxinifolius* (Pink cedar)**

Family: *Caesalpiniaceae*

Semi-deciduous, medium to tall tree with orange-red emerging foliage and greenish yellow flowers.

***Aesculus indica* (Horse chestnut tree)**

Family: *Sapindaceae*

Deciduous, medium to tall tree having exfoliating bark on trunk and branches. Good for planting in hills.

***Ailanthes excelsa* (Tree of heaven)**

Family: *Simaroubaceae*

Deciduous, medium sized foliage tree. Good for planting plains and low hill areas.

***Anthocephalus indicus* (Kadamb)**

Family: *Naucleaceae*

Deciduous, coarse texture foliage tree and globosely yellow flowers during July to September.

***Azadirachta indica* (Neem)**

Family: *Meliaceae*

Evergreen, medium sized foliage tree with white flowers during April to June.

***Araucaria columnaris* (Monkey puzzle)**

Family: *Araucariaceae*

Tall straight growing tree with beautiful formal branching pattern and ornamental foliage.

***Bauhinia purpurea* (Mountain Ebony)**

Family: *Caesalpiniaceae*

Semi-deciduous quick growing medium height tree having bi-lobed leaves and lilac to red purple flowers with fragrance during autumn to winter season.

***Bauhinia variegata* (Kachnar)**

Family: *Caesalpiniaceae*

Deciduous quick growing medium height tree having bi-lobed leaves and white with red purple markings flowers during spring to summer season.

***Brownea coccinea* (Rose of Venenzula)**

Family: *Caesalpiniaceae*

Evergreen, medium height tree with large compound leaves, drooping scarlet-red flowers in clusters during March to April.

***Callistemon lanceolatus* (Bottle brush)**

Family: *Myrtaceae*

Evergreen, slow growing dwarf-medium height tree, with drooping branching pattern and thick dark green leaves and bottle- brush shaped bright red flowers throughout the year.

***Cassia fistula* (Indian Laburnum/ Amaltas)**

Family: *Caesalpiniaceae*

Deciduous slow growing medium height tree suited for dry localities with dull green large compound leaves, bright yellow flowers in drooping racemes during April- June and brown- black pods throughout year.

***Cassia fjavanica* (Java Cassia)**

Family: *Caesalpiniaceae*

Deciduous quick growing medium- tall height with large compound leaves having small leaflets and pink flowers borne in clusters in leaf axis during May-June.

***Chorisia speciosa* (Mexican silk cotton tree)**

Family: *Bombacaceae*

Deciduous, medium-large tree with almost green prickly stem and branches, pink with yellow centre flowers during October- November.

***Colvillea racemosa* (Colville's glory)**

Family: *Caesalpiniaceae*

Deciduous, medium- tall tree, dark green, compound and fine texture leaves with orange-red flowers in drooping racemes during July- October.

***Cupressus sempervirens* (Italian Saru)**

Family: *Cupressaceae*

Evergreen, dwarf- medium height tree with columnar shape canopy and fine texture dark green foliage.

***Delonix regia* (Red Gulmohar)**

Family: *Caesalpiniaceae*

Deciduous quick growing tree, with umbrella shaped canopy, fine texture compound dark green leaves and scarlet-orange flowers borne in panicles during April-June.

***Erythrina indica var. variegata* (Coral tree)**

Family: *Papilionaceae*

Deciduous medium sized tree with large yellow variegated leaves and crimson-red flowers during April to June.

***Ficus infectorea* (Pilkhan)**

Family: *Moraceae*

Semi-deciduous, medium to large tree with spreading canopy.

***Grevillea robusta* (Silver oak)**

Family: *Proteaceae*

Evergreen medium to tall tree with almost conical canopy, fine texture dark green foliage (above), grayish (beneath) and yellow orange fragrant flowers during April to June.

***Jacaranda mimosifolia* (Blue gulmohar)**

Family: *Bignoniaceae*

Deciduous, medium sized tree with spreading canopy, fine texture light green foliage and mauve-blue flowers during March-May.

***Kigenia pinnata* (Sausage tree)**

Family: *Bignoniaceae*

Semi-deciduous medium sized tree with wide oval canopy, coarse texture pinnate leaves and maroon-red flowers during April-July and October-November and drooping cucumber like brown fruits throughout the year.

***Koelreuteria paniculata* (Golden rain tree)**

Family: *Sapindaceae*

Deciduous, dwarf tree with umbrella shaped canopy and compound leaves. Yellow -orange flowers appear during august to October and orange-red trifid fruits during October-December.

***Lagerstroemia speciosa* (Pride of India)**

Family: *Lythraceae*

Deciduous, medium sized tree with informal to umbrella canopy, pink-red to purple-pink flowers appear during April to August.

***Magnolia grandiflora* (Him Champa)**

Family: *Magnoliaceae*

Evergreen, medium sized tree with almost cylindrical canopy with glossy green leaves on upper side and bronze beneath and white large fragrant flowers appear during March to May.

***Peltophorum ferrugineum* (Yellow gulmohar)**

Family: *Caesalpiniaceae*

Evergreen, medium sized quick growing tree with umbrella shaped. Bright yellow flowers are borne in terminal racemes during April-June and again during September-November.

***Platanus orientalis* (Chenar)**

Family: *Platanaceae*

Deciduous, large sized tree with informal canopy and leaves turning yellow during autumn looks very ornamental.

***Plumeria acuminata* (Temple tree)**

Family: *Aprocynaceae*

Deciduous, dwarf tree with umbrella to globular canopy and coarse texture light green leaves and cream with yellow centre flowers appearing throughout the year.

***Polyalthia longifolia var. pendula* (Ashok tree)**

Family: *Annonaceae*

Evergreen medium sized columnar shaped canopy with glossy green foliage borne in drooping branches.

***Pterospermum acerifolium* (Kanak Champa)**

Family: *Sterculiaceae*

Evergreen, medium sized tree with informal canopy and coarse texture large leaves. Flowers are white with mild fragrance.

***Rhododendron arboreum* (Rhododendron)**

Family: *Ericaceae*

Evergreen, dwarf tree with glossy green foliage makes contrast with red flowers during March-May in hilly areas.

***Roystonea regia* (Royal palm)**

Family: *Palmaceae*

Evergreen, tall tree with bottle shaped trunk and pinnate shaped large leaves.

***Spathodea campanulata* (Tulip tree)**

Family: *Bignoniaceae*

Evergreen, medium-tall tree with bright green foliage makes contrast with crimson-red flowers throughout the year.

***Thespesia populnea* (Portia tree)**

Family: *Malvaceae*

Evergreen, medium-tall tree with light green heart shaped leaves and yellow flowers with red marks throughout the year.

Exercise: Visit the commercial Floriculture farms/ nurseries/ Florist shops and identify different ornamental trees being grown or sold based upon their distinguishable morphological characters.

Observations:

S. No.	Name of the ornamental tree	Plant characteristics	Flowers and inflorescence	Remarks
1				
2				
3				

Precautions:

- Do not damage the ornamental trees during identification.
- Carefully note the most distinguishable characters of ornamental trees identified.

EXERCISE 5.2: IDENTIFICATION OF MAJOR ORNAMENTAL SHRUBS FOR AVENUES

Objective :

- To identify various ornamental shrubs for avenues based on primary morphological characters.

Delivery schedule : 1 period

Student's expectations/ Learning objectives:

- To get acquaint with different ornamental shrubs for avenues grown in India

Pre-learning required : Knowledge about ornamental shrubs for avenues.

Handouts/material required/equipment's & tools: Ornamental shrubs for avenues, hand lens and standard encyclopedia and books on Floriculture

Introduction:

A shrub is a woody or semi-woody perennial plant with little or no trunk and grows from 50cm to 4 meters. The major purpose of planting shrubs is given below:

- To enhance the beauty of surroundings
- To provide fragrance in the garden
- To act as boundary of property line
- To secure privacy for the family
- To divide different areas or features in the garden
- Softening harsh building lines
- To screen off unwanted sites/ features
- To reduce winds
- To control traffic while planted in avenues and gardens
- To provide background for growing annual flowers
- To reduce soil erosion
- To conserve moisture
- To discourage weed growth
- To provide natural habitat for wildlife especially birds

Description of ornamental shrub	Photograph

***Acacia auriculiformis* (Australian Acacia)**

Family: *Mimosaceae*

Dwarf to medium sized, evergreen tree with light yellow fragrant flowers year round. Good for planting in hills.

***Acalypha hispida* (Acalypha)**

Family: *Euphorbiaceae*

Dwarf medium sized shrub with multi-colour foliage and drooping red catkins during March-June. Good for planting in tropical areas.

***Achania malvaviscus* (Chinese lantern)**

Family: *Malvaceae*

Medium sized semi-deciduous shrub with dark green foliage and orange-red flowers throughout the year.

***Allamanda cathartica* (Allamanda)**

Family: *Apocynaceae*

Climbing evergreen shrub with green glossy foliage and bright yellow flowers appearing throughout the year. Good for planting in tropical areas.

***Azalea species* (Azalea)**

Family: *Ericaceae*

Dwarf to medium sized, evergreen shrub with pink, red, white and purple flowers appearing during February-July. Good for planting in hills.

***Bougainvillea species* (Bougainvillea)**

Family: *Nyctaginaceae*

Climbing type thorny evergreen shrub valued for ornamental bracts with almost every colour throughout the year. Good for planting in tropical to sub-tropical areas.

***Buddleja linleyana* (Buddleia)**

Family: *Buddlejaceae*

Evergreen, grayish- green foliage and mauve-blue fragrant flowers during March-October. Good for planting in hills.

***Caesalpinia pulcherrima* (Peacock flower)**

Family: *Caesalpiniaceae*

Deciduous, medium-large shrub with red-yellow flowers throughout the year and good for planting in sub-tropical areas.

***Camellia japonica* (Camellia)**

Family: *Theaceae*

Evergreen, medium sized shrub with shining dark green foliage with pink, red and white flowers during February to May and is good for planting in acidic soils in hills.

***Cestrum norcturnum* (Rat kee rani)**

Family: *Solanaceae*

Evergreen, large shrub with greenish-yellow fragrant flowers throughout the year and good for planting in subtropical and sub-temperate areas.

***Codiaeum variegatum* (Croton)**

Family: *Euphorbiaceae*

Dwarf, evergreen shrub with multi-colour foliage and good for planting in tropical areas.

***Crossandra infundibuliformis* (Crossandra)**

Family: *Acanthaceae*

Dwarf, evergreen shrub with orange-yellow flowers throughout the year and good for planting in sub-humid tropical areas.

***Dombeya spectabilis* (Dombeya)**

Family: *Sterculiaceae*

Large deciduous shrub with coarse texture foliage and white fragrant flowers during March-November and good for planting in tropical to temperate areas.

***Euphorbia pulcherrima* (Poinsettia)**

Family: *Euphorbiaceae*

Medium-large deciduous shrub grown for coloured red, orange, cream or yellow bracts mainly during January to March. Good for growing sub-temperate to tropical areas.

***Forsythia viridissima* (Forsythia)**

Family: *Oleaceae*

Dwarf deciduous shrub grown for bright yellow flowers borne on leafless branches during February-April and good for growing in hills.

***Gardenia jasminoides* (Cape jasmine)**

Family: *Rubiaceae*

Evergreen, medium sized shrub with glossy light green leaves and white highly fragrant flowers during March-July. Good for growing temperate to sub-tropical areas.

***Hibiscus rosa-sinensis* (Shoe flower/ China rose)**

Family: *Malvaceae*

Evergreen, large shrub with glossy green leaves and red, cream, saffron, yellow or white flowers almost throughout the year and it is good for planting in subtropical to sub-temperate areas.

***Hiptage benghalensis* (Madhavi lota)**

Family: *Malpighiaceae*

Large deciduous rambling shrub with orange-light red emerging foliage and turning reddish in autumn and creamy white fragrant flowers are borne during February- June. It is good for planting in subtropical to sub-temperate areas.

***Holmskioldia sanguinea* (Cup and saucer)**

Family: *Verbenaceae*

Large, deciduous rambling shrub, grown for red or yellow cup and saucer shaped flowers appearing during October to February. Good for growing temperate to sub-tropical areas.

***Hydrangea macrophylla* (Hydrangea)**

Family: *Hydrangeaceae*

Dwarf deciduous shrub grown for coarse texture green leaves and large blue, pink, red or white flowers borne in globose shaped corymbs during April to September and good for growing in hills.

***Ixora coccinea* (Rukmani)**

Family: *Euphorbiaceae*

Evergreen medium sized shrub with dark green foliage and orange-red flowers appearing during April to September. It is good for planting in subtropical to tropical areas.

Jasminum primulinum (Primrose jasmine)

Family: *Oleaceae*

Large deciduous rambling shrub with green drooping branches bearing yellow star shaped semi-double flowers before appearing leaves during March-May. It is good for planting in subtropical to sub-temperate areas.

Mussaenda frondosa (Mussaenda)

Family: *Rubiaceae*

Evergreen medium sized shrub with light green foliage and white, cream, orange or red bracts appearing during March-September. It is good for planting in subtropical to tropical areas.

Nerium indicum (Red kaner)

Family: *Apocynaceae*

Evergreen, large shrub with dark green shining thick leaves and white, pink or red flowers borne in bunches almost throughout the year. It is good for planting in subtropical to sub-temperate areas.

Russelia juncea (Coral bush)

Family: *Scrophulariaceae*

Evergreen medium sized shrub with drooping green branches bearing red tubular flowers almost throughout the year. It is good for planting in subtropical to sub-temperate areas under partially shady areas.

Spiraea japonica (Spiraea)

Family: *Rosaceae*

Dwarf deciduous shrub with drooping brown braches bearing white and fragrant flowers on leafless branches during February to April. It is good for planting in hills.

Tabernaemontana divaricata (Double chandani)

Family: *Apocynaceae*

Evergreen, medium sized shrub with light green leaves and double white flowers almost throughout the year. Good for growing sub-temperate to sub-tropical areas.

Tecoma stans (Yellow bells)

Family: *Bignoniaceae*

Medium sized deciduous shrub valued for yellow, bell shaped flowers appearing throughout the year. Good for growing sub-temperate to sub-tropical areas.

Exercise : Visit the commercial Floriculture farms/ nurseries/ Florist shops and identify different ornamental shrubs being grown or sold based upon their distinguishable morphological characters.

Observations:

S. No.	Name of the ornamental shrub	Plant characteristics	Flowers and inflorescence	Remarks
1				
2				
3				

Precautions:

- Do not damage the ornamental shrubs during identification.
- Carefully note the most distinguishable characters of ornamental shrubs identified.

EXERCISE 5.3: IDENTIFICATION OF MAJOR LAWN GRASSES FOR GARDENS AND PARKS

Objective :

- To identify major lawn grasses for gardens and parks based on primary morphological characters.

Delivery schedule : 1 period

Student's expectations/ Learning objectives:

- To get acquaint with different lawn grasses grown in India

Pre-learning required : Knowledge about lawn grasses.

Handouts/material required/equipment's & tools: Lawn grasses, hand lens and standard encyclopedia and books on Floriculture

Introduction:

Lawn is a ground cover of perennial grass, which persists in close mowing and requires proper management practices. The important characteristics of grasses for making lawn are given below:

- Look fresh and green throughout the year
- Not patchy
- Cold or drought resistant
- Free from attack of diseases and insects
- Quick growing
- Soft to touch
- Not giving fowl or bad odour

Description of lawn grass	Photograph

***Agrostis canina* (Velvet bent grass)**

It is dark green and fine textured grass. It is highly suitable for shady and cool areas in hills. It has moderate wear tolerance and requires medium fertilizers.

***Agrostis palustris* (Creeping grass)**

It is green and medium-fine textured grass. It is moderately tolerant to shade, drought and heat, but highly tolerant to cold and salinity. It has poor wear tolerance and requires high fertilizers.

***Cynodon dactylon* (Bermuda grass)**

It is green and fine textured grass. It is moderately tolerant to drought and cold. It has high wear tolerance and requires high fertilizers. Selection 1, Hariyali and Culcuttia are its popular varieties.

Dactylis glomerata

It is bluish green and medium textured grass. It is suitable for growing in shady areas in mild climate areas. It requires moderate fertilizers and has poor wear tolerance. It requires moderate fertilizers.

***Festuca arundinacea* (Tall fescue)**

It is shining green and medium-coarse textured grass. It is tolerant to drought and cold. It has good wear tolerance. It requires medium fertilizers.

***Lolium perene* (Perennial rye grass)**

It is shining green and medium textured grass. It is low tolerant to drought, shade and cold. It has high wear tolerance and requires medium fertilizers.

Paspalum notatum (Bahia grass)

It is green and coarse textured grass. It is moderately tolerant to drought, shade, heat, cold and wear- tolerance. It requires low fertilizers.

Phleum bertolonii

It is shining green and fine-medium textured grass. It is highly suitable for shady and cool areas in hills. It has moderate wear tolerance and requires medium fertilizers.

Poa pratensis (Kentucky grass)

It is shining green and fine-medium textured grass. It is moderately tolerant to drought, cold and wear tolerance and requires medium fertilizers.

Stenotaphrum secundatum (St. Augustine)

It is dark green and coarse textured grass. It is tolerant to shade, drought and wear, but less tolerant to cold. It requires high fertilizers.

Zoysia japonica (Japanese/ Korean grass)

It is green and fine textured grass. It is moderately tolerant to drought, heat and cold. It has high wear tolerance and requires medium fertilizers.

Exercise: Visit the commercial Floriculture farms/ nurseries/ Florist shops and identify different lawn grasses being grown or sold based upon their distinguishable morphological characters.

Observations:

S. No.	Name of the Lawn grasses	Plant characteristics	Remarks
1			
2			
3			

Precautions:

- Do not damage the lawn grasses during identification.
- Carefully note the most distinguishable characters of lawn grasses identified.

EXERCISE 5.4: IDENTIFICATION OF HEDGES AND EDGES PLANTS FOR GRADENS AND PARKS

Objective :

- To identify various hedges and edges plants for gardens and parks based on primary morphological characters.

Delivery schedule : 1 period

Student's expectations/ Learning objectives:

- To get acquaint with different hedges and edges plants grown in India

Pre-learning required : Knowledge about hedges and edges.

Handouts/material required/equipment's & tools: Hedges and edges plants, hand lens and standard encyclopedia and books on Floriculture

Introduction:

Hedges:

Hedge is a dense, permanent, continuous row or line of living woody or semi-woody perennial- plants grown at regular interval and frequently trimmed to answer the purpose of a fence, wall, screen or wind- break in the garden.

Purposes of hedges:

- Serve as a compound wall, living fence and physical barrier
- Protection against theft, animals and trespassing
- Give shelter from strong gales and winds
- Ensure privacy in the garden
- Dividing different portions in the garden like drive way, parking, etc. from the garden
- Demarcate garden from the public road and buildings

- Hiding unwanted sites/ spots like lavatory, compost pit, etc.
- Protection from noise, air and dust pollution
- Form a background for a floral display of ornamentals
- As a part of garden on its own

Edges:

Evergreen, low growing plants having same characteristics like hedge plants are grown to form an edge. Edge normally grows from few centimeters to 50cm. To distinguish it from hedge, it is low growing and does not block the view in the gardens and parks.

Purposes of edges:

- To direct traffic in the garden by growing it along the paths, walkways, beds, borders, etc.
- To divide different areas or features in the garden like rosary, rockery, lawn, children playing area, etc.
- To mark the outline of tree basins

HEDGES:

Description of hedges	Photograph

***Azalea* species:**

Evergreen, dusty green to dark green shining foliage and white, pink, purple, red and yellow flowers in different varieties. Good for ornamental hedge in well drained light and acidic soils in mid and high hills.

***Bougainvillea* species**

Family: *Nyctaginaceae*

It is an evergreen, different varieties valued for beautiful colour bracts and foliage. Good to be grown as tall protective and ornamental hedge in low and mid hill areas which don't experience prolonged frost during winter.

***Casuarina equisetifolia* (Jod tod)**

Family: *Casuarinaceae*

Evergreen angiosperm tree with needle shaped dark green foliage. Good for tall ornamental hedge in low and mid hills.

Clerodendrum inerme

Family: *Verbenaceae*

Evergreen, dark green foliage and pinkish-white mildly fragrant flowers. Good for growing tall ornamental hedge even in drought prone, but frost free areas in low and mid hills.

***Cuphia melvillea* (Cigar plant)**

Family: *Lythraceae*

Evergreen, multi-stemmed vertical, reddish bronze to green foliage and yellow, orange- red flowers. Good for dwarf ornamental hedge in moist areas in mid hills.

***Duranta repens variegata* (Duranta/ Pigeon berry)**

Family: *Verbenaceae*

It is an evergreen, tall, thorny stem, drooping branches with light green yellow variegated foliage, blue flowers and yellow-orange berries. It is good for growing tall protective hedge subtropical to sub temperate areas.

***Duranta repens* (Duranta/ Pigeon berry)**

Family: *Verbenaceae*

It is an evergreen, tall, thorny stem, drooping branches with light green foliage, blue flowers and yellow-orange berries. It is good for growing tall protective hedge subtropical to sub temperate areas.

Eumonymus japonicus

Family: *Celastraceae*

Evergreen, multi-stemmed vertical and shining dark green foliage. Good for growing in hills.

Gardenia jasminoides: **(Cape jasmine)**

Family: *Rubiaceae*

Evergreen, shining light green foliage and white highly fragrant flowers. Good for ornamental hedge in mid hills.

Hamelia patens: **(Scarlet bush)**

Family: *Rubiaceae*

Evergreen, bronze-green foliage and orange-red, mildly fragrant flowers. Good for ornamental hedge in tropical areas to low hills.

Hibiscus rosasinensis: **(China rose)**

Family: *Malvaceae*

Evergreen, dark green and variegated foliage and varieties with red, maroon yellow, cream and saffron flower colours in single, semi-double or double flower forms. Good for growing tall ornamental hedge in frost free areas in low and mid hills.

Hydrangea macrophylla

Family: *Hydrangeaceae*

Deciduous, coarse texture foliage and mauve-blue, pink and white flower colour varieties. Good for ornamental hedge in mid and high hills.

Lantana camara

Family: *Verbenaceae*

Semi-deciduous, branches prickly, wrinkled hairy green foliage and multi-coloured flowers capitates. Good for ornamental and protective hedge in low to high hills.

Ligustrum ovalifolium var. variegatum

Family: *Oleaceae*

Evergreen, dark green and variegated foliage. Good for ornamental hedge in mid and high hills.

***Murraya exotica* (Kamini)**

Family: *Rutaceae*

Evergreen, shining dark green foliage and white fragrant flowers. Good for tall ornamental hedge in low and mid hills.

Opuntia species

Family: *Cactaceae*

Different species of Opuntia with flat spiny stem are good for making hedge in low and mid hills even in drought prone and rocky soils.

Spiraea japonica

Family: *Rosaceae*

Deciduous, bronze-red branches, green foliage and white fragrant flowers. Good for ornamental hedge in mid and high hills.

Thuja orientalis var. compacta

Family: *Cupressaceae*

Evergreen, conifer tree with fine texture dark green foliage. Good for tall ornamental hedge and topiary in mid and high hills.

EDGES:

Description of edges	Photograph
***Alternanthera* species:** Herbaceous to semi-woody stem, multi-colour, bronze, red, pink and purple foliage. Very good for compact low edging of 20-30cm height in frost free areas in low and mid hills.	
***Cuphea* hyssopifolia:** Semi-deciduous, low growing, fine texture green foliage and pink and white flowers. Good for growing as edge in mid and high hills.	
***Duranta repens var.* Golden:** Evergreen with golden yellow foliage. Good for growing edge in frost free areas in low and mid hills.	
***Hypoesetes* species:** Herbaceous perennial with green foliage mottled with pink, red and white spots. Good for edging in mid hills.	
***Iresine* species:** Herbaceous perennial, blood red and green with red foliage. Good for edge in frost free areas in low and mid hills.	
Myrsine africana: Evergreen, shining dark green foliage and red flowers. Good for planting in partially shady areas in mid and high hills.	
Ophiopogon intermedius: Evergreen, dark green grassy foliage and white fragrant flowers. Good for growing in partially shady moist areas in mid and high hills.	
Serrisa foetida: Evergreen, dark green with creamy-white margin foliage and white flowers. Good for edging in low and mid hills.	

Exercise: Visit the commercial Floriculture farms/ nurseries/ Florist shops and identify different hedges and edges plants being grown or sold based upon their distinguishable morphological characters.

Observations:

S. No.	Name of the hedge/ edge plant	Hedge/ edge	Plant characteristics	Flowers and inflorescence	Remarks
1					
2					
3					

Precautions:

- Do not damage the hedges/ edges plants during identification.
- Carefully note the most distinguishable characters of hedges/ edges identified.

Practical 6

IDENTIFICATION OF INDOOR AND OUTDOOR FOLIAGE ORNAMENTALS, CACTI-SUCCULENTS AND BULBOUS PLANTS

Introduction:

Different indoor and outdoor foliage plants are identified based upon the knowledge of morphology and anatomy. For describing indoor and outdoor foliage plant, every part of it is to be studied in detail and compared with similar structures of other plant. Every plant part has a name and its study is called as **Phytography**. It is a branch of taxonomy or plant systematic. It deals with the descriptions of plants and their organs (parts). The main plant parts used for description of flowering plants are given below:

- Roots (position and morphology)
- Stem (Branching pattern, texture, shape, bark-surface, form, modifications, etc.)
- Buds (position, protectiveness, time of sprouting, etc.)
- Foliage (Leaf-simple/ compound, insertion, arrangement, parts, stalk, base, apex, shape, serration/ margins, incision, venation, surface/ texture, sap, duration, etc.)
- Inflorescence (type, size and number of flowers, duration, etc.)
- Flowers (shape, symmetry, completeness, parts, arrangement, insertion, union of floral parts, calyx- sepals, corolla- petals/ tepals, colour, shape, size, androecium- stamens, anthers, gynoecium- stigma, style, ovary, fragrance, duration, etc.)
- Fruits (type, shape, size, colour, fragrance, duration, etc.)
- Ovule/ Seed (shape, size, colour, number, duration, etc.)

EXERCISE 6.1: IDENTIFICATION OF MAJOR INDOOR FOLIAGE PLANTS

Objective :

- To identify various foliage/ house plants based on primary morphological characters.

Delivery schedule : 1 period

Student's expectations/ Learning objectives:

- To get acquaint with different foliage/ house plants grown in India

Pre-learning required : Knowledge about various foliage plants.

Handouts/material required/equipment's & tools: Foliage/ house plants, hand lens and standard encyclopedia and books on Floriculture

Introduction:

Indoor gardening is the art of growing and arranging plants indoor or in the house for its best use for function and/ or beauty. The purposes of growing live/ indoor/ house- plants are given below:

- Primitive ways to cultivate ornamentals
- Exceptional value in interior decoration
- Cultivation for desired satisfaction
- Sense of interest for recreation
- Source of exercising gardening adventures
- To reduce expenditure on wide open areas outside the houses, since population density is increasing at alarming rate in urban areas
- Plants used to divide indoor living areas
- Brings permanence in the house

Major qualities of indoor plants:

- Robust (ability to tolerate hot, cold or dryer conditions inside the house)

- Evergreen
- Attractiveness

Description of indoor foliage plants — Photograph

***Aglaonema commutatum* (Aglaonema)**

Family: *Araceae*

Leaves are many, small to medium, ovate-lanceolate, broad, grayish-green irregular bands very prominent.

***Aglaonema modestum* (Chinese evergreen)**

Family: *Araceae*

Leaves elliptic, acuminate, green to dark green and branches freely.

***Asparagus plumosus* (Asparagus fern)**

Family: *Liliaceae*

A fine foliage climber with dark green foliage arranged in one plane, triangular in outline and cladodes numerous in fascicles. Flowers are small, white and berries are black.

Asparagus sprengeri (Asparagus)

Family: *Liliaceae*

A tuberous rooted, much branched plant with soft, needle shaped leaves called cladodes. Flowers are small, white in clusters and bright red berries.

***Aspidistra elatior* (Cast Iron plant)**

Family: *Liliaceae*

Thick rooted compact plant with bluish green, shining, oblong-lanceolate, leathery leaves upto 60cm long and narrowly channel stalk. It is good for growing in dark areas in the house.

***Aucuba japonica* (Hill croton)**

Family: *Cornaceae*

Leaves are leathery, narrowly oval, shining and dark green with yellow spots. It has greenish flowers and scarlet-red berries.

***Beaucarnea recurvata* (Elephant foot plant)**

Family: *Agavaceae*

It is a dwarf tree, but grown in pots for several years for its globose thick base of stem which is tapering upward and recurving dark green, tufted and thin leaves upto 1m.

***Begonia rex* (Foliage begonia)**

Family: *Benoniaceae*

Rhizomes are short and fleshy. Leaves are in various colours, large, obliquely ovate on the stalk.

***Calathea zebrina* (Zebra plant)**

Family: *Marantaceae*

Leaves are large, velvety, dark green with veins and midrib light green making strip patterns like zebra and purplish beneath.

***Chamaedorea elegans* (Chamaedorea)**

Family: *Palmaceae*

Plant is stem upto 2m. Leaves are pinnate, spirally arranged. Leaflets are straight and acuminate. Flowers are reddish orange and fruits small globose in shape.

***Codiaeum variegatum* (Croton)**

Family: *Euphorbiaceae*

It is an evergreen shrub with variety of size, shape and colour of leaves, which are simple, alternate, entire or twisted.

***Coleus blumei* (Coleus)**

Family: *Lamiaceae*

It is a soft perennial herb, branched and growing to one meter. Leaves are ovate, toothed and varied shape, size and colouring pattern.

***Cordyline terminalis* (Red dracaena)**

Family: *Liliaceae*

It is growing to 3m. Leaves are elliptic, ovate-lanceolate on slender stem, which is coppery green with red shade. Flowers are lilac tinted in long panicles.

***Cycas revolute* (Sago palm)**

Family: *Cycadaceae*

It is palm like foliage plant with naked seed bearing habit like gymnosperms. Leaves are crowded at top of cylindrical trunk.

***Dieffenbachia amoena* (Dumb cane)**

Family: *Araceae*

Leaves are large, oblong, pointed, stripped, spotted or speckled with white or yellow, 15-40cm long and poisonous sap causing pain and swelling of tongue.

Dracaena marginata tricolor **(Rainbow plant)**

Family: *Dracaenaceae*

Leaves are long, linear, multi-colour, striped cream, yellow, green and red on margins.

Dracaena sanderiana **(Lucky bamboo)**

Family: *Dracaenaceae*

Plants are with erect and slender growth. Leaves are lanceolate, 10-15cm long, wavy, green and cut leafy shoots are good for growing in plain water for interior decoration.

Ficus benjamina **(Java fig tree)**

Family: *Moraceae*

Though a large tree in open, but grown as indoor pot plant or bonsai for its beautiful dark green leaves, shining, slender pointed in drooping branches.

Ficus elastica **(Rubber plant)**

Family: *Moraceae*

Though a large tree in open, but grown as indoor pot plant for its glossy, oblong, thick leaves enclosed in rosy-red sheaths before opening.

Fittonia verschaffeltii **(Fittonia)**

Family: *Acanthaceae*

Plants are herbaceous and are marked with coloured netted leaves having oval shape.

***Monstera deliciosa* (Monstera)**

Family: *Araceae*

Plants are climbing with thick stem. Leaves are large, thick, glossy, dark green (also variegated cream/ yellow) with slashes and holes in leaf lamina. Greenish-brown aerial roots droop down from the climbing plants.

***Peperomia caperata* (Emerald ripple)**

Family: *Piperaceae*

It is a small compact plant bearing clusters of round, heart shape, corrugated leaves having dark green, chocolate or bronze colour with ridges often grayish or brown and petiole striped red.

***Philodendron selloum* (Selloum)**

Family: *Araceae*

It is a climbing plant on its own with thick large, bipinnate, dark green and lobed leaves without holes in lamina.

***Pilea cadierei* (Aluminium plant)**

Family: *Urticaceae*

Leaves are fleshy, obovate, quilled and dark green with irregular silvery bands between veins and greenish white flowers are borne in clusters.

***Platycerium bifurcatum* (Stag horn fern)**

Family: *Polypodiaceae*

It is a large epiphytic fern with large fronds, drooping, leathery, grayish to dark green and covered with white hairs. Fronds have forked twice and have soral patches at the end of the segments.

Schefflera arboricola **((Umbrella plant)**

Family: *Araliaceae*

Leaves are palmate, dark green with splashes or blotches of white, cream or yellow colours and arranged in a circle of 6-8 soft, leathery leaflets.

Scindapsus aureus **(Money plant)**

Family: *Araceae*

It is a quick growing indoor climber having ovate, waxy, dark green with splashed white, cream or yellow leaves.

Senecio cineraria **(Cineraria/ Silver dust)**

Family: *Asteraceae*

It is a semi-woody perennial with pinnately cut, thick ash or dusty silver colour leaves.

Senecio radicans **(Fish hook)**

Family: *Asteraceae*

It is a succulent, trailing plant forming mats. Leaves are alternate, dark green, cylindrical, tapering, hooked and with translucent longitudinal lines.

Senecio rowleyanus **(String of beads)**

Family: *Asteraceae*

It is a succulent, trailing plant and stem is filiform and forming mats. Leaves are globular like beads of green colour and flowers are creamy- white.

Syngonium podophyllum **(Syngonium)**

Family: *Araceae*

It is a quick growing indoor climber with arrow shaped green and variegated leaves.

Zebrina pendula (Silvery wandering jew)

Family: *Commelinaceae*

It is a trailing herb with small dark green to purple leaves having bright silvery bands and purple colour beneath.

Exercise: Visit the commercial Floriculture farms/ nurseries/ Florist shops and identify different foliage/ house plants being grown or sold based upon their distinguishable morphological characters.

Observations:

S. No.	Name of the foliage/ house plant	Plant characteristics	Remarks
1			
2			
3			

Precautions:

- Do not damage the foliage plants during identification.
- Carefully note the most distinguishable characters of foliage plants identified.

EXERCISE 6.2:
IDENTIFICATION OF MAJOR CACTI AND SUCCULENTS PLANTS

Objective :

- To identify various cacti and succulents plants based on primary morphological characters.

Delivery schedule : 1 period

Student's expectations/ Learning objectives:

- To get acquaint with different cacti and succulents plants grown in India

Pre-learning required : Knowledge about cacti and succulents plants.

Handouts/material required/equipment's & tools: Cacti and succulents plants, hand lens and standard encyclopedia and books on Floriculture

Introduction:

Cacti and succulents are the group of plants, which have developed a special capacity to store water in thick fleshy leaves and/ or stem. These thrive well in sunny situation and are light loving requiring little care except when actively growing. Most of these plants are native to dryer part of the world. Cacti are different from succulents because of the following characters:

- ❖ All cacti are perennial belonging to dicotyledonous group
- ❖ All cacti are succulents on account of storing water, but all the succulents are not cacti
- ❖ Cacti are characterized by the presence of areoles (thick wooly hair cushions like barber hair brush) carrying spines, hairs or glochids
- ❖ All cacti belong to family Cactaceae
- ❖ Flowers arise from or near the areoles at top of ovary having almost every colour
- ❖ Fruits of cacti are one-celled berry
- ❖ Spines in cacti are modified leaves, provide shade, save from sun-scorching, protect from birds and conserve moisture by reducing transpiration
- ❖ Cacti plants are leafless except Pereskia (Rose cactus)

Description of cacti and succulents plants	Photograph

***Aeonium arboreum* (Aeonium)**

Family: *Crassulaceae*

It is a shrubbery succulent growing to one meter tall. Leaves appear in dense rosette form at the apical part of branches. Flowers are golden yellow.

***Agave victoriae-reginae* (Queen Agave)**

Family: *Agavaceae*

Rosette spherical shaped plant with numerous leaves marked with white lines on the margins and terminal stiffed spine.

***Aloe arborescens* (Aloe)**

Family: *Liliaceae*

Plants are initially stem less. Leaves appear in loose rosette, spreading sword shaped and thick. Flowers are red or yellow appearing tall inflorescence like spike.

***Astrophytum ornatum* (Monk's hood)**

Family: *Cactaceae*

Stem spherical is with 8 spiral or straight ribs with silvery scales. Areoles are with 5-11 yellow-brown spines. Flowers are light yellow appearing at tip.

***Cephalocereus senilis* (Old man cactus)**

Family: *Cactaceae*

Stem is columnar growing straight and 20-30 ribs. Areoles are large with 1-5 yellowish spines and 20-30 hair like white bristles. Flowers are reddish and opening during night.

***Crassula arborescens* (Silver dollar/ jade)**

Family: *Crassulaceae*

It is a tree branching shrubbery succulent. Leaves are thick green and nearly attached with the stem and with reddish dots. Flowers are white to pink.

***Echeveria spp* (Rock rose)**

Family: *Crassulaceae*

It is a low growing stem less plant with leaves appearing in rosette and in various colours. Flowers are red, pink, yellow colour and appear in raceme.

***Echinocactus grusonii* (Golden ball)**

Family: *Cactaceae*

Stem is globular and flat at top with white/ yellow wooly growth. It has 10-30 ribs. Areoles are large with 8-10 radical spines and 3-5 central spines of yellow or white colours. Flowers are small tubular and brown in colour.

***Euphorbia milii* (Crown of thorns)**

Family: *Euphorbiaceae*

It is a spiny shrubbery succulent with long green leaves. Inflorescence is with coloured cyathophylls in red pink and yellow colours.

***Gasteria carinata verrucosa* (Warty aloe)**

Family: *Liliaceae*

It is an attractive succulent with suckering from the base with green leathery leaves having white spots and red tips.

***Gymnocalcium mihanvichii* (Plain chin cactus)**

Family: *Cactaceae*

Stem is depressed with globular shape in many colours like pink, yellow red, etc. Areoles are 3 on each rib and radical 5 spines. Flowers are creamy white.

Haworthia species

Family: *Crassulaceae*

Stem less rosette of various coloured leathery leaves with spiny tips and white markings in parallel lines

***Kalanchoe blossfeldiana* (Kalanchoe)**

Family: *Crassulaceae*

It is a bushy and compact stem growing erect with fleshy ovate-oblong leaves having sinuate and crenate margins. Flowers appear in bunches of red, yellow, pink or purple colours.

***Opuntia ficus indica* (Indian fig)**

Family: *Cactaceae*

Plant is shrubbery growing to 3-4m tall with profuse flat branching. Areoles are white with yellow glochids. Flowers are pale yellow and fruits pear shaped and red when ripened.

***Pereskia aculeata* (Rose/ Lemon vine cactus)**

Family: *Cactaceae*

It is leafy climbing cactus with yellow to pink colour foliage. Areoles are 1-3, short and needle like spines. Flowers are white to yellow lemon scented.

Schlumbergera bridgesii (Christmas cactus)

Family: *Cactaceae*

Stem is initially erect, flat, segmented and recurving later with 2-3 notched on either side. Flowers are cherry red.

Sedum morganianum (Donkey tail)

Family: *Crassulaceae*

It is a sub-shrub with thick, round and drooping stem. Leaves are curved/ elongate and overlapping densely. Inflorescence is terminal with small scarlet flowers.

Selenicereus grandiflorus (Queen of night/ Brahma Kamal)

Family: *Cactaceae*

Climbing type cactus with flat segmented stem and pinkish red large scented flowers opening during mid night.

Exercise: Visit the commercial Floriculture farms/ nurseries/ Florist shops and identify different cacti and succulents plants being grown or sold based upon their distinguishable morphological characters.

Observations:

S. No.	Name of the Cacti/ succulents plant	Cacti/ Succulent	Plant characteristics	Flowers and inflorescence	Remarks
1					
2					
3					

Precautions:

- Do not damage the cacti/ succulents plants during identification.

- Carefully note the most distinguishable characters of cacti/ succulents plants identified.
- Do not injure yourself from spine and areoles of cacti.

EXERCISE 6.3:
IDENTIFICATION OF MAJOR BULBOUS PLANTS

Objective :

- To identify various bulbous flower crops based on primary morphological characters.

Delivery schedule : 1 period

Student's expectations/ Learning objectives:

- To get acquaint with different bulbous flower crops grown in India

Pre-learning required : Knowledge about bulbous flower crops.

Handouts/material required/equipment's & tools: Bulbous flower crops, hand lens and standard encyclopedia and books on Floriculture

Introduction:

Those ornamental plants, which have specialized modified underground stem structures to overcome the unfavorable environmental conditions are known as ornamental bulbous plants. Different specialized modified underground structures, which function as storage of food- material are given below:

- ❖ Bulbs
- ❖ Corms
- ❖ Rhizomes
- ❖ Tubers
- ❖ Tuberous roots
- ❖ Tuberous stems, and
- ❖ Pseudo-bulbs

In Ornamental Horticulture (Floriculture), all these are known as bulbs or bulbous plants, but in Botany all differ in morphology and physiology, thus are known with

separate entity. The major purposes of planting bulbous plants in the garden are as follows:

- ❖ To enhance the beauty of surroundings
- ❖ To provide fragrance in the garden
- ❖ To divide different areas or features in the garden
- ❖ Softening harsh building lines as corner and foundation planting
- ❖ To provide background for growing annual flowers
- ❖ To grow alongside of stream, pond
- ❖ To make herbaceous borders
- ❖ To reduce soil erosion
- ❖ To conserve moisture
- ❖ To discourage weed growth
- ❖ To grow in pots and hanging baskets

Description of bulbous plants	Photograph

***Agapanthus africanus* (Agapanthus/ Blue African Lily)**

Family: *Alliaceae*

It has long, thick, narrow and dark green foliage. Flowers are trumpet shaped blue or white coloured and borne in umbels on long stalk. It has true tunicate bulbs.

***Amaryllis belladonna* (Amaryllis)**

Family: *Amaryllidaceae*

The plant is 60-70 cm tall and has long strap shape, long and dark green leaves. Flowers are large trumpet shape in red, pink, white or in strips during in 2-4 flowers borne on long scape. It has true tunicate bulbs.

***Begonia tuberhybrida* (Tuberous begonia)**

Family: *Begoniaceae*

The tuberous rooted begonia plants are growing to 45 cm tall and has beautiful flowers resembling rose mainly double in various colours. It has true tubers.

***Canna indica* (Canna/Indian shot)**

Family: *Cannaceae*

Canna plants are growing to 1.5m tall and have green to bronze colour foliage. Flowers are orchid or truss flowering in various colours like red, yellow and orange. It has true rhizomes.

***Clivia miniata* (Kaffir lily)**

Family: *Amaryllidaceae*

It is an attractive evergreen bulbous plant having dark green strap shape leaves. Flowers are orange-yellow funnel shape and borne in umbels on scape during February-April. It has true tunicate bulbs.

***Crocosmia aurea* (Montbretia)**

Family: *Iridaceae*

It is an attractive bulbous plant with orange-yellow flowers (florets) borne in spikes during May-September. It has true corms.

***Crocus sativus* (Saffron)**

Family: *Iridaceae*

It is a dwarf growing with grass like green leaves and fragrant violet-blue flowers borne on slender long stalks during September-October. It has true corms.

***Dahlia variabilis* (Dahlia)**

Family: *Asteraceae*

Dahlia has plants from one 0.3 to 2m. Leaves are on every node in opposite having 3-5 leaflets. Flowers are single to double from 5cm to 20cm across in almost every colour. It has true tuberous roots.

***Freesia refracta* (Freesia)**

Family: *Iridaceae*

It is a dwarf bulbous plant. Highly fragrant trumpet shape flowers (florets) in various colours are borne in racemes/ spikes during December-April. It has true corms.

***Gloriosa superba* (Glory lily)**

Family: *Liliaceae*

It is a climbing bulbous flower. It has primrose yellow to dark red flowers with wavy and corrugated petals during July to September. It has true tubers.

***Haemanthus multiflorus* (Football lily)**

Family: *Liliaceae*

It is medium height bulbous flower with strap shape green and oblong leaves. Flowers are large ball shape and crimson red coloured during May-September. It has true bulbs.

***Hemerocallis fulva* (Day lily)**

Family: *Liliaceae*

It is tall bulbous flower opening during day- time. Flowers are large trumpet shape and orange-yellow colour during May-September. It has true bulbs.

Hyacinthus orientalis (Hyacinth)

Family: *Liliaceae*

It is dwarf bulbous flower. Flowers are tubular to bell shaped in compact racemes of various colours during February to April. It has true bulbs.

Iris nepalensis (Iris)

Family: *Iridaceae*

It is a medium height bulbous plant. Leaves are sword shaped. It has blue to lilac flowers appearing during February-April. It has true rhizomes.

Kniphofia aloides (Torch lily)

Family: *Liliaceae*

It is medium height bulbous flower. Leaves are narrow, long and recurving. Flowers are tubular, yellow, orange and red colour and borne in long spikes at upper portion during March to August. It has true bulbs.

Lilium tigrinum (Tiger lily)

Family: *Liliaceae*

It is a tall bulbous flower. Leaves are small, glossy green and growing upward on the whole stem. Flowers are recurving, light orange with black spots during April-July. It has true non-tunicate bulbs.

Narcissus pseudonarcissus (Daffodil)

Family: *Amaryllidaceae*

Leaves are narrow, dark green and growing straight upward. It has large trumpet flowers. Flowers are yellow, orange, white with same of different color corona during December-April. It has true tunicate bulbs.

Ornithogalum thyrsoides (Chinchee-rinchee)

Family: *Liliaceae*

It is a dwarf bulbous flower. Leaves are green, long and narrow. Flowers are white, star shape and fragrant during April to June. It has true tunicate bulbs.

Tulipa hybrida (Tulip)

Family: *Liliaceae*

It is a dwarf bulbous flower. Leaves are strap shape large at base and narrow upward. Solitary flowers are borne on long scape in various colours during February to April. It has true tunicate bulbs.

Zantedeschia aethiopica (Calla lily)

Family: *Araceae*

Leaves are large, dark green and arrow- head shape. It has beautiful white, cream and yellow spathe and spadix during February to June. It has true rhizomes.

Zephyranthes grandiflora (Zephyr lily)

Family: *Liliaceae*

It is a dwarf bulbous flower. Leaves are barrow grass like appearing after flower scape emergence. Star shape pink, white flowers borne solitary on scape during April to July. It has true tunicate bulbs.

Procedure:

- Visit the commercial Floriculture farms/ nurseries/ Florist shops and identify different bulbous flowers being grown or sold based upon their distinguishable morphological characters.

Observations:

S. No.	Name of the bulbous flower/ plant	Under ground plant part	Plant characteristics	Flowers and inflorescence	Remarks
1					
2					
3					

Precautions:

- Do not damage the bulbous flower crops during identification.
- Carefully note the most distinguishable characters of flower crops identified.

Practical 7

PROPAGATION THROUGH SEEDS

EXERCISE 7.1: PROPAGATION OF FLOWER CROPS THROUGH SEEDS

Objective :

- To recognize the importance and methodology to raise healthy seedlings of ornamental flowers and plants.

Delivery schedule : 2 period

Student's expectations/ Learning objectives:

- To raise the seedlings of ornamental annual flowers and plants
- To raise the new hybrids developed through crossing different ornamental plants
- To prepare ideal type of growing medium for seed sowing

Pre-learning required : Knowledge about nursery raising of flower crops.

Handouts/material required/equipment's & tools: Spade, Khutti, Hand shovel, soil leveler, measuring tape, rope, watering can with fine rose head, leaf mould/ FYM, SSP, sand, soil disinfectant chemical, black polythene/ tarpaulin, fungicide (Bavistin/ Dithane-M. 45/ Captan/ Ridomil), insecticide (Fenvalerate dust/ chloropyriphos), seed material, dry grass/ thatch, flexible stick, transparent polythene sheet, etc.

Introduction:

Several horticultural crops primarily ornamental annuals and vegetable crops are grown through seed. Some horticultural crops like papaya which can not be grown through other vegetative means of propagation and for developing new cultivars of horticultural crops, these are also grown through seed. Seeds are normally sown in well- prepared nursery beds, but the costly and precious seeds are sown in the containers such as pots, trays, troughs and wooden pots. The nursery-raising in beds and containers results in easy management, better care and economy of seed.

Procedure:

- Select a site in south/ south-west/ south-east direction, which is sunny for most part of the day and is away from the shade of building or trees.
- Thoroughly dig-up the land to a depth of 30-40 cm. Break all clodes. Remove stones, pebbles, roots, debris, etc. and bring the soil to fine tilth.
- Prepare ideal nursery bed (1-1.5 m width, upto 3 m lengthy and 15-20 cm raised or the amount of nursery required or depending upon the seed to be sown)
- For disinfecting nursery beds formalin (Formaldehyde 40%) @ one litre in seven litre of water is drenched on the prepared nursery bed until thoroughly wet.
- Cover the nursery beds with black polythene or tarpaulin for about a week.
- After one week do light raking, so that remaining fumes of formalin gas comes out.
- For disinfecting nursery beds other chemicals like vapam, chloropicrin, methyl bromide, Captan (0.2%), etc. can also be drenched.
- Steaming of nursery beds, heating nursery soil, burning grass on nursery soil or solarization are other techniques to kill harmful microbes in the soil.
- Mix about 20-25 kg well rotten FYM, 200g SSP, 15g Dithane M. 45 and 15g Fenvalerate dust or 10 litre solution of chloropyriphos (0.05%) in the bed size mentioned above.
- Treat seed with Captan/ Thiram/ Bavistin @ 2-3g per handful seed.
- Sow the seeds in lines 5 cm apart at a depth of about 0.5 cm.
- For evenly distribution of the very small seeds, mix in sand or saw dust.
- The ideal seed sowing time for nursery of different season annuals is as under:

Season	N.I. Plains	Low Hills	Mid Hills	High Hills
Summer	Feb.	Feb. Mar.	Mar.-April	Mar.-April
Rainy	May-June	May-June	May-June	May-June
Winter	Aug.-Oct.	Sep.-Nov.	Sep.-Feb.	Sep.-Oct./ Feb.-Mar.

- Do seed sowing at fortnightly interval for regular supply of nursery for longer duration.
- For costly seeds at one time sow half of the seeds and remaining half at later stage after seeing the performance of first half seed sown otherwise seek expert's opinion.
- Cover the beds with dry grass/ heshion cloth until germination.
- Remove grass/ heshion cloth/ khas-khas after germination and do light hoeing/ raking to facilitate germination of left out seeds.
- During winter cover the nursery beds at night so as to avoid chilling or frost injury.
- Spray Dithane M. 45 (0.2%) and Ridomil (0.1%) alternatively at weekly interval to get rid off the diseases and Metasystox (0.05%) or Rogor (0.1%) for killing various insects feeding on the young seedlings in the nursery.
- Spray of Urea (0.1 %) is beneficial at 2-3 leaf stage.
- Spray Multiplex nutrient mixture for improving the health and vigour of nursery.
- Irrigate nursery beds with fine rose head watering can twice during summer and once during winter preferably in the evening so as to minimize the danger of frost injury to nursery during night.
- When there is likely possibility of frost then at sunset time collect all dried leaves and make smoke so as reduce the damage of frost to the plants in nursery.

Observations:

S. No.	Crop	No. of seeds sown	Seeds germination on different days					Total No. of seeds germinated	Germination (%)	Remarks
			7	15	21	28	35			
1										
2										

Precautions:

- Do not sow the seeds until all the fumes of formalin gas are removed
- Ensure treatment of seed before sowing.
- The depth of the seeds should be kept 2-3 times than the diameter of the seed.
- Mix the very fine seeds in sand/ saw dust for even distribution.
- Avoid thick sowing.
- Remove the dry grass or heshion cloth cover when the seeds start germinating.
- Irrigate the nursery beds/ seed pans copiously.
- Do not irrigate until the seeds germinate and during noon/ after noon on a sunny day

Nursery bed preparation

Seed sowing in lines

Nursery beds covered with dried grass

Flower seedlings become ready for sale at 4- leaf stage

EXERCISE :

7.2 SOWING OF DIRECT SEEDED CROPS

7.3 RAISING SEEDLINGS OF VEGETABLE CROPS

Objective :

- To impart knowledge of innovative nursery raising techniques and growing of direct seeded crops

Delivery schedule : 01 period

Student expectations/learning objective:

- Importance of nursery raising in vegetable crops
- Location for raising healthy seedlings
- Method for preparation of nursery seed bed
- Sowing methods for vegetable cultivation

Pre-learning required: Innovative vegetable raising technique

Handouts/material required/equipment's & tools: Paper sheet and pen to note down the instructions, different tools for land preparation, farmyard manure, fertilizers, seeds of vegetable crop, bavistin, herbicide, etc.

Introduction:

Majority of the vegetables are raised through seeds. The planting materials other than seeds which are used for propagation of vegetable crops are bulb (onion), tuber (potato), crown/suckers (asparagus, globe artichoke), root cutting (horse radish, globe artichoke), stem cuttings (moringa) etc. Vegetable crops propagated through seeds are either directly seeded or transplanted in the field by raising the seedlings first in the nursery beds. A nursery could be considered as a location where plants are cared for during the early stages of growth by providing optimum conditions for germination and subsequent growth until they become strong enough for planting in the open field conditions. The seeds of solanaceous vegetables, cole crops, onion etc. are first sown in the nursery.

Direct seeded vegetable crops

Various methods of sowing seed/planting material are as under:

- Broadcasting

- Drilling
- Dibbling

Procedure for direct sowing of different vegetable crops

- The direct seeded crops are grown on flat beds, raised beds or ridges.
- Prepare raised beds or ridges to a height of 15-20 cm.
- Separate two beds/ridges by making furrow of 30-45 cm width for providing irrigation.
- Leafy vegetables like spinach, mustard, amaranth, coriander, fenugreek etc. are sown by broadcasting the seeds. However, the crops sown in the rows grow better than the ones broadcasted.
- Growing of vegetables in rows is advantageous for taking up intercultural operations like hoeing-cum- weeding, fertilizer application, and irrigation along with easy harvesting.
- Apply fertilizers in the rows by mixing it thoroughly with the soil. The seeds should not come in direct contact with fertilizers.
- Treat the seed with fungicide(s) before taking up sowing to minimise the incidence of seed borne diseases
- Sow the seeds of garden pea, French bean, okra, beet leaf, spinach, cluster bean and cow pea etc. directly in the rows.
- Pre-soaking of seeds of pea, French bean and okra in water for overnight before sowing gives better germination. Discard the seeds which float on water surface.
- Sowing of seeds of root vegetables is generally done on ridges but sometimes on flat beds also. Mix seeds of root vegetables or any small seeded vegetables with fine sand to regulate their sowing.
- Pre-germinated seeds of cucurbits also enhance better crop stand.

Mechanical methods of sowing

- Most of the commercial vegetable growers use machine planter to sow the seeds.
- Machines do the sowing operations much better and more rapidly than hand sowing.

- The common seed drills open the furrows, drop the seeds and cover it simultaneously i.e. in a single operation.
- These drills can be regulated to sow at various rates and at desired depth.
- By regulating the seed rate mechanical methods, thinning can be reduced to the minimum.

Seed drill

Manual method of sowing

- Seed sowing by hand is commonly practised in home gardens as well as when the quantity of seed to be sown is less.
- A garden line or marker should be used to provide straight row furrows to do hand sowing.

Manual seed sowing
Source: www.flickr.com

- The furrows are made with the rake or with the corner of an ordinary hoe or with a heart shaped hoe attached with plough or teeth of a wheel hoe.
- The seed should be distributed uniformly in the furrow.
- The seeds should be covered immediately with the soil by trampling with the help of back of a hoe to prevent loss of soil moisture.

Exercise 1:

Prepare small area for raising vegetable crops. Keeping in mind the principles of establishing a kitchen garden, take up manual sowing at proper spacing and depth of any direct seeded vegetable crops. Write the steps in your practical note book as per data sheet along with your experience.

Data sheet

Name of the crop	
Season	
Aspect of the garden	
Slope of the garden	
Date of pre-sown irrigation, if needed Plot size	
Size of drainage channel	
Tools/Implements used	
Date of sowing	
Method of sowing (Flat bed/raised bed)	
Seed rate	
Seed treatment (mention the fungicide and rate)	
Fertilizers used and quantity applied	
Spacing	
Weedicide applied and its rate	
Any other operation	
State your experience	

Nursery raising:

Advantages of nursery raising in vegetable production

- It is very easy and convenient to look after the young tender seedlings growing in a small but compact area of a nursery.
- Favourable conditions of growth can be provided easily to the growing seedlings in a nursery.
- It eliminates the problem of seed emergence in heavy soils

- It provides temporary protection from extreme weather conditions.
- Timely and easy management of pests and diseases in short growing period of 4-5 weeks.
- Weed control is easy
- There is economy of land and more time is available for the preparation of land where transplanting is to be done.
- More uniform crop is possible
- Optimal use of expensive hybrid seeds by sowing in nursery beds.
- Sowing seeds in the nursery bed and then transplanting into the main fields help in eliminating a part of the unfavourable weather conditions and in getting early crops by adjusting suitable date of planting and there by securing a higher price for the produce.

Factors to be taken into consideration for raising nursery

Location of the nursery:

- Near the main field for transplanting
- Nursery area should receive sunlight right from morning till evening i.e. sunny south-west aspect is most suitable.
- Area must be free from water stagnation i.e. proper drainage must be provided.
- Well protected from stray animals and strong winds.
- The area should be near the water source for continuous supply of good quality water

Soil

- Soil should have good organic matter
- Soil texture should be neither too coarse nor too fine.
- Soil should be sufficiently porous and adequately aerated.
- It should have a fair degree of water holding capacity.
- Soil pH of nursery bed should be in the range of 6 to 7.

- Acidic and alkaline soils are not suitable for raising nursery rather, neutral soils are suitable.
- Soil should normally be rich in all essential nutrient elements, but this can be further improved by addition of manures.

Procedure

Nursery bed preparation:

- The soil of the nursery area should be fine and fertile with good water holding capacity. For the preparation of beds, the field should be ploughed and levelled well. Soil should be worked to obtain a fine textured soil free of clods and debris.
- Prepare raised beds to facilitate proper drainage of excess water. The level of the bed surface is also made little slanting on the two sides.
- The length of nursery bed should be 3-5 m but it can be increased or decreased according to the availability of land and requirement of plants but the breadth of the beds should not be more than 1.00 -1.2 m and the beds should be 15-20 cm raised from the ground surface.
- The standard size of nursery bed is 3m × 1m × 15 cm.
- A space of 20 - 25 cm should be left between two beds. This space can be utilized to perform intercultural operations such as weeding, disease and insect-pest management and also for draining out the excess rain water from the nursery beds.
- Add 20-25 kg well rotten farmyard manure in each standard size nursery bed along with 200g single super phosphate and 15-20 g each of fungicides and insecticides like mancozeb and dusts like methyl parathion.
- The number of nursery beds depends on the particular crop, season and growing area of crop for transplanting.
- The beds should be prepared in the east and west direction and lines/rows for sowing of seeds should be made from north to south direction on the beds

Seed Sowing

- Treat the seed with fungicides like bavistin or thiram or captan @ 3g/kg of seed to check the infection of soil borne diseases.

- Make rows at a spacing of 5 cm.
- Sow the seeds at 1 cm depth. The general rule for sowing depth is 2-3 times of the thickness of seed.
- Mix a little of sand in the seed for uniform distribution in the rows and cover it with soil or farmyard manure.
- Avoid broadcasting seeds in the nursery-bed. Thick sowing or sowing with broad casting also leads to increase in the incidence of damping off disease.
- If seeds are sown too deep nutrient reserves will be exhausted before the plant emerges or emerging plants will be weak or liable to die, if sown too shallow then it is likely to be eaten by birds or washed away by the splash of rains or irrigation water.

Use of mulch

- After sowing, cover the seed bed with a layer of dry grass.
- Apply water over the grass so that seed do not come up on the surface of the bed.
- Mulching maintains the soil moisture and temperature for seed germination.
- It protects the growing seeds/seedlings from direct sunlight and raindrops.
- It protects seeds against bird damage

Removal of mulch

- Due attention is given to remove the covered mulch from the seedbed.
- After three days onward, observe the seed beds daily.
- As and when the white thread like structure is seen above the ground, remove the mulch carefully to avoid any damage to emerging plumules.
- Always remove mulch in the evening hours to avoid harmful effect of bright sun on newly emerging seedlings

Use of shading nets or polysheets

- After seed germination during the seedling growth, if there is very high temperature ($> 30^{\circ}$ C), cover the nursery bed with 50% or 60% shading nets

(green or green + black coloured) about 60 - 90 cm above ground by providing suitable support.

- During winter season, cover the nursery bed over night with polythene sheet about 60-90 cm above ground by providing suitable support. Remove the sheet in the morning before the temperature rises. This technique protects young seedlings from severe winter frost or low temperature injury.
- During rainy season, cover the nursery bed with polysheet by providing proper support.

Watering

- The nursery beds require light irrigation with the help of rose can till the seeds germinate.
- During summers, irrigate the beds twice, once in the morning and once in the evening.
- During winters, irrigation once in a day is sufficient.
- Keep beds moist but not wet otherwise "damping-off of seedling" may appear.
- Excess rainwater or irrigated water should be drained out from the nursery bed otherwise plants may die due to excess of water.
- Watering in the beds depends upon the weather condition. There is no need to irrigate the beds during rainy days.

Thinning

- It is an important operation to remove weak, unhealthy, diseased, insect pest damaged and densely growing plants from the nursery beds keeping distance of about 0.5 to 1.0 cm from plant to plant.
- The thinning facilitates balanced light and air to each and every plant. It also helps in monitoring the disease and insect pest infestation.

Interculture and weed control

- Timely weeding in nursery is very important to get healthy seedlings. If there are some weeds in the seed bed, remove them manually either by hand or by hand hoe (thin forked Khurpi).

- Pre emergence herbicides can also be sprayed soon after seed sowing to control the weeds. Stomp @ 3 ml/litre of water should be sprayed on the nursery beds after the seed sowing and covering with mixture of farmyard manure, soil and sand.
- For good quality seedlings, spray urea @ 0.3 per cent when the plants are 8-10 cm tall.

Plant protection

- Adoption of plant protection measures in the nursery against the incidence of insect pest and diseases is very important task to get the healthy seedlings.
- Damping off is a very serious disease affecting seedlings in the nursery. The care for controlling them time to time is essential.
- Treat the seeds with bavistin or thiram or captan.
- If the disease appears after the seed emergence, drench the nursery beds with 0.1% solution of brassicol or 0.7% captan or thiram after germination.
- It will be better to remove and dispose off the affected seedlings from the beds to avoid further spread of disease and insect-pests.

Hardening of the plants in the nursery

- Withhold irrigation in the nursery beds 4-5 days before the date of transplanting but on the day of transplanting, first apply water to the nursery beds and then take out the plants for transplanting.
- Hardening should be gradual to prevent or check the growth.
- Warm season crops like tomato, brinjal and chillies cannot withstand severe hardening.
- Hardened plants withstand more efficiently unfavourable weather conditions like hot day winds or low temperature than non-hardened seedlings.

Transplanting

- After 4-6 weeks of sowing, the plants become 10-15 cm tall and are ready for transplanting.
- Select healthy plants for transplanting and always transplant in the afternoon.

- Before transplanting, the seedlings should be dipped in a solution of 0.25 per cent mancozeb and 0.05 per cent carbendazim.
- Fix the plants well in the soil and water them daily till they establish well in the fields.

Exercise

1. Prepare nursery beds and raise the seedlings of vegetable crops by protecting them from severe frost.
2. Prepare seed plots in a field by providing proper drainage channels and take up manual sowing of any vegetable crop at proper spacing and depth

EXERCISE :

7.4 RAISING SEEDLINGS AND ROOTSTOCKS OF FRUIT PLANTS IN NURSERY.

7.5 PRE-SOWING SEED TREATMENTS FOR GERMINATION

Objective :

- To multiply those fruit plants through seed, that can not be multiplied by other means of propagation
- To raise rootstocks for various grafting/budding purposes
- To overcome seed germination barriers such as hard seed coat, dormancy

Delivery schedule : 01 period

Student expectations/learning objective:

- Importance of multiplication of fruit plants through seed
- Pre-sowing seed treatments to overcome dormancy
- Techniques of propagation of fruit plants and rootstocks through seed

Pre-learning required: Knowledge of raising of fruit plants through seed and seed dormancy.

Handouts/material required/equipment's & tools: Paper sheet and pen to note down the instructions, different tools for land preparation, farmyard manure, fertilizers, seeds of fruit plants, File, wooden boxes, tin boxes, plastic containers, refrigerator, sterilized sand, sphagnum moss, mercuric chloride, gibberellins, thiourea, sulphuric acid, labels, hammer, nut cracker, bavistin, herbicide, etc.

Introduction: Nursery is a place where seedlings, cuttings and grafts are raised with more care before transplanting. Nursery is consequently the basic need of horticulture. Plant propagation techniques and practices is the core of horticulture nurseries. The planting material of horticultural crops is raised from seeds and vegetative parts.

Advantages of raising seedlings/rootstocks of fruit plants in nursery

1. It is very convenient to look after the tender seedlings
2. It is easy to protect the seedlings from pests and diseases
3. Economy of land usage (duration in the main field is reduced)
4. Valuable and very small seeds can be raised effectively without any wastage.
5. Uniform crop stand in the main field can be maintained by selecting healthy, uniform and vigorous seedlings in the nursery itself.
6. Seedlings and grafts are produced in nursery and the fruit orchards and ornamental gardens can be established with minimum care, cost and maintenance.
7. The nursery planting materials are available at the beginning of the planting season.
8. This saves the time, money and efforts of the farmers to raise seedlings.
9. There is a wide scope for fruit orchards, ornamental, vegetable, and landscape gardens at public gardens, highways and co operative housing societies.

Propagation by seed

Papaya, phalsa, kagzi lime and jamun are usually propagated by seeds. Seeds are also used to raise rootstock seedlings in many fruit crops such as citrus and mango. This method being the easiest and cheapest is generally employed on a commercial scale in the fruit crops. In mango and citrus, nucellar seedlings can be used to raise true-to-type plants. Seed propagation is essential for breeding new plant type, conserving gene pools. Propagation by seed requires a thorough knowledge of seed viability, its

storage, time of sowing, factors responsible for germination and care of germinated seedling is essential.

The condition in which the seed can germinate immediately upon the absorption of water in the absence of any internal germination barrier, the embryo (or seed) is said to be quiescent. While those seeds which fail to germinate even though the embryo is alive, moisture is absorbed and favourable condition are provided are known as dormant seeds.

In many fruit crops, seeds required pre-sowing treatments to overcome dormancy or to enhance germination rate. The dormancy in seeds of ber, guava and walnut is due to presence of hard seed coat which inhibits penetration of water and oxygen required for germination. Presence of chemical inhibitors (abscisic acid) is responsible for dormancy in seeds of most of temperate fruits (apple, pear, peach and walnut). Besides ABA, higher concentration of pectin, gum, tannin and amino acids (trypophan) are also responsible for dormancy in seeds of temperate fruits.

Seed dormancy due to hard seed coat can be overcome by softening the seed coat and other covering. It can easily be done either by scarification, stratification or by use of chemicals and hormones.

Scarification:

- It is the process of breaking, scratching, altering or softening the seed covering to make it permeable to water and gases. Scarification can be achieved mechanically, or by hot water and acid.
- In mechanical scarification, cracking of seed with hammer, rubbing with sand paper or cutting with a file without injury to embryo is generally employed to break the dormancy (ber, peach and walnut).
- Impermeable seed coat of guava can be softened by hot water scarification. Seeds are placed in hot water at 77°-100°C. They are immediately removed from hot water and allowed to soak gradually in cool water for 12-24hr.
- Acid scarification consists of treating guava seeds with concentrated sulphuric acid for 3 minutes, ber for 5-6 hr and strawberry seeds with 0.25% nitric acid or hydrogen peroxide results in higher germination.

Stratification:

- It is the method of handling of dormant seeds, in which, the imbibed seeds are subjected to a period of chilling to after-ripen the embryo. This term originated as the nurserymen used to place seeds in stratified layers interspaced

with a moist medium such as soil or sand out of door or in pits during winter. The term moist chilling has been used as synonym to stratification. Stratification can be achieved by refrigeration of dormant seed.

- Dormant seeds of temperate fruits like apple, cherry, pear and apricot are generally placed in layers of sand in a box at a temperature of 1°-5°C. Depending upon the seed type, treatment time varies from 1-5 months for breaking dormancy of seeds.
- Keep the fungicide treated soaked seeds in wooden boxes or in soil pits containing moistened sand in alternate layers (seed followed by sand and so on) maintained at a low temperature (below 7.2°C).
- Generally, it is done in the months of November-December. For small quantities of seed, use tin cases or rigid plastic containers (used ice cream or freezer containers). Make holes in their base and place the seed in alternate layer of stratification medium (sphagnum moss/sand/perlite).
- Keep the containers in a refrigerator/deep freezer maintaining temperature below 7.2°C for varied period depending upon the fruit crop.
- Ensure that the site of stratification is rodent - free, shady and adequate moisture is maintained. Prepare a map indicating which seed lot is in each box/pit container in addition to labels tagged on them.



The seed dormancy due to presence of growth inhibitors can be broken by placing the seeds in running water. It results in leaching of inhibitors. The freshly extracted seeds of strawberry and grape if placed in running water for 7-12 days result in increased germination.

Chemical treatments:

- Many freshly harvested dormant seeds usually respond to soaking in potassium nitrate solution. This technique is largely used in seed testing laboratories

where seeds are placed in petri-dishes containing 0.2% solution of potassium nitrate.

- The seeds of peach and grape, treated with 5,000ppm of thiourea show enhancement in their germination.

Use of hormones:

- The seed dormancy can also be overcome by the treatment of growth regulators.
- Treatment of seeds of apple, cherry, peach, strawberry and hazelnut with 100-500ppm of GA_3 for 24-48hr improves germination and better growth of seedlings.
- Ethrel (5,000ppm)-treated seeds of guava and strawberry also show better germination and growth of seedlings.
- Treatment of apple and peach seeds with 10-20ppm solution of benzyle adenine (BA) is effective for higher seed germination.

Seed sowing

- The fruit seeds are sown in seed bed, polythene bags or in situ.
- Seeds of tropical and subtropical fruits are sown during monsoon (June-July) or in the beginning of spring (February-March).
- Generally seeds of mango and jackfruit are sown during June-July while those of guava, ber and aonla during February-March.
- Seeds of temperate fruits are generally available during June-October and their sowing should be done after the dormancy period is over.
- In citrus, mango, loquat, litchi and jackfruit, seed viability is very less, so these should be sown immediately after extraction.
- In north India, seeds of different citrus types are available during winter months. Germination of seeds is low due to prevailing low temperature. Hence use of polythene sheet on seed beds during December-January is useful in increasing germination percentage and faster growth of seedlings.
- The seeds are usually sown at a depth 3-4 times of their size. It should be a little deep in light soils while shallow in heavy soils.

- Nowadays, sowing of seeds in polythene bags, earthen pots and pans is becoming popular. It is usual practice to sow papaya seeds in polythene bags. For epicotyl grafting, mango stones are also sown in polythene bags.
- While raising the plants in polythene bags, care should be taken that root system develops properly. It has been observed a number of times that the roots get twisted and there is difficulty in establishment of the plants in field due to poor anchorage.
- In-situ sowing: In walnut, pecan nut, jackfruit and ber, the tap-root system is very vigorous. So during the process of transplanting, root system is disturbed which ultimately affects their establishment in the field. Therefore, for these fruits, sowing of seeds in-situ is recommended. In rocky soils, in-situ sowing of mango seeds and grafting later on is recommended.

Procedure

1. Procure the seeds from well maintained seed orchards or from fruit processing industries. The former is a better source of seed. Seeds should be mature with uniform colour, size and shape.
2. Stratify or scarify the seeds, if required.
3. Prepare the seed beds in an area which is flat, fertile, well drained, irrigated, rich in organic matter and receives adequate sunshine.
4. Precondition the nursery beds by applying 60-80 tonnes FYM/ha, 60-120 kg N/ ha and 60-90 kg P2Os/ha.
5. Sow the seeds of small size (e.g. of apple and pear) at a depth of 3-5 cm, 5-6 cm apart in rows at a distance of 10-15 cm. Sow large seeds (e.g. of stone fruits) at a distance of 6-10 cm from seed to seed.
6. Cover the seeds with a thin layer of fine sand and mulch with dry grass or polythene sheet.
7. Irrigate lightly after the sowing of seeds.
8. Once the seedlings have emerged, these should be looked after properly, single stemmed to a height of 45-60 cm, so that the main stem is healthy.

- Acidic and alkaline soils are not suitable for raising nursery rather, neutral soils are suitable.

- Soil should normally be rich in all essential nutrient elements, but this can be further improved by addition of manures and fertlizers.

Exercise1: Evaluate scarification techniques and their effect on germination percentages.

Select 10 seeds for each of the four treatments and put in the four different containers provided.

a. Treatment 1- Control (no scarification)

b. Treatment 2- Seeds soaked in hot water

c. Treatment 3- Seeds soaked in acid (sulfuric acid)

d. Treatment 4- Mechanical scarification (use sandpaper, file, or clippers)

Record the seed germination data for your group and the entire class.

Exercise 2: Evaluate stratification techniques and their effect on germination percentages.

Select 100 seeds and put them under stratification in a box and keep it in refrigerator. Record your observations.

Practical 8

PROPAGATION THROUGH CUTTINGS, LAYERING, RUNNERS, SUCKERS, GRAFTING AND BUDDING

EXERCISE 8.1: PROPAGATION OF HORTICULTURAL CROPS THROUGH CUTTINGS

Objective :

- To acquaint the student with some of the basic techniques used in propagating horticultural plants using cuttings.

Delivery schedule : 01 period

Student expectations/learning objective:

- Basic techniques used in propagating horticultural plants through cuttings

Pre-learning required: Knowledge about different types of cuttings, treatment of cuttings with rooting hormones and planting of cuttings

Handouts/material required/equipment's & tools: Appropriate plant material, Propagation media/ material, Secateur and knives, Labels and marking pens, Rooting hormones (IBA, NAA)

Introduction:

Asexual or vegetative propagation of plants by cuttings is a very important part of horticulture. Asexual techniques allow the increase of plants so that all propagules are genetically identical to the parents. This differs greatly from sexual propagation where there remains the potential for diverse genetic variation. Seedling populations from many horticultural crops are so variable that asexual propagation affords the only way to practically maintain these individuals in order to retain their uniformity.

In propagation through cuttings, a portion of a stem, root, or leaf is cut from the parent plant, after which this plant part is placed under environmental conditions conducive to the formation of roots and shoots, thus producing a new independent plant which, in most cases, is identical with the parent plant. There are many different

ways to propagate plants using cuttings. The process involves determining which cutting type is best suited for the propagation of large numbers of plants and then using the appropriate preparation of the plant material for propagation.

Advantages of propagation through cutting: New plants can be started in a limited space from a few stock plants. The method is inexpensive, rapid and simple and does not require special techniques. There is no problem of incompatibility or of poor graft union. Greater uniformity is obtained. The parent plant is reproduced with no genetic change.

Cuttings are broadly classified as stem cuttings, leaf cuttings, leaf bud cuttings and root cuttings. Stem cuttings are of hardwood (deciduous and narrow-leaved evergreens), semi -hardwood, softwood and herbaceous plants.

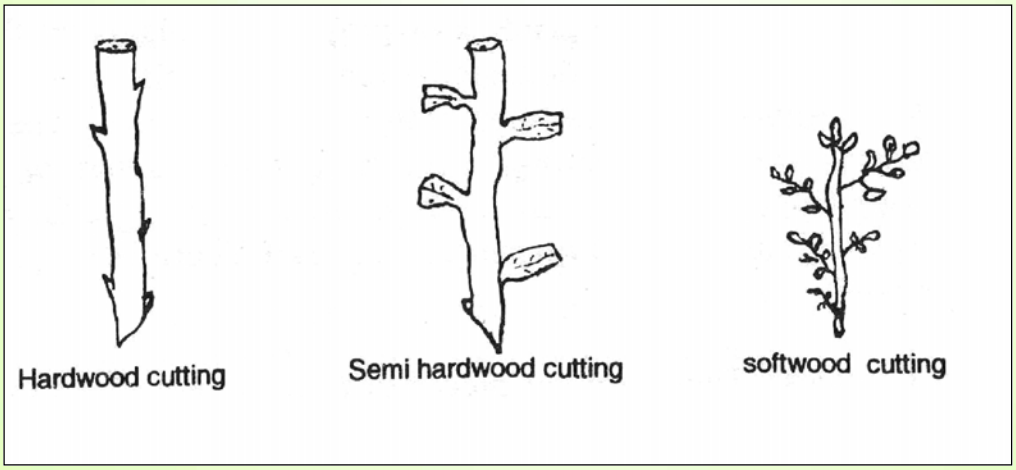
Hard wood Cuttings

Hardwood cuttings are made from mature, dormant firm wood after leaves have abscised. The use of hardwood cuttings is one of the least expensive and easiest methods of vegetative propagation. Hardwood cuttings are easy to prepare, are not readily perishable, may be transported safely over long distances and require little or no special equipment during rooting. These cuttings are prepared during the dormant season - late fall, winter or early spring - from wood of the previous season's growth. For a few species, such as the fig or olive, two year old or even older wood is used. Hard wood cuttings are often used in propagation of deciduous woody plants, although some broad leaved evergreens such as the olive can be propagated by leafless hardwood cuttings. A few fruit species such as fig, quince, olive, mulberry, grape, currant, gooseberry, pomegranate and some plums are propagated commercially by this method. Many deciduous ornamental shrubs are started readily by this type of cuttings. Some common ones are privet, forsythia, wisteria, honeysuckle, willow, poplar, dogwood, *Poinsettia*, *Sambucus*, and Spiraea. Rose rootstocks are propagated by hardwood cuttings.

Procedure:

- Collect one-year-old mature shoots from the fruit plants to be propagated such as fig, quince, olive, mulberry, grape, currant, gooseberry, pomegranate or deciduous ornamental shrubs (privet, forsythia, wisteria, honeysuckle, willow, poplar, dogwood, *Poinsettia, Sambucus,* and *Spiraea)* whichever is available in your locality during November-February.

- Discard the tip portion of the shoots because they are usually low in stored carbohydrates and often contains unwanted flower buds.
- Central and basal parts generally make the best cuttings, but there are exceptions.
- Length of cuttings should be between 10 and 45cm.
- Cuttings should contain at least 2 nodes.
- Give a straight cut just on the base of shoot below the node while a slanting cut on the top of the cutting, 1-2cm above the bud. This helps maintain the polarity of the shoot and if rain occurs, water does not accumulate on the tip of cutting.
- Apply rooting hormone (IBA/NAA).
- Plant the cuttings in well prepared beds or under polyhouses.



Semi hardwood cuttings

These are made from woody, broad-leaved evergreen species but leafy summer cuttings taken from partially matured wood of deciduous plants can also be considered as semi hardwood. Cuttings of broad leaved evergreen species are generally taken during the summer from new shoots just after a flush of growth has taken place and the wood is partially matured. Many broad-leaved evergreen shrubs such as Azalea, Camellia, Rhododendron, Euonymus, and holly are commonly propagated by semi-hard wood cuttings. A few fruit species, such as citrus and olive, can also be propagated by semi-hard wood cuttings.

Procedure:

- Collect the cuttings from the plants such as *Azalea, Camellia, Rhododendron*, *Euonymus*, and holly or fruit plants (citrus or olive) during the summer from new shoots just after a flush of growth has taken place and the wood is partially matured.
- The shoot terminals are often used in making cuttings but the basal parts of the stem will also root usually.
- Make the cuttings 7.5 to 15 cm long with leaves retained at the upper end. If the leaves are very large, these should be reduced in size to lower the water loss and to allow closer spacing in the cutting bed.
- Give a straight cut just on the base of shoot below the node while a slanting cut on the top of the cutting, 1-2cm above the bud.
- Obtain the cuttings in the cool, early morning hours when leaves and stems are turgid.
- Keep the cuttings out of the sun until they can be stuck and propagation is initiated. Therefore, cuttings should be placed in large containers, which are covered with clean moist burlap to maintain high humidity or put in large polythene bags.
- Apply rooting hormone (IBA/NAA).
- These cuttings are commercially rooted under intermittent mist or fog.

Soft wood cuttings

Cuttings prepared from the soft, succulent, new spring growth of deciduous or evergreen species may properly be classed as softwood cuttings. Many ornamental woody shrubs can be started by softwood cuttings. Typical examples are the hybrid French lilacs, Magnolia and Forsythia. Some deciduous ornamental trees such as the maples also can be started in this manner. Although fruit species are not commonly propagated by softwood cuttings, those of apple, peach, pear, plum, apricot and cherry will root, especially under mist. *Hydrangea, Fuchsia, Forsythia,* Lilac, *Magnolia,* Scented Geraniums, deciduous azaleas, assorted herbs and *Sedum*, etc. are also propagated by softwood cuttings.

Softwood cuttings generally root easily and more quickly than other types but require more attention and sophisticated equipment. This type of cuttings is always

made with leaves attached. They must be handled carefully to prevent desiccation and be rooted under conditions which avoid excessive water loss from the leaves. Temperature should be maintained during rooting at 23-27 °C at the base of the cuttings for most species.

Procedure:

- Collect the cuttings from the soft, succulent, new spring growth of deciduous or evergreen species such as *Hydrangea, Fuchsia, Forsythia,* Lilac, *Magnolia,* Scented Geraniums, deciduous azaleas, assorted herbs and Sedum, etc. or fruit species like apple, peach, pear, plum, apricot and cherry.
- Collect the cutting material early in the day. Keep them moist, cool and turgid at all times since keeping the cutting material or preparing cuttings in the sun even for few minutes will cause serious damage.
- It is important to obtain proper type of cutting material. The best cutting material has some degree of flexibility but is mature enough to break when bent sharply.
- Make the cuttings 7.5 to 12.5 cm long with two or more nodes.
- Remove the leaves on the lower portion of the cutting while those on the upper part are retained.
- Large leaves should be reduced in size. All flowers and flower buds should be removed.
- Apply growth regulator (1000 or 3000 ppm IBA)
- Plant the cuttings under intermittent mist.

Herbaceous cuttings

Procedure:

- Collect the cuttings from succulent herbaceous plants such as geranium, chrysanthemum, coleus, carnations and many foliage plants.
- Prepare cuttings 7.5 to 12.5 cm long with leaves retained at the upper end while remove the leaves on the lower portion of the cutting.
- Herbaceous cuttings of some plants that exude a sticky sap, such as pineapple and geranium do better if the basal ends are allowed to dry for a few hours

before they are inserted in the rooting medium. This practice tends to prevent the entrance of decay organisms.

- These cuttings are rooted under the same conditions as softwood cuttings. Bottom heat is also helpful. Under proper conditions, rooting is rapid and in high percentage.
- Although rooting hormones are usually not required, they can be often used to get uniformity in rooting and the development of better root system. Apply growth regulator (1000 or 3000 ppm IBA)

Leaf Cuttings

In this type of cutting, the leaf blade, or leaf blade and petiole are utilized in starting a new plant. Adventitious buds, shoots and roots form at the base of the leaf and develop into the new plant. The original leaf does not become a part of the new plant. Frequent watering and high humidity and bottom heating are desirable for better and rapid rooting of leaf cuttings. Sand or sand and peat moss (1:1) are satisfactory rooting media for leaf cuttings. Only a limited number of plant species can be propagated by leaf cuttings. African violets, begonias and peperomea are routinely propagated by leaf cuttings.

Procedure:

- Leaf cuttings of African violets can be made of an entire leaf (leaf blade plus petiole), the leaf blade only or just a portion of the leaf blade. The new plant forms at the base of the petiole or midrib of the leaf blade.
- In Sansevieria, long tapering leaves are cut into sections 7.5 to 10 cm long. These leaf pieces are inserted three-forth of their length into sand, and after a period of time, a new plant forms at the base of the leaf piece.
- For propagation of plants by leaf cuttings with thick, fleshy leaves such as Begonia rex, the large veins are cut on the undersurface of the mature leaf, which is then laid flat on the surface of the propagating medium. The leaf is pinned or held down with the natural upper surface of the leaf exposed. After some time under humid conditions, new plants form at the point where each vein was cut. The old leaf blade gradually disintegrates.
- In fibrous rooted Begonias, large well matured leaves are cut into triangular sections, each containing a piece of a large vein. The thin outer edge of the leaf is discarded. These leaf pieces are then inserted upright in sand with the

pointed end down. The new plant develops from the large vein at the base of the leaf piece.

- Leaf cuttings should be rooted under the same conditions of high humidity as those used for softwood or herbaceous cuttings.
- Cuttings are commercially rooted under mist or high humidity.
- Most leaf cuttings root readily but the development of adventitious bud and shoot is the limitation. Therefore, cytokinins can be used to induce buds to form.

Leaf cutting of Kalanchoe

Leaf cutting of Sansevieria

Leaf cuttings of Pepromea

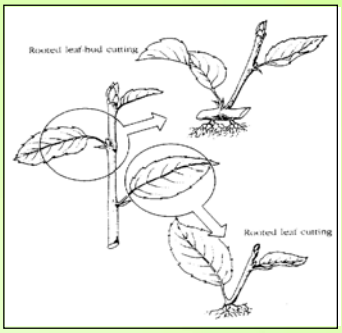
Leaf lamina cuttings of Iron cross Begonia

Leaf lamina cuttings of Rex begonia

Leaf bud cuttings

This type of cutting consists of leaf blade, petiole, and a short piece of the stem with the attached axillary bud. Such cuttings are of particular value for species that are able to initiate roots, but not shoots, from detached leaves. In such cases, the axillary bud at the base of the petiole provides the essentials of shoot formation. A number of plant species such as black raspberry (Rubus occidentalis), blackberry, boysenberry, lemon, camellia, and rhododendron can be readily propagated by leaf bud cuttings.

This method is particularly valuable when the propagating material is scarce, because it will produce at least twice as many new plants from the same amount of stock material as can be started from stem cuttings. Each node can be used as a cutting.

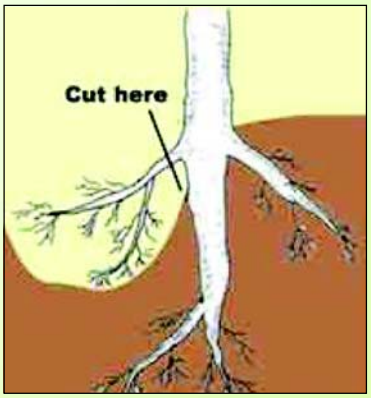


Procedure:

- Prepare leaf bud cuttings only from material having well developed buds and healthy, actively growing leaves.
- Remove section of stem. Cut stem into sections, each with a leaf attached
- Insert the cuttings into rooting media, with the bud about 1.3 - 2.5 cm below the surface.
- High humidity is essential and bottom heat is desirable for rapid rooting.
- Clean quartz sand and peat moss (1:1) are also satisfactory rooting media for such cuttings.

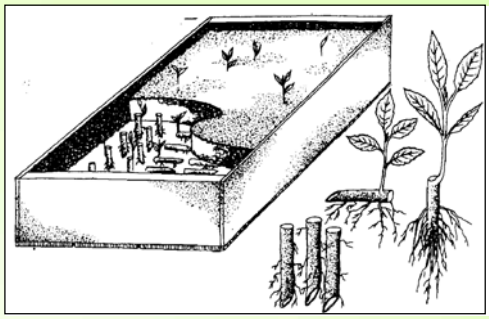
Root cuttings

These are applicable for the propagation of more woody plants than is commonly realized. They are also beneficial as a means of propagating rootstocks of fruit crops. They also play a particularly important role in the propagation of herbaceous perennials. Root cuttings are usually obtained during the dormant season from young stock plants when the roots are well supplied with carbohydrates. Once the soil is removed from the root system by shaking or then prepared by cutting to a length of about 4 in, although cuttings from plants such as phlox, anemones, and gaillardias may be smaller. Blackberry and raspberry are commercially propagated by this method. This method is also advocated in pecan nut, apple, pear and peach.



- Take root pieces preferably from young stock plants in late winter or early spring when the roots are well supplied with stored foods but before new growth starts.

- Securing cutting material in quantities for root cuttings can be quite laborious unless it can be obtained by trimming roots from nursery plants as they are dug.
- Correct polarity should be taken into consideration when planting is done. To avoid planting them upside down, the proximal end may be made with a straight cut and the distal end with a slanting cut. The proximal end of the root piece should always be up.



- While planting, insert the cutting vertically so that the top is at about soil level. With many species, however, it is satisfactory to plant the cuttings horizontally 2.5 - 5.0 cm deep.
- The size of root cuttings depends upon the nature of the roots. In plants with small delicate roots, the roots are cut 2.5 - 5 cm long. In plants with fleshy roots, the root size may be 5-7.5 cm, whereas in plants having large roots, the root cuttings are made 5-15 cm long.
- Place the cuttings under mist.

Precautions: Take cuttings only from healthy plants. To prevent the spread of disease, use clean tools and pots (clean with 10% bleach, rinse, and let dry thoroughly). Use fresh soil less potting mixture since garden soil can harbor plant diseases.

Exercise 1: Prepare the cuttings of various types from available plant material and plant them. Observe the rooting patterns for the next few weeks. Remove and keep plants which rooted successfully.

Exercise 2: Enlist the horticultural crops grown in your area propagated through various types of cuttings in the given data sheet.

Type of cuttings	Examples of horticultural crops	Remarks, if any
Hard wood cuttings		
Semi-hard wood cuttings		
Soft wood cuttings		
Herbaceous cuttings		
Leaf cuttings		
Leaf bud cuttings		
Root cuttings		

EXERCISE 8.2:
PROPAGATION OF HORTICULTURAL PLANTS THROUGH LAYERING, RUNNERS AND SUCKERS

Objective :

- To demonstrate and prepare the various types of layering that can be used to propagate horticultural plants.

Delivery schedule : 01 period

Student expectations/learning objective:

- Basic techniques used in propagating horticultural plants through layering
- To develop skill in the art of layering

Pre-learning required: Knowledge about different types of layering.

Handouts/material required/equipment's & tools : Appropriate plant material; Secateur and grafting knives; 15 x 20 sq. cm sheet of polyethylene film, rubber bands or pieces of twine, and a 15 x 20 sq. cm sheet of either craft paper, cloth or aluminum foil; Labels and marking pens.

Introduction:

Layering is a method of vegetative propagation by which a good stem is induced to produce roots while it is still attached to the parent plant. After proper rooting, the stem is detached and becomes a new plant for growing on its own roots. In this manner a new plant usually can be developed in a relatively short time and with less trouble than other methods of propagation. It can be used successfully on many fruit trees and woody ornamental shrubs grown.

The high success of layering is obtained by ringing or wounding, etiolation (absence of light), use of rooting hormone (IBA, NAA) and favourable environmental condition (temperature and humidity).

The layering can be natural means of propagation as in black raspberries and

trailing blackberries or can be artificially created by different means. The layering techniques generally employed in horticultural plants are:

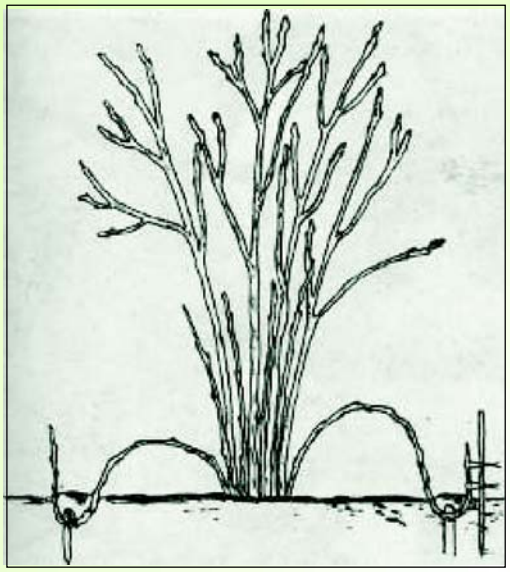
Simple Layering :

Simple layering is the bending of an intact shoot to the ground and covering a single portion of the stem between the base and shoot tip with soil or rooting medium so that adventitious roots form. The method can be used to propagate a wide range of plants, indoor or outdoor, on woody shrubs that produce numerous new shoots annually or on trees that tend to produce suckers, such as filberts (Corylus sp.). The usual time for layering is early spring.

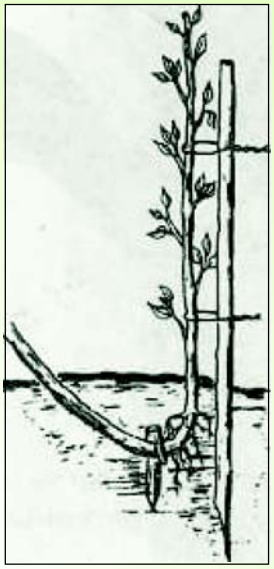
Procedure:

- Select flexible, dormant, one- year-old shoots, which can be bent easily.
- Bend these shoots over to the ground during early spring or fall.
- Make a second bend in the branch at a location 15 to 20 cm (6 to 9 in.) from the tip, forming a "U".
- Hold it in place with wire hooks or wood stakes.
- Injure the stem at the underground section to stimulate rooting. Injury can be imparted through notching, bending, twisting, cutting, or or girdling at the bottom of the "U"
- Cover the base of the layer with soil leaving the tip exposed.
- Roots will form on the buried part of the shoot near the bend.
- Shoots layered in the spring will usually be rooted by the end of the growing season and remove them either in the fall or in the next spring before growth starts.
- Mature shoots layered in summer should be left through the winter and either removed the next spring before growth or left until the end of the second growing season.
- The rooted layer is detached from the parent plant. When the rooted layer is removed from the parent plant, it is treated essentially as a rooted cutting.

- New shoots growing from the base of the plant during the rooting year are used for layering during the next season. With this system a supply of rooted layers can be produced over a period of years by establishing a layering bed composed of stock plants far enough apart to allow room for all shoots to be layered.



Bending of shoots



Formation of roots near the bend

Rooted layer

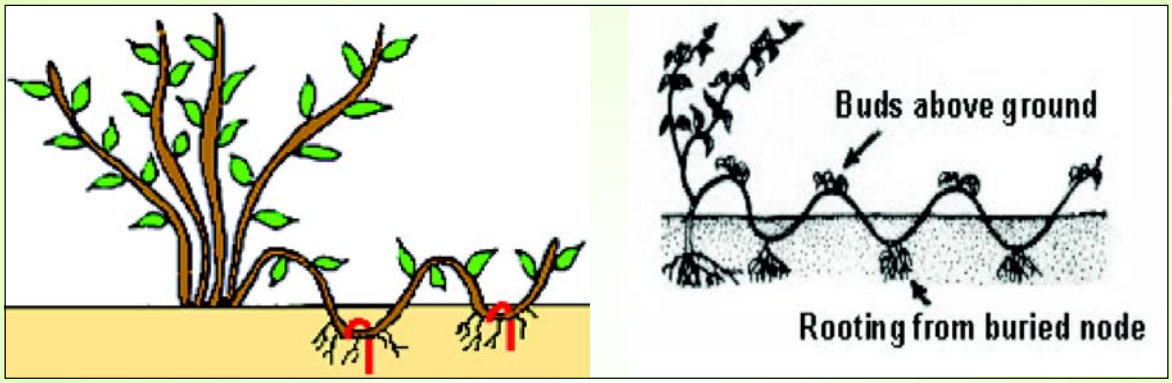
Compound layering:

It is similar to simple layering, except that the branch to be layered is laid horizontally to the ground and numerous shoots for rooting develop from various nodes rather than just one. A variation of this method (sometimes called serpentine layering) is used for propagating plants that have long, flexible shoots; for example, the Muscadine grape (*Vitis rotundifolia*) and omamental vines such as Wisteria and Clematis. The horizontal shoots are alternately covered and uncovered to produce roots at different nodes. Several new plants are thus possible from a single branch.

Procedure:

- Permanent layering beds are established with plants spaced 1.8 to 3 m (6 to 10 ft) apart and grown for several years to establish a good root system.
- The vegetative top is then cut back to 2.5 cm (1 in.) from the ground and shoots are allowed to grow for the following season.

- Bend long shoots over horizontally to the ground before the beginning of the season, and held down with wire pegs.
- Once new shoots grow about 10 cm (4 in.), the pegs are removed, a shallow trench is dug adjacent to the stem, and the shoots are laid in the bottom of the trench with additiona1 pegs applied to hold them in place.
- Soil or other media is filled in as the shoots grow.
- Roots will form on the buried part of the shoot near the bend.
- The rooted layer is removed from the parent plant.



Compound Layering

Tip-layering:

- Tip layering occurs naturally in trailing blackberries, dewberries, and black and purple raspberries (*Rubus*).
- In tip-layering, rooting takes place near the tip of current season's shoot which is bent to the ground.
- The stem of these plants complete their life in 2 years. During first year, vegetative growth takes place while in the second year fruiting takes place.
- After harvesting plants are heavily pruned which give rise to number of lateral shoots. The tips of these shoots are buried 5-10cm deep in soil.
- Roots will form on the under ground part of the shoot near the bend.
- Rooted layers are detached from the parent plant and planted in soil during spring.

Mound (Stool) Layering or Stooling:

Mound layering is a method where the shoots are cut back to the ground and soil or rooting medium is mounded around them to stimulate roots to develop at their bases. Apple and pear rootstocks and guava are commercially propagated by this method. However, this method is also advocated in other fruits like plum, cherry, hazelnut, pecannut, mango, jackfruit and litchi. It is also useful for quince, currants, and gooseberries.

Procedure:

Establishing the Stool Bed

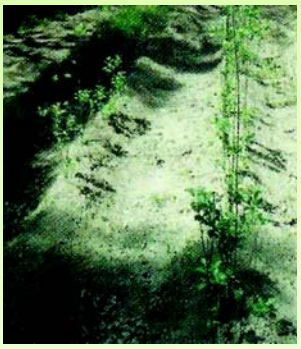
- The establishment of the mother stool bed is achieved during the first year.
- The planting of the mother stocks is done during the months of December-January when the plants are fully dormant.
- The field should be throughly cultivated and the soil of the plot should be loose, fertile and well-drained.
- Plant healthy stock plants of suitable size (8 to 10 mm) in diameter and 60-75 cm (24-30 in.) long with well developed roots.
- Keep plant to plant distance as 30 to 37.5 cm (12 to 15 in.) apart in a row.
- Keep a minimum row spacing of 2.5 m (8 ft). Width between rows should allow for cultivation and hilling operations during spring and summer.
- At planting, the plants are cut back to 45 to 60 cm (18 to 24 in.) and allowed to grow for one year.

Annual Operations:

- Allow these mother stools to grow unchecked for one year.
- In the second year, cut back plants to 2.5 cm (1 in.) above ground level before new growth starts in the spring.
- Two to five new shoots usually develop within two months from the crown the first year, more in later years.

- Girdling of these shoots can be done near base and rooting hormone (IBA), made in lanolin paste is applied to the upper portion of cut with moist soil. These shoots are left as such up to two days for proper absorption of rooting hormone (IBA) before they are covered. The concentration of rooting hormone varies from plant-to-plant but in general 3,000-5,000ppm is most commonly used.
- When these shoots have grown 7.5 to 12.5 cm (3 to 5 in.), cover each shoot to one-half of its height with loose soil, bark, sawdust, or a soil- sawdust mixture.
- When shoots have grown 20 to 25 cm (8 to 10 in.), a second hilling operation (a horti-cultural term that refers to the mounding up of soil or other media around the base during layering) should be done by adding additional rooting medium around the bases of the shoots to cover about half of its height.
- A third and final hilling operation is done in midsummer (July) when the shoots have developed approximately 45 cm (18 in.). The bases of the shoots will then have been covered to a depth of 15 to 20 cm (6 to 8 in.).
- During the next winter, sufficient roots will form on the stool shoots by the end of the growing season.
- After natural leaf fall, the soil is forked away from the earthed shoots carefully.
- Rooted shoots are cut close as possible to their bases and utilized either for nursery production by grafting/budding or for establishing additional stool beds.
- After the shoots have been cut away, keep the stool beds exposed until new shoots have grown 7.5 to 12.5 cm (3 to 5 in.). At this time, the stooling cycle is repeated annually.
- A stool bed can be used for 15 to 20 years with proper handling, providing it is maintained in a vigorous condition and diseases, insects, and weeds are controlled.

Stool bed started by planting a rooted layer In a small trench



Established mother stool after one year growth

Top is removed to 2.5 cm above ground just before growth begins

Mother stool during 2nd year of establishment

The final earthing with fine soll to the height of 15-20 cms above the ground level

In the following winter the soll is forked away and the rooted shoots are harvested during December-January when all the leaves have dropped.

Rooted layear are cut off and are lined out in the nursery

Basic steps in mound layering

Trench Layering

Trench layering is a layering method in which the mother plants are established in a sloping position such that shoots can be layered horizontally in the base of a trench. Soil, bark, sawdust, or other rooting material is filled in around the new shoots as they develop so as to bring about etiolation. The method can be used for clones of woody species that are difficult to root by mound layering (stooling), including cherry, quince, apple, mulberry, and walnut etc.

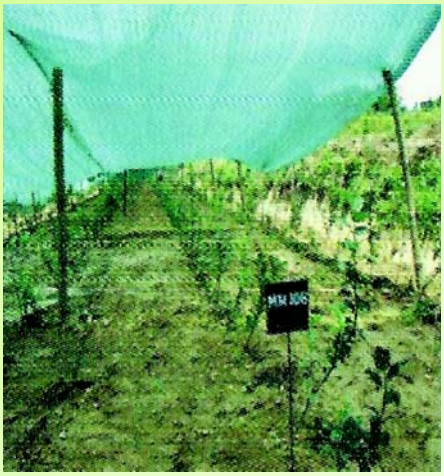
Establishing the Layer Bed

- The establishment of the mother stocks is achieved during the first year.
- The planting of the mother stocks is done when the mother stock material is dormant.
- The field should be throughly cultivated and the soil of the plot should be loose, fertile and well-drained.
- The mother stocks should be planted about 30-35 cm apart and 10 cm deep.
- The distance between two trenches should be kept about 1-1.5 m.
- The mother plants are planted at an angle of 30 to 45° along the row and are usually pointed southwards.
- The plants are allowed to grow during the first year to establish a good root system.

Annual Operations:

- The steps during cultivation in the first season are same as described for mound layering.
- By the end of the growing season or during that winter a shallow trench 5 X 23 cm (2 X 9 in.) is dug down the row.
- Bend the main mother plant as horizontally along the bottom of the trench as possible. This is done by using pegs or hinged wooden pegs.
- Select two-three suitable side growths on either side of the main mother stock plant and bend the same down in the trench alongside the main stem so that the trench is evenly filled with the mother plant.

- Care should be taken not to pin down too much material causing over crowding and making the mother plant too wide.
- The best time to pinning down the side shoots is late autumn. However, this operation can be taken at the same time when bending and pinning down of the main mother plant is done in winter when the growth has ceased.
- After bending and pinning down, these shoots should be shortened back to even, strong wood removing the thinner tip growth.
- Shorten back the remaining shoots on the mother plants, which were not required for pinning down. These shoots should be pruned back to the main stem in the mother plant leaving a stub of approximately 1.5 to 2 cm.
- Successful layering depends on etiolation. Buds are covered with about a 2.5 cm (1 in.) of soil before they emerge.
- Subsequent applications of rooting medium such as sawdust are added periodically to etiolate 5 to 7.5 cm of the developing shoots. Final depth should be 15 to 20 cm.
- Rooting should take place by the end of the season.
- In the following winter, the soil is forked away and the rooted shoots are cut off close to the original branch, leaving a small stub for next year's growth.
- The shoots that have not formed the roots are left to be laid and pegged down as before.
- If all the shoots have rooted, care must be taken to leave at least one shoot at every one feet distance in the trench. During the first year, cut off each rooted shoots leaving a stub of 1.5-2 cm and in the subsequent years, it should be cut back to the crown created by initially left stubs.
- The process is repeated in subsequent years. A well-cared-for stock bed should last 15 to 20 years.



Mother plants after one year's growth which were planted in the row at an angle of 30°-45°

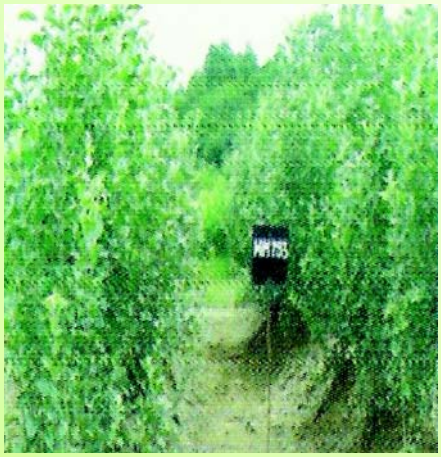
Established mother plant after 1 year of growth

Laying of plant in the bottom of trench before the start of growth

The plants are kept completely flat with the help of pegs

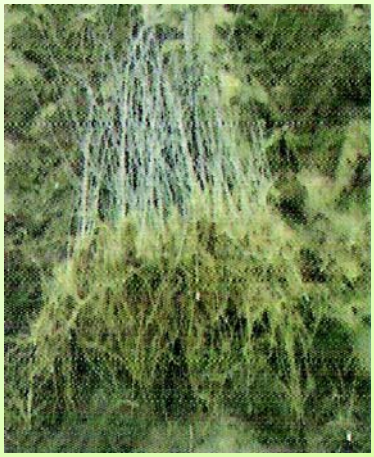
Even bud break across the whole bed

Shoot ready for first earthing up when the new shoots are 35 in. high



The final earthing with fine soil should be 15-20 cms above the ground level at the centre of the trench

In the following winter the soil is forked away and the rooted shoots are harvested. During December-January) when all the leaves have dropped.



Rooted layers are cut off and are lined out in the nursery

Basic steps in trench layering

Air Layering

Air layering a type of layering in which an aerial stem is girdled and enclosed with rooting media to produce rooted layers in the upper part of the plant. This method is commonly known as goottee. It is also called pot layering, circumposition and marcottage. Plants commonly propagated by air layering include litchi, kagzi lime, jackfruit, guava and cashewnut as well as *Ficus* species, litchi, lime, lemons, guava, jackfruit, cashew nut, *Croton, Monstera,* Rubber plant, Hibiscus, Calliandra, Gardenia, Bougainvillea and philodendron are propagated through air-layering. February-March and June-July are the ideal periods for air-layering.

Procedure:

- Select young, vigorously growing healthy shoots 0.5 to 2 cm in diameter. Generally, shoots from the previous season's growth are preferred. However, shoots older than one year can be used in some cases, but rooting is less satisfactory and the larger plants produced are somewhat more difficult to handle after rooting.
- Remove leaves and twigs on the selected shoot 7 to 10 cm above and below the point where the cut is to be made.
- Girdle the shoot at a point 15 to 30 cm back from the tip just below a node by completely removing a ring of bark 2 to 3.5 cm wide all around the shoot by making two circular cuts with a knife.
- Scrape the exposed surface to ensure complete removal of the phloem and cambium. This will prevent callus formation and allow roots to be initiated.
- In difficult-to-root species, treat the girdled portion with the recommended growth regulator (IBA) to induce better rooting.
- Cover the girdled portion with a ball of moist sphagnum moss as soon as possible. Make sure that the excess moisture is squeezed out before applying it to the cut surface. If the moisture content of the sphagnum moss is too high, the shoot will decay.
- Place a wrapping of transparent polyethylene film (200-300 gauze) 20 to 25 cm (8 to 10 in.) square, around the sphagnum moss. The ends of the sheet should be folded with the fold placed on the lower side and tie at each end. Tying should be perfect so that no water can enter the treated part.
- Roots develop on air layers generally within 25-30 days which can be observed through the transparent polyethylene sheet and layers are ready for transplanting within 3 months.

- At this stage, remove the layer from the parent plant and transplant the layer appropriately. Removal of the layer for transplanting is best when growth is not active.
- Pruning to reduce the top in proportion to the roots is usually advisable.

Basic steps in air layering

Runner:

- It is a specialized stem which is produced from the leaf axil at the crown of plant and prostrate horizontally.
- The roots appear at one of the nodes having contact with soil.
- After root formation in the new plant, the contact with the mother plant is automatically detached and new plant can be separated and planted.
- Strawberry is the typical example which is commercially propagated through runners.

Suckers:

- A sucker is a shoot which arises on a plant below the ground.
- However, in practice, shoots which arise from vicinity of the crown are also referred to as suckers.
- Banana is usually propagated through suckers.
- In banana, 2 types of suckers are produced-water sucker and sword sucker.
- Water suckers are broad leaved while sword suckers are pointed and in the shape of a sword.
- For propagation purpose, sword suckers are preferred over water suckers.

Exercise: Practice and perform air layering in pomegranate/litchi and mound layering in guava.

EXERCISE 8.3:
PROPAGATION OF HORTICULTURAL PLANTS THROUGH GRAFTING

Objective :

- To demonstrate and prepare the various types of grafting that can be used to propagate horticultural plants.

Delivery schedule : 01 period

Student expectations/learning objective:

- Basic techniques used in propagating horticultural plants through grafting
- To develop skill in the art of grafting

Pre-learning required: Knowledge about different types of grafting.

Handouts/material required/equipment's & tools : Appropriate plant material; Secateur and grafting knives; Tying material (polythene sheet-150gauge/ paraffin wax etc.); Labels and marking pens.

Introduction:

Grafting is a method of asexual plant propagation widely used in agriculture and horticulture where the tissues of one plant are encouraged to fuse with those of another. It is most commonly used for the propagation of trees and shrubs grown commercially. In most cases, one plant is selected for its roots, and this is called the rootstock. The other plant is selected for its stems, leaves, flowers, or fruits and is called the scion. The scion contains the desired genes to be multiplied in future production by the compound stock and scion combined plant.

For successful grafting to take place, the vascular cambium tissues of the stock and scion plants must be placed in contact with each other. Both tissues must be kept alive until the graft has taken, usually a period of a few weeks. Successful grafting only requires that a vascular connection take place between the two tissues. A physical

weak point often still occurs at the graft, because the structural tissue of the two distinct plants, such as wood, may not fuse.

Grafting and budding terminology

Before discussing grafting methods further, some of the key terms involved need to be clarified.

- The **scion** is the part of the stem that develops into a shoot system following successful grafting.
- The **stock or rootstock** is the part that develops into a root system following successful grafting. A rootstock may be grown from seed or from rooted cuttings.
- An **interstock** is sometimes grafted in between a stock and scion to impart certain important characteristics to the unified plant. Interstocks are useful for dwarfing, to overcome stock-scion incompatibility, impart winter hardiness, and reduce disease problems. (The interstock may be only a thin section of wood, a short section of trunk in a fruit tree, or the trunk and lower portions of scaffold branches.) This is often referred to as "double working."
- **Topworking** applies to the process of changing the top of a plant from one cultivar to another by grafting or budding. This procedure may sometimes involve a series of multiple grafts.
- The **cambium** is a layer of dividing cells in a stem that is responsible for increasing the stem diameter. Plants lacking cambium (example: monocots such as corn) cannot be grafted. The cambium of a stock and scion must be in close contact to form a union. Cambial activity during spring facilitates easy separation of bark from the wood.
- **Callus** is a mass of cells produced from the cambium. The newly formed mass of cells grows over the wound and unites the plant parts. Thus, callus plays a crucial role in uniting the stock and scion.
- **Bench grafting** is uniting container-grown or bare-root rootstocks with scion indoors, often on a bench.
- **Sap** is the fluid transported via conductive tissues such as **xylem** and **phloem**. While **xylem** transports water from roots to the aerial parts of the plant,

phloem conducts sugars, nutrients and hormones from the leaves to the roots and storage organs (fruits).

Selecting and Handling Scion Wood

The best quality scion wood usually comes from shoots grown in the previous season. Scions should be severed with sharp, clean knives and placed immediately in moistened plastic bags. It is good practice to clean the cutting tools regularly. This may be done by flaming or immersing them in a sterilizing solution. Ethyl alcohol also works well as a sterilant, although it evaporates quite readily. An alternative sterilizing solution may be prepared by mixing one part household bleach with nine parts water. However, this bleach solution can be highly corrosive to certain metals.

For best results, harvest only as much scion wood as can be used for grafting during the same day. Select only healthy scion wood that is free from insect, disease or physical damage. Be sure the stock plants are of good quality, healthy, and true to type. If large quantities of scion wood must be harvested at one time, follow these steps:

- Cut all scions to a uniform length, keep their basal ends together, and tie them in bundles of known quantity (for example, 50 scions per bundle).
- Label them, recording the cultivar, date of harvest, and location of the stock plant.
- Wrap the base of the bundles in moistened burlap or sphagnum moss. Place them in polyethylene or waterproof paper bags, and seal the bags.
- Store the bundles for short periods, if necessary, either iced down in insulated coolers or in a commercial storage unit at 0o to 1.1oC.
- Never store scions in refrigerated units where fruits or vegetables are currently kept or have been stored recently. Stored fruits and vegetables release ethylene gas, which can cause woody plant buds to abort, making the scions useless.
- The scions should not be frozen during storage.

In grafting, as well as budding, the vascular cambium of the scion or bud must be aligned with the vascular cambium of rootstock. In woody plants the cambium is a very thin ribbon of actively dividing cells located just below the bark. The cambium produces conductive tissue for the actively growing plant. This vascular cambium

initiates callus tissue at the graft and bud unions in addition to stimulating tissue growth on the basal end of many vegetative cuttings before they have rooted.

Procedure:

1. Veneer grafting:

- This method of propagation holds promise for large scale commercial propagation. The method is simple and can be adopted with success.
- Eight months to one year old seedlings are used as rootstocks.
- A downward and inward 3-4 cm long cut is made in the smooth area of the stock at a height of about 20 cm.
- At the base of cut, a small shorter cut is given to intersect the first so as to remove the piece of wood and bark.
- Proper selection and preparation of scion are of utmost importance.
- The scion should be of matching thickness with the stock, preferably a terminal non-flowered shoot of 3 to 4 months maturity.
- Remove the leaf blades from the selected scion shoot on the mother plant keeping the petiole intact, about 7 to 10 days prior to detaching.
- This helps in forcing the buds to swell and in increasing the grafting success.
- The scion stick is given a long slanting cut on one side and a small short cut on the other so as to match the cuts of the rootstock.
- The scion is inserted in the rootstock and the graft union is then tied with polythene strip.
- The rootstock should be clipped in stages when the scion takes and remains green for more than 10 days.
- It is used widely for grafting plants such as Avocado, Mango etc.

2. Epicotyl (Stone) Grafting:

- This method of grafting is done on the epicotyl region of the young seedlings; hence the name epicotyl grafting.
- This method is simple, economical and useful for multiplication of mango plants in large number in a less time.

- Fresh mango stones are sown in the nursery beds.
- Germinated seedlings of 10-15 days old with tender stems and coppery leaves are lifted along with stones.
- The roots and stones are dipped into 0.1 per cent Carbendazim solution for 5 minutes after washing the soil.
- The seedling stems are headed back about 6-8 cm above the stone.

Preparation of scion

The scion is prepared with a long cut along one side

A short cut is given at the base of the scion on the

Steps involved in performing side veneer grafting in mango

- A vertical split (about 3-4.5 cm longitudinal cut) is made into the middle portion of the seedlings.
- A wedge shaped cut is given on the lower side of scion.
- The scions should be 4-5 months old and 10-15 cm long containing plumpy terminal buds.
- The scion is then inserted in the cleft of the seedlings and tied with polythene tape.
- Immediately thereafter, the grafts are planted in polybags filled with the mixture of soil and farmyard manure (1:1).
- The polybags are watered and then kept in the shade protecting from sun and heavy rain.
- The successful grafts should be shifted to open space or may be planted in nursery beds when their leaves become green.
- The most suitable time for stone grafting is July.
- Examples are Cashew, mango etc.

3. Soft wood grafting:

- This method is similar to that of cleft or wedge grafting.
- In the past, this technique has been used for in situ orchard establishment under dry land conditions as the grafting operation is performed using cleft/ wedge method on the newly grown top portion of the plant one year after the establishment of rootstock in the field.
- In this method, 3 to 8 months old seedlings are used as rootstocks.
- The scion shoots of the thickness equal to that of rootstocks are defoliated 7-10 days prior to grafting.
- The graft should be secured firmly using 1.5 cm wide, 150-gauge polythene strip.
- The best time for the success of softwood grafting is July and August.

4. Cleft grafting:

- This method is employed in the nursery when the rootstock is quite thicker than the scion.

- It can be done successfully in the rootstock having a diameter of 3-10 cm. A vertical split (5 cm) is made in the rootstock with a sharp knife.
- The scion should be one year old, about 15-20 cm long and having 3-4 buds above the slanting cuts.
- For preparing the scion, two slanting cuts (5-6 cm) each are given on the opposite sides.
- The scion is inserted into the split of the rootstock in such a way that the cambium of both stock and scion coincides.
- Careful tying is necessary to avoid displacing the scion and separating the cambiums.
- The graft union is then tied with the help of 150 gauge polythene strip.
- Sprouting of scion shoots starts within 3 weeks of grafting.
- The polythene strip is removed after about 6-8 weeks of grafting.
- The sprouts arising below the graft union should be removed periodically.
- The best time for cleft grafting is December- February in temperate fruits.

5. Tongue Grafting

- This method is highly effective and widely employed for the propagation of temperate fruits.
- The diameter of the scion and the rootstock should be equal.
- A flat slanting cut, about 5 cm long is given at the base of the scion so that the lowest bud is about midway along the cut but on the opposite side.
- A downward pointing tongue is made in the upper half of the slanting surface.
- A slanting cut, corresponding in length to that of the scion, is made upwards through the stock 15-20 cm above the ground.
- An upward pointing tongue is made in the upper half of this slanting surface.
- The cut surfaces of the scion and stock are now placed together so that the tongues interlock and the cambial regions are in close contact. This interlocking of tongue gives greater surface for the root stock and scion come into contact with each other to make the strong union.
- Careful tying is necessary to avoid displacing the scion and separating the cambiums.

- The graft union is then tied with the help of 150 gauge polythene strip. Sprouting of scion shoots starts within 3 weeks of grafting.
- The periodical removal of sprouts below the graft union should be carried out.
- The polythene strip is removed after about 6-8 weeks of grafting.
- The best time for tongue grafting is December- February in temperate fruits.
- Examples are apple, pear, peach, plum, apricot, almond, cherry, kiwifruit, pecan nut etc.

Preparation of root stock

Preparation of scion

The top of the stock should be cut off

This split is made by pounding the knife

a vertical split of 5-8 cm down the center of the stock

At the basal end of each scion a smooth long, sloping wedge cuts of 5 cm is made

Placement of scion with proper contact of cambium layer of scion and stock

Scion and stock are firmly tied together with a plastic strip

The scion are inserted in a stub into the vertical split

Steps involved in performing cleft grafting









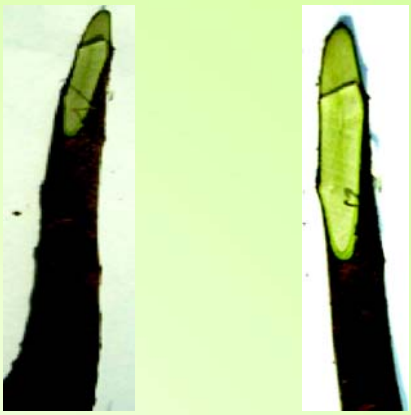


Steps involved in performing wedge grafting in guava

Preparation of rootstocks

Rootstock

Slanting Cut on rootstock



Upward pointing tonque is made in the upper half of this slanting surface

Preparation of scion

Scion stick

Slanting Cut Made on scion

Downward pointing tanque is made in the upper half of the slanting surface

The cut surfaces of the scion and stock are now placed together so that the tongues interlock

Cambial contact

Scion and stock are firmly tied together with a plastic strip

Steps involved in performing Tongue grafting

Exercise 1: Practice and perform veneer grafting and soft wood grafting in mango, tongue and cleft grafting in apple/pear/peach and wedge grafting in guava etc. under the supervision of your resource person.

Exercise 2: Visit any well established private nursery unit/University or Government nursery. Enlist the fruit plants grown and supplied to the public. Discuss with the owner and prepare a list of methods of propagation being used for the multiplication of available fruit plants.

Exercise 3: Enlist the fruit crops grown in your area and their methods of propagation.

EXERCISE 8.4:
PROPAGATION OF HORTICULTURAL PLANTS THROUGH BUDDING

Objective :

- To demonstrate and prepare the various types of budding that can be used to propagate horticultural plants.

Delivery schedule: 01 period

Student expectations/learning objective:

- Basic techniques used in propagating horticultural plants through budding
- To develop skill in the art of budding

Pre-learning required: Knowledge about different types of budding.

Handouts/material required/equipment's & tools : Appropriate plant material; Secateur and grafting/budding knives; Labels and marking pens; Tying material (polythene sheet 150 gauge).

Introduction:

In contrast to grafting, in which the scion consists of a short detached piece of stem tissue with several buds, budding utilizes only one bud and a small section of the bark, with or without wood. Budding is often termed 'bud grafting' since the physiological processes involved are the same as in grafting.

The commonly used budding methods depend upon the bark's "slipping". This term indicates the condition in which the bark can be easily separated from the wood. It denotes the period of year when the plant is in active growth, the cambium cells are actively dividing, and newly formed tissues are easily torn as the bark is lifted from the wood.

In propagating nursery stock of the various fruit and ornamental species by budding, a root stock plant is used. It should have the desired characteristics of vigour, growth resistance to soil born diseases and pests and should be capable of being easily propagated. This root stock plant can be a rooted cutting, a rooted layer, or, more commonly, a seedling.

Procedure

1. T-Budding

This method of budding is known as T-budding (because of T-like appearance of the cut in the stock), as well as shield budding (because of shield like appearance of bud piece when it is ready for insertion in the stock). The procedure for T-budding is as follows:

- Make a vertical cut about 2.5 cm long in the stock.
- Make a horizontal cut through the bark about one-third the distance around the stock. Give the knife a slight twist to open the two flaps of bark.
- Starting about 1.2 cm below the bud, make a slicing cut under and about 2.5 cm beyond the bud.
- Make a horizontal cut about 2 cm above the bud through the bark and into the wood permitting the removal of the bud piece.
- Insert the shield piece by pushing it downward under the two flaps of bark till the horizontal cuts on the shield and the stock are even.
- Tie the bud union tightly with polythene strip but leaving the bud exposed.

2. Inverted T-Budding

- In rainy localities, water running down the stem of the root stock may enter

the T-cut, soak under the bark, and prevent the shield piece from healing into place.

- Under such conditions an inverted T-bud may give better results, since it is more likely to shed excess water.
- In citrus budding, the inverted T-method is widely used, even though the conventional method also gives good results.
- In species that bleed badly during budding, such as chestnuts, the inverted T-bud allows better drainage and better healing.
- In the inverted T-budding method, the incision in the stock has the transverse cut at the "bottom rather than at the top of the vertical cut, and in removing the shield piece from the bud stick the knife starts above the bud and cuts downward below it.

3. Patch Budding

Patch budding is quite successful when the plants are in active phase of growth. It is slower and more difficult to be done than T-budding but it is widely practiced in thick barked species like pecan nut and walnut. The best time to perform patch budding in pecan and walnut is May- June. In this method a rectangular patch of bark is removed completely from the stock and replaced with a patch of bark of the same size containing a bud of the desired cultivar. The procedure is as follows:

- Remove a rectangular patch of bark approximately 2.5 cm x 1.5 cm, with a bud in its centre from the scion by making two parallel horizontal cuts above and below the bud and two vertical cuts connecting the transverse cuts on either side of the bud. Remove the bud patch by sliding it off to one side.
- Then remove a patch of the bark of same size from the smooth place on the stock and then the scion patch is fitted in its place.
- It is more important that the bark piece fits tightly at top and bottom then along the sides. Trim along one side for a tight fit, if necessary.
- Wrap the patch with polythene strip taking care to cover all the cuts but leaving the bud exposed.

Steps involved in performing T-budding in citrus

Preparation of root stock

Top is removed to 2.5 cm above ground just before growth begins

Preparation of scion

Scion bud

A rectangular patch of bark approximately 2.5 cm × 1.5 cm, with a bud in its centre is removed from the scion

The patch of bark containing the scion bud is fitted tightly on the stock

The budded portion is tied tightly with polythene strip leaving the bud naked

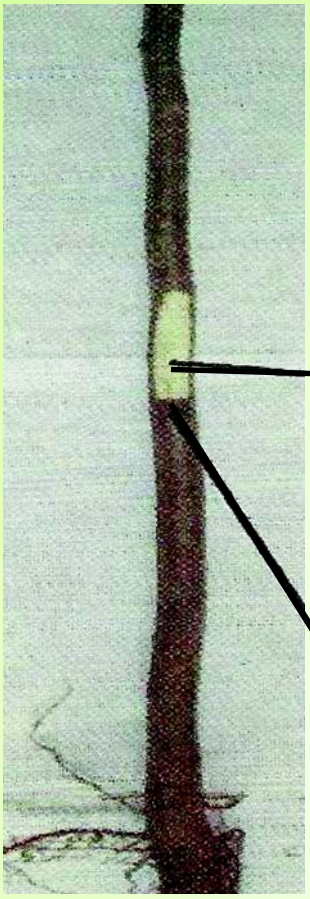
Steps involved in performing patch budding

4. Chip Budding

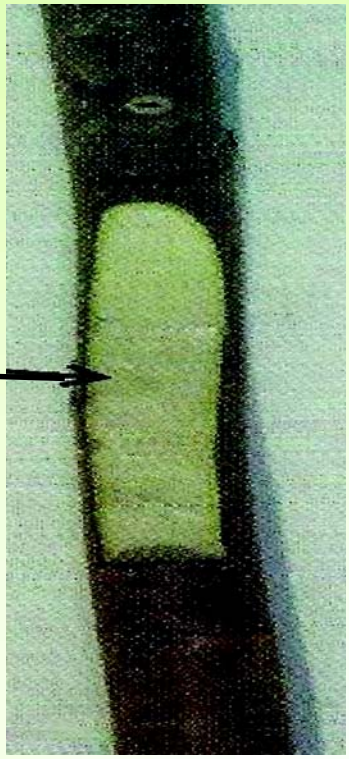
A method which overcomes the problems faced in traditional T-budding is chip budding in which cambium of scion and rootstocks are placed opposite one another and unite quickly in a week following budding. Chip budding can be used at times when bark is not slipping, that is early in the spring before growth starts or during the summer when active growth has stopped prematurely. This is commonly used for the propagation of apple and pear. Chip budding also give good percentage of bud take in walnut when performed during June-July. The procedure is as follows:

- A chip of bark along with wood is removed from the smooth portion between nodes.
- On the bud stick, the first cut is given 0.5 cm below the bud down into the wood at an angle of 30-40° to a depth of approximately one quarter of the rootstock diameter.
- A second cut starts about 2.5 cm above the bud and goes inwards and downwards behind it until meets the first cut.
- The sequence of the cut may be reversed.
- In the rootstock a similar chip is removed in a similar manner.
- The cambium of bud stick and rootstock should be opposite to each other, at least at one side of the union. To obtain a good success, both chips should be cut to the same size and shape.
- The chip is lifted between thumb and knife blade and placed on the rootstock.
- Tying must be done very soon after budding as in case of T- budding.
- The polythene tie over bud should be released after about 3 weeks in summer and a month in autumn.
- In June budding, the rootstock is headed back at about 10 cm above the bud after removal of polythene, whereas in autumn budding the rootstock is only headed back in spring as growth starts.

Preparation of root stock



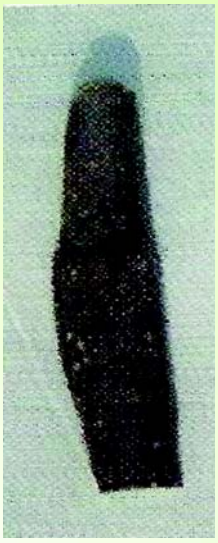
Trim the rootstock to give the clean stem beyond the budding height

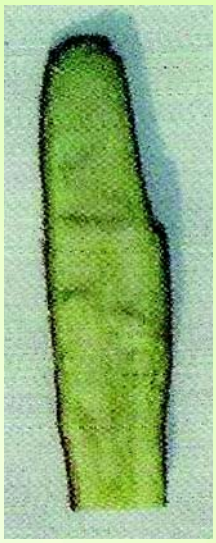


A chip of bank along with wood is removed from the smooth portion between nodes

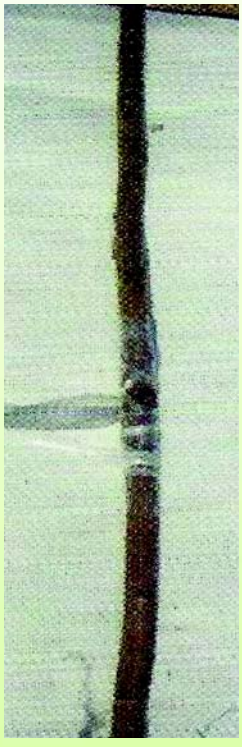
The chip is lifted between thumb and knife blade and fitted tightly on the rootstock

Preparation of scion





Similar size chip of bark along with wood containing bud in its center is removed from the scion stick



The budded portion is tied tightly with polythene strip leaving the bud naked.

Steps involved in performing chip budding

5. Annular Budding

Annular budding gives a very high percentage of bud take in walnut and pecan nut when performed during the month of July.

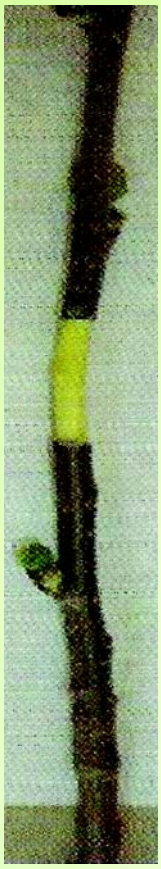
Procedure:

- Remove a complete ring of bark about 3.5 cm wide from the stock by giving two transverse cuts and a vertical cut to connect the two horizontal cuts permitting the ring of bark to be removed.
- Then remove a similar ring of bark containing a healthy bud in the centre from the scion-stick by giving two transverse cuts above and below the bud and a vertical cut through the width of ring opposite to the scion bud.
- Place the ring of bark containing the scion bud on the stock
- Tie the budded portion tightly with polythene strip leaving the bud naked. In order to match the two, both stock and bud stick should be of almost same size otherwise it may be necessary to shorten the circumference of the bud by removing the surplus bark. Similarly, for the removal of rings of bark of identical width from the stock and scion, double/parallel bladed knife should be used.

Exercise 1: Practice and perform T-budding in rose/citrus, patch and annular budding in walnut and chip budding in apple and kiwi.

Exercise 2: Enlist the horticultural crops grown in your area being propagated through various budding methods.

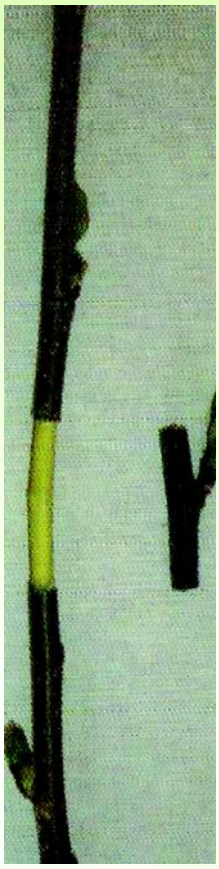
Preparation of root stock



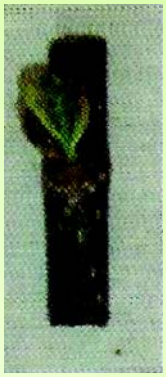
Root stock

A complete ring of bark about 3.5 cm wide is removed from the stock by giving two transverse cuts and a vertical cut to connect the two horizontal cuts

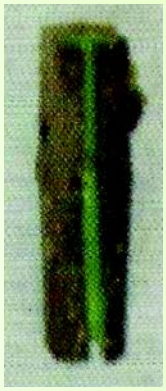
Preparation of scion



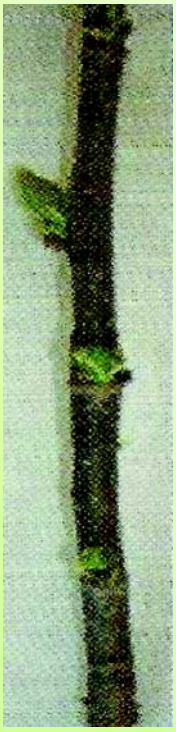
A similar ring containing a healthy bud in the centre, is then removed from the bud stick

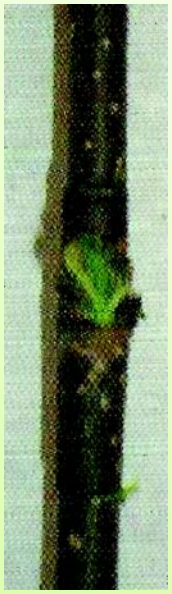


The ring of bark containing the scion bud

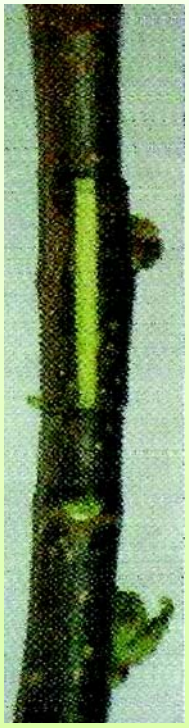


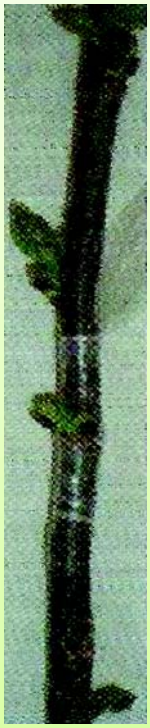
A vertical cut through the width of ring opposite to the scion





The ring of bark containing the scion bud is fitted on the stock





The budded portion is tied tightly with polythene strip leaving the bud naked.

Steps involved in performing annular budding

Practical 9

PREPARATION OF POT FOR PLANTING, CLEANING, MEDIA PREPARATION AND FILLING

EXERCISE 9.1: PREPARATION OF MEDIA FOR GROWING DIFFERENT ORNAMENTAL PLANTS

Objective :

- To understand the steps for preparing ideal growing media for plants growing in pots/ containers

Delivery schedule : 01 period

Student's expectations/ Learning objectives:

- To get acquaint with different constituents of soil based and soil less growing medium
- To understand the procedure for making growing medium in right proportion

Pre-learning required: Knowledge about different media used for growing ornamental plants.

Handouts/material required/equipment's & tools: Soil (Clay/ Loam/ Sandy loam), FYM, Leaf mould, Sand, Peat moss, Perlite, Vermiculite, Lime, Gypsum, inorganic fertilizers, etc.

Introduction:

The ideal growing media is essential for quality seedling, sapling and pot plant production. The constituents of different types of growing media are Bagasse, Bark, Cinders, Clay, FYM, Garbage, Leaf mould, Moss, Peat moss, Perlite, Rice hulls, Sand, Saw dust, Soil, Vermiculite and Wood shavings. The characteristics of any growing medium are given below:

- ❖ Good drainage
- ❖ Proper aeration
- ❖ Proper salinity level

- ❖ Adequate nutrients
- ❖ Good water holding capacity

Procedure:

- Take the different constituents of the growing media and mix them thoroughly in different ratios (by volume). The composition of the growing media in nursery beds/ seed pans/ containers for different type of ornamental plants is given below:
  - Soil (Loam/ sandy loam): Sand: Leaf mould (one part each)
  - Soil (Clay/ Silt): Sand: Leaf mould:: 1: 2: 1
  - Soil (Clay/ Silt): Sand: Leaf mould: FYM:: 1: 1: 1: 1
  - Peat moss: Perlite: Vermiculite (one part each)
  - Peat moss: Sand:: 3: 1
  - Peat moss: Perlite:: 3: 1

Precautions:

- Do not use un-decomposed leaf mould or FYM
- Adjust the soil pH with addition of lime/ gypsum depending upon the plant to be grown

Ideal soil based growing medium (soil: sand: leaf mould: 1:1:1)

EXERCISE 9.2: POTTING, DE-POTTING AND RE-POTTING IN DIFFERENT ORNAMENTAL PLANTS

Objective :

- To recognize the importance of preparing pot for potting and repotting
- To understand the steps for preparing ideal growing media for plants growing in pots/ containers

Delivery schedule : 2 period

Student's expectations/ Learning objectives:

- To get acquaint with different types of pots/ containers used for growing ornamental plants
- To prepare pots for planting of ornamental plants
- To prepare soil based and soil-less growing medium
- To understand the procedure for potting, de-potting and re-potting of ornamental plants

Pre-learning required : Knowledge about potting, de-potting and re-potting of ornamental plants.

Handouts/material required/equipment's & tools: Containers (Pots), crocks (broken pieces of pots), pebbles, coarse sand, growing medium, plant material (seed/ bulb/ seedling/ sapling), secateur, pruning knife, hand trowel, dibbler, Khutti, watering can, fungicide and insecticide

Introduction:

Potting is a process of planting of new seedlings/ saplings of ornamental plants in a pot/ container with a suitable growing medium for its establishment. This requires a skill and a person becomes perfect with experience/ practice and patience. The growing medium in the containers is restricted and it also leads to restricted growth of plants, thus these require repotting. De-potting is the procedure to gently take out the plant from the pot/ container. Repotting is process of again planting the ornamental plant in the same or different container with suitable freshly growing medium after judicious root/ shoot pruning.

Procedure:

Potting:

- Get acquaint with different types of containers (earthen, plastic, concrete, brass, glass, metal, pvc, wooden, etc.) for growing ornamental plants.
- Select the appropriate container and ensure that there is a hole at the bottom for proper drainage of excess water. Otherwise, gently make the hole at the bottom of pot.
- Wash the container both from inside and outside with clean water
- Place 2-3 crocks on the drainage hole in such a way that it does not block the hole at a later stage
- Put smaller pieces of crocks on side and then put 2-3 cm thick layer of coarse sand or dry leaves
- Fill the pots with suitable growing medium and when the containers are half way filled then press the growing medium firmly and again fill upto the rim of the container, press the medium and ensure that 2-3 cm unfilled space is left for watering in the container
- Use above filled container for sowing of seeds or planting of bulbs or planting of seedlings/ saplings of ornamental plants
- With the hand trowel scoop out a hole in the centre of the pot and plant the seedling/ sapling in such a way that its roots are well spread in the container
- Put growing medium all around and press firmly so that no air pocket s are left.
- Do adequate watering
- Keep the container in a cool shady place

Repotting:

- Thoroughly do watering in the container in which repotting is to be done about 2-3 days prior to repotting
- Hold the ornamental plant with right hand between fingers and put the thumb alongside the container

- Turn the container upside down and tap the edge gently on the ground until the ball of the growing medium along with roots comes out
- Do adequate roots and shoots pruning before planting in the container
- Clean/ wash the container from inside/ outside and fill the container with fresh growing medium
- Do planting of the prepared plant after scooping out the growing medium as described in potting of the plant as above
- Do adequate watering and place the container at a cool and shady place for few days

Precautions:

1. Ensure for drainage hole at the bottom of the container
2. Clean/ wash the container
3. Use clean crocks, pebbles and sand
4. Use suitable growing media for different plant species
5. Moisten the growing medium before filling the container
6. Fill the growing medium firmly
7. Keep adequate space for watering
8. Use optimum size container depending upon the growth of the plant to be planted
9. Do potting/ repotting in a cool- shady place and keep them there until establishment
10. After establishing remove the plant from shady area and keep under optimum growing condition depending upon the requirement of different ornamental species

Observations:

S. No.	Name of the plant	Type of container	Size Height and Top diameter	Growing medium type	Remarks
1					
2					

Practical 10

EXERCISE 10.1: IDENTIFICATION OF DIFFERENT FERTILIZERS

Objective :

- To impart knowledge to identify different fertilizers used in horticultural crops

Delivery schedule : 02 period

Student expectations/learning objective:

- The characteristic features of different fertilizers for their easy identification

Pre-learning required: Importance of fertilizers in horticultural crops

Handouts/material required/equipments & tools: Paper sheet and pen to note down the instructions, samples of different fertilizers, petri dishes.

Introduction

Any natural or manufactured material, dry or liquid which is added to the soil in order to supply one or more plant nutrients other than lime or gypsum is known as fertilizer. These are industrially manufactured chemicals containing higher nutrient contents in comparison to organic manures and are in soluble form. In India, five types of fertilizers are generally used in crop production.

1. Nitrogenous fertilizers
2. Phosphatic fertilizers
3. Potassic fertilizers
4. Complex fertilizers
5. Mixed fertilizers

Table 2: Characteristic features of important fertilizers.

Fertilizer	Nutrient composition	Characteristic features
Nitrogenous fertilizers: They supply nitrogen.		
Calcium Ammonium Nitrate (CAN)	25% N	It is available in granular form and brown or light grey or white in colour
Urea	46% N	It is white, crystalline organic chemical and soluble in water.
Ammonium sulphate	20.6 % N	It is white to yellowish grey in colour
Calcium nitrate	15% N	It is in prilled form
Phosphatic fertilizers: They contain phosphorus in absorbable form		
Single superphosphate	16% P_2O_5	Ash coloured powder like material or granular grey coloured material
Potassic fertilizers: They supply potassium to the plants.		
Muriate of Potash	60% K_2O	Reddish or dirty white crystalline material
Potassium sulphate	48% K_2O	Dirty white powdery material
Compound fertilizers		
Ammonium phosphate	20: 20	Granulated fertilizer
Mixed fertilizers		
NPK (12:32:16)		Granular in form and brown or ash coloured.

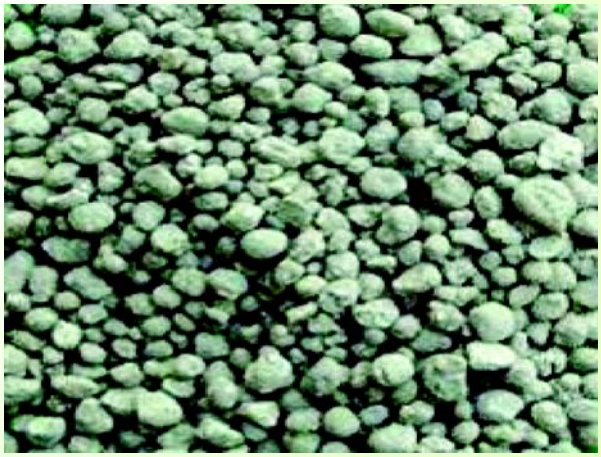
Urea

Calcium ammonium nitrate (CAN)

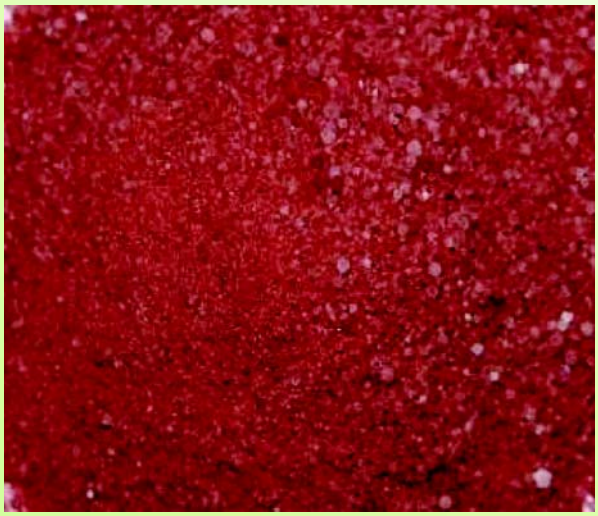
Urea, single super phosphate and muriate of potash are important chemical fertilizer used in horticultural crops. Nutrients are lost from the soil through leaching, runoff, volatilization, fixation by soil or consumption by weeds *etc*.

Ammonium nitrate

Magnesium potassium sulphate



Single super phosphate (SSP)



Muriate of potash (MOP)

Exercise: Identify the given sample of fertilizers and record your observations in the data sheet.

Handouts/material required/equipments & tools: Data sheet and pen to note down the observations, samples of fertilizers, petri dishes, beaker

Procedure/methodology:

1. Spread the fertilizer sample on a piece of paper or in a petri dish. Note its colour. The colour may range from snow white to dark grey.
2. Note the texture of the fertilizer which may varies from powder to globular granules. Some fertilizers have crystalline texture.
3. Observe the hygroscopicity of fertilizer material. Hygroscopicity refers to the absorbance of water vapours from the atmosphere. The hygroscopic fertilizers material usually form small to big lumps while non-hygroscopic fertilizer materials maintain their original texture and do not form any lumps.
4. Test the material for its solubility in water. Put a pinch of fertilizer in a beaker containing water. Stir it and carefully observe whether the fertilizer forms a solution or suspension over a time span of 5-15 minutes. Hygroscopic fertilizers quickly dissolve in water while others take a long time. Some may not dissolve at all and remain suspended in water.

Data sheet

Sample number	Name of fertilizer	Type of fertilizer	Nutrient contents	Specific identifying feature		
				Texture (granular/ crystalline/ powder)	Colour	other
1						
2						
3						
4						
5						
6						
7						

PRECAUTIONS

- Identify each sample separately to avoid confusion.
- Avoid tasting of the samples.
- Handle the fertilisers carefully.

Practical 11

IDENTIFICATION OF ORGANIC MANURES

EXERCISE 11.1: IDENTIFICATION OF ORGANIC MANURES-FARM YARD MANURE, VERMICOMPOST, CAKES, BONEMEAL

Objective :

- To impart knowledge to identify organic manures and bio-fertilizers used in horticultural crops.

Delivery schedule : 02 sessions

Student expectations/learning objective:

- The characteristic features of organic manures for their easy identification

Pre-learning required: Importance of organic manures in horticultural crops.

Handouts/material required/equipments & tools: Paper sheet and pen to note down the instructions, samples of different organic manures, petri dishes.

Introduction

Organic manures are plant and animal wastes that are used as nutrients after decomposition. Manures are complex compounds from plant, animals, and human residues that are used by plants as source of nutrient. Manures are low in nutrient content and have longer residual effect. Nutrients from manures are released only after decomposition of manure by micro organisms. Organic manures and leguminous green manures are most valuable from crop nutrition point of view. In addition, farmyard manure, crop residues and composts are most important from utilization and organic recycling point of view. Organic resources reduce the mining of soil nutrients and improve physical property of the soil by improving soil tilth, aeration, water-holding capacity and activity of microorganisms. Manures are classified into two groups depending upon nutrient content they contain e.g.

I. Bulky manures: Farmyard manure, compost, vermicompost, Sewage and sludges

II. Concentrated manures: Oil cakes, Blood meal, Meat meal, Fish meal

I. Bulky Manures

Farmyard manure

1. **Farmyard manure (FYM):** It is blackish brown in colour, moist and sticky. It carries foul smell. The decomposed mixture of dung and urine of farm animals along with litter and left over materials from roughages or fodder fed to cattle is farmyard manure.

2. **Compost** is mass of rotted organic matter made from farm waste. Composting is a process in which both aerobic and anaerobic micro-organisms decompose organic matter under medium to high temperature and low carbon-nitrogen ratio of refuse.

Vermicompost

3. **Vermicompost:** It is granular, non-sticky and blackish brown in colour. It does not carry any smell. The compost is prepared with the help of earthworms. It is a rich mixture of major and minor plant nutrients. It also increases total microbial population on plant root system and thus improves soil fertility.

Concentrated organic manures

Oil cakes: Oil cakes can be grouped into edible oil cakes which are suitable for cattle feeding and non-edible oil cakes which are unfit for cattle consumption.

Blood meal: An adult cattle gives about 13.6 kg blood meal and goat or sheep about 1.36kg. It is effective for all horticultural crops and all types of soils.

Meat meal: The meat is converted into meat meal. It is quick acting and suitable for all types of horticultural crops and soils.

Fish meal: Non-edible fish carcasses and fish offal are used to prepare fish meal. These are crushed and powdered before use.

Bone meals: Bone meals have been used as manures for time immemorial. Bone meals are of two kinds (i) Raw bone meal and (ii) Steamed bone meal. Raw bone meal

contains about 25% P_2O_5 and 4% N which is in the slow acting organic form. Steam bone meal contains 25-30% total phosphorus(P_2O_5) and about 1-2% N. It contains about 25% citrate soluble phosphorus (P_2O_5). Steam bone meal is applied to soil few days before sowing of crop.

Basic slag: It is a by product of the steel industry where the original iron ores contain appreciable amounts of phosphorus. It is a grayish black powder with a very high specific gravity. It contains 8-12% P_2O_5.

OIL-CAKES

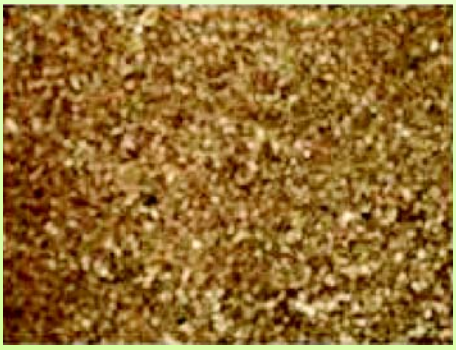
Jatropha oil cakes

Pongamia oil cakes

Cottonseed oil cakes

ANIMAL BASED CONCENTRATED ORGANIC MANURES

Horn and Hoof meal



Raw bone meal

Crushed bone meal

Sources of manures: The various sources of manures are as follows:

1. Cattle shed wastes- dung, urine and slurry from biogas plants
2. Human habitation wastes- night soil, human urine, town refuse, sewage, sludge and silage
3. Poultry Jitter, droppings of sheep and goat
4. Slaughterhouse wastes such as bone meal, meat meal, blood meal, horn and hoof meal, Fish wastes
5. Byproducts of agro industries like oil cakes, biogases and press mud, fruit and vegetable processing wastes etc.
6. Crop wastes namely, sugarcane trash, stubbles and other related material
7. Water hyacinth, weeds and tank silt, and
8. Green manure crops and green leaf manuring material

Exercise : Identify different organic manures and record your observation in the data sheet

i) Bulky organic manure

   a. Farmyard manure

   b. Vermicompost

ii) Concentrated organic manures

   a. Oil cakes

   b. Fish meal

   c. Bone meal

   d. Blood meal etc.

PRECAUTIONS

- Identify each sample separately to avoid confusion.
- Avoid tasting of the samples.
- Handle the manures carefully.

Data sheet

Sample number	Name of organic manure	Origin	Specific identifying feature
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Practical 12

PREPARATION OF MODEL OF A LOW COST STORAGE STRUCTURE FOR HORTICULTURAL PRODUCE

EXERCISE 12.1: Preparation of Model of Zero Energy Cool Chamber for Storage of Fruits and Vegetables.

Objective :

- To acquaint with the principle and working of Zero Energy cool chamber for storage of fruits and vegetables.
- To prepare model of low cost storage structure for horticultural produce.

Delivery schedule : 02 periods

Student expectations/learning objective:

- Studying the principle and working of Zero Energy Cool Chamber for storage of horticultural produce.

Pre-learning required: Knowledge about different storage methods of horticultural produce with particular reference to low cost storage structures.

Handouts/material required/equipment's & tools: Paper sheet and pen to note down the instructions, bricks (400 No.), sand, bamboo, khaskhas/straw, gunny bags, plastic crates etc., with a source of water.

Introduction:

Owing to improper post-harvest operations, especially storage, 30-40% of the fruits and vegetables produced in the country are lost resulting in poor returns to farmers and high cost to consumers. Storage of fresh horticultural produce, being highly perishable, particularly under the tropical climate in India, is a major challenge needing immediate attention. Horticultural produce are living entities and carry out all the vital activities such as respiration and/or transpiration, etc.,

while in storage. The spoilage of these commodities can be controlled to a large extent by maintaining proper storage conditions. In this direction, indigenous low cost storage structures have been developed for the preservation of different horticultural produce. The indigenous low cost methods for storage of horticultural crops are designed to check microbial, enzymatic and oxidative spoilage in the stored/preserved materials. These produces can be stored safely up to a few months without excessive spoilage.

Zero Energy Cool Chamber (ZECC) is based on the principle of direct evaporative cooling system. It is a double brick-wall structure, the cavity is filled with sand and walls of the chamber are soaked in water. It can be constructed easily anywhere with locally available materials like bricks, sand, bamboo, khaskhas/straw, gunny bags, etc., with a source of water. The chamber can keep the temperature 10-15°C cooler than the outside temperature and maintain about 90% relative humidity. It has been found to be very useful. It is most effective during the dry season. It can be easily constructed near the farmer's fields and store a few days' harvest before dispatching it to the market. In this way, the farmers can avoid the clutches of the middlemen and are not forced to make any distress sale. In India, 90% of horticultural produce is sold in fresh form. Owing to the presence of middlemen, the price of horticultural raw material is 60-100% higher in mandis than in growing areas. Apart from farmers' fields, the cool chambers can be installed profitably wherever fruits and vegetables are held temporarily, e.g., (i) packing stations, (ii) village mandis, (iii) whole sale markets in metropolitan cities, (iv) railway stations, (v) interstate bus terminals, (vi) retail outlets, (vii) big hotels and institutional catering centres, (viii) defence establishments in remote places where supplies come once in a week or so, and (ix) fruits and vegetables processing factories.

Some specific advantages of ZECC

- Can be constructed by an unskilled person
- No mechanical or electrical energy needed
- Reduces losses and pays for itself in a short time.
- Useful for temporary storage of curd, milk and cooked food.
- Can also be used for mushroom cultivation, sericulture, storage of bio-fertilizers, hardening of tissue-cultured plants, etc.

The following table gives a comparison of the storage life of different horticultural produce under cool chamber and ambient conditions.

Crop	Part of the year	Cool chamber		Ambient temperatures	
		Days	Weight loss (%)	Days	Weight loss (%)
Mango	June-July	9	5.0	6	14.9
Banana	Oct .-Nov.	20	2.5	14	4.6
Grapefruit	Dec.- March	70	10.2	27	11.9
Sapota	Nov.- Dec.	14	9.5	10	20.9
Lime	Jan.-Feb.	25	6.0	11	25.0
Kinnow	Dec.-Feb.	60	15.3	14	16.0
Potato	March-May	90	7. 7	46	19.1
Tomato	April-May	15	4.4	7	18.6
Amaranth	May-June	3	11.0	<1	49.6
Methi	Feb.-March	10	10.8	3	18.0
Parwal	May-June	5	3. 9	2	32.4
Okra	May-July	6	5.0	1	14.0
Carrot	Feb.-March	12	9.0	5	29.0

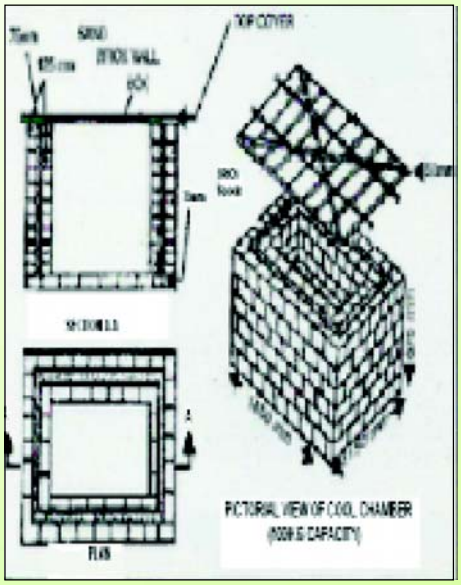
Construction:

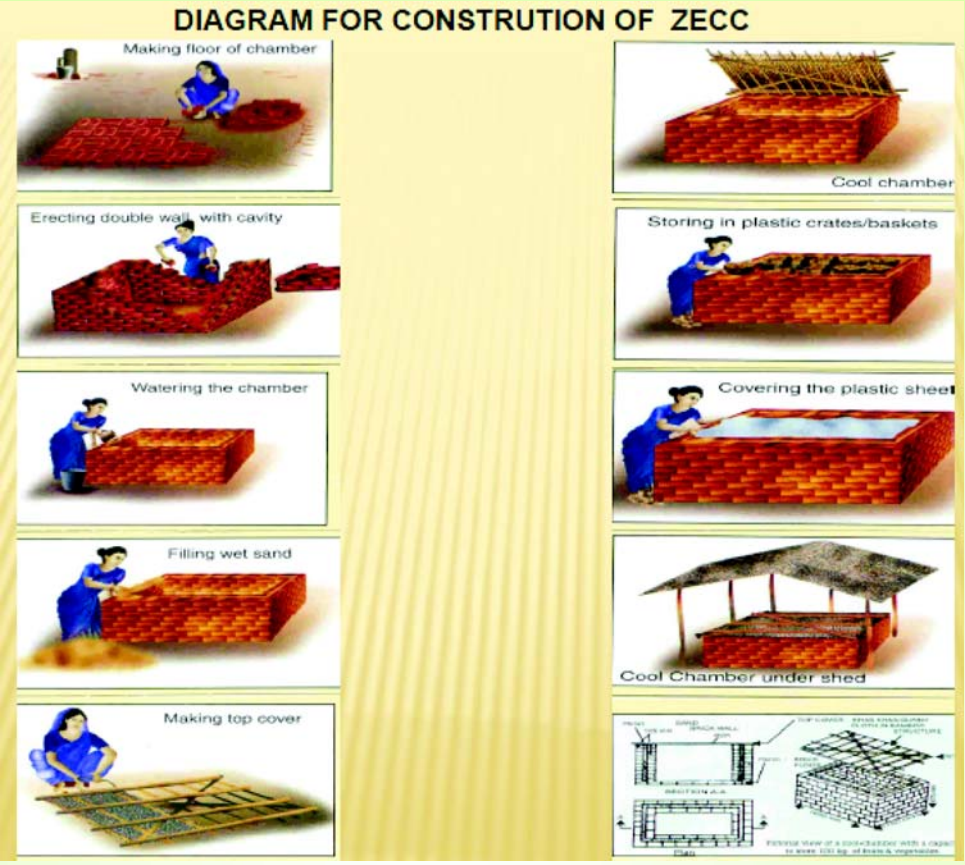
- Select an-upland having a nearby source of water supply.
- Make floor with brick 165 cm x 115 cm..
- Erect the double wall to a height of 67.5 cm leaving a cavity of 7.5 cm.
- Drench the chamber with water. Soak the fine river bed sand with water.

- Fill the 7.5 cm cavity between the double walls with this wet sand.
- Make top cover with bamboo (165 cm x115 cm) frame and 'sirki' straw or dry grass.
- A thatch/tin shed made over chamber to protect from direct sun or rain or snow.

Operation:

- Keep the sand, bricks and top cover of the chamber wet with water.
- Water twice daily (morning and evening) to achieve desired temperature and relative humidity.
- Alternatively fix a drip system for watering with plastic pipes and micro tubes connected to an overhead water source.
- Store the fruits and vegetables in perforated plastic crates.
- Cover crates with thin polyethylene sheet.
- Cool chamber should be reinstalled once in 3 years with new bricks
- Utilize the old bricks for other purposes.





Exercise:

1. Visit any nearby farm where a Zero Energy Cool Chamber has already been constructed and being used for storage of horticultural produce.
2. Prepare a model of Zero Energy Cool Chamber.


BUILDING SKILLS • BUILDING FUTURE •

CENTRAL BOARD OF SECONDARY EDUCATION

Shiksha Kendra, 2, Community Centre, Preet Vihar, Delhi - 110092, India
Tel.: 91-11-22509252-59 Fax : 91-11-22515826
E-mail : cbsedli@nda.vsnl.net.in website : www.cbse.nic.in