Fundamentals of Horticulture

FSC-111

Practical Manual

Yamuna Pandey

S. Vinodh

College of Horticulture

CENTRAL AGRICULTURAL UNIVERSITY

Bermiok, South Sikkim-737134

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The views expressed in the manual are the personal opinion of the contributors.

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FOREWORD

In the recent past, country has witnessed a tremendous growth in Horticulture in terms production, production of an array of food stuffs, value added products, creating new job opportunities for rural youth etc. Acquiring complete understanding of different disciplines of Horticulture viz., fruits, vegetables, flowers, processing and value addition have become an indispensable part of life not only for commercial production but for domestic needs also. Theoretical knowledge cannot be implemented in totality without assimilation and refinement of practical skills. Further, practical exercises provide an opportunity to students and learners to organize different activities in well plan manner by arranging steps that you have identified by sequence and priority. Thus, it helps to improve self-confidence to execute the programme to achieve the targeted goals. The Practical Manual 'Fundamentals of Horticulture' has been prepared according to syllabus of 5th Deans' Committee is a very timely and relevant initiative towards improving practical skills of undergraduate Horticulture students.

I am well confident that exercises described under different units of practical manual of Fundamentals of Horticulture would be of great help not only to the students but also to all those dealing with the field/laboratory exercises in horticulture. I congratulate the authors for their making arduous efforts to knitting the various exercises in a very scientific manner.

(Prpf. Anupam Mishra)

PREFACE

Practical exercises are integral part of course curricula. The syllabus of Fundamental Horticulture has been designed in such a meticulous way that deals basic of all the branches of Horticulture including, pomology, olericulture, floriculture and landscaping etc. Undergraduate students of Horticulture disciplines once going further strengthen their knowledge of different streams; it is utmost necessary to develop practical skills not in laboratory but in field also. Practical manual prepared for this particular course would be immensely useful as it contains all the necessary information in depth, allowing students and beginners to learn from basic. Further, practical exercises in Horticulture discipline are often of great interest because they enable students to apply scientific principles and aesthetic sense enabling them to impregnate with full of inquisitiveness to watch germinating seeds, regenerating propagules, unifying alien tissue masses in budding/grafting, taming the twigs in pruning and training operations so on. Authors are well confident that exercises detailed in the "Practical Manual on Fundamentals of Horticulture" (FSC-111) prescribed as per syllabus of “Fifth Deans’ Committee” would be of immense use to horticulture undergraduate students in their professional careers.

Authors

SYLLABUS

Features of orchard, planning and layout of orchard, tools and implements, identification of various horticultural crops, layout of nutrition garden, preparation of nursery beds for sowing of vegetable seeds, digging of pits for fruit plants, planting systems, training and pruning of orchard trees, preparation of fertilizer mixtures and field application, preparation and application of growth regulators, layout of different irrigation systems, identification and management of nutritional disorder in fruits, assessment of bearing habits, maturity standards, harvesting, grading, packaging and storage.

CERTIFICATE

This is to certify that Mr./Ms …….…….....…….

Reg. No…….……has performed Practical for the semester ……....

B. Sc. (Hons) Agriculture in the Course No…….……

Title……..……

During the academic year……

He/She has performed……. practical out of ……

US ID:……..

Course Teacher

CONTENTS

Exercise No. 1 **Date:**

IDENTIFICATION OF HORTICULTURAL CROPS

Objectives:

1. To introduce plant nomenclature and classification.
2. To become familiar with basic plant morphology.
3. To classify plants based on climatic requirements.
4. To begin to identify plants using morphological characteristics.

Word HORTICULTURE Derived from Latin words a) hortus- garden, b) cultura cultivation "Horticulture is a science and technology of production, processing and merchandising of fruits, vegetables, flowers, spices plantations, medicinal and aromatic plants".

BRANCHES

1. Pomology: It refers to cultivation of fruit crops.
2. Plantation crops: It refers to cultivation of crops like coconut, arecanut, rubber, coffee, tea etc.
3. Olericulture: It refers to cultivation of vegetables.
4. Spices crops: It refers to cultivation of crops like, cardamom, pepper, nutmeg etc.
5. Floriculture: It refers to cultivation of flower crops.
6. Medicinal and aromatic crops: It deals with cultivation of medicinal and aromatic crops.
7. Post-harvest technology: It deals with post-harvest handling, grading, packaging, storage, processing, value addition, marketing etc. of horticulture crops.

Classification of Fruits

Tropical Fruits

Tropical fruits cannot stand even a light frost and are also raised mainly in the tropics. Mango, Bananas Jackfruit, Papaya and pineapples are the best and good known tropical fruits. They are grown throughout the tropics and much of each crop is exported. Other tropical fruits also include Guava, Annona, Breadfruit etc.

Sub-Tropical Fruits

Subtropical fruits need warm or mild temperatures throughout the year, but they can survive in a light frost. The most common subtropical fruits are citrus fruits: oranges, grapefruits, lemons, and limes. Oranges, the leading citrus fruit, are grown from southern

Japan. In the United States, Florida is expert in producing the most oranges. Other subtropical fruits include Litchi, Loquat, dates, figs, olives, pomegranates, and certain types of avocados.

Temperate Fruits

Temperate fruits are largely made up of deciduous fruit trees. When you selecting temperate fruits it's very important to consider their pollination and chill hour requirements. As the coastal region and south east Old have such as a mild climate, care should be taken to choose deciduous fruit trees appropriate for the mild winters. The selected varieties we sell have the lowest chill factor of their groups. The most common and good temperate fruits are apples, peaches, pears, cherries, and plums. In addition, most fruits that grow on the bushes are raised mainly in the temperate Zone.

List of the common fruits for identification

S.N.	COMMON NAME	BOTANICAL NAME	FAMILY
1.	Almond	*Prunus dulcis*	Rosaceae
2.	Aonla	*Phyllanthus emblica*	Phyllanthaceae
3.	Apple	*Malus domestica*	Rosaceae
4.	Avocado	*Persea americana*	Lauraceae
5.	Apricot	*Prunus armeniaca*	Rosaceae
6.	Banana	*Musa paradisiaca*	Musaceae
7.	Bael	*Aegle marmelos*	Rutaceae
8.	Ber (Indian jujubi)	*Ziziphu smauritiana*	Rhamnaceae
9.	Bilimbi	*Averrhoa bilimbi*	Oxalidiaceae
10.	Blueberry	*Vaccinium corymbosum*	Ericaceae
11.	Bread Fruit	*Artocarpus lakoocha*	Moraceae
12.	Cherry	*Prunus avium*	Rosaceae
13.	Chestnut	*Castana sativa*	Fagaceae
14.	Citron	*Citrus medica*	Rutaceae
15.	Cleopatra mandarin	*Citrus reshni*	Rutaceae
16.	Coconut	*Cocos nucifera*	Arecaceae
17.	Common guava	*Psidium guajava*	Myrtaceae
18.	Crab apple	*Mallus baccata*	Rosaceae
19.	Custard apple (Sweet sop/Annona/Sugar apple)	*Annona squamosa*	Annonaceae
20.	Date Palm	*Phoenix dactylifera*	Arecaceae
21.	Dragon fruit	*Hylocereus undutus*	Cactaceae
22.	Durian	*Durio zibethinus L*	Bombaceae
23.	Fig	*Ficus carica*	Moraceae
24.	Gooseberry	*Ribes uva-crispa*	Grossulariaceae
25.	Grapes	*Vitis vinifera*	Vitacea
26.	Grapefruit	*Citrus paradise*	Rutaceae
27.	Guava	*Psidium guajava*	Myrtaceae

S.N.	COMMON NAME	BOTANICAL NAME	FAMILY
28.	Hanuman phal	*Annona cherimola*	Annonaceae
29.	Hazelnut	*Corylus avellana L*	Betulaceae
30.	Jackfruit	*Artocarpus heterophyllus*	moraceae
31.	Jamun	*Syzygium cumini L.*	Myrtaceae
32.	Kiwi fruit	*Actinidia deliciosa*	Actinidiaceae
33.	Karonda	*Carissa carandus L*	Apocyanaceae
34.	Laxmanphal/ sour sop	*Annona muricata*	Annonaceae
35.	Lemon	*Citrus Limon*	Rutaceae
36.	Lime	*Citrus aurantifolia*	Rutaceae
37.	Loquat	*Eriobotrya japonica*	Rosaceae
38.	Lúcuma	*Pouteria lucuma*	Sapotaceae
39.	Lychee	*Litchi chinensis*	Sapindaceae
40.	Mandarin	*Citrus reticulata*	Rutaceae
41.	Mango	*Mangifera indica*	Anacardiaceae
42.	Mangosteen	*Garcinia mangostana L*	Guttiferae
43.	Macadamia Nut/Queens land nut	*Mecademia ternifolia*	*Proteaceae*
44.	Mulberry	*Morus alba, Morus rubra*	Moraceae
45.	Nectarine	*Prunus persica*	Rosaceae
46.	Orange	*Citrus aurantium*	Rutaceae
47.	Papaya	*Carica papaya*	Caricaceae
48.	Passionfruit	*Passiflora edulis*	Passifloraceae
49.	Pear	*Pyrus Communis*	Rosaceae
50.	Peach	*Prunus persica*	Rosaceae
51.	Pecan Nut	*Caryailli noinensis*	Juglandaceaea
52.	Persimmon	*Diospyros kaki*	Ebenaceae
53.	Pineapple	*Ananas comosus*	Bromeliads
54.	Pistachio Nut	*Pistacia vera*	Anacardiaceae
55.	Plum	*Prunus domestica*	Rosaceae
56.	Pomegranate	*Punica granatum*	Punicaceae
57.	Pumello	*Citrus Grandis/C. Maxima*	Rutaceae
58.	Prickly pear	*Opuntia stricta*	Cactaceae
59.	Prunus	*Prunus domestica*	Rosaceae
60.	Quandong	*Santalum acuminatum*	Santalaceae
61.	Quince	*Cydonia oblonga*	Rosaceae
62.	Rangpur lime	*Citrus limonia*	Rutaceae
63.	Rambutan	*Nephelium lappaceum*	Sapindaceae
64.	Ramphal	*Annona riticulata*	Annonaceae
65.	Raspberry	*Rubusidaeo batus*	Rosaceae
66.	Redcurrant	*Ribes rubrum*	Grossulariaceae
67.	Rose apple	*Syzygium jambos*	Myrtaceae
68.	Rough lemon	*Citrus jambhiri*	Rutaceae

S.N.	COMMON NAME	BOTANICAL NAME	FAMILY
69.	Sapota	*Manilkara zapota/ Achras zapota*	Sapotaceae
70.	Star fruit (Carambola)	*Averrhoa carambola*	Oxalidaceae
71.	Sweet Orange	*Citrus sinensis*	Rutaceae
72.	Strawberry	*Fragaria × ananassa*	Rosaceae
73.	Trifoliate orange	*Poncirus trifoliata*	Rutaceae
74.	Walnut	*Juglans regia*	Juglandaceae

Plantation crops

Plantation crops are grown on plantations. Plantations are large farms where crops are grown for profit. There are many different types of plantation crops. Some of the most common plantation crops are sugar cane, cotton, and tobacco.

Plantation crops can be classified into 5 different groups: -

1.	Beverage Crops	Tea, Coffee Coca
2.	Oil Yielding Crops	Coconut, Oil Palm, Palmyra Palm
3.	Nuts	Cashew Nut
4.	Industrial Crop	Rubber
5.	Masticatory Crop	Areca nut

Beverage Crops: The crops which products are used to make beverage other than water.

1) **Oil Yielding Crops:** These crops are used to extract oil.
2) **Nuts:** Nuts are dry single seeded fruits and have high oil content.
3) **Industrial Crops:** The crops which are used to make industrial products rather than consumption.
4) **Masticatory Crops:** Masticatory crops are used for chewing purposes.

List of Plantation Crops

Sl.No.	**Plantation crops**	**Scientific Name**	Family
1.	Coconut	*Cocus nucifera*	Aracaceae
2.	Arecanut	*Areca Catechu*	Aracaceae
3.	Datepalm	*Phoenix dactylifera*	Aracaceae
4.	Oil Palm	*Elaeis guineensis*	Arecaceae
5.	Palmyra Palm	*Borasus flabellifer*	Aracaceae
6.	Tea	*Camellia sinensis L.*	Camelliaceae (Theaceae)
7.	Coffee	*Coffea arabica*	Rubiaceae

		Coffea robusta	
8.	Cocoa	*Theobroma cacao*	Sterculiaceae
9.	Cashew nut	Anacardium occidentale	Anacardiaceae
10.	Rubber	*Hevea brasilensis*	Euphorbiaceae

In India, Plantation Crops are mainly confined to less populated South Indian states like Kerala, Karnataka, Tamil Nadu, Andhra Pradesh and some North Eastern states like Assam, Meghalaya and West Bengal.These crops in India cover the area of 4 million hectares. It occupies 27% of total agricultural commodities and 4.8% of total export. India leads in production of Tea, Cashew, Areca nut, Coconut and Rubber.

Classification and identification of Vegetables

Class: Monocotyledonous		
Family	**Common Name**	**Scientific Name**
Alliaceae	Onion	*Alliaceae Allium cepa*
	Multiplier onion	*Allium cepa var. aggregatum*
	Leek	*Allium porrum*
	Garlic	*Allium sativum*
	Welsh onion	*Allium fistulosum*
	Shallot	*Allium ascalonicum*
	Chive	*Allium schoenoprasum*
Liliaceae	Asparagus	*Asparagus officinalis*
Araceae	Taro	*Colocasia esculenta*
Dioscoreaceae	Lesser yam	*Dioscorea esculenta*
	Greater yam	*Dioscorea rotundata*
	White yam	*Dioscorea alata*
Class: Dicotyledonous		
Aizoaceae	New Zealand spinach	*Tetragonia expansa*
Chenopodiaceae	Beet leaf	*Beta vulgaris var. bengalensis*
	Chard	*Beta vulgaris var. cicla*
	Spinach	*Spinacia oleracea*
	Beetroot	*Beta vulgaris*
Compositae	Lettuce	*Lactuca sativa*
	Chicory	*Cichorum intybus*
	Endive	*Cichorum endivia*
	Artichoke	*Cynara scolymus*
Convolvulaceae	Sweet potato	*Ipomoea batatas*
Brassicaceae	Cabbage	*Brassica oleracea var. capitata*
	Cauliflower	*Brassica oleracea var. botrytis*
	Brussels sprouts	*Brassica oleracea var. gemmifera*
	Broccoli	*Brassica oleracea var. italica*
	Kale	*oleracea var. acephala*
	Kohlrabi or knol-khol	*Brassica napus var. napobrassica rutabaga*
	Turnip	*Brassica campestris var. rapa*
	Chinese cabbage	*Brassica chinensis*
	Radish	*Raphanus sativus*
	Horse radish	*Armoracia rusticana*

Cucurbitaceae	Pumpkin	*Cucurbita moschata*
	Summer squash	*Cucurbita pepo*
	Winter squash	*Cucurbita maxima*
	Watermelon	*Citrullus lanatus*
	Round melon (Tinda)	*Praecitrullus fistulosus*
	Cucumber	*Cucumis sativus*
	Muskmelon	*Cucumis melo*
	West Indian gherkin	*Cucumis anguria*
	Long melon	*Cucumis melo var. flexuosus*
	Ridge gourd	*Luffa acutangula*
	Sponge gourd	*Luffa cylindrica*
	Bottle gourd	*Lagenaria siceraria*
	Bitter gourd	*Momordica charantia*
	Pointed gourd	*Trichosanthesdioica*
	Snake gourd	*Trichosanthesanguina*
	Chow-chow	*Scchium edule*
	Ivy gourd	*Coccania grandis*
Euphorbiaceae	Tapioca or cassava	*Manihot esculenta*
Polygonaceae	Rhubarb	*Rheum rhaponticum*
Leguminosae	French bean	*Phaseolus vulgaris*
	Lima bean	*Phaseolus lunatus*
	Broad bean	*Viciafaba*
	Cowpea	*Vigna unguiculata*
	Southern pea (Asparagus bean)	*Vigna unguiculata var. sesquipedalis*
	Cluster bean	*Cyamopsis tetragonoloba*
	Indian bean	*Dolichos bean*
	Winged bean	*Psophocarpus tetragonolobus*
	Soy bean	*Glycine max*
	Fenugreek	*Trigonellafoenum-graecum*
Malvaceae	Okra or lady's finger	*Abelmoschus esculentus*
Polygonaceae	Rhubarb	*Rheum rhaponticum*
Solanaceae	Potato or Irish potato	*Solanum tuberosum*
	Eggplant or brinjal	*Solanum melongena*
	Tomato	*Solanum lycopersicum*
	Chilli or hot pepper	*Capsicum annuum*
	Bell pepper or sweet pepper	*C. annuum var. grossum*
Apiaceae	Carrot	*Daucus carota*
	Parsley	*Petroselinum crispum*
	Celery	*Apium graveolens*
	Parsnip	*Pastinaca sativa*

Classification and Identification of Spices, Plantation and Aromatic crops

Spice Picture	Description
	**Common Name :** Cardamom (Small) **Botanical Name :** *Elettaria cardamomum* Maton **Family :** Zingiberaceae **Economic part :** Fruit, Seed
	**Common Name :** Cardamom (Large) **Botanical Name :** *Amomum subulatum* Roxb **Family :** Zingiberaceae **Economic part :** Fruit, Seed
	**Common Name :** Black Pepper **Botanical Name :** *Piper nigrum* L. **Family :** Piperaceae **Economic part :** Fruit
	**Common Name :** Bird's Eye (Chilli) **Botanical Name :** *Capsicum frutesence* L. **Family :** Solanaceae **Economic part :** Fruit
	**Common Name :** Capsicum (Chilli) **Botanical Name :** *Capsicum annum* L. **Family :** Solanaceae **Economic part :** Fruit
	**Common Name :** Capsicum (Chilli) **Botanical Name :** *Capsicum annum* L. **Family :** Solanaceae **Economic part :** Fruit
	**Common Name :** Capsicum (Chilli) **Botanical Name :** *Capsicum annum* L. **Family :** Solanaceae **Economic part :** Fruit
	**Common Name :** Ginger **Botanical Name :** *Zingiber officinale Rosc.* **Family :** Zingiberaceae **Economic part :** Rhizome
	**Common Name :** Turmeric **Botanical Name :** *Curcuma longa* L. **Family :** Zingiberaceae **Economic part :** Rhizome

	**Common Name :** Coriander **Botanical Name :** *Coriandrum sativum* L. **Family :** Apiaceae **Economic part :** Leaf & Fruit
	**Common Name :** Cumin **Botanical Name :** *Cuminum cyminum* L. **Family :** Apiaceae **Economic part :** Fruit
	**Common Name :** Fennel **Botanical Name :** *Foeniculum vulgare Mill.* **Family :** Apiaceae **Economic part :** Fruit
	**Common Name :** Fenugreek **Botanical Name :** *Trigonella foenum-graecum* L. **Family :** Fabaceae **Economic part :** Seed
	**Common Name :** Celery **Botanical Name :** *Apium graveolens* L. **Family :** Apiacceae **Economic part :** Leaf, Fruit & Stem
	**Common Name :** Aniseed **Botanical Name :** *Pimpinella anisum* L. **Family :** Apiacceae **Economic part :** Fruit
	**Common Name :** Ajowan **Botanical Name :** *Trachyspermum ammi* L. **Family :** Apiacceae **Economic part :** Fruit
	**Common Name :** Caraway **Botanical Name :** *Carum carvi* L. **Family :** Apiacceae **Economic part :** Fruit
	**Common Name :** Dill **Botanical Name :** *Anethum graveolens* L. **Family :** Apiacceae **Economic part :** Fruit

	**Common Name :** Cinnamon **Botanical Name :** *Cinnamomum zeylanicum* Breyn. **Family :** Lauraceae **Economic part :** Bark
	**Common Name :** Cinnamon **Botanical Name :** *Cinnamomum cassia* Blume **Family :** Lauraceae **Economic part :** Bark
	**Common Name :** Garlic **Botanical Name :** *Allium sativum* L. **Family :** Alliaceae **Economic part :** Bulb (clove)
	**Common Name :** Curry leaf **Botanical Name :** *Murraya koenigii* (L) Sprengel **Family :** Rutaceae **Economic part :** Leaves
	**Common Name :** Kokam **Botanical Name :** *Garcinia indica* Choisy **Family :** Clusiaceae **Economic part :** Rind
	**Common Name :** Mint **Botanical Name :** *Mentha piperita* L **Family :** Lamiaceae **Economic part :** Leaves
	**Common Name :** Saffron **Botanical Name :** *Crocus sativus* L. **Family :** Iridaceae **Economic part :** Stigma
	**Common Name :** Parsely **Botanical Name :** *Petroselinum crispum* Mill. **Family :** Apiaceae **Economic part :** Leaves

	**Common Name :** Vanilla **Botanical Name :** *Vanilla planifolia* Andr. **Family :** Orchidaceae **Economic part :** Pod
	**Common Name :** Tejpat **Botanical Name :** *Cinnamomum tamala* (Buch Ham) Nees & Eberum **Family :** Lauraceae **Economic part :** Bark & Leaves
	**Common Name :** Pepper Long **Botanical Name :** *Piper longum* L **Family :** Piperaceae **Economic part :** Fruits
	**Common Name :** Star Anise **Botanical Name :** *Lllicium verum* Hook **Family :** Llliaceae **Economic part :** Fruits
	**Common Name :** Sweet Flag **Botanical Name :** *Acorus calamus* L. **Family :** Araceae **Economic part :** Rhizome
	**Common Name :** Greater Galanga **Botanical Name :** *Alpinia galanga* Wild **Family :** Zingiberaceae **Economic part :** Rhizome
	**Common Name :** Horse Radish **Botanical Name :** *Armoracia rusticana* Gaerth **Family :** Brassicaceae **Economic part :** Root
	**Common Name :** Caper **Botanical Name :** *Capparis spinosa* L. **Family :** Capparidaceae **Economic part :** Flower buds
	**Common Name :** Clove **Botanical Name :** *Syzygium aromaticum* (L) Merr. & Perry **Family :** Myrtaceae **Economic part :** Unopened Flower buds

	**Common Name :** Asafoetida **Botanical Name :** *Ferulaasa foetida* L **Family :** Apiaceae **Economic part :** Oleogum resin from rhizome and thickened root
	**Common Name :** Camboge **Botanical Name :** *Garcinia cambogia* (Gaertn). Desr **Family :** Clusiaceae **Economic part :** Rind
	**Common Name :** Hyssop **Botanical Name :** *Hyssopus officinalis* L. **Family :** Lamiaceae **Economic part :** Leaf
	**Common Name :** Juniper Berry **Botanical Name :** *Juniperus communis* L. **Family :** Cupressaceae **Economic part :** Berry
	**Common Name :** Bay Leaf **Botanical Name :** *Laurus nobilis* L. **Family :** Lauraceae **Economic part :** Leaf
	**Common Name :** Lovage **Botanical Name :** *Levisticum officinale* Koth **Family :** Apiaceae **Economic part :** Leaf & Stem
	**Common Name :** Marjoram **Botanical Name :** *Marjorana hortensis* Moench. **Family :** Lamiaceae **Economic part :** Leaf
	**Common Name :** Nutmeg **Botanical Name :** *Myristica fragrans* Houtt. **Family :** Myristiaceae **Economic part :** Seed
	**Common Name :** Mace **Botanical Name :** *Myristica fragrans* Houtt. **Family :** Myristiaceae **Economic part :** Aril

	**Common Name :** Basil **Botanical Name :** *Ocimum basilicum* L. **Family :** Lamiaceae **Economic part :** Leaf
	**Common Name :** Poppy seed **Botanical Name :** *Papaver somniferum* L. **Family :** Papaveraceae **Economic part :** Seed
	**Common Name :** All spice **Botanical Name :** *Pimenta dioica* (L) Merr. **Family :** Myrtaceae **Economic part :** Fruit & Leaf
	**Common Name :** Rosemary **Botanical Name :** *Rosmarinus officinalis* L. **Family :** Lamiaceae **Economic part :** Leaf
	**Common Name :** Sage **Botanical Name :** *Salvia officinalis* L. **Family :** Lamiaceae **Economic part :** Leaf
	**Common Name :** Savory **Botanical Name :** *Satureja hortensis* L. **Family :** Lamiaceae **Economic part :** Leaf
	**Common Name :** Thyme **Botanical Name :** *Thymus vulgaris* L. **Family :** Lamiaceae **Economic part :** Leaf
	**Common Name :** Oregano **Botanical Name :** *Origanum vulgare* L. **Family :** Lamiaceae **Economic part :** Leaf
	**Common Name :** Tarragon **Botanical Name :** *Artemisia dracunculus* L. **Family :** Asteraceae **Economic part :** Leaf
	**Common Name :** Tamaring **Botanical Name :** *Tamarinds indica* L. **Family :** Caesalpiniaceae **Economic part :** Fruits

Flowers and their identifications

Flowers	Description	Image
1. Alyssum:	Alyssum is a low growing flower plant that usually blooms white flowers. They branch freely and flowers have the scent of honey. This compact plant looks like a carpet of flowers.	
2. Antirrhinum (Snapdragon):	Antirrhinum has many colourful varieties which are used for pot and bedding culture. It is commonly known as dragon flowers because its flower face looks like a dragon that closes and opens its mouth when laterally squeezed.	
3. Aster:	Aster is an amazing cut flower, comes in many different types, sizes, and colours	
4. Calendula (Pot Marigold):	Calendula flower is a single or double flowering plant. It varies from straw colour to deep orange used for potting, bedding and window boxes.	
5. Clarkia:	This plant is hardy annual, which has slender branches. The Clarkia flower has attractive long spikes and can be grown as a pot plant.	
6. Dianthus: (Sweet William)	Dianthus are colourful flowers with double or single fragrant flowers. The plant flowers at the top of the branches in rounded clusters, best suitable for borders, beds, rock garden and window boxes.	

7. Hollyhock:	Hollyhocks are tall majestic annual flowers borne on the axis of leaves all along the stem length. It can be used as a screen, annual border, background plant or open space shrubbery.	
8. Larkspur:	This plant is a very popular mauve purple, pink, blue cut flower. Larkspur grows well in front or background of a border or tall hedge and pots.	
9. Pansy:	Pansy is a favourite of butterflies. It is available in almost all shades of colours. Their blotched and combination, marked, variegated, stripped in contrasting colours. They grow well under the shade of other tall plants.	
10. Petunia:	Petunias are the loveliest, valuable race and popular garden plants. Their flowers are trumpet-shaped and can be large or small. They are classified into many different types of flowers.	
11. Phlox:	Phlox is the best flower for display. Their bloom lasts for a long period. Its flowers have a delicate scent and are available in a wide variety of colours.	
12. Salvia:	Salvia has lost terminal spikes with tubular bright scarlet flowers. Its flower borne on the foliage and ideal for growing in mass, background, borders, beds, under trees, semi-shaded places and shrubbery.	

13. Sweetpea:	Sweetpea is widely known for its range of flower colours, fragrance, elegant form, and cut flowers. It has earned a reputation as a climber.	
14. Verbena:	Verbena is a low growing, spreading plant and free flowering. Their flowers grow in clusters with light mauve, white & pink colours.	
15. Statice:	The flowers used for decoration and retain shades for a long time when dried and are everlasting.	

Exercise

1 Classify the horticultural crops based on botanical nomenclature.

2. Classify horticultural based on plant morphology.

3. Classify horticultural crops based on type of fruit.

4. Classify horticultural crops based on type of inflorescence.

Exercise No. 2 **Date:**

TO STUDY ABOUT GARDEN TOOLS AND IMPLEMENTS

Major field operations for horticultural crops include nursery/seedling preparation, post hole digging for planting, intercultural operation, aeration, earthing up, irrigation, plant protection, harvesting, handling, packaging transport. The cultivation of horticultural crops is predominantly dependent upon human labour, since commercial cultivation is only on a limited scale. Animal/power tiller or tractor-drawn mould board ploughs, disc ploughs, harrows, cultivators and rotavators, are available and used for land preparation. The fruit plants are generally perennial plants planted in pits. The tractor or power tiller operated pothole diggers are available in the country up to 30 cm diameter. These pits are filled with good soil and manure. Inter-row spaces of the pits can be tilled with power tiller/tractor drawn tillage machinery to destroy the weeds, increase aeration and conserve moisture. Small power tillers can be used in terraced fields.

Description of Some important Horticultural Tools

1. Budding Knife

The budding knife is an important hand tool of a gardener, which consists of a folding blade and a handle. The blade has two edges. One of the edges is sharpened all along its length; whereas the blunt on the other edge is sharpened on the tip and is slightly curved. This sharpened curved portion is used to create a 'T' opening or slot on the bark of the mother branch or twig for the insertion of the bud. The edge sharpened all along its length is used for cutting of scion stick or defoliation of leaves from the scion and slashing of bud from the stick: Some budding knives have a short and round plastic blade at the end of handle called budder, which is used for raising of the bark of the slot for insertion of the bud. The blade when not in use is folded into the handle. The blade is made from high carbon steel, tool steel or alloy steel and hardened to 460-510 HB. The outer part of the handle quality wood is made and the from internal the horn, fittings plastic from brass or fine or aluminium alloy and a spring steel strip is provided to lock the blade in operating position.

For operation the sharp edge of the blade is held against the scion stick and force is applied at an angle, which causes cutting of the stick.

Specifications

The budding knives are available in various sizes according to the length of the blade.

The specifications of a typical budding knife are

Blade length (mm) : 60 Blade width (mm) : 15 at the budding end and 10 mm at the handle

Blade thickness (mm) : 1.5 which is sharpened to the cutting edge

Uses: The budding knife is used for the budding operation, cutting of scion stick, defoliation of leaves and removing or cutting of unwanted thin twigs of the plants.

2.Grafting Knife

The Grafting knife is another important plant propagation hand tool, which resembles a household knife. The principal parts of the knife are blade and the handle. The cutting edge of the blade is sharpened all along its length and the other edge is blunt. The blade of the knife can be folded when not in use. The blade is made from high carbon steel, tool steel of alloy steel and hardened to 460-510 HB. The operation of the knife is similar to that of budding knife and it is mainly used to cut the scion sticks for veneer grafting, cleft and stone grafting and inarching. Defoliation of the leaves of the scion stick, making 'V' groove for grafting and making of chisel point of the scion for insertion in the 'V' groove are the functions performed with the grafting knife. The outer portion of the handle is made from horn, plastic or good quality wood and the inner portion is fitted with aluminum or brass strips and a spring steel strip for locking of the blade in working position.

Specifications

Grafting knives are available in various sizes and are specified by the working length of the blade. The typical specifications of a grafting knife are

Blade length (mm): 60, working Blade width (mm): 11

Blade thickness (mm): 1.5 at the blunt edge and sharpened at cutting edge

Uses: For cutting and defoliation of scion stick, making of chisel point and 'V' grooves for grafting and slashing of thin twigs and for general-purpose cutting.

3. Budding and Grafting Knife

The budding and grafting knife is a multipurpose knife to accomplish both the budding and grafting jobs. It consists two blades each for budding and grafting, which are either joined to a common hinge or are fixed to the ends of the handle. A plastic budder is provided to the other end of the knife in which both the blades are joined to a common hinge or end of the handle. When not in use, both the blades can be folded into the handle. The blades are made from high carbon steel, tool steel or alloy steel and hardened to 460-510 HB. With both the blades it is a versatile knife of the gardener and is extensively used in

orchards, vegetable gardens and plantations for budding and grafting purposes in order to evolve new varieties. The handle of the knife is thicker to accommodate two blades. The outer portion of the blade is made from horn, plastic or good quality wood and the inner part has brass or aluminium strips with spring steel strips for locking of the blade in working position.

Specifications

Blade working length (mm) :	65-75
Blade width (mm) :	15 (budding) and 11 (grafting)
Blade thickness (mm) :	1.5, sharpened to the cutting edge
Handle length (mm):	95-105

Uses: For budding and grafting in vegetables, nurseries and fruit gardens. The knife is also used for cutting of thin unwanted twigs, defoliation of leaves and general cutting works in nurseries and orchards.

4. Pruning Secateurs: Pruning secateurs also known as pruning shears resembles a multipurpose combination pliers used in a workshop. The need of secateurs arose to cut the branches or twigs, which are difficult to cut by pruning knives. Being handy and easy to operate, it is considered to be an essential tool of the gardener in plant propagation. Various types of pruning secateurs are fabricated for removing or cutting of unwanted branches or twigs, cutting of scion sticks, defoliation of leaves from the sticks and topping of small trees. These are single cut, double cut, parrot nose cut, roll cut, base cut, replaceable blade type, easy cut, kiln cut etc. The pruning secateurs consist of two cutting blades or one cutting blade and an anvil, handle, volute spring to keep the blade and handle in open position and a locking device for keeping the secateurs in closed position. The blade is important part of the tool and is made from high carbon steel, tool steel or alloy steel. The blades are forged to shape, ground sharp at the cutting edge and hardened to 460-510 HB. Handles are made from aluminum or mild steel and in some cases a cover of plastic is provided on the arms of the handle. Usually the arms of the handle follow a fixed path during cutting operation but in some secateurs one of the arms of the handle is made rotating type for easy operation. For operation the branch or the twig is held in between the blades and handles pressed together which produces shearing

action and cutting of the material. The secateursis selected according to the operation and size of the twig or branch.

Specifications

The pruning secateurs are known by various names depending upon the shape of blades and are available in various sizes. The size refers to overall length of the secateurs.

Size (mm) : 150, 175,200,225, and 250

Cutting capacity (dia. mm): up to 20

UsesFor cutting of the unwanted branches or twigs of the orchard tree, vines, scion sticks, defoliation etc.

5. Pneumatic Secateurs The pneumatic secateurs, also known as pneumatic pruning shears, are used for pruning vines using pneumatic power. Gripping blade of the shear is stationary and shearing action is imparted by the other blade through the movement of piston. at the end of which it is fixed, with high-pressure air carried I in a portable cylinder. The device offers effortless, accurate and swift cutting, at the same time ensuring the quality of vines. The double acting piston facilitates easy pruning of even large branches. The extension member helps access to branches inside canopy. The cutting head of the shear can be adjusted as needed across 360°.

Specifications

Air pressure required(bars) :	7-15
Length (mm)	260
Extension rod (mm)	600, 1200 and 1500
Weight (g)	685

Uses Pneumatic secateurs are used for pruning vine.

6. Chain Saw

It is also called power saw and is a light and portable machine normally and operated by one person. Cutting is done by an endless chain fitted with cutters, which runs around a flat piece called the bar. The drive links of the chain runs in a groove, machined in the edge of the bar and are pulled along by the teeth of a sprocket, which engage them. The sprocket in turn is driven at full speed either by small two- stroke petrol engine or electric motor. The power to the chain is transmitted through a centrifugal clutch mounted on crankshaft of the engine. The chain is of roller type and has left and right-hand cutters spaced

alternately along its length. In front of each of the cutters is a small projection called a depth gauge whose purpose is to control the depth of cut made by the cutter.

Specifications

Length(mm)	830
Width (mm)	240
Height (mm)	200
Maximum cutting length (mm)	400
Motor power (kW)	1.6
Weight (kg)	3.9

Uses The chain saw is used to trim dead or diseased wood from trees, to remove inconveniently placed branches or fell trees.

7. Hedge Shear

The hedge shear is manually operated hand tool for pruning, trimming and cutting of hedges and shrubs. The tool essentially consists of two blades with tangs. The tangs are inserted in the wooden handle and secured by ferrule. The cutting action takes place between two blades, which are pivoted, and the material t\} be cut is sheared between these blades. The blades are forged to shape and edges are ground to obtain a bevel angle just less than 90 degrees. It is important to maintain the desired cutting while sharpening these blades to obtain clean cut. The blade and tang are made in single piece from high carbon steel, tool steel or alloy steel and hardened to 420-470 HB. The handles are made from high quality wood. For operation the handles are pulled apart to open the blades. The material or hedge twigs to be cut are brought in between these blades and moving the handles inward shears the twigs. This action is repeated fast for trimming of the hedges and shrubs. Some of the models are provided with pruning notch near the pivot of blades for cutting of thick twigs.

Specifications

Blade length (mm) :	150,200,250, and 300
Blade thickness (mm) :	8
Opening angle of blade (O) :	95
Handle angle with blade (O) :	27-30

Uses The hedge shear is used for pruning and trimming of hedge and giving it desired shape. It is also used for cutting of shrubs and removing of haphazard growth in gardens and lawns.

8. Hedge Trimmer

Hedge trimmer consists of a cutter bar having two sets of reciprocating blades. The teeth along the top blade are diamond round and double edged to stay sharp for long. It can cut even branches of up to 16 mm in diameter. The cutter bar is driven either by engine or motor. The unit can be moved in various directions- to the left, right, upwards or downwards. A baffle guard is provided to protect the user from flying leaves, stems or branches. The motor power unit is provided with flexible chord, which permits the movement of the trimmer to all places in the garden. An extra trigger switch is integrated in the handle for quick, error free operation.

Specifications (electric motor model)

Length (mm) :	860
Width (mm) :	145
Height (rom) :	180
Power requirement (W) :	400
Blade length (mm) :	510
Blade strokes (per min) :	3700
Blade gap (mm) :	16
Weight (kg) :	2.4

Uses: Hedge trimmer is used for trimming hedges, shrubs and brambles. It is also used for contouring plants in desired shapes and sizes for enhancing the aesthetics of the garden.

9. Lopping Shear

The lopping shear is manually operated hand tool with long handles for pruning of orchard trees in standing position. It is used for pruning and cutting of the twigs, which are beyond the reach of human hands and cannot be cut with pruning secateurs. The shape of the lopping shear is similar to pruning secateurs or hedge shear depending upon the manufacturers. The shear consists of two shearing blades joined to the sockets to which wooden handles are inserted. The blades are fabricated from high carbon steel, tool steel or alloy steel, forged to shape and the cutting edges are hardened

to 425-450 HB. The sockets are made from mild steel. Both the blades are pivoted at the common point, which allows them to open or close. For operation the handles are pulled apart which open the blades and the branch or twig to be cut is brought in between the blades. The blades are closed to put cutting pressure on the branch, which thus get sheared. Due to long handle thick branches can also be cut with the lopping shear.

Specifications

Blade length (mill)	150-250
Blade thickness (mm)	6-8
Overall length (mm)	800
Cutting capacity (dia. mm)	50

Uses The lopping shear is used for pruning and cutting of branches and twig~ of the orchard trees in standing position, which are beyond the reach, and capacity of pruning secateurs.

10. Crow Bar

The crowbar is a hand tool fabricated from an octagonal bar. One of the ends is pointed and the other is spoon or chiseled shaped. The spoon or chiseled shape end is either forged from the bar or separately made and welded to the end of crow bar. The crow bar is made either from the structural steel or from medium carbon steel. The crow bar ends are forged to shape and hardened to 350-400 HB. For its operation, the tool is held in both hands in vertical position and driven into the soil by impact.

Specifications

	Chisel shaped	**Spoon shaped**
Overall length (mm)	1060	1066
Bar thickness (mm)	22 to25	22 to25
Chisel/ spoon length (mm)	152	190
Chisel/spoon width (mm)	75	100
Weight (kg)	3.6-4.5	3.6-4.5

Uses For digging holes or pits for planting and fencing

11. Tea Pruning Dao

Local Name: Kalam katari Features It is a long blade-cutting knife with a curved tip. The dao blade is made from leaf spring or mild steel flat section by forging operation. The blade made from spring steel is hardened and tempered. A wooden handle is joined to other end of the

blade by riveting. It is a popular tool among tea growers for pruning. It is operated by a pulling action. The curved tip helps in easy pulling and cutting of tea branches.

Specification

Raw materials used	
Blade	Leaf Spring or mild steel flat
Handle	Wood
Dimension of blade (LengthxWidthxThickness (rnrn)	120-150 x 25-35 x3-5
Angle between the blade and handle	180
Dimension of handle Diameter (mm) Length (mm)	20-30 100-120
Weight (kg)	0.20-0.50

Uses*:*Pruning of tea branches.

Exercise

1. Draw the schematic diagram of following tools and implements and also write down the uses:

Sl. No.	**Name of garden tools**		
1.	Axe	**17.**	Rake
2.	Bill hook	**18.**	Sickle
3.	Budding Knife	**19.**	Secateurs
4.	Carpenter Saw	**20.**	Spade
5.	Cultivator	**21.**	Tree pruner
6.	Dibbler	**22.**	Tree caliper
7.	Digging fork	**23.**	Trowel
8.	Fork		
9.	Hand fork		
10.	Hand leveler		
11.	Hedge shear		
12.	Hose pipe		
13.	Khurpi		
14.	Lawn Mower		
15.	Pruning Saw		
16.	Pruning Knife		

Exercise No. 3 **Date:**

ESTABLISHING COMMERCIAL NURSERY

Nursery is a place where planting material, such as seedlings, saplings, cuttings, etc., are raised, propagated and multiplied under favourable conditions for transplanting in prepared beds. The availability of quality and true-to-type planting material is the prerequisite of successful and remunerative ornamental crop production. Setting up of a nursery is a long-term venture, and requires planning and expertise. In a nursery, plants are nurtured by providing them with optimum growing conditions to ensure germination. Nursery saves considerable time for the raising of the next crop. Among flower crops, majority of the annuals are propagated by seeds and require a nursery for raising the seedlings. Herbaceous perennials need nurseries for sowing of seeds and planting of cuttings for rooting and establishment. Woody perennials are grown from seeds for multiplying the rootstocks from cuttings, layers and through grafts to perpetuate the same genetic properties. Nursery is an area, in which new saplings are raised and nourished until they are ready for sale or transplanting at a permanent place in a field.

Importance of Nursery

- It is possible to grow and maintain a large number of plants per unit area.
- Small and expensive hybrid seeds can be raised more effectively due to better care and management.
- When seeds are sown in seedbeds, their germination percentage increases and the vigour of the seedlings also improves.
- The management of seedlings can be done in a better way with minimum care, cost and maintenance as the nursery area is small.
- Manipulation of growing conditions for plants becomes easy.
- Better and uniform crop growth can be obtained in the main field by selecting vigorous and healthy seedlings.
- Off-season sowing of seeds becomes possible, which ultimately results in fetching more returns.
- The seed requirement of nursery raised crops is less as compared to direct seed sowing of the same crop due to better management.
- Sowing seeds in a nursery allows additional time for doing preparatory tillage in the main plot. Harvesting of the previous crop can also be prolonged, if needed.
- Management of insect-pests, diseases and weeds is easy in a nursery.

Nursery Site Selection

Selection of a nursery site should be carried out with proper judgement and consideration, since several important factors, such as the location of the proposed site, soil, climatic factors, topography, economic factors and water supply, have a major effect on its overall success.

The important factors and criteria in the selection of an ideal nursery site are described below.

Topographical of Nursery Site

- The nursery should be located on level or gently sloping ground. However, ground with a slight slope not exceeding 3% is recommended for better surface drainage.
- Areas with slopes greater than 3% should be avoided because of the possibility of soil erosion and the difficulty faced in carrying out ground maintenance. Such areas may also sometimes cause undesirable translocation of soluble fertilizers.
- Furthermore, areas with high water table and those prone to regular seasonal flooding should also be avoided. However, in some cases a nursery is established on a terrain, especially short-term nursery. Terrace is made to ease the arrangement of the seedlings.

Soil

- The nursery site should have fertile top soil which is moderately well-drained and preferably sandy loam. Areas with rocks and large stones are less desirable because such obstacles may impede many operations associated with modern nursery practices.
- The optimum soil pH value for most tropical woody plants is between5.5-7.5. It is therefore desirable that the soil at the nursery should have a pH value within or close to this range.
- The soil and vegetation at the site should be closely examined to determine whether the site is free of insects, fungi and nematodes, or weeds that can damage or kill stock plants later on.

Location & Accessibility

- Locating the nursery near a major road will facilitate the movement of plants to and from the site.
- Located at area not flooded, not exposed to strong winds and with good light exposure.

- Good accessibility is a requirement for a nursery area, so that delivery of nursery materials and transportation of seedlings to the planting sites is easy and safe.

Power Supply

- A nursery site should be accessible to transmitted electricity supply because electric power is needed for Lighting and the operation of nursery equipment, including irrigation pumps, refrigerator and so on. If electricity supply is not available, then diesel-powered generators will have to be used.

Water supply

- nursery site should be close to natural water sources, such as rivers, waterfalls, streams, Lakes, ponds and wells. The water should be clean and free from pollutants and industrial wastes that might be detrimental to plant growth.

All water sources to be used in production must be tested.

Space & Size

- The nursery site should have ample space to accommodate all the nursery requirements.
- A regular four-sided site, preferably a square, is desirable to minimize the Length of the boundary fence.
- An adequate area is also needed for future expansion of the nursery.

Labour

- Even though many of the operations at the nursery can continuously and effectively be carried out using machines, manual workers nevertheless have to be employed to carry out specific jobs. The nursery should not be far away from settlement areas where workers are available.

Design & Lay-Out

A well-designed nursery should have proper roads, fencing, office, potting and transplanting sheds, seed germination and growing areas, water supply, telecommunications, water sprinkler system etc.

Consideration should also be given to the construction of storage facilities for nursery equipment, tools, fertilizers, pesticides and other materials

Roading

- Paths, trails & road system are necessary for the efficient movement of materials & personnel within the nursery.

Infrastructure & Facilities

- Office and store buildings should be located at the entrance of the nursery. However, for a large nursery, the office and store should be in the center of the whole area. In planning, consideration should be given to the construction of a double storey building with sufficient floor space that can be taken up as office space, a proper room with good ventilation to store and dry newly collected seeds prior to sowing, and a separate

Growing beds

- In tropical countries, the growing beds should be laid out in a north-south direction. This direction provides maximum sunlight to all the seedlings.
- The width of the growing bed should normally be 1 m. The spacing between the growing beds should be between 0.5-1.0 m.

Water supply

- The amount of water needed depends on the size of the nursery, kind of soil, species to be raised, and quantity of seedlings & method of watering to be employed.
- For permanent nurseries, it is recommended to install overhead water system (sprinkler) by conducting water to the nursery thru the pipes & distribute it over the seedlings as a fine spray with low pressure system with a pressure of 30 psi or more.
- Adequate water supply and a proper water sprinkler system are extremely essential for a containerized nursery. A pump house should be constructed within the nursery area and near to a water source.
- All water sources to be used in production must be tested.

Exercise

1. Students will be taken to commercial nursery and after visit exercise will be given to describe the important features of nursery.
2. Exercise will be given to students for preparing the layout of model nursery in horticulture farm of the college.

Exercise No. 4 **Date:**

VEGETATIVE / ASEXUAL PROPAGATION, TYPES AND BENEFITS

Vegetative Propagation, also known as vegetative reproduction, is any asexual mode of plant reproduction in which a new plant develops from a cutting, fragment, or other reproductive organs of the parent plant. For example, bud, tuber, corm, etc. are the organ units of plants.

Natural Vegetative propagation

Asexual reproduction in which a part or part of the plant body is separated from the parent plant and produces a new plant in a natural way without any external interference is known as Natural Vegetative propagation.

Rhizomes, stems, bulbs, runners, and tubers are the units of the parent plant from which a new plant grows by natural vegetative propagation.

Natural vegetative reproduction is of the following types:

Vegetative propagation by Roots

The main root and adventitious roots of the plant participate in the Vegetative propagation. The main root of some plants produces adventitious buds, from which new plants grow, eg. Dalbergia (Sheesham), Guava, Albizia, etc. Some new plant grows from the ectopic bud arising from the fleshy root, such as Sweet potato, Tapioca, Dahlia, Asparagus,

Vegetative propagation by stem

Different types of different plants are participating in Vegetative propagation as follows

Aerial stem

The stems of *Opuntia* plants are thick and succulent and form phylloclades. Each segment of such a stem separates from the mother body to give rise to a new plant. Acacia (sugar cane) roots are formed from the plant phases. A new plant will emerge from the plant when the plant is planted in the soil with the adventitious root. Each part of such a stem helps in the creation of a new plant.

Underground stems

There are different kinds of underground stems that are responsible for vegetative propagation as follows.

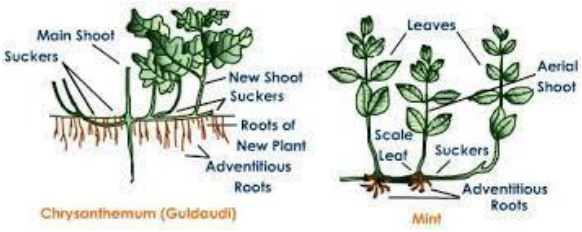
Tuber: A new plant is formed from the bud located in the round potato. If the potato bud is cut and planted in the ground, a new plant is born.

Bulbs: Bulbs of garlic, onion, etc. have small disk-like compressed pods. The stem has one or more buds. New plants grow from these buds

Underground Rhizome

Corms: It is a type of underground stem. Orbital buds are formed in their cyclic phase. From these axillary buds, the shoot is formed. Amorphophallus, Colocasia, etc. are produced from axillary buds.

Rhizome: Rhizome is a type of underground stem. In such trunks the tree stores food for the future. In the tip there are buds and in the bract cells are the orbital buds. New plants grow from these buds. This type of organ growth is seen in plants like ginger, turmeric, banana, etc.



Suckers: From the base of the aerial stem grow a kind of narrow and long underground branch. After this branch grows some distance it separates from the parent body and forms a new trunk. Durbaghas, chandramallikas, are such plants where Vegetative reproduction is found.

Leaves

Some plant leaves leave the parent plant and grow into a new plant. Begonia (Begonia), petioles form axillary buds on the edges of the leaves.

Bulbil

It is a kind of multicellular thick bud called bulbil. Isolated from bulbs (*Dioscorea*), Globba, Agave, etc. The flower buds play a role in vegetative reproduction.

Plant Propagation by cutting

Cutting is a detached vegetative part of a plant, which on separation and planting is able to regenerate the missing parts and develop itself into a new plant. It is an inexpensive and quick method of propagation. A large number of uniform plants can be produced using few parent plants. It does not involve specialised skills. The method is named after the part of plant used for cutting, e.g., stem, root and leaf.

Stem cutting

Based on the age and maturity of shoots detached for vegetative propagation, stem cuttings is of four types.

Hardwood cutting

Such a cutting is taken from woody plants. Mostly, deciduous plants are propagated by this method. One-year old mature branch is cut into pieces of suitable sizes and planted in the rooting medium, e.g., rose, grapes, fig, pomegranate, bougainvillea, *Tabernaemontana, Lagerstroemia*, jasmine, hibiscus, etc.

How to prepare hard wood cuttings

- Select branches of one-year old healthy plants, having pencil thickness. Cut the branches into 10–15 cm long cuttings.
- Long cuttings are used to raise rootstocks for fruit trees. Each cutting must have at least 4–5 dormant vegetative buds. Leaves and thorns, if present, are completely removed. This checks transpiration loss.
- A slanting cut is given at the base of the cuttings just below the node and a straight upper cut is given away from the top bud.
- The cut portion will help identify the planting position. Slanting cut at the base is given so that a large area of the cuttings is in contact with the rooting medium for inducing roots.
- The secretion of hormones at the bud near the cut portion induces rooting. Straight cut at upper end reduces transpiration loss, which can be inhibited by the application of wax.
- The cuttings are planted slant-wise in a nursery bed or small poly bags for growing plants. Callus tissues form the cambium layer and rooting takes place in this region. The best season for planting the cuttings is monsoon for evergreen plants and November–February for deciduous plants. Cuttings can be planted in greenhouse or poly-house for better results.

Semi-hardwood cutting

A semi-hardwood cutting is taken from 4 to 9-month old shoots of current season woody plants. Most ornamental foliage plants like croton, acalyphas, aralias, diffenbachia, russelia, cestrum, nerium, etc., are propagated by semi-hardwood cuttings

How to Prepare Semi-hardwood cuttings

Semi-hardwood cuttings are prepared from branches having pencil thickness. The length of these cuttings varies from 7.5 to 15 cm. The cuttings must have at least 4–5 dormant vegetative buds. Some leaves are retained as they help in preparing food by photosynthesis. Large leaves are reduced in size by cutting. A slant basal cut is given just near the vegetative bud and a straight top cut must be given away from the bud. The slant cut helps to expose more area of the cambium layer, which helps in more water absorption and callus formation. The upper straight cut minimizes exposure to the atmosphere, which reduces transpiration loss from the cuttings. It is useful to dip the top of the cuttings in wax to check transpiration and infections. Dipping the base of the cuttings before planting in IBA @ 5000 ppm induces early rooting. The cuttings are planted in slanting position so that their maximum base is in contact with the rooting medium. The planting season for semi-hardwood cuttings is monsoon. Commercially, such cuttings are rooted under mist spray or fog.

Softwood cutting

Such a cutting is taken from herbaceous or succulent plants. Shoots of 2 to 3-month old plants are selected for softwood cuttings. Examples are alternanthera, coleus, duranta, clerodendrum, etc.

How to Prepare Softwood cuttings

Softwood cuttings are prepared from tender but mature branches. The length of these cuttings varies from 10–12 cm. Tender shoots do not have sufficient food material. Hence, all leaves present on the shoots are retained for photosynthesis. The cutting material are gathered early in the morning and must be kept moist by keeping them in a wet cloth. Sandy loam medium is the best for planting softwood cuttings.

Herbaceous cutting

Such a cutting is taken from herbaceous plants. Shoots of 1- to 2-month-old plants are selected for herbaceous cuttings. Examples are chrysanthemum, iresine, pilea, dahlia, petunia, carnation, marigold, etc.

How to Prepare Herbaceous cuttings

Herbaceous cuttings are made from tender succulents, especially the leafy part of the stems of herbaceous plants. Terminal, measuring 8–12 cm, of a healthy shoot is cut and the basal leaves are removed, leaving the upper leaves undisturbed. The cuttings once detached must not desiccate at the cut and are rooted well under mist. The application of auxins

promotes the regeneration of adventitious roots. Sandy loam medium is the best for planting herbaceous cuttings

Grafting

The method of joining parts of two plants in a manner that they form a unit and function as one plant is known as 'grafting'.

Advantages of grafting

- Plants propagated by grafting are true-to-type, and bear flowers and fruits early.
- The plants can be multiplied and preserved by grafting.
- Local variety of older plants can be improved to superior variety by top working.
- Wounded or damaged tree trunks can be repaired by special grafting methods.
- Rootstock has an influence on resistance, vigour and quality of grafted plants.

Raising of rootstock

Generally, rootstocks are raised by seeds (mango and citrus fruits), or sometimes, by cuttings (rose). Seed**s** are sown or cuttings are planted on raised beds or in poly bags for raising rootstocks. After the germination of seeds or rootings of cuttings, the seedling rootstocks are transplanted in poly bags or nursery beds. Once they reach the stage of growth, they are used as rootstocks for grafting or budding. Sometimes, the rootstocks are not of the same species, e.g., for grapes (*Vitis vinifera*), the rootstock used is a related species *Vitis berlandieri*.

Scion The upper portion of graft combination taken from the desired plant to be multiplied is known as 'scion'.

Characteristics of scion

• Scion wood must be of the previous season but not from more than one-year old plant.

• Flowering shoots or shoots from where the harvesting is recently done must be avoided.

• Healthy and well-developed vegetative buds must be selected.

• The scion or bud sticks must be selected from known performing orchard trees

Selection of scion

• The mother plant must be vigorous, high yielding, true-to-type and free from undesirable bud mutation and viral diseases

• It is advisable to collect scion from grown-up trees.

• It must be preconditioned by defoliating the branch before it is used for budding or grafting. Defoliating helps the buds to swell.

Methods of grafting

Grafting methods can be grouped into the following.

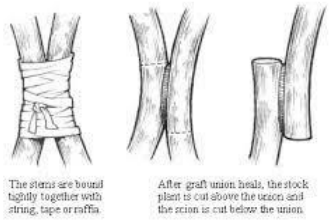
Scion attached method: In this method, the scion shoot is not detached from the mother plant until the union takes place. After the successful union of the scion and rootstock, the scion is separated in gradual cut from the mother plant. For making the grafting handy, the rootstock is grown in a container or polythene bag. This method is followed in plants, in which successful graft unions are difficult to obtain.

'Approach grafting' is a type of scion attached method. It is classified into two types.

• Sliced approach grafting

• Tongue grafting

Approach grafting: Approach grafting is also known as 'inarching'. The main feature of approach grafting is that two independent self-sustaining plants are grafted together. After the successful union of the graft, the scion plant is detached below the graft union from the mother plant and the top of the rootstock plant is removed above the graft. This method is useful for plants, in which successful graft unions are difficult to obtain. This method is, usually, performed for plants growing in a container, as well as, big trees. In the latter case, the rootstock seedling is brought near the scion branch by erecting a platform.

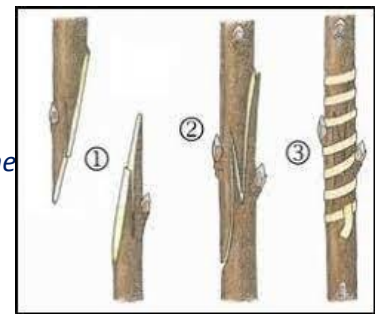


Steps for Approach Grafting

- Bring the selected rootstock and scion close together.
- Find out the most comfortable point of contact.
- At the point of contact, a thin slice of wood along with a 2.5 to 5-cm long bark from the rootstock and the scion is removed.
- The operated size must be uniform on both the stems of the rootstock and the scion.
- The cut surfaces are then brought together so that they cover each other completely by overlapping. Press them firmly together and tie them with a waxed string or polythene tape, so that water does not enter.
- After successful union, head back the rootstock above the union and cut the scion below the union, e.g., mango, guava, sapota, etc.

Tongue grafting

This method differs from the former as cuts are given on both the scion and rootstock.



Steps for Tongue Grafting

- Bring the selected rootstock and scion close together.
- Find out the most comfortable point of contact.
- Remove a slice of wood along with a 2.5 to 5-cm long bark from the rootstock and scion.
- A second slanting partial cut downward on the stock and upward on the scion is made, producing a thin tongue-like structure of the same size on the stem of the stock and the scion.
- Insert the scion in the stock so that these tongue cuts interlock.
- All operated portions must be in contact with each other.
- Tie the operated portions.

Veneer grafting

It is a simple and economical method of grafting. It isthe most ideal method for establishing *in situ* orchards and top working of old unproductive orchards. The best time in north India for veneer grafting is March−April and July−August. Mango, cashew and peach are commercially propagated by this technique. Veneer grafting differs from side grafting. In this, the vertical flap of the stock is completely removed and a slanting cut is given on one side of the scion.

Steps for Veneer Grafting

- A shallow 3 to 5-cm long downward cut is made on the selected rootstock.
- At the base of the first cut, a short inward and downward cut is made that intersects the first cut.
- In between both the cuts, remove the piece of wood along with the bark by making a small notch in the rootstock.
- The scion is operated with a matching long cut on one side and a short cut on the opposite side is given at the base.
- Insert the scion and fix it in the rootstock. Care must be taken to ensure that the cambium layer matches at least one side of the cut surface.
- Wrap and tie the scion and rootstock firmly.
- Cut back the rootstock above the union after successful union.
- This method is used for grafting conifers, deciduous trees and shrubs.

Exercise

1. Students will be asked to differentiate between runners and suckers with suitable examples.
2. Students will be asked to differentiate bulbs and corms with suitable.
3. Students will be asked to differentiate root and tuber with suitable.
4. Students will be asked to prepare the cuttings of fruit crops.
5. Students will be asked to perform Grafting, budding and layering in suitable fruit crops.

Exercise No. 5 **Date:**

PREPARATION AND APPLICATION OF PLANT GROWTH REGULATOR SOLUTIONS FOR SEED GERMINATION AND VEGETATIVE PROPAGATION

Materials Required: Plant growth regulator(s), measuring cylinder, volumetric flask, beaker(s), electronic balance, distilled water.

Procedure:

Preparation of growth regulator solution:

- The strength of growth regulators is calculated in ppm (parts per million).
- One ppm means 1.0mg of chemical dissolved in one litre of water.
- After weighing the required quantity of growth regulator transfer it to a beaker and dissolve it with the small quantity of solvent.
- Auxins are soluble in alcohol or 0.1% NaOH. Gibberellins are soluble in absolute alcohol, while, cytokinins can be dissolved in 1-2 ml N/10 HCl.
- Abscisic acid is highly soluble in NaOH. Shake the beaker till the growth regulator/chemical is fully dissolved. Now transfer it into volumetric flask and make final volume with distilled water to one litre.
- For every use one should prepare fresh solution. Following formula is used for conversion of hormonal strength.

I) Percent solution = ppm 10,000

II) ppm solution = % x 10000 = % x 104

Preparation of hormonal powder:

- For preparation of hormonal powder, the required quantity of hormone is weighed precisely with the help of sensitive balance.
- It is dissolved in ½ litre ethanol, methanol or acetone in a beaker. This material is poured into one kilogram of talc taken in mortar and mixed thoroughly with a glass rod.
- After mixing, the mixture is kept open in air for few hours. The alcohol will evaporate soon, after which, the dried talc is ground to a fine powder.
- This fine powder should be kept in air tight containers to avoid moistening and can be used as and when required.

Preparation of hormonal paste:

- For preparing hormonal pastes, the required quantity of the hormone is weighed accurately and dissolved completely in a few drops of alcohol.
- The required quantity of lanolin (wool fat, a product similar to grease and is greenish-yellow in colour) is weighed and heated slightly in a beaker under gentle flame.
- When the lanolin is slightly liquefied the dissolved hormone is poured in it.
- The mixture is dissolved thoroughly with constant stirring with a glass rod. The mixture is allowed to cool down.

The paste is ready for use. Until use, the paste may be kept for few months in a cool dry place but one should prefer to use fresh paste.

Precaution:

- First of all check the expiry date of the hormone powder.
- The weight should be taken precisely, preferably on electronic balance.
- Proper solvent should be used to avoid precipitation.
- Hormones deteriorate under high temperature, so store in cool and dry place.
- Hormones are photosensitive; therefore they must be stored in dark or amber colored bottles.
- Use hormonal solutions for treatment of cuttings and lanolin paste for layers.
- Solutions should be prepared fresh. If required to store for some time use, refrigerators.
- The treated cuttings should be planted with the help of some stick to make hole, so as to avoid removal of solution from basal end of cutting.

Method of application of growth regulators:

The effectiveness of growth regulators not only depend the concentration, but also on the method of application. Auxins are most effectively and widely used rooting hormone. Among synthetic auxins IBA and NAA are found to be most effective for inducing rooting. The different methods used for treatment of cuttings and layers are as under:

Prolonged soaking method:

- In this method, the basal end of cuttings is dipped in the dilute solution of the hormone for 24 hours in a cool dry place.

- The concentration of hormone or growth regulator usually varies from 20ppm to 200 ppm, depending upon plant species and type of cutting.
- After treatment cuttings are planted in growing medium. The concentration is usually low in growing medium.
- The concentration is usually low for easy to root species and vice versa.
- This method is very useful for difficult to root species, where some materials like vitamins, sugars and nitrogenous compounds are also used along with the growth regulators for facilitating rooting.

Quick dip method:

- In this method, the basal end of cuttings is dipped in the concentrated solution of a hormone for a short time, usually for 5 seconds to 2 minutes depending upon the species to be propagated.
- Treated cuttings are planted in the rooting medium or field. The concentration of hormone for quick dip method may vary from 500 to 10,000 ppm depending upon the type of cutting and species, but generally a concentration of 3000 to 5000 ppm is used.

Powders dip method:

- In this method also basal ends of cuttings are dipped in the hormonal powder which carries (talc) for some time.
- After treatment of cuttings, extra amount of powder adhering to the cuttings should be removed by shaking and cuttings are immediately inserted into the rooting medium.

- For effective rooting, the cut ends of the cuttings should be moistened before the treatment and care should be taken that extra powder adhered to cuttings should be shaken off, otherwise, it may cause adverse effect on the rooting process.
- Seradix, Rootex or many other formulations are available in the market as powders.

Lanolin paste method:

- As described under preparation of hormonal paste, the paste of growth regulators made in lanolin is applied to the girdled portion of a layer or stool for inducing rooting in them.

Spray method:

Spraying of growth regulators is sometimes done to mother plants before taking cuttings from them. Spraying of stock plants with 2,4,5-T in concentrations ranging from 25 to 100 ppm is done about 30 to 40 days before taking cuttings from them, Cuttings taken from such plants root better as compared to untreated plants.

Exercise

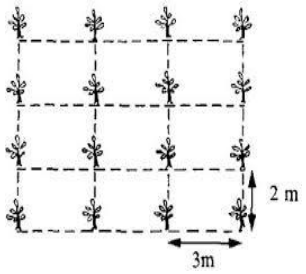
1. Identification of different plant hormones (Auxin, Gibberellins. Ethylene).
2. Exercise on dissolving the hormones in suitable solvents.
3. Preparation of Stock solution and dilution of solution as per the given concentration.
4. Exercise on treatment of cuttings in hormonal solution and rootex.

Exercise No. 6 **Date:**

ORCHARD LAYOUT & SYSTEM OF PLANTING

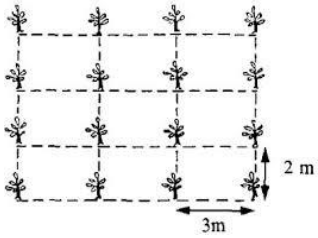
The plan showing the arrangement of plant in an orchard is known as plant layout. Although several systems of planting are followed, but selection of a suitable system, depending on soil, climate, plant type, system of training and pruning is very important. Adoption of improper system results in over lapping of plant parts and competition for water, light, nutrient and unequal distribution of water etc. There are several planting plans or systems which can be adopted for planting an orchard. The different system of planting is as follows:

1. Square system

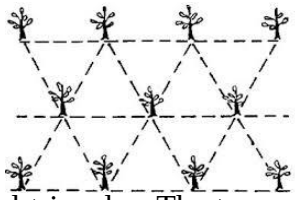


It is the most easy and popular method of planting fruit plants. In this system row to row and plant to plant distances are kept similar. The plants are planted exactly at right angle at each.Thus, every four plants make one square. Intercultural operations can be done in both directions as the distances between trees and rows are similar. Adequate space is there to for inter-cultivation of remunerative crops like vegetables

2.Rectangular system: The field is laid out into rectangular shape plot keeping more space between row and row. The plant to plant distance is kept comparatively less. Thus, rectangular system accommodates more plants in rows. Inter-cultural operations can be carried out through both ways. The plants get proper space and sunlight for their growth and development.



3. Hexagonal system: This system accommodates 15 % more plants than square system. It allows three directionals cultivation in the orchard. In this system, the orchard is laid out similar to rectangular system.

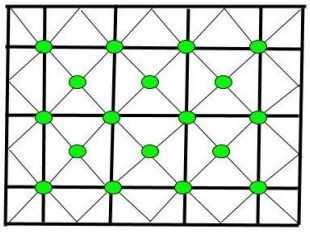


The diagonals of rectangles are intersected to form equilateral triangles. The trees are planted at the vertex of each equilateral triangle. Thus, six trees form hexagon with the seventh tree in the centre. Hence, this system is also called as “septule’ as it accommodates seventh tree in the centre.

The hexagonal system is considered as a grid of contiguous equilateral triangle in which the length of each arm of the triangle is desired tree to tree distance. This is very intense method of planting and hence requires fertile land. In the suburb of cities where land

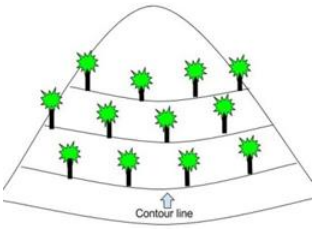
is costly, this system is worth adoption. However, the laying out of system is hard and cumbersome

4. Quincunx system



This system is similar to square system except one additional plant is planted in the centre of each square. The plants that are planted in the centre of each square alongwith tall growing plants at the corners of squares are termed as 'filler' plants. These plants areplanted with a view to generate income when the main orchard plant is under non-bearing stage.

5. Contour system: It is adopted in hilly areas for planting fruit plants where land is undulated and soils erosion is a great threat. Under such circumstances, contour terrace is developed by scratching and leveling the hill-slope. The width of contour terrace varies according to the slope of the hill. At stiff hill slope, the width is kept narrower.



Calculation of Number of Plants in different Systems of Planting

The number of plants that can be accommodated by each of the systems in a unit area should be calculated by the formula shown against each system as under:

1.Square System : A/ L x P

A= Field Area

L= Row to Row spacing

P= Plant to Plant spacing

Example- Area is 10000 sq. metre and planting distance is 10x10 (m) then – Number of Plants = 10000/10x10 = 100 plants

2. Rectangular System : A/ L x P

A= Field Area

L= Row to Row spacing

P= Plant to Plant spacing

Example- Area is 10000 sq. metre and planting distance is 10x 8 (m) then- Number of plants=10,000/10 × 8 = 125 Plants

3.Quincunx System- As the plants are planted additionally in the centre of the square, hence first the number of plants is calculated for square system of planting

which is- No of Plants= Area in square metre/Planting distance in metre square=10,000/10 X 10 = 100 Plants.

Additional plants = (No. of rows length wise - 1) × (No. of rows width wise -1)

In 100 × 100 sq. metre field if planting distance is10 × 10 m. then number of rows length wise and width wise will be 10. Hence, No of additional plants (10-1) × (10-1) = 9 × 9 = 81

Total number of plants = Plants planted in Square system of planting + additionally planted plants in the centre of square ie. 100 + 81 = 181

4.Hexagonal system = Area x 115

Spacing 100

5.Triangular system =__ S_____

D 2x0.8666

S= unit surface

D = Length of the triangle side

Exercise

1. Practical exercise on developing the sketch of various types of planting systems.
2. Field measurement with the measuring tapes and drawing the straight line for layout of planting systems.
3. Mathematical questions for calculating the no. of plants required in given area under different systems of planting.

Exercise No. 7 **Date:**

PREPARATION OF NURSERY BEDS FOR SOWING OF VEGETABLE SEEDS

Advantages of nursery rising in vegetable crops: Production Nursery is a place or an establishment for raising or handling of young seedlings until they are ready for more permanent planting. It is possible to provide favorable growth conditions i.e. germination as well as growth. Better care of younger plants as it is easy to look after nursery in small area against pathogenic infection, pests and weeds. Crop grown by nursery raising is quite early and fetch higher price in the market, so economically more profitable. There is saving of land and labour as main fields will be occupied by the crops after a month. More intensive crop rotations can be followed. More time is available for the preparation of main field because nursery is grown separately. As vegetable seeds are very expensive particularly hybrids, so we can economize the seed by sowing them in the nursery (Reddy, 2020).

Selection of site

- Area selected should be well drained, and free from water logging.
- There should be proper sunlight.
- The nursery should be near the water supply so that irrigation can be easy.
- The area should be well protected from pet and wild animals.

Soil and Soil preparation

Raising of vegetable seedlings requires deep, fertile and healthy soil with good water holding capacity. Preferably, the soil for nursery should be loam to sandy loam, loose and friable, rich in organic matter and well drained. The soil pH should be close to the neutral i.e. about 7.0. It needs a deep cultivation of the nursery land either by soil turning plough or by spade and subsequent 2-3 hoeing with cultivator. After that all the clots, stones and weeds from the field should be removed and land should be leveled. Mix 2 kg well rotten and fine farm yard manure/compost or leaf compost or 500 g vermicompost per square meter and mix in the soil. If the soil is heavy, mix 2-3 kg sand per square meter so that the seed emergence may not be hampered.

Soil treatment:

Soil is treated by following methods:

A. Soil solarization: Soil solarization is an important practice. The suitable time period for soil solarization is May-June as temperature rises up to 45oC at this time. In this process, wet the soil surface with water, or saturate it with water. Then white polythene of 200 gauges is spread on the whole nursery area for about 5-7 weeks. The margin of the polythene should be covered through wet soil (compressed mud) to check the entry of air. After 5-7 weeks the polythene sheet should be removed. Prepare the beds for seed sowing.

B. Biological soil treatment: In this type of soil treatment, apply 10-25 g of trichoderma powder per 100m2 of nursery bed. Application of neem cake and FYM before treatment increases the efficacy. The trichoderma may suppress the growth of the pathogen population in the rhizosphere through competition and thus reduce disease development. It produces antibiotics and toxins such as trichothecin and a sesquiterpine, Trichodermin, which have a direct effect on other organisms. The antagonist (Trichoderma) hyphae either grow along the host hyphae or coil around it and secrete different lytic enzymes such as chitinase, glucanase and pectinase that are involved in the process of mycoparasitism. Examples of such interactions are T. harzianum acting against Fusarium oxyporum, F. roseum, F. solani, Phytophthora colocaciae and Sclerotium rolfsii. In addition, trichoderma enhances yield along with quality of produce, boosts germination rate, increases in shoot & root length, solubilizing various insoluble forms of phosphates augment nitrogen fixing. Promote healthy growth in early stages of crop. Increase dry matter productions substantially provide natural long term immunity to crops and soil.

C. Formalin Solution treatment: This type of soil treatment should be done 15-20 days before seed sowing. Firstly prepare the formalin solution (1.5 to 2%) in one container and drench the soil @ 4-5 liter of water per square meter soil surface to saturate it up to a depth of 15-20 cm then the drench area should be covered with polythene sheet of 200 gauge. Put the wet soil on the margin of the covered polythene sheet so as it does not allow the polythene film blown away by the wind and air from the covered area to outside. 15 days after the cover (polythene) should be removed. Finally prepare the beds for seed sowing. E. Steam treatment: Hot steam can be used to treat the soil against harmful insect pest. For this, cover the required area with the help of polythene sheet and stop the movement of air in the covered area. Supply the hot steam for at least 4-6 hours continuously. This way all the harmful pathogen and insect pest will be killed.

Nursery bed preparation The length of the bed may be kept 3 to 5 meter, however, width is restricted to 1.0 meter only which facilitates intercultural operations. The beds are raised 15 to 20 cm high from the ground level. A space of 30 - 40 cm is left in between two beds. The space between two beds helps in weeding, nursery care against diseases and insect pest and also for draining out the excess rain water from the nursery beds. The number of beds depends on the particular crop, season and growing area of crop. The beds should be prepared in the east and west direction and line should be made from north to south direction on the beds (Tiwari, 2009).

Use of mulch

To maintain the soil moisture for seed germination cover the seed bed with a thin layer of mulch of paddy straw or sugar cane trash, or sarkanda or any organic mulch during hot weather and by plastic mulch (plastic sheet) in cool weather. It has following advantages:

- Maintains the soil moisture and temperature for better seed germination.
- Suppresses the weeds.
- Protects from direct sunlight and raindrops.
- Protects against bird damage.

Removal of mulch: Due attention is given to remove the covered mulch from the seedbed. After three days, 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 net: After seed germination during the seedling growth, if there is very high temperature (> 30o C) then beds should be covered by 50% or 60% shading nets of green/green + black coloured, about 60 - 90 cm above ground by the use of suitable support.

Watering: The first watering should be done just after seed sowing. Thereafter light irrigation should be given with the help of rose can till the seeds get germinated. Excess rainwater or irrigated water should be drained out from the field as and when it is required otherwise plants may die due to excess of water. Watering in the beds depends upon the weather condition. If temperature is high, open irrigation is applied. Need not to irrigate the beds during rainy days.

Optimum temperature ranges for growth of various vegetable transplants: The optimum day and night growing temperature requirements differ for every crop and are listed in table (1.1). Warm-season vegetable crops (tomatoes, peppers, eggplant and cucurbits) are

susceptible to low temperature. Chilling occurs when transplants are exposed to temperatures below 10°C but above freezing point for an extended period. Chilling causes stunting of growth and can have a long lasting effect on field establishment. For susceptible crops, maintain a minimum greenhouse temperature of 10°C. The DIF (difference) Method is a method of managing greenhouse day/night temperatures to control plant height. The DIF is determined by subtracting the night-time from the daytime temperature. A higher day temperature gives a positive DIF and promotes growth while a lower day temperature gives a negative DIF which retards growth.

Optimum temperature ranges for growth of various vegetable transplants

Crops	Growing Temperature in Day (°C)	Growing Temperature in Night (°C)
Tomato	18-21	10-18
Egg plant	18-21	10-18
Sweet pepper	18-21	12-18
Cucurbits	21-24	12-18
Cole crops	12-18	8-15
Onion	16-18	8-15

Thinning: It is an important operation to remove weak, unhealthy, diseased, insect pests damaged and dense plants from the nursery beds keeping distance of about 0.5 to 1.0 cm from plant to plant. The thinning facilitates balance light and air to each and every plant. It also helps in watching the disease and insect pest attack on plants while moving around the nursery.

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/liter of water should be sprayed on the nursery beds after the seed sowing and seed covering with mixture of FYM, soil and sand (Ola and Tewari, 2020)

Plant protection: Adaptation 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 seedlings, leaf curl, leaf blight diseases and leaf miner and borer infect the seedling in the nursery. These insects- pests should be managed timely. Damping off: This is very serious disease of nursery. Pre-emergence death of seeds is seen. In first instance girdling takes place on the stem near base of the stem and seedlings bent down near the ground and die. The causal organisms are Pythium, Phytopthora, Rhizoctonia and Fusarium

fungi. Treat the nursery bed either by soil solarization, formalin solution or Hardening of the plants in the nursery The term hardening includes "Any treatment that makes the tissues firm to withstand unfavourable environment like low temperature, high temperature and hot dry wind "Hardening is physiological process. Plants accumulate more carbohydrates reserves and produce additional quiticle on the leaves. In this process seedlings are given some artificial shocks at least 7-10 days before uprooting and transplanting. These shocks include exposure to the full sunlight, removal of all the shading nets, polythene sheets and irrigation is stopped slowly and slowly. Techniques of hardening: The hardening is done by the following ways withhold the watering to the plant by 4-5 days before transplanting. Lowering the temperature also retards the growth and adds to the hardening processes. Application of 4000 ppm NaCl with irrigation water or by spraying of 2000 ppm of cycocel are also recommended for hardening. Duration and degrees of hardening: It is very necessary that plants should be hardened according to their kind so that there is an assurance of high percentage of survival and slow growth under the condition to be expected at the time of transplanting. Hardening should be gradual to prevent or check the growth. In Indian condition allowing the soil to become dry for 5-6 days does the hardening. Effect of hardening: Hardening improves the quality and modifies the nature of colloids in the plant cell enabling them to resist the loss of water. Hardening increases the presence of dry matter and decreases the percentage of freezable water and transpiration per unit area of leaf. Hardened plants can withstand better against unfavorable weather conditions like hot day winds or low temperature. Hardening of the plants increases the waxy covering on the leaves of cabbage (Tiwari, 2009).

Exercise

1. Exercise on preparation of seed bed for sowing the solanaceous/ brassica vegetables.
2. Measurement of nursery area in proportion to the planting area.
3. Sowing depth and distance between the seeds.
4. Merits and demerits of broadcasting of seeds and line sowing.
5. Exercise on seed treatment and treatment of nursery bed.
6. Exercise on raising the nursery under different structures.
7. Exercise on seed counts and germination percentage.

Exercise No. 8 **Date:**

USE OF AND APPLICATION OF MIXED FERTILIZER AND PRECAUTIONS

Mixed fertilizers

For over hundred years the mixed fertilizers are in use besides straight fertilizers. Many fertilizer mixtures are made available now and this account for a major portion of the consumption of N, P and K. Present day statistics show that numerous grades of fertilizers mixtures are manufactured and the fertilizer mixing industry is being considered as one of the major agro- industry.

The following are some of the common term frequently used in the mixed fertilizer industry.

Fertilizer: The substance which is used for the supply of plant nutrients Mixed fertilizer :

A mixture of more than one straight fertilizer which can supply more than one plant nutrient element

Complete fertilizer: A single fertilizer material containing the entire three major plant nutrients viz, N, P and K.

Fertilizer grade: This refers to the minimum guarantee with regard to the nutrient content of the fertilizer mixture in terms of N, P and K.

Fertilizer formula: This related to the quantitative expression of the analysis of the different ingredients included in the mixed fertilizer in terms of N, P and K.

Fertilizer ratio: This indicates the relative percentage of N, P2O5 and K2O in the manure mixture.

Acidic fertilizer: Fertilizer capable of increasing the acidity of the soil by continued applications.

Basic fertilizer: Fertilizers which increase the pH and the soil on continued use by leaving a basic residue in the soil.

Neutral fertilizer: Materials which are neither increasing nor decreasing the pH of the soil Filler : It is called as the ‘make-weight’ material added to the fertilizer mixtures.

Filler materials are inert materials like sand, saw dust etc, are added to make up the difference between weight of ingredients added to supply the plant nutrients in a tonne and the final weight viz., 1,000 kg.

Advantages of Mixed Fertilizers

All the three major plant nutrients are made available in one and the same material. There is saving of time and labour. The residual effects will not be there. The fertilizer mixtures are usually prepared taking into account the acidic or alkaline nature of the

ingredients, and other chemical reactions. Hence, some of the residual effects like acidity will not be there. Usually mixed fertilizers are prepared to suit a group of crops and soils.

Disadvantages

- Specific needs of crops and deficiency of individual nutrient elements cannot be satisfied by using mixed fertilizers as efficiently as in the case of straight fertilizers.
- The use of mixed fertilizer in such cases of specific needs will be a waste as other nutrients are also added to the soil.
- Unit cost of the various nutrients contained in the mixed fertilizer will always be higher when compared to the unity cost of nutrients contained in the straight fertilizers.
- Improper mixing and storage of fertilizers can result in large nutrient losses.

Some important aspects to consider in fertilizer mixing and storage include the following:

- ✓ Urea should not be mixed with ammonium calcium nitrate (CAN), KCl, SSP or TSP.
- ✓ Urea can be mixed with most other fertilizers but fertilizer mixtures containing urea should be applied immediately after mixing. Do not store fertilizer mixtures containing urea.
- ✓ Ammonium phosphates and super phosphates should not be mixed with lime, slag, rock phosphate or CAN.
- ✓ Potassium chloride and sulfate of potash can be mixed with most fertilizers, but mixtures of these fertilizers with urea and calcium ammonium nitrate should not be stored.
- ✓ CAN should not be mixed with basic slag but can be mixed with urea, single superphosphate, and ammonium phosphates immediately prior to application.
- ✓ Do not store fertilizers in damp or dirty places. Make sure that bags of fertilizer in the store do not absorb moisture from leaky roofs or water seepage through walls and floors.

Preparation of mixed fertilizers

Many kinds of materials are used in the manufacture of fertilizer mixtures. The materials are found to be highly varying in their properties. However, only a limited number of materials are being used like $(NH_4)_2SO_4$, $CO(NH_2)_2$, Super phosphate, ammonium phosphate, muriate of potash, limestone, gypsum and some fillers.

The manufacture of fertilizer mixtures usually involves the weighing and proportioning of ingredients that are used, sieving and sizing of the various ingredients, mixing the different materials and packing. All the above operations are done both mechanically and by hand operation.

Different kinds of machineries are being used.

Guide for mixing

To determine the amount of individual fertilizer in a mixture, the quantity is calculated as follows:

Quantity = (Percentage of plant nutrient desired x (Weight of final mixture) in the mixture)

(The Percentage of the plant nutrient in the straight fertilizer)

$$A = \frac{R \times T}{P}$$

A = P R = Percentage in the mixture

T = Final weight of the mixture

P = Percentage in the straight fertilizer.

To prepare a mixture of 10: 5: 10 using $(NH_4)2_SO_4$, (20% N), Super phosphate (16% P2O5) and muriate of potash (60% K_2O), following quantities will be required per tonne (1,000 kg).

1. Ammonium sulphate =10 x 1000/20 = 500 Kg
2. Super phosphate = 5 x 1000 /16 =312.5 Kg
3. Muriate of potash=10 x 1000/60 =166.5 Kg

Total = 979.0 Kg. Filler = 1000 – 979 = 21 Kg.

If the total calculated weight exceeds the final weight, a mixture of that ratio can not be prepared. Changes that occur while manufacturing mixed fertilizer. The ingredients used in fertilizer mixtures vary widely in their physical and chemical characteristics. When such widely varying materials in physical and chemical properties are mixed together, naturally many changes are expected to take place during or after the mixing. Some changes will be of physical nature and some will be of chemical nature.

Following are the most important physical changes that will take place during or after the mixing of fertilizers.

Hygroscopicity: It is a property of any substance which absorbs from air and gets converted to semi- solid or liquid condition. Fertilizer like Ca $(NO_3)_2$, NH_4NO_3, $NaNO_3$ and $CO(NH_2)_2$ are capable of absorbing moisture from air and become hygroscopic. In such cases handling

will be very difficult for such mixtures. Caking up Moisture present in some of the ingredients is responsible for caking up. Moisture dissolves some of the easily soluble ingredients and forms a saturated solution. This saturated solution on evaporation gives out crystals which knit together forming larger lumps.

The caking up can be prevented by the use of certain kind of materials called as 'conditioners'. The commonly used conditioners are groundnut hulls, lime, clay etc. Another was of preventing the caking up is manufacture of granulated fertilizer mixture. The granulation aims at preparation of uniform sized particles with reasonable stability, which presents caking up.

Segregation: This relates to separation of different sized particles individually. When ingredients of different sizes and densities are included there will be the tendency for the segregation (sorting out to different sizes) to take place. To prevent this bad effect, granulation is conveniently followed. The following are some of the most important chemical changes that take place either during or after the manufacture of fertilizers mixtures. These changes are found to be influenced by temperature, moisture content and particle size of the in gradients.

Double decomposition: The reaction is between two compounds without a common ion in the presence of moisture. New compounds are formed which may have different physical and chemical properties.

(a) $Ca(H_2PO_4)_2 + (NH_4)_2SO_4 \rightarrow CaSO_4 + 2\ NH_4H_2PO_4$

(b) $NH_4NO_3 + KCl \rightarrow NH_4Cl + KNO_3$

(c) $(NH_4)_2SO_4 + 2\ KCl_{\ 2} \rightarrow NH_4Cl + K_2SO4$

(b) Neutralization: This reaction takes place when free acids present in some of the fertilizers are neutralized by alkalis or Ca containing salts included in the mixture.

$H_2PO_4 + NH_3 \rightarrow NH_4\ H_2\ PO_4$

$2H_3\ PO_4 + CaCO_3 \rightarrow Ca\ (H_3\ PO4)_2 + H_2CO_3$

(c) Hydration The process of tying up of water by the anhydrous form of salts is called hydration. Some of the fertilizers are found to have this property.

$CaSO_4 + 2H_2O = CaSO_4\ .2\ H_2O$

$Ca\ HPO_4 + 2H_2\ O = CaHPO_4.\ 2\ H_2O$

(d) Decomposition Under certain conditions of moisture and temperature, there will be break down in the composition of molecules forming new compounds.

$CO(NH_2)_2 + H_2\ O \rightarrow 2\ NH_3 + CO_2$

$(NH_4)_2\ HPO_4 \rightarrow NH_4H_2\ PO_4 + NH_3$

However, the following important principles must be taken into consideration while preparing mixed fertilizers.

1. All fertilizers containing ammonia are not mixed directly with the basic fertilizers (e.g. RP, limestone, basic slag, $CaCN_2$ as reaction will take place resulting in the loss of gaseous NH_3.

2. The water – soluble phosphates are not mixed with those materials which contain free lime (e.g) lime stone, $CaCN_2$ as there will be reaction towards the reversing of water – soluble phosphate to water – insoluble phosphates.

3. Hygroscopic fertilizers are not included as they will facilitate caking up.

4. The acidic fertilizers are likely to produce some free acids which may damage the container or packing materials.

Manufacturing process: The principal steps in the manufacture of solid mixed fertilizers are calculating, weighing, sieving, sizing, mixing the materials and packing the product.

Calculating and weighing: With a good weighing device the calculated quantities of the various ingredients are weighed accurately for preparing mixtures.

(1) Sieving and sizing

If the raw materials have undergone too much of caking in the storage piles, it may be necessary to subject them to preliminary grinding, sieving and sizing. The raw materials must be converted into uniform sized particles to have effective making and to avoid segregation during subsequent handling.

(2) Mixing

Many kinds of fertilizer mixing machines have been proposed and used at present. Rotary drum type is found to be more common than the vertical cylinder type. Weighed quantities of different materials are introduced into the mixer and mixed thoroughly.

(3) Packing

Equipments for packing fertilizer mixture range from the simplest types of hand operated facilities to highly sophisticated automatic machines. Granular mixtures Compared to pulverized or powdered mixture, the advantages of granular mixtures are reduced caking up tendency, less dusting loss and easy handling. Of late, attention is found in the manufacture of only granular mixtures.

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Exercise

1. Identification of single and mixed fertilizer.
2. Developing manually fertilizer mixtures involving different fertilizers.
3. Observations on texture and reaction on fertilizer mixture.
4. Exercise on chemical formula and reaction on fertilizers and their mixtures.

Exercise No. 9 **Date:**

DIFFERENT IRRIGATION SYSTEM

Drip Irrigation

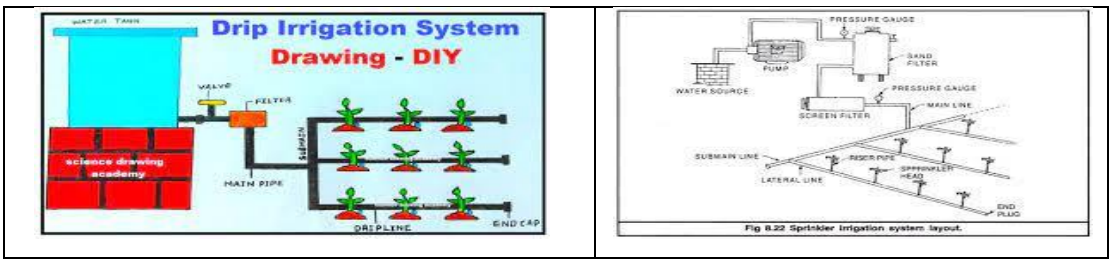
- In drip irrigation, water is applied near the plant root through emitters or drippers, on or below the soil surface, at a low rate varying from 2-20 liters per hour. The soil moisture is kept at an optimum level with frequent irrigations.

Sprinkler Irrigation

- In this method, water is sprayed into the air and allowed to fall on the ground surface somewhat resembling rainfall. The spray is developed by the flow of water under pressure through small orifices or nozzles. The sprinkler irrigation system is a very suitable method for irrigation on uneven lands and on shallow soils.

Nearly all crops are suitable for sprinkler irrigation systems except crops like paddy, jute, etc. The dry crops, vegetables, flowering crops, orchards, plantation crops like tea, coffee are all suitable and can be irrigated through sprinklers.

Furrow Irrigation: Furrow irrigation is a type of surface irrigation in which trenches or "furrows" are dug between crop rows in a field.



Exercise

1.Exercise on developing understanding about different methods irrigation systems describing merits and demerits.

2. Practical exercise through drawing the sketch on paper about drip and sprinkler system of irrigation in different fruit crops.

Exercise No. 10 **Date:**

TRAINING & PRUNING IN FRUITS AND VEGETABLES

A primary objective of training and pruning is to develop a strong tree framework that will support fruit production. Improperly trained fruit trees generally have very upright branch angles, which result in serious limb breakage under a heavy fruit load. This significantly reduces the productivity of the tree and may greatly reduce tree life. Another goal of annual training and pruning is to remove dead, diseased, or broken limbs. Proper tree training also opens up the tree canopy to maximize light penetration. For most deciduous tree fruit, flower buds for the current season's crop are formed the previous summer. Light penetration is essential for flower bud development and optimal fruit set, flavor, and quality. Although a mature tree may be growing in full sun, a very dense canopy may not allow enough light to reach 12 to 18 inches inside the canopy. Opening the tree canopy also permits adequate air movement through the tree, which promotes rapid drying to minimize disease infection and allows thorough pesticide penetration.

Pruning vs. Training

Pruning is the removal of a portion of a tree to correct or maintain tree structure. Training is a relatively new practice in which tree growth is directed into a desired shape and form. Training young fruit trees is essential for proper tree development. It is better to direct tree growth with training than to correct it with pruning.

Time of Pruning

Trees respond very differently to dormant and summer pruning. Dormant pruning is an invigorating process. During the fall, energy is stored primarily in the trunk and root system to support the top portion of the tree. If a large portion of the tree is removed during the winter, while the tree is dormant, the tree's energy reserve is unchanged. In the spring, the tree responds by producing many new vigorous, upright shoots, called water sprouts, which shade the tree and inhibit proper development. Heavy dormant pruning also promotes excessive vegetative vigor, which uses much of the tree's energy, leaving little for fruit growth and development.

Timing of dormant pruning is critical. Pruning should begin as late in the winter as possible to avoid winter injury. Apple and pecan trees should be pruned first, followed by cherry, peach, and plum trees. A good rule to follow is to prune the latest blooming trees first and the earliest blooming last. Another factor to consider is tree age. Within a particular fruit

type, the oldest trees should be pruned first. Younger trees are more prone to winter injury from early pruning.

Pruning for crop Regulation

Pruning in fruit trees play important role in crop regulation also. Recently it has been found very effective in managing the canopy of guava as wel as regulating the fruiting time also. In a humid and high rainfall area like Arunachal Pradesh, crop regulation of guava by using chemicals and growth regulators such as Urea, NAA, etc. are not much effective because the plant do not go into dormancy due to abundant rainfall received in this area which starts from the month of March. Therefore, pruning could prove to be the most effective method for eliminating rainy season crop and production of winter season guava. If the guava tree is left unpruned, they tend to prolong the vegetative growth, reduce the bearing area, thus leading to decrease in fruit size, yield and quality. Hence, to get a good balance between the vegetative and reproductive growth, pruning becomes essential(HauNgaih Lian *et al*., 2019)

Pruning in Vegetable Crops

Currently, practice of pruning is not only limited in fruit crops, it has now been one of the necessary operation in vegetable crops also especially which are grown in protected conditions like indeterminate tomato, capsicum and various cucurbits. Resh (1996) reported that the pruning of peppers cultivated in a greenhouse improves light interception, fruit set and fruit quality due to the reduced number of branches. Jovicich*et al.* (1999) reported higher marketable yields from sweet pepper plants pruned to four stems, compared to those pruned to two or one stem. In general, no or light pruning results in excessive vegetative growth of plants with small fruit size. Bhatt and Rao (1997) indicated that removal of the fruit in the first flowering node of bell pepper plants ten days after fruit set did not increase the partitioning of dry mass to fruit on upper nodes of the plant. With the advancement of fruit growth, the first flowering node fruit acts as a major sink for photosynthates (10.2%) up to 20 days after flowering, and afterwards becomes a weaker sink.

Training

Physical techniques that control the shape, size and direction of plant growth are known as training.

Objectives:

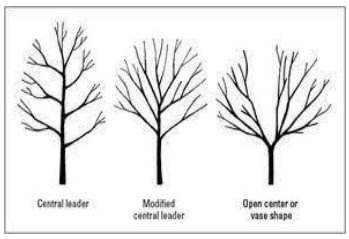
- To improve appearance and usefulness of plant/tree through providing different shapes and securing balanced distribution.
- To ease cultural practices including inter cultivation, plant protection and harvesting.
- To improve performance like planting at an angle of 45° and horizontal orientation of branches make them fruiting better.
- To admit more sunlight and air to the centre of the tree and to expose maximum leaf surface to the sunlight.
- To direct the growth of the tree so that various cultural operations, such as spraying and harvesting are performed at the lowest cost.
- To protect the tree from sunburn and wind damage.
- To secure a balanced distribution of fruit- bearing parts on the main limbs of the plant.

Training Systems

• Central Leader

• Open- Centre

• Modified Leader



Central Leader System

• Main trunk extends from the soil surface to the total height of the tree

• Several side branches grow at different heights in various directions.

Advantages:

- Such trees are structurally best suited to bear crop load and to resist the damage from strong winds.

Disadvantages: – Trees under this system grow too tall and are less spreading.

- Tree management (spraying, pruning, thinning and harvesting) is difficult.
- Shading effect on interior canopy (the lower branches of such trees may be so much in shade that the fruit may not be able to develop proper colour).

Open Centre System

Main trunk is allowed to grow upto 1.0 m by cutting within a year of planting.

• 3-5 lateral branches are allowed to develop from short main stem.

• good for mechanical harvesting.

Advantages:

- The trees so trained allow maximum sunshine to reach their branches.

- Better clouration of fruits on the interior side of the tree.
- Trees are more fruitful and low spreading tree greatly facilitate operations like spraying, pruning, thinning and harvesting.

• **Disadvantages**: –

- Such trees are structurally weak, and their limbs are more likely to break with crop load and strong winds.
- This system does not only need severe pruning to start with but also constant effort to maintain its form through drastic pruning treatment.

Modified Leader System

• This system combines the best qualities of the central leader and open centre systems.

• A leader develops on the young tree until it reaches the height of 2-3 m and then the growth is restricted.

• Laterals are selected to ascent in a spiral fashion up the central trunk and are cut until the proper number and distribution of branches have been obtained.

Advantages:

- The branches are well distributed, allowing plenty of sunshine to reach the interior of the tree.
- The trees is structurally strong and not prone to limb breakage. –
- Owing to limited height of trees, spraying, pruning and harvesting may be done easily.

Bower System

This system is also called overhead, arbour or pergola.

• Owing to vigorous of the vine and pronounced apical dominance in the tropics, this system is found most suitable for many of the commercial grape cultivars.

• Though it is very expensive, it was found most appropriate one and associated with highest yield.

• Bower system of training provides a desirable microclimate in the vine canopy and reduces the adverse effects of arid and hot weather on vine metabolism and life.

Kniffin system

In this system, two trellis of wire are strongly supported by vertical posts. The vines such as grape when trained in this system has four canes one along

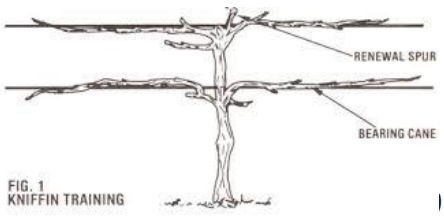


FIG. 1
KNIFFIN TRAINING

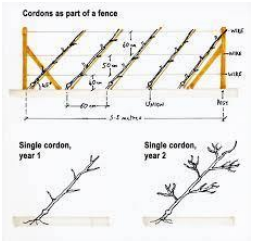
each wire and the bearing shoot hangs freely with no tying being necessary.

Telephone system

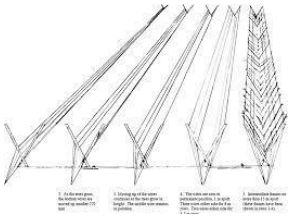
This system consists of 3 or 4 wires usually kept at 45-60 cm apart fixed to the cross-angle arms supported by vertical pillars or posts. Vines are allowed to grow up to a height of 1.5 to 2.0 m and then trained on this system. Moderately vigorous cultivars with apical dominance are best trained on such system.

Head System: It is mostly used for spur bearing grape cultivars. In this system, vines are trained like a small bush. Vines are allowed to, grow up to 1.2 meters, and then headed back to produce laterals. Four laterals- one in each direction is allowed to grow and rest are thinned out. In next dormant season, these laterals are cut back to 2 buds and further two arms of 20-30 cm are allowed on each secondary arm. After 3-4 years these vines will give a dwarf bush like appearance and requires no staking.

Other training systems which require no staking are Palmette, Spindle bush, Dwarf pyramid and Head and spread systems.



Cordon and Espalier system: Plants are trained to grow flat on trellis or on horizontal wires by training the branches perpendicularly to the main stem on both the sides, and trained horizontally on the wires. Plants trained in this system are called 'espaliers'. An espalier with one shoot or two shoots growing in opposite or parallel directions are called a ‘cordon'.



Tatura trellis: In this system, trees are trained to a multi-layered wire trellis. The trellis is V-shaped, supported by two long, stout poles embedded into the soil angles of 600 from the horizontal. Five wires at 60cm intervals are fastened to these poles. This system is being now followed for pome fruits, nut fruits and grapes. The trees are grown as double leader. Trees with each leader inclined at an angle of 600 from the horizontal.

For Further reading

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Exercise

1. Practical exercise on pruning of different fruits available in the experimental farm of COH, Bermiok.

2. Pruning exercise on polyhouse grown tomato, capsicum and other flower crops.

3. Exercise on training of kiwifruit plant at COH, Bermiok, Sikkim

Exercise No. 11 **Date:**

ASSESSING MATURITY INDICES FOR FRUITS AND VEGETABLES

The principles dictating at which stage of maturity a fruit or vegetable should be harvested are crucial to its subsequent storage and marketable life and quality. Post-harvest physiologists distinguish three stages in the life span of fruits and vegetables: maturation, ripening, and senescence. Maturation is indicative of the fruit being ready for harvest. At this point, the edible part of the fruit or vegetable is fully developed in size, although it may not be ready for immediate consumption. Ripening follows or overlaps maturation, rendering the produce edible, as indicated by taste. Senescence is the last stage, characterized by natural degradation of the fruit or vegetable, as in loss of texture, flavour, etc. (senescence ends at the death of the tissue of the fruit). Some typical maturity indexes are described in following sections.

Skin colour: This factor is commonly applied to fruits, since skin colour changes as fruit ripens or matures. Some fruits exhibit no perceptible colour change during maturation, depending on the type of fruit or vegetable. Assessment of harvest maturity by skin colour depends on the judgment of the harvester, but colour charts are available for cultivars, such as apples, tomatoes, peaches, chilli peppers, etc.

Optical methods: Light transmission properties can be used to measure the degree of maturity of fruits. These methods are based on the chlorophyll content of the fruit, which is reduced during maturation. The fruit is exposed to a bright light, which is then switched off so that the fruit is in total darkness. Next, a sensor measures the amount of light emitted from the fruit, which is proportional to its chlorophyll content and thus its maturity.

Shape: The shape of fruit can change during maturation and can be used as a characteristic to determine harvest maturity. For instance, a banana becomes more rounded in cross-sections and less angular as it develops on the plant. Mangoes also change shape during maturation. As the mango matures on the tree the relationship between the shoulders of the fruit and the point at which the stalk is attached may change. The shoulders of immature mangoes slope away from the fruit stalk; however, on more mature mangoes the shoulders become level with the point of attachment, and with even more maturity the shoulders may be raised above this point.

Size: Changes in the size of a crop while growing are frequently used to determine the time of harvest. For example, partially mature cobs of *Zea mays saccharata* are marketed as sweet corn, while even less mature and thus smaller cobs are marketed as baby corn. For bananas,

the width of individual fingers can be used to determine harvest maturity. Usually a finger is placed midway along the bunch and its maximum width is measured with callipers; this is referred to as the calliper grade.

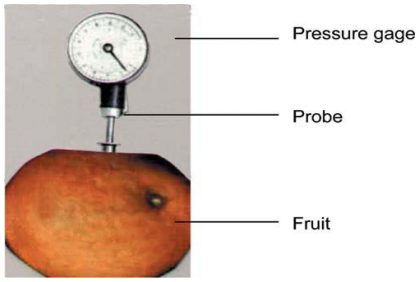
Aroma: Most fruits synthesize volatile chemicals as they ripen. Such chemicals give fruit its characteristic odour and can be used to determine whether it is ripe or not. These doors may only be detectable by humans when a fruit is completely ripe, and therefore has limited use in commercial situations.

Fruit opening: Some fruits may develop toxic compounds during ripening, such as ackee tree fruit, which contains toxic levels of hypoglycine. The fruit splits when it is fully mature, revealing black seeds on yellow arils. At this stage, it has been shown to contain minimal amounts of hypoglycine or none at all. This creates a problem in marketing; because the fruit is so mature, it will have a very short post-harvest life. Analysis of hypoglycine 'A' (hyp.) in ackee tree fruit revealed that the seed contained appreciable hyp. at all stages of maturity, at approximately 1000 ppm, while levels in the membrane mirrored those in the arils. This analysis supports earlier observations that unopened or partially opened ackee fruit should not be consumed, whereas fruit that opens naturally to over 15 mm of lobe separation poses little health hazard, provided the seed and membrane portions are removed. These observations agree with those of Brown *et al*. (1992) who stated that bright red, full sized ackee should never be forced open for human consumption.

Leaf changes: Leaf quality often determines when fruits and vegetables should be harvested. In root crops, the condition of the leaves can likewise indicate the condition of the crop below ground. For example, if potatoes are to be stored, then the optimum harvest time is soon after the leaves and stems have died. If harvested earlier, the skins will be less resistant to harvesting and handling damage and more prone to storage diseases.

Abscission: As part of the natural development of a fruit an abscission layer is formed in the pedicel. For example, in cantaloupe melons, harvesting before the abscission layer is fully developed results in inferior flavoured fruit, compared to those left on the vine for the full period.

Firmness: A fruit may change in texture during maturation, especially during ripening when it may become rapidly softer. Excessive loss of moisture may also affect the texture of crops. These textural changes are detected by touch, and the harvester may simply be able to gently squeeze the fruit and judge whether



the crop can be harvested. Today sophisticated devices have been developed to measure texture in fruits and vegetables, for example, texture analyzers and pressure testers; they are currently available for fruits and vegetables in various forms. A force is applied to the surface of the fruit, allowing the probe of the penetrometer or texturometer to penetrate the fruit flesh, which then gives a reading on firmness. Hand held pressure testers could give variable results because the basis on which they are used to measure firmness is affected by the angle at which the force is applied. Two commonly used pressure testers to measure the firmness of fruits and vegetables are the Magness-Taylor and UC Fruit Firmness testers (Fig.1).

Juice content: The juice content of many fruits increases as the fruit matures on the tree. To measure the juice content of a fruit, a representative sample of fruit is taken and then the juice extracted in a standard and specified manner. The juice volume is related to the original mass of juice, which is proportional to its maturity. The minimum values for citrus juices are presented in (1.3).

Table (1.3). Minimum juice values for mature citrus

Citrus fruit	**Minimum juice content (%)**
Naval oranges	30
Other oranges	35
Grapefruit	35
Lemons	25
Mandarins	33
Clementines	40

Oil content and dry matter percentage:

Oil content can be used to determine the maturity of fruits, such as avocados. According to the Agricultural Code in California, avocados at the time of harvest and at any time thereafter, shall not contain in weight less than 8% oil per avocado, excluding skin and seed (Mexican or Guatemalan race cultivars). Thus, the oil content of an avocado is related to moisture content. The oil content is determined by weighing 5-10 g of avocado pulp and then extracting the oil with a solvent (e.g., benzene or petroleum ether) in a destillation column.

This method has been successful for cultivars naturally high in oil content (Nagy and Shaw, 1980). A round flask is used for the solvent. Heat is supplied with an electric plate and water recirculated to maintain a constant temperature during the extraction process (Figure 2.2). Extraction is performed using solvents such as petroleum ether, benzene, diethyl ether, etc., a process that takes between 4-6 h. After the extraction, the oil is recovered from the flask through evaporation of the water at 105°C in an oven until constant weight is achieved.

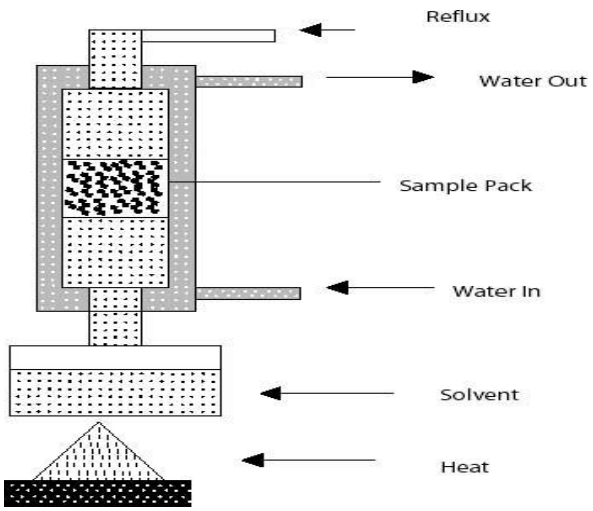


Fig. 2.2. Distillation column used for oil determination.

Moisture content

During the development of avocado fruit the oil content increases and moisture content rapidly decreases (Olaeta-Coscorroza and Undurraga-Martinez, 1995). The moisture levels required to obtain good acceptability of a variety of avocados cultivated in Chile are listed in Table 2.3.

Table 2.3 Moisture content of avocado fruit cultivated in Chile.

Cultivar	**Moisture content**(%)
Negra de la Cruz	80.1
Bacon	77.5
Zutano	80.5
Fuerte	77.9
Edranol	78.1
Hass	73.8
Gwen	78.4
Whitesell	79.1

Sugars: In climacteric fruits, carbohydrates accumulate during maturation in the form of starch. As the fruit ripens, starch is broken down into sugar. In non-climacteric fruits, sugar tends to accumulate during maturation. A quick method to measure the amount of sugar present in fruits is with a brix hydrometer or a refractometer. A drop of fruit juice is placed in the sample holder of the refractometer and a reading taken; this is equivalent to the total amount of soluble solids or sugar content. This factor is used in many parts of the world to specify maturity. The soluble solids content of fruit is also determined by shining light on the fruit or vegetable and measuring the amount transmitted. This is a laboratory technique however and might not be suitable for village level production.

Starch content: Measurement of starch content is a reliable technique used to determine maturity in pear cultivars. The method involves cutting the fruit in two and dipping the cut pieces into a solution containing 4% potassium iodide and 1% iodine. The cut surfaces stain to a blue-black colour in places where starch is present. Starch converts into sugar as harvest time approaches. Harvest begins when the samples show that 65-70% of the cut surfaces have turned blue-black.

Acidity: In many fruits, the acidity changes during maturation and ripening, and in the case of citrus and other fruits, acidity reduces progressively as the fruit matures on the tree.Taking samples of such fruits, and extracting the juice and titrating it against a standard alkaline solution, gives a measure that can be related to optimum times of harvest. Normally, acidity is not taken as a measurement of fruit maturity by itself but in relation to soluble solids, giving what is termed the brix: acid ratio.

Specific gravity: Specific gravity is the relative gravity, or weight of solids or liquids, compared to pure distilled water at 62°F (16.7°C), which is considered unity. Specific gravity is obtained by comparing the weights of equal bulks of other bodies with the weight of water. In practice, the fruit or vegetable is weighed in air, then in pure water. The weight in air divided by the weight in water gives the specific gravity. This will ensure a reliable measure of fruit maturity. As a fruit matures its specific gravity increases. This parameter is rarely used in practice to determine time of harvest, but could be used in cases where development of a suitable sampling technique is possible. It is used however to grade crops according to different maturities at post-harvest. This is done by placing the fruit in a tank of water, wherein those that float are less mature than those that sink.

Exercise

1. Exercise on determining the maturity indices in tomato.
2. Exercise on determining the maturity indices in avocado.
3. harvesting of the fruit at different stages and analyzing their chemical compositions.

Exercise No. 12 **Date:**

UNDERSTANDING THE GRADING OF FRUITS & VEGETABLES

Grading of capsicum

Agricultural produce particularly fruits and vegetables form an important part of trade both nationally and internationally. Among the post-harvest operations applied during handling of fruits and vegetables, grading plays an important role to remove undesirable or foreign matters from the harvested crops into various fractions. Grading is sorting or categorisation of fruits and vegetables into different grades according to the size, shape, colour, and volume to fetch high price in market. Besides grading, the other post-harvest operations such as precooling of produce to remove field heat, post-harvest treatments and packaging etc are also critical to marketing success.

Produce brought in many markets often has variable characteristics and sometimes it may be delivered immature or contain shrivelled, damaged and rotten materials. Delivering such produce generally results in lower prices. Thus, systematic grading is pre-requisite for efficient marketing of fruits and vegetables. The bruised, damaged and mis-shapen produce should be sorted out and healthy fruits or vegetables should be graded according to their size, weight, shape, colour, maturity etc. The fruits or vegetables can be graded in extra fancy, superior and standard grades or class I, II and III, respectively. Various advantages of grading are outlined below:

Advantages of Grading

- The graded produce fetch better price in the market.
- Grading helps to develop greater confidence between buyers and growers.
- Increase the marketing efficiency by facilitating buying and selling a produce without personal selection.
- Heavy marketing cost in packing and transportation can be avoided by grading.
- Increasing distributors' profits.
- Increasing producers' profits.
- Grading improves product uniformity within a particular grade and serves as the basis for price.

Methods of Grading

Grading of fruits and vegetables is generally done on the basis of physical characteristics like weight, size, colour, shape, specific gravity, and freedom from diseases.

For fresh marketing, the known methods of grading of fruits and vegetables are manual grading, or machine grading. In both the methods, the produce is graded on the basis of size. However, electronic grading systems are gaining impetus in the horticultural sector and have been used successfully in pilot scale studies. Grading process is fully mechanised but in India it is still done manually. Basic process behind mechanical grading consist of a conveyor belt with a bag at the end wherein smaller produce fall through the chain making grading process less extensive. Fruits and vegetables are generally graded on the basis of state, federal, and international standards. Every country has set their own standards of different grades as per the market requirements. However, for international market three general grades are considered as: Extra class, Class I and Class II.

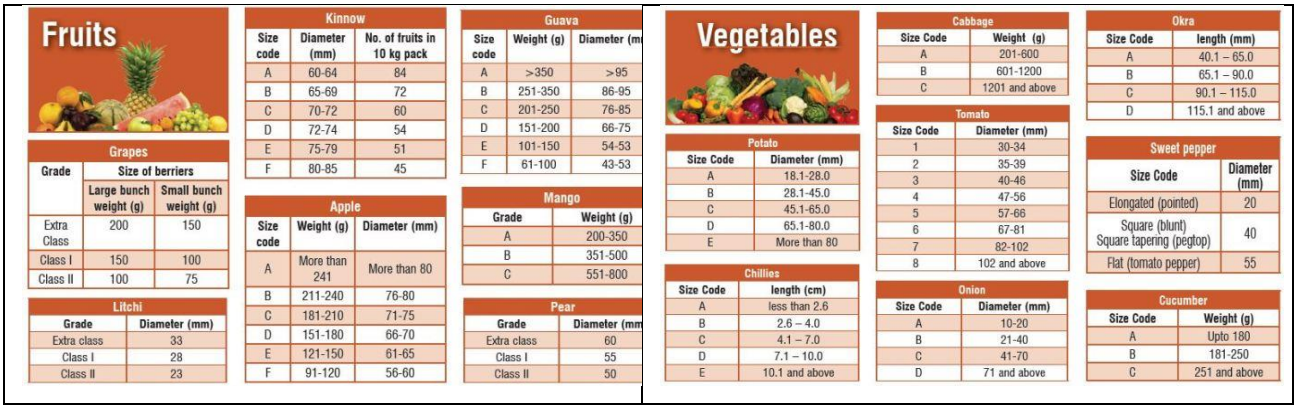
Extra Class: The extra class is of superior quality poses the shapes and colour of the variety and without internal defect likely to affect the inherent texture and flavour. A 5 per cent tolerance is allowed for errors. It must be carefully presented taking into accounts the uniformity of the produces in size, colour, and condition arrangement of the produce in the package, quality and appearances of the packing or pre-packing material.

Class I: Almost having a same quality is like the Extra Class except that a 10% tolerance is allowed. Individual fruit is allowed a slight defect in shape, colour and minor skin defect which do not affect the general appearance for keeping qualities.

Class II: This class product may exhibit some external or internal defects provided they are fit for consumption while fresh. This class is the best fitted for local or short distance market. This category will satisfy the needs of customers who are not too demanding and for whom price is more important than quality.

Grades of different fruits & vegetables as suggested by Directorate of Marketing and Inspection (DMI)

Directorate of Marketing and Inspection (DMI) under Ministry of Agriculture and Farmers Welfare, Government of India was set up in the year 1935 to frame the grade standards in a scientific manner. The different grades used in some important fruits and vegetables with respect to weight, diameter or length as applicable are given as under. For grading information on other fruits and vegetables, following site i.e. www.dmi.gov.in can be accessed.



Manually grading is costly and grading operation is affected due to shortage of labour in peak seasons. Human operations may be inconsistent, less efficient and time consuming. New trends in marketing as specified by World Trade Organisation (WTO) demand high quality graded products. Farmers are looking forward to having an appropriate agricultural produce-grading machine in order to alleviate the labour shortage, save time and improve graded product's quality. Grading of fruits is a very important operation as it fetches high price to the grower and improves packaging, handling and brings an overall improvement in marketing system. The fruits are generally graded on basis of size and graded fruits are more welcome in export market. Grading could reduce handling losses during transportation.

Exercise

1. Exercise on grading of mandarin, sweet oranges and lemon.
2. Grading of vegetables as per market demand and consumers preferences.
3. Creating awareness among the students about the national and international standards of fruits and vegetables for export.
4. Practical information about different types of graders available in market.

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