

# Temprate Fruits

**Dr. J. S. Chandel**



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All About Agriculture...

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# INDEX

SN	Lecture	Page No.
1	Classification of temperate fruits	5-9
2	Apple: introduction, area and production, climate and soil, varieties, propagation, planting, training and pruning	10-18
3	Apple: flowering. Pollination, manure and fertilizers, cultural practices, fruit thinning and drop, maturity and harvesting, post	19-27
4	Apple: insect pests and diseases, special problems like low productivity, premature leaf fall, replant problem	28-38
5	Pear cultivation: introduction, area and production, climate and soil, varieties, propagation, planting, training and pruning, manure and fertilizers, cultural practices, , maturity and harvesting, post	39-47
6	Peach cultivation: introduction, area and production, climate and soil, varieties, propagation, planting, training and pruning, thinning, manure and fertilizers, cultural practices, , maturity and harvesting, post	48-58
7	Apricot cultivation: introduction, area and production, climate and soil, varieties, propagation, planting, training and pruning, thinning, manure and fertilizers, cultural practices, , maturity and harvesting, post	59-66
8	Plum cultivation :introduction, area and production, climate and soil, varieties, propagation, planting, training and pruning, manure and fertilizers, cultural practices, , maturity and harvesting, post	67-74
9	Cherry cultivation: introduction, area and production, climate and soil, varieties, propagation, planting, training and pruning, manure and fertilizers, cultural practices, , maturity and harvesting, post	75-84
10	Almond cultivation: introduction, area and production, climate and soil, varieties, propagation, planting, training and pruning, manure and fertilizers, cultural practices, , maturity and harvesting, post	85-88
11	Kiwifruit cultivation: introduction, area and production, climate and soil, varieties, propagation, planting, training and pruning, manure and fertilizers, cultural practices, thinning, crop regulation , maturity and harvesting, post	89-96
12	Strawberry cultivation: introduction, area and production, climate and soil, varieties, propagation, planting, manure and fertilizers, flowering, cultural practices, maturity and harvesting.	97-104
13	Persimmon cultivation :introduction, area and production, climate and soil, varieties, propagation, planting, manure and fertilizers, flowering, cultural practices, maturity and harvesting.	105-108
14	Walnut cultivation: introduction, area and production, climate and	109-114

	soil, varieties, propagation, planting, manure and fertilizers, pollination, cultural practices, maturity and harvesting.	
15	Pecan nut cultivation: introduction, area and production, climate and soil, varieties, propagation, planting, manure and fertilizers, flowering, cultural practices, maturity and harvesting.	115-120
16	Chestnut and hazelnut cultivation: introduction, area and production, climate and soil, varieties, propagation, planting, manure and fertilizers, flowering, cultural practices, maturity and harvesting.	121-126
1	Preparation of seed and nursery beds	129-130
2	Propagation of rootstocks	131-137
3	Propagation of scion cultivar and nursery management practices	138-141
4	Identification and description of varieties of pome fruits	142-150
5	Identification and description of varieties of stone fruits	151-154
6	Identification and description of varieties of strawberry and persimmon	155-156
7	Identification and description of varieties of nut crops	157-158
8	Description and identification of varieties of kiwifruit	159-160
9	Methods of layout of an orchard	161-165
10	Training and pruning of pome fruits	166-169
11	Training and pruning of stone fruits	170-172
12	Training and pruning of stone fruits (cont...)	173-174
13	Training and pruning of kiwifruit	175-176
14	Preparation of growth regulators solution for foliar sprays	177-180
15	Manure and fertilizers application in pome stone fruits	181-183
16	Visit to private orchards to diagnose nutrient deficiency and other maladies	184-184
	Glossary	185-186
	Suggested readings	187-187
	Question bank	188-189

### Lecture 1: Horticultural Classification of Temperate Fruits

#### INTRODUCTION

##### What are Temperate Fruit Plants?

- Temperate fruit plants are specific in the climatic requirement.
- They can tolerate both diurnal and seasonal wide fluctuation of temperature and are grown only in place where winter is distinctly cold.
- They require exposure of specific chilling temperature for certain period to break bud dormancy and initiate bud break.
- These fruit plants are generally deciduous and suitable of higher elevation as they can withstand frost.
- Examples are: apple, pear, plum, apricot, almond, peach, strawberry, walnut, pecan nut and cherry.

##### Horticultural classification of temperate fruits

- Classification is a system of placing an individual or a number in various groups, or to categorizes them according to a particular plan or sequence which is in conformity with the nomenclature

##### Classification helps:

- (i) To identify and name them
- (ii) to find some idea of the closeness of their relationship
- (iii) to suggest with what other kind they possibly may or may not be interbred or crossed
- (iv) to suggest the kind with which they possibly may or may not be intergrafted
- (v) to suggest soil and cultural requirements and climatic adaptations.

- Fruit can be classified on several basis but their classification on the basis of climatic adaptability and morphological features seems to be more relevant from the horticulture point of view.

#### CLASSIFICATION

##### 1. Classification on the basis of plant stature:

**a. Temperate tree fruits:** Fruits borne on the trees growing in the temperate climates such as apple, pear, stone fruits etc.

**b. Temperate small fruits:** Fruits generally borne on the vines, brambles or herbaceous plants grown under temperate climate like strawberry, cranberry, blackberry, blueberry etc.

**c. Temperate nuts:** Nuts are characterized by the hard shell outside, separating the kernel and husk of the fruit. Pecan nut, hazel nut and walnut are good examples of temperate fruit plants producing nuts.

##### 2. Classification based on fruit morphology

Depending on number of ovaries involved in fruit formation, fruits are classified into three groups.

- (i) simple fruits
- (ii) aggregate fruits
- (iii) multiple (composite) fruits

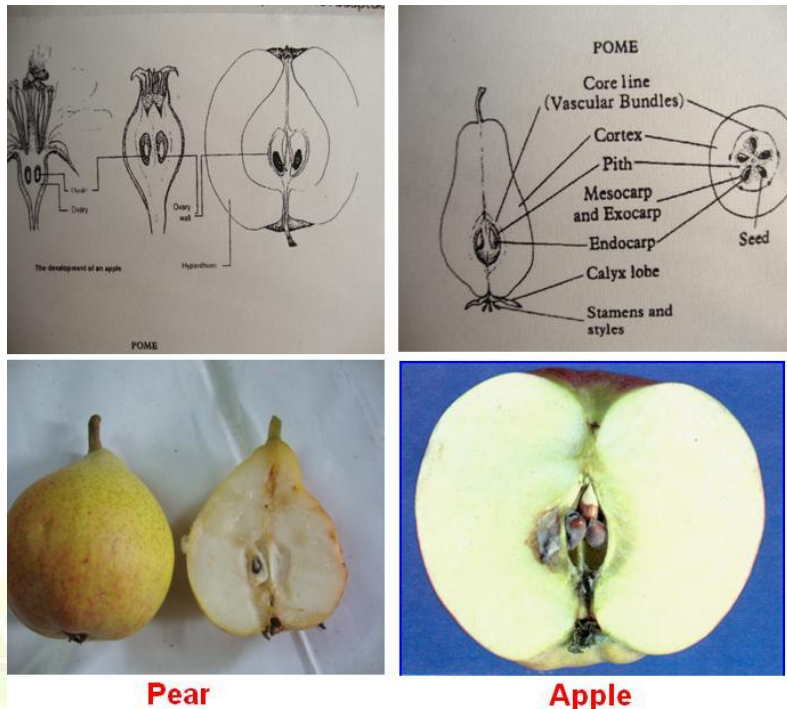
## Temperate Fruits

**i. Simple fruits:** Simple fruits are derived from a single ovary of one flower. Simple fruits are further classified as fleshy and dry fruits.

**A. Fleshy fruits:** These are those fruits whose pericarp (ovary wall) becomes fleshy or succulent at maturity. The temperate fleshy fruits may be either pome or drupe.

**a. Pome:** The pome is an inferior, two or more celled fleshy, syncarpous fruit surrounded by the thalamus. The fruit is referred to as a false fruit as the edible fleshy part is not derived from the ovarian tissues but from external ovarian tissue thalamus. Examples of temperate pome fruits are apple, pear and quince).

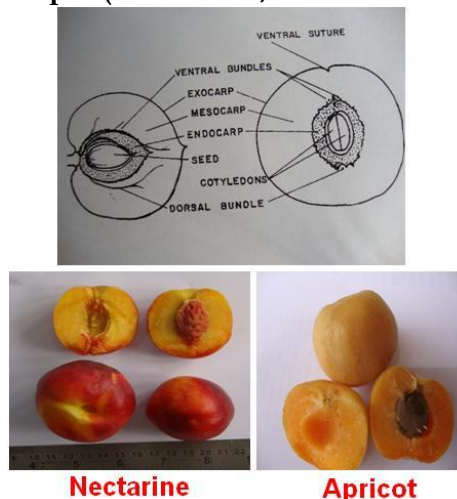
### Fleshy fruit : Pome (leathery carpels, edible portion is receptacles)



**b. Drupe (stone):** This type of fruit derived from a single carpel, however, the olive is an exception in that the flower has two carpels and four ovules but one carpel develops. Two ovules are borne in most of drupes but one seed develops. In this type of fruit, the pericarp is differentiated into three distinct layers; thin exocarp or peel of the fruits, the fleshy mesocarp, and the stony endocarp, enclosing the seed. Examples of temperate drupe fruits are cherry, peach, plum and apricot.

In almond at maturity exocarp and mesocarp get separated as leathery involucre and are removed before marketing, only endocarp containing the edible seed is used hence it is nut.

### Fleshy fruit : Drupes (one seeded, seed within stony endocarp)



## Temperate Fruits

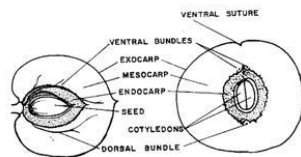
**B. Dry fruits:** This type of fruit has been classified on the basis of pericarp (ovary wall) at maturity. The entire pericarp becomes dry and often brittle or hard at maturity.

- They are dehiscent ( in which the seeds are dispersed from fruit at maturity) and indehiscent ( not split open when ripe) Nuts are typical example of indehiscent dry fruits

**a. Nut:** A fruit in which carpel wall is hard or bony in texture. Fruit is derived from an hypogynous flower ( filbert) or an epigynous one ( walnut) and is enclosed in dry involucre (husk). It is only one seeded, but in most cases in derived from two carpels. Examples are walnut, almond, chestnut, hazelnut and pecan nut. Dry fruits are not juicy or succulent when mature and ripe. When dry, they may split open and discharge their seeds (called dehiscent fruits) or retain their seeds (called indehiscent fruits).

### Dry fruit

One seeded  
Seed within stony endocarp



#### Almond

- Mesocarp dries and separates
- Endocarp is hard to soft
- Eat seed

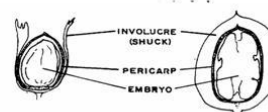
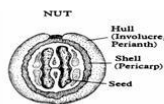
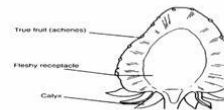
HORT 319 - Temperate Fruit and Nut  
Production

**b. Achene:** A one seeded fruit in which the seed is attached to ovary wall at one point. Example is strawberry.

### Dry fruit: Indehiscent

Single carpel  
Does not split when ripe

- Achene
  - One seeded, free from pericarp
  - Strawberry, sunflower
- Nut
  - Similar to achene
  - Enclosed by pericarp (leathery in chestnut, woody in walnut)
  - Husk (shuck) is fusion of sepals, bracts, bracteoles.



HORT 319 - Temperate Fruit and Ni  
Production

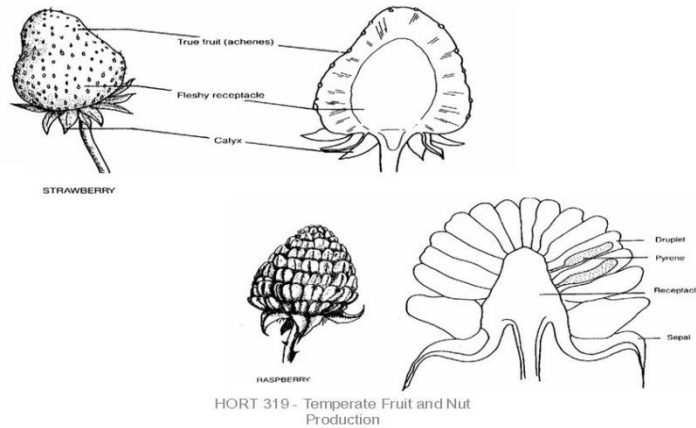


## Temperate Fruits

ii. **Aggregate fruits:** Aggregate fruits develop from numerous ovaries of the same flower. Individual ovary may be drupe or berry. Raspberry is included in this category.

### Aggregate Fruit

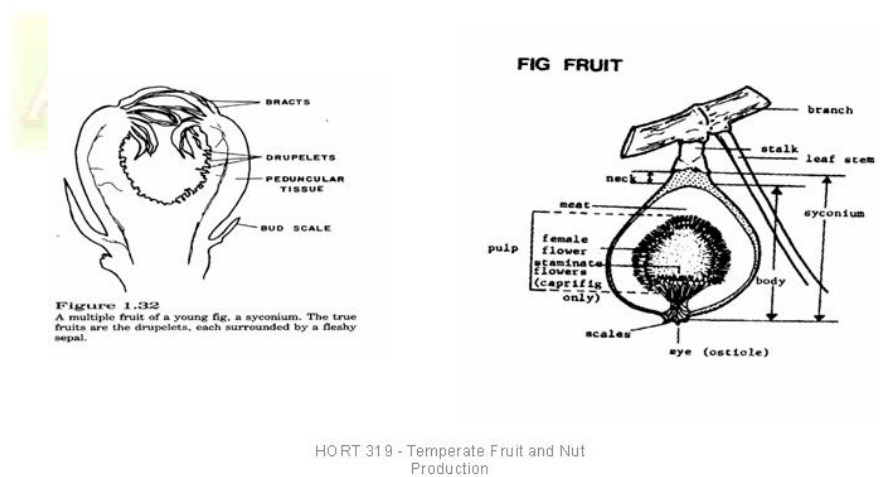
Many ovules  
One flower



iii. **Multiple (composite) fruits:** Multiple or composite fruits are produced from the ripened ovaries of several flowers crowded on the same inflorescence. The example of this type is mulberry.

### Multiple fruit

Many flowers  
Along a common axis or inflorescence



### 3. Classification based on bearing habit:

The flower bud is either terminal or lateral. Based upon the location of fruit buds and type of flower bearing structure to which they give rise, the temperate fruits are classified as under.

#### 1. Terminal bearer:

(a) Flower buds mixed, flowering shoot with terminal inflorescences. Examples are apple, pear, walnut (pistillate flowers) and pecan (pistillate flowers)

#### 2. Lateral bearer:

(a) Flower bud containing flower parts only e.g peach, apricot, plum, cherry, almond, walnut (staminate catkin) and pecan (staminate catkin)

(b) Flower buds mixed, flowering shoot with terminal inflorescences e.g blackberry, raspberry, blueberry,



## Temperate Fruits

apple and pear(occasionally)

(c) Flower buds mixed, flowering shoot with lateral inflorescences e.g. persimmon, chestnut, pistachio nut, cranberry.

### 4. Classification based on Fruit Growth Pattern:

#### 1. Sigmoid pattern:

- The combined growth of fruit results from cell division, cell enlargement and air space formation results in sigmoidal (S- shaped) curve when fruit weight is plotted as function of time. Examples are apple, walnut, pecan, strawberry and pear

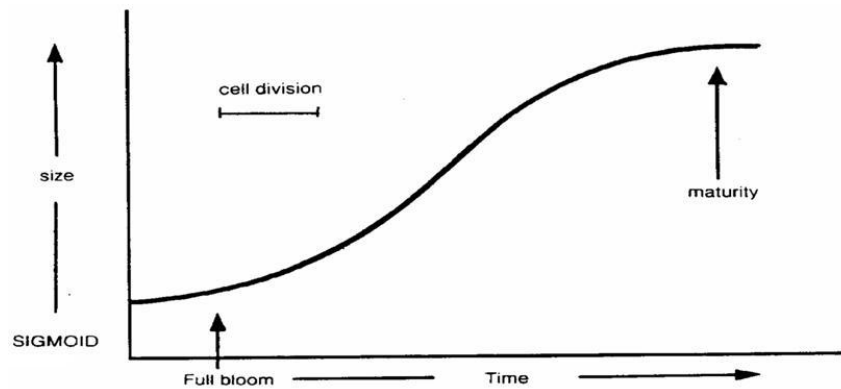


Fig. Single sigmoidal growth curve

#### 2. Double sigmoid:

- The first slow growth period coincides with the period of pit hardening, during which lignification of the endocarp (stone) proceeds rapidly, while mesocarp and seed growth suppressed. Near the end of pit hardening, flesh cells enlarge rapidly until fruit is ripe, after which growth slows down and ceases. Examples are peach, plum, cherry and kiwifruit

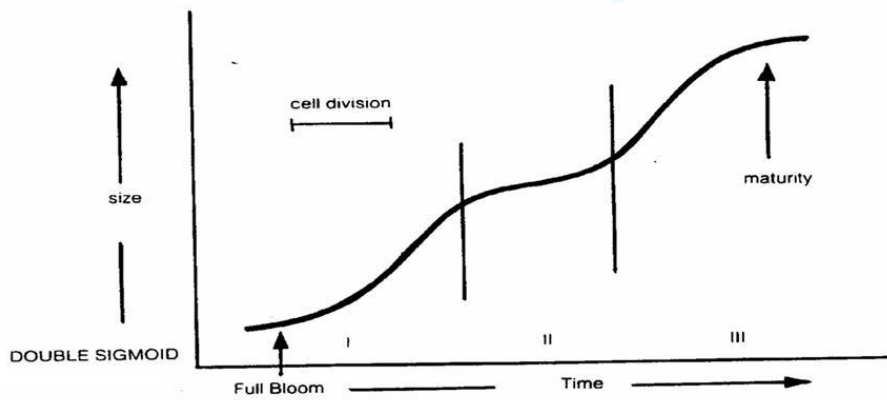


Fig. Double sigmoidal growth curve



### Lecture 2: Cultivation of Apple

#### INTRODUCTION

##### Taxonomic classification of apple

Order = Rosales

Family = Rosaceae

Sub-family = Pomoideae

Genus = Malus

Species = domestica

Basic chromosome = 17

Somatic no"s = 34, 51, 68

#### INTRODUCTION

- The apple ( Malus x domestica Borkh.) is an important temperate fruit and is grown in areas where winter are cold, springs are frost free, summer are mild.
- The genus Malus has 25 species.
- The primary center of origin of apple is thought to be the region which includes the South Western Asia , the Caucasus, Soviet Central Asia and Hindu-Kush Himalayan region.
- In India, apple was introduced by Captain Lee in 1865 in Kullu Valley of Himachal Pradesh.
- Later on , red coloured Delicious group varieties were introduced at Kotgarh in Shimla district of Himachal Pradesh in 1917 by American missionary Mr Satya Nand Stokes.
- Apple fruit is rich in carbohydrate (15 %) protein (0.3 % ) and nutrients like in K, P and Ca.

#### AREA AND PRODUCTION

- In India, Apple is grown on commercial scale in Jammu and Kashmir, Himachal Pradesh and Uttarakhand .
- It is also cultivated on limited scale in North-Eastern states like Arunachal Pradesh, Sikkim, Nagaland, Meghalaya and Manipur and Nilgiri hills of Tamil Naidu.
- In India, apple occupies an area of 2,82,940 hectares with a total production of 17,77,230 MT (NHB,2009-10).

**Table 1 : Area and production of apple in India**

State	Area (000hectares)	Production (000 MT)
Jammu and Kashmir	138.10	1373.000
Himachal Pradesh	99.6	280.10
Uttarakhand	32.4	114.0
Arunachal Pradesh	12.8	10.0
<b>Total</b>	<b>283</b>	<b>1777.10</b>

Source : (NHB, Data base 2009-10).

## Temperate Fruits

### Climate and Soil

- The apple is a typical temperate fruit and is generally grown in the temperate regions of the world.
- Northern aspect is considered most suitable for its cultivation.
- Most of apple varieties require 1000-1600 chilling hours during winter to break the rest period, however some low chill varieties require only 500-800 chilling hours.
- The average summer temperature should be around 21-24°C during active growth period.
- Low temperature below 15°C, rains and cloudy weather during bloom restrict the bee activity, which is completely inhibited below 5°C and adversely affect fruit set.
- The optimum temperature for pollination, pollen germination and fruit setting is 18 to 22°C.
- The areas with frost free spring and adequate sunshine during summer without wide fluctuation in temperature are most suitable for apple growing.
- Well distributed rainfall of about 100-125 cm throughout the season is considered most favorable.
- The long drought spells during fruit development and excessive rains and foggy conditions at maturity hamper fruit size and quality.
- Apple thrives best in loamy soils, which are rich in organic matter.
- A soil pH between 6.0 to 6.5 with good drainage and aeration are considered most suitable.
- The soil should be deep, fertile and free from hard substrates and waterlogged conditions.

### VARIETIES

Table 2. Recommended varieties of apple in different states of India.

Season	Jammu and Kashmir	Himachal Pradesh	Uttarakhand
Early season	Irish Peach, Benoni	Tydeman's Early Worcester(P), Michael, Mollies Delicious, Schlomit, Starkrimson, Anna	Early Shanburry(P), Fenny, Benoni, Chaubattia Princess
Mid season	American Mother, Razakwar, Jonathan(P) Cox' Orange Pippin(P), Queen's Apple, Rome Beauty, Scarlet Siberian	Starking Delicious, Red Delicious, Rich-a-red, Vance Delicious, Top Red, Lord Lambourne(P) Red Chief, Oregon Spur, Red Spur, Red Gold(P), Silver Spur, Scarlet Gala, Well Spur, Super Chief, Scarlet Spur.	Red Delicious, Starking Delicious, McIntosh(P), Cortland, Golden Delicious(P)
Late season	King Pippin, American Apirouge, Kerry Pippin, Lal Ambri, Sunheri Chamure, Golden Delicious(P), Red Delicious, Ambri, Baldwin, Yellow Newton(P),	Golden Delicious(P), Yellow Newton(P), Winter Banana, Granny Smith(P), Red Fuji, Coe Fuji	Rymer, Buckingham(P)

\*P = Pollinizer

**Spur types and colour sports:** Red Chief, Oregon Spur-II, Silver Spur, Well Spur, Red Spur, Super Chief, Starkrimson, Hardi Spur., Schelet Spur, Ace Spur

## Temperate Fruits



Plate 1. Red Chief



Plate 2. Oregon Spur

**Standard colour mutants:** Vance Delicious, Top Red, Skyline Supreme, Hardiman, Bright-N-Early.



Plate 3. Vance Delicious

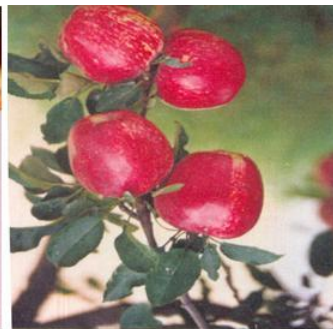


Plate 4. Top Red

**Standard varieties:** Starking Delicious, Red Delicious, Rich-a-red



Plate 5. Rich-a-red



Plate 6. Starking Delicious

**Low chilling varieties:** Michal, Schlomit, Anna, Vered, Tamma, Tropical Beauty and Parlins Beauty.

**Pollinizing varieties:** Golden Delicious, Red Gold, Tydeman's Early Worcester, Summer Queen, Golden Spur, Granny Smith, Winter Banana, McIntosh, Scarlet Gala and flowering crabs like Manchurian, Snow Drift and Malus floribunda

## Temperate Fruits



Plate 7. **Granny Smith**



Plate 8. **Golden Delicious**



Plate 9. **Manchurian (crab apple)**

**Scab resistant varieties:** Prima, Priscilla, Sir Prize, Florina, Flrdous, Shireen, Macfree, Coop-12, Coop-13, Liberty and Freedom.

**Hybrid Varieties:** Lal Ambri (Red Delicious x Ambri), Sunheri (Ambri x Golden Delicious) Chaubattia Princess and Chaubattia Anupam ( Early Shanburry x Red Delicious), Ambred (Red Delicious x Ambri), Ambrich ( Richared x Ambri), Amroyal ( Starking Delicious x Ambri).

### ROOTSTOCKS AND PROPAGATION

Apple is propagated by asexual method of grafting and budding on rootstocks.

#### Rootstocks:

##### (1) Seedling rootstocks

- Seedling rootstocks are vigorous and not uniform in size.
- Seeds of crab apple (*Malus baccata*) or self pollinizing varieties like Golden Delicious and Granny Smith are used for raising seedling rootstocks.

##### (2) Clonal rootstocks

- Clonal rootstocks are precocious, uniform and resistant to some insect pests and diseases.
- In recent years size controlling clonal rootstocks are gaining popularity especially for establishment of high density.
- The promising clonal rootstocks of apple are:
  - M9 or EMLA9 and M26 or EMLA26 (Dwarf)
  - M7 or EMLA7, MM106 or EMLA106 ( Semi dwarf)
  - MM111 or EMLA111 (Semi vigorous)
  - Merton 793 ( vigorous)
- Malling series( M) rootstocks are size controlling but not resistant to woolly apple aphid.
- Malling Merton series (MM) are size controlling and resistant to woolly apple aphid.
- EMLA series rootstocks are virus free.

#### Propagation

##### Propagation of rootstocks

##### (a)Seedling rootstock

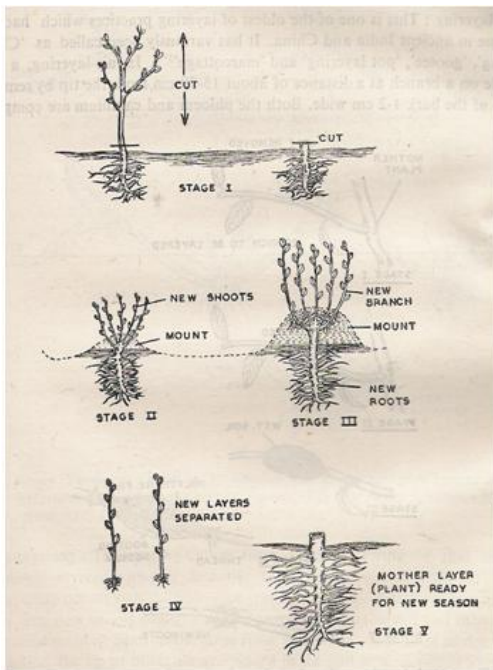
- Seeds of apple are dormant, which require stratification treatment (moist chilling) to break dormancy.

## Temperate Fruits

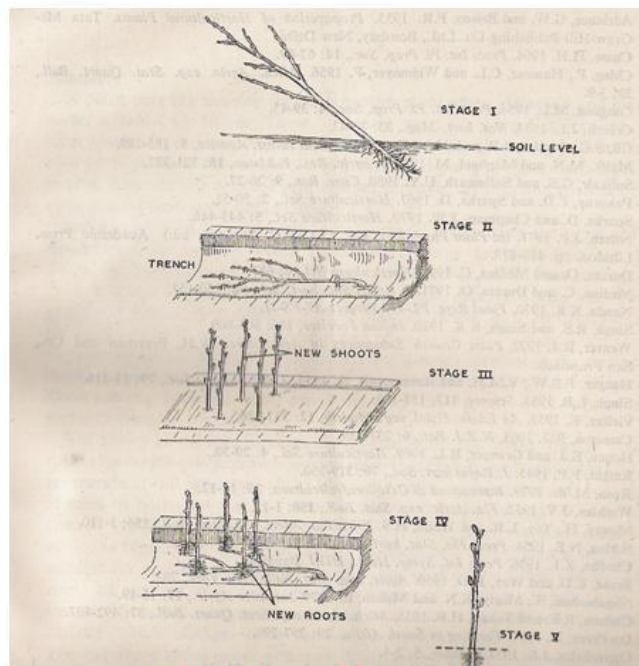
- Seeds are stratified for 60-70 days in alternate layers of moist sand at 4-6 oC during December to February.
- The stratified seeds are sown in nursery beds during March at a spacing of 8-10 cm from seed to seed and 15-20 cm from line to line.
- After sowing, the nursery beds are mulched with 10 cm thick dry grass and light irrigation is given to avoid desiccation of stratified seeds.
- Mulch is removed as soon as seed start germinating.
- Cultural operations like weeding, hoeing, irrigation and spray of insecticide and fungicides are done at regular intervals.
- The seedling rootstock attain graftable size of 15 mm diameter in a year.

## (b) Clonal rootstock

- The clonal rootstocks are commercially propagated through mound layering or trench layering (Fig 1 and 2)



**Fig. 1 Mound Layering**



**Fig. 2 Trench Layering**



**Plate 10. Trench layering**

## Temperate Fruits

### Propagation of scion

- The commercial method of propagation of apple scion varieties is grafting and chip budding.
- For grafting and budding the scion wood should be collected from healthy, disease free, true to type mother trees during January.
- The scion wood is collected from one year old shoots and packed in moist sphagnum moss, after proper labeling of variety.
- These bundles of scion wood are stored in cold storage or buried deep in the soil at shady place till required for grafting .
- The best time of grafting of apple is February to March with tongue and cleft methods.
- Chip budding can also be done in March and July.



**Plate 11. Chip budding**

### PLANTING AND PLANTING DENSITY

- The best time of planting of apple is January - February.
- The planting distance varies according to variety, rootstock and fertility status of soil.
- Before planting, orchard layout should be planned. In flat land square or hexagonal system of layout is adopted, whereas in sloppy land contour and terrace system of layout is done.
- After layout of an orchard, the pits of 1x1x1 m size are dug well in advance of planting.
- The pits are filled atleast one month before planting with soil in which 40-50 kg well rotten FYM and 1 kg single super phosphate are mixed.
- After planting, watering is done and tree basins are mulched with 10 cm thick dry grass, which helps in conserving the soil moisture and control the weed population.
- In apple, most of the varieties are self unfruitful, therefore, at the time of planting proper proportion of pollinizer varieties (25 or 33%) should be planted in the orchard.

## Temperate Fruits

Table 3 Spacing and planting density for different scion stock combinations

Fruit crop	Scion/variety	Rootstock	Tree size	Spacing (m)	Density (trees/ha)
Apple	Standard	Seedling	Vigorous	7.5 x 7.5	178
	Standard	MM111 and Merton 793	Semi vigorous	6.0 x 6.0	278
	Standard	MM106, M7	Semi dwarf	4.5 x 4.5	494
	Standard	M9 and M26	Dwarf	1.5 x 1.5	4444
	Spur type	Seedling	Semi vigorous	5.0 x 5.0	400
	Spur type	MM111, Merton 793	Semi dwarf	3.5 x 3.5	816
	Spur type	MM106, M7	Dwarf	3.0 x 3.0	1111

### TRAINING AND PRUNING

Training and pruning are most important orchard management practices for proper canopy development and quality fruit production.

#### Training

- Training is done to shape or build a strong framework of the trees in order to support maximum crop when plant reaches bearing stage.
- There are several systems of training in apple especially for dwarf plantations like spindle bush, dwarf pyramid and cylinder spindle etc., but modified central leader system is most suitable for standard plantation.

#### Modified central leader system

- Generally, one - year - old whip without a single branch is planted in the dormant season.
- Immediately after transplanting the tip of plant is headed back 60 to 75 cm above the ground level.



## Temperate Fruits



Fig 3. Pruning at planting

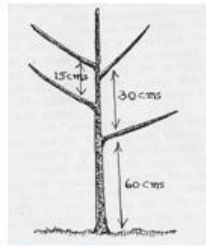


Fig. 4. Selection of primary branches

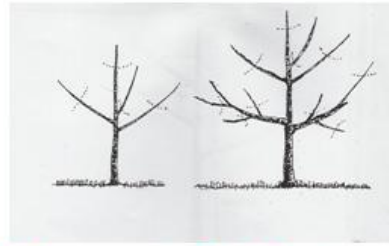


Fig. 5 First year pruning

Fig. 6 Second year pruning



Fig. 7 Third year pruning



Fig. 8 Fourth year pruning

Fig.2-8 Modified Leader System of Training

- In the following summer, most of the buds on main branch will sprout.
- In order to develop clean stem up to 45 cm from the ground the sprouted buds are pinched off soon after their appearance.
- Three or four well spaced buds projecting in opposite directions are retained with lowest one 45 cm above ground . If summer pruning is not done, then 3-4 well spaced primary branches having wider crotch angle are selected during dormant pruning.
- The selected branches should be spaced 10-15 cm apart in spiral fashion. The branches emerging below 30 cm from ground level and other undesirable branches are pruned off.
- The selected branches are headed back to  $\frac{1}{4}$  of growth to a bud projecting to the outer direction.
- The leader is also headed back to 30 cm above the last branch.
- During the second dormant pruning, 2-3 well spaced primary branches are selected on the leader.
- On the primary branches selected during previous year, two secondary branches which are growing outward direction should be selected.
- The selected primary and secondary branches are headed back to  $\frac{1}{3} - \frac{1}{4}$  of the growth.
- The secondary and tertiary branches selected should be spreading horizontally and upright or downward growing branches should be removed.
- The third year training consists of thinning out of unwanted branches and heading back of desirable side branches.
- The central leader should be headed back to a bud or weak shoot, which will develop in the form of a side branch.
- By fourth year training should be completed.

## Pruning

- The objective of pruning is to maintain a proper balance between vegetative growth and spur development.
- The training is completed during initial 4-5 years after planting of plant, but pruning is continued after training throughout the life of tree.
- In pruning, thinning out and heading back are two basic components. The pruning consists of thinning out of all upright laterals and those growing inside the trees and heading back of leaders and laterals.

## Temperate Fruits

- In apple, the fruit is obtained not only on spurs but also on fruit buds on young laterals. Therefore, pruning should be done in such a way that continuous supply of new, healthy shoots, spurs and branches are maintained.



**Plate 12. Pruning of apple tree**

- While pruning, some part of tree is pruned and some left unpruned. The pruned parts produce shoot growth and unpruned parts will produce fruit buds.
- The laterals which have been left unpruned in one year, may be either shortened or left unpruned in the next year depending on the growth, spur formation and crop load.
- Once the laterals have cropped and become weak, they must be severely shortened leaving them 5-6 cm long.
- The severe shortening will promote the production of new growth from these stubs, which in two years will give a crop.
- The whole cycle is accordingly repeated every year to ensure regular growth, spur formation and cropping.
- At the time of pruning dead, diseased and broken branches are removed and on the cut surface Chaubattia or Bordeaux paste is applied to avoid any fungal infection.
- The best time of pruning is during the dormant season (December to January).



### Lecture- 3: Apple cultivation

#### POLLINATION AND NUTRITION

##### Morphological characters and Flowering:

- Apple plant is deciduous without spiny branches.
- Buds are ovoid with imbricate scales, leaves are serrate or lobed, folded in bud and stipulate.
- Floral buds are mixed buds borne terminally on spurs and terminally or laterally on long shoot, depending upon the cultivar, age and vigour of tree.
- The initiation of flower primordia starts about 3-6 weeks after full bloom (June).
- The inflorescence is determinate having five flowers. Flowers white or pink or carmine in cymes.
- Flower of most cultivars are epigynous and hermaphrodite.
- Flower consists of five petals, five sepals, 15-20 stamens and a pistil which is divided into five carpals each containing two ovules.
- Ovary is inferior.



**Plate. 1 Different stages of flowering**

##### Pollination and Pollinizers:

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- Most of apple varieties are self unfruitful and can not produce fruit if fertilized by their own pollen and thus require some compatible cultivars for cross pollination and good fruit set.
- Apple tree produce abundant bloom but fail to set fruit especially under adverse climatic conditions due to lack of pollination. Inadequate fruit set often results from a failure during the pollination period, which is associated with pollen production, transfer and germination, pollen tube development or fertility of the ovule.
- Sterility and incompatibility are two main causes of unfruitfulness in apple. Self incompatibility is most common, although cases of cross incompatibility are also known. The commercial cultivars Red Delicious, Royal Delicious, Top Red, Vance Delicious, Red Chief and Oregon Spur are self incompatible.
- Various climatic and edaphic factors are also responsible for poor pollination and fruit set.
- Low temperature, rainfall and cloudy weather at flowering time adversely affect the bee activity, transfer of pollen to stigma, pollen germination, and ultimately result in poor fruit set.

## Temperate Fruits



Plate 2. Non synchronization of flowering of main and pollinizer cultivars due to insufficient winter chilling

### Planting Plan For Pollinizers

O	O	O	O	O	O	O	O	O	O
O	X	O	X	O	X	O	X	O	X
O	O	O	O	O	O	O	O	O	O
O	X	O	X	O	X	O	X	O	X
O	O	O	O	O	O	O	O	O	O
O	X	O	X	O	X	O	X	O	X
O	O	O	O	O	O	O	O	O	O
O	X	O	X	O	X	O	X	O	X
O	O	O	O	O	O	O	O	O	O
O	X	O	X	O	X	O	X	O	X

Fig.1.25 per cent pollinizer (Every second plant in second row is a pollinizer)

O	X	O	O	X	O	O	X	O	O
O	X	O	O	X	O	O	X	O	O
O	X	O	O	X	O	O	X	O	O
O	X	O	O	X	O	O	X	O	O
O	X	O	O	X	O	O	X	O	O
O	X	O	O	X	O	O	X	O	O
O	X	O	O	X	O	O	X	O	O
O	X	O	O	X	O	O	X	O	O
O	X	O	O	X	O	O	X	O	O
O	X	O	O	X	O	O	X	O	O

Fig. 2 33 per cent pollinizer (Every third row is a pollinizer variety)

O = Commercial variety

X = Pollinizer varieties

## Temperate Fruits



**Plate 3. Hand pollination**



**Plate 4. Bouquet placement**



**Plate 5. Top working**



**Plate 6. Placement of bee hive**

- The cross pollination and fruit set in apple can be improved by planting atleast 25 to 33 per cent of pollinizers,
- placement of 5 to 6 honey bees colonies per hectare,
- top working of 2-4 shoots of commercial varieties with pollinizers.
- placement of bouquets.

### Insufficient winter chilling

- The cross pollination and fruit set in apple can be improved by planting atleast 25 to 33 per cent of pollinizers,
- placement of 5 to 6 honey bees colonies per hectare,
- top working of 2-4 shoots of commercial varieties with pollinizers.
- placement of bouquets.

### NUTRITIONAL REQUIREMENTS

- Apple requires all the essential nutrients for proper growth and fruit production.
- The nutrient requirement is mainly met through the application of manures and fertilizers, which should be applied annually.

### Manure and fertilizers

- The manure and fertilizer requirement depend upon the soil fertility, age of tree, cultural practices and crop load.
- To judge the actual nutrient requirement, the leaf and soil analysis should be done to know the status of nutrients in the tree and soil.
- The manure and fertilizer schedule for any fruit crop is suggested after long term fertilizers trial.
- In the orchard of optimal fertility, nitrogen, phosphorus and potassium is applied in the ratio of 70:35:70 g per year age of apple tree and doses of these NPK fertilizers are stabilized at the age of 10 years .

## Temperate Fruits

- For ten or more than ten year- apple tree, 100 kg FYM, 700 g N, 350 g P<sub>2</sub>O<sub>5</sub> and 700 g K<sub>2</sub>O should be given annually.

**Table 1: Recommended fertilizers schedule for apple in Himachal Pradesh**

Age of the tree(year)	FYM (kg)	N (g)	CAN (g)	P <sub>2</sub> O <sub>5</sub> (g)	SSP (g)	K <sub>2</sub> O (g)	MOP (g)
1	10	70	280	35	220	70	115
2	20	140	560	70	440	140	230
3	30	210	840	195	660	210	350
4	40	280	1120	140	880	280	470
5	50	350	1400	175	1100	350	585
6	60	420	1680	210	1320	420	700
7	70	500	1960	245	1540	500	820
8	80	560	2240	280	1760	560	935
9	90	630	2520	315	1980	630	1050
10 and above	100	700	2800	350	2000	700	1170
Off year	100	500	2000	250	1560	400	670

- The N, P and K are applied in the form of calcium ammonium nitrate, single super phosphate and muriate of potash fertilizers, respectively.

## Time and method of application

- FYM along with full dose of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O is applied during December-January.
- Nitrogen is applied in two split doses. Half dose of N is applied one month before flowering (March) and remaining half dose one month after fruit set.
- These fertilizers should be applied when there is enough moisture in the soil.
- The fertilizers should be broadcasted in tree basins 30 cm away from the trunk..
- However, in very steep slopes and heavy rainfall areas band application of fertilizers is recommended to avoid leaching and run off losses of fertilizers.
- For higher fertilizer use efficiency, soluble fertilizers can also be applied through drip irrigation.

## Foliar application of nutrients

- The micro-nutrients particularly boron, zinc, iron and manganese are essential for normal growth of plant and their deficiency is frequently observed in apple.
- It can be corrected by two foliar sprays of ZnSO<sub>4</sub> (0.5%) and boric acid (0.01%) before flowering and in May-June.

## CULTURAL PRACTICES

### Orchard floor and weed management

- Weeds if allowed to grow in the orchard exhausts nutrients and moisture from soil. Thus it is suggested that apple orchard should be managed as clean basin management system.

## Temperate Fruits

- In this system, the basin of trees are kept clean and free from weeds either by hand weeding, use of mulches and weedicides.
- In the initial years of plantation, the intercrops like peas, beans, cabbage, cauliflower and ginger are grown in the vacant area in between the trees but not in basin area.
- Some green manuring crops like bean, peas and gram can also be grown which helps in improving soil texture and nutrient status.
- In bearing orchard, mulching of basin area of trees with 10 cm thick layers of hay or black alkathene is a good floor management practice for efficient weed control and insitu moisture conservation.
- Sod grasses like white clover, red clover, orchard grass and rye grass are grown in the vacant area between the trees.
- For herbicidal weed control , pre-emergence and post emergence weedicides can also be used. Spray of simazine at the rate of 4 kg/ha in March, followed by two sprays of glyphosate @ 800 ml/ha at monthly intervals in July and August have been found very effective to control the weeds in apple orchards.



**Plate. 7. Mulching of tree basin  
with black alkathene and hay**

## Irrigation

- Apple require optimum soil moisture particularly during the period of fruit growth and development to get good size and better quality fruits.
- The cultivation of apple in India is mainly in hilly areas, where land is sloppy and water for irrigation is also inadequate. Moreover, in these areas rainfall is also very less or no rainfall occurs particularly during critical period of growth.
- The most critical periods of water requirement is April to July, when flowering, fruit set , fruit growth and development occurs.
- Therefore, water management is very important in apple orchards Water management includes rainwater harvesting, in-situ soil moisture conservation and efficient use of water for irrigation through drip irrigation.
- The rain water should be harvested and collected in water storage tanks. The harvested water should be used for irrigation particularly during critical periods of water requirement.
- Drip irrigation method saves more than 50 per cent irrigation water and can be adopted in water scarce areas.
- About 6-8 irrigations at 7-10 days interval should be given during April to July in Apple.
- Besides irrigation,tree basins should be mulched with hay or black polythene in the month of March.

## Temperate Fruits

### Fruit Thinning

- Heavy bearing in apple during on year, results in small sized and poor quality fruits. Therefore, judicious thinning at proper stage of fruit development (pea stage) is must to regulate cropping and improving fruit size and quality.
- The thinning can be achieved either manually or with the use of growth regulators.
- Removal of fruit lets by hand thinning is very laborious and uneconomical, therefore chemical thinning with foliar spray of 20 ppm Nephthalene acetic acid (NAA) at petal fall results in optimum fruit thinning

### Fruit Drop

- Although apple bloom profusely, yet a small percentage of flower will mature into fruit.
- Most of the flowers fall soon after full boom with small amount dropping later. Fruit drop is a serious problem in apple.
- In most of the commercial varieties 40 to 60 per cent fruit drop occurs in three phases.
  - Early Drop is a natural and occurs due to lack of pollination after petal fall to three weeks later. This drop can be controlled by assuring effective pollination and placement of bee hives and planting of more pollinizer varieties in the orchard.
  - The June Drop is a major drop which is caused by moisture stress. This drop can be controlled with the application of irrigation water and mulching of tree basins.
  - The Pre-Harvest Drop occurs before harvesting of fruits and caused economic loss to farmers, which is due to reduction in levels of auxins and increase in ethylene in the fruit. Application of 10 ppm NAA 20-25 days before harvest checks this drop.

### Use of growth regulators:

Growth regulators plays a significant role in breaking seed dormancy and improving seed germination, rooting in cuttings of clonal rootstocks, flowering fruit set, vegetative growth, fruit size and shape, colour development, ripening and abscission and control of fruit drop in apple. The role of these growth regulators are broadly described as:

1. **Plant propagation:** Growth regulators help in breaking seed dormancy and initiation of rooting in cuttings of clonal rootstocks. GA3 at 100-200 ppm can overcome the physiological dormancy and stimulate germination in seeds. Application of IBA at 2000 ppm and NAA @200 ppm helps in rooting in cuttings of clonal rootstocks.
2. **Effect on growth:** Growth regulators like auxin and GA3 helps in increasing the vegetative growth, growth retardants like PP333 retard the growth of trees and help in flower bud formation. Foliar spray of PP333 @ 500 to 1000 ppm reduces the vegetative growth of apple trees. Application of 250 ppm GA3 stimulate the vegetative growth but also enhances alternate bearing phenomenon.
3. **Effect on fruit set and yield:** In apple there is a problem of fruit setting in marginal and warm areas. Application of triacantanol (20 ppm), miraculan (0.6 ml/L), Paras 0.6 ml/L or Biozyme at 2ml/ L sprayed at bud swell and petal fall stages helps in improving fruit set and yield in Delicious apple.
4. **Fruit drop:** The problem of pre-harvest fruit drop is more severe in early maturing cultivars, where 40-60% of fruit drops. The pre-harvest dropping is mainly because of hormonal imbalance and can be controlled with the application of 10 ppm NAA, (1 ml of Planofix in 4.5 L of water) one week before the expected fruit drop.
5. **Fruit thinning:** Many cultivars like Red Gold , Starking Delicious and Golden Delicious are prone to bear heavily resulting in smaller, low quality fruits thus promote biennial bearing cycle. The application of 10-20 ppm NAA, 7-15 days after petal fall is most effective for fruit thinning and to maintain regular production of good size and quality fruits.



## Temperate Fruits

- Improvement of fruit shape:** In apple market price depends upon the size and shape having well developed calyx lobes especially in Delicious Group apples. Application of promalin 30-60 ppm (GA3+7 + cytokinin) at pea stage helps to improves the shape of the apple fruits.
- Improvement of fruit colour and maturity:** Apple surface colour development is greatly hampered in low lying apple growing areas due to warmer conditions. Fruits with poor colour fetch low prices. Application of ethrel (2- chloro ethyl phosphonic acid) @ 1200 ppm a.i. or 4.5 ml ethrel/ litre of water + 25 ppm NAA improves surface red colour in apple.

## Maturity indices and Harvesting

- Apple is a climacteric fruit in which the maturity of fruit does not coincide with ripening.
- The fruits do not attain ripe edible quality on the tree at harvest. If the fruits are picked immature, these fruits lack flavour and taste, which shrivel in storage.
- The harvesting of over mature fruit develops soft scald and internal breakdown and has poor shelf life.
- To judge the optimum harvesting time several maturity indices are adopted.
- The maturity indices like days from full bloom to harvest, change of ground colour of fruit from green to yellow to pale, TSS of fruit pulp, ease of separation of fruit from spur, change of seed colour to light brown and fruit firmness are used singly or in combination.
- The entire fruit does not attain full colour and mature on the tree at one time, therefore, fruits should be picked in 2-3 pickings.
- Harvesting of fruit is done in such a way that bruising and stem puncture are avoided and pedicel must retain with fruit.
- Fruits of apple are grasped between index finger, middle finger and thumb and quick twist of wrist will easily pluck the fruit along with pedicel.
- Picked fruits are placed softly in the picking bag or basket and transported to packing houses for grading and packing.

**Table 2. Maturity indices for important varieties of apple**

Fruit	Variety	DFFB (Days)	Firmness (kg/cm <sup>2</sup> )	TSS (%)
Apple	Tydemans Early Worcester	90 ± 4	7.8 ± 0.15	12.0-13.0
	Starking Delicious	120 ± 5	8.2 ± .4	13.0-15.0
	Red Chief	110±5	8.5± .4	14.0-15.0
	Red Delicious	134±5	8.5± .4	13.0-14.0
	Golden Delicious	148±5	8.4± .4	12.0-14.5
	Granny Smith	180± 5	8.4± .4	13.0-14.0

## Temperate Fruits



Plate 8. Harvesting of apple fruits

### PRE- AND POST-HARVEST MANAGEMENT

- After harvesting of fruits, proper handling, grading and storage is important. In apple fruits, about 30% post harvest losses have been recorded, which can be minimized by proper handling of fruits.

#### (a) Precooling:-

- Immediately after picking, the fruits should be placed in a cool and ventilated place for removal of field heat before packing.
- For the removal of field heat, the methods like use of air cooler, cold water sprinkling, fruit washing and keeping of fruits over night in a cool place are adopted.

#### (b) Grading:-

The fruits are graded according to fruit size and fruit appearance like colour and shape. On the basis of size, the apple fruits are graded manually or by mechanical grades as:

Table 3. Size grades of apple

Grade	Fruit diameter (mm)
Super Large	85 ± 2.5
Extra Large	80 ± 2.5
Large	75 ± 2.5
Medium	70 ± 2.5
Small	65 ± 2.5
Extra Small	60 ± 2.5
Pittoo	55 ± 2.5

- On the bases of fruit colour shape, quality and appearance fruits are graded as AAA, AA, and A.
- The quality of fruits during transportation, storage and marketing are influenced by the packing. Usually, apples are packed in telescopic corrugated fibre board (CFB) cartons.
- The usual dimensions of telescopic CFB carton with trays are 50.4 x 30.3 x 28.2 cm (outer jacket) 50 x 30 x 28.2 cm (inner case).

## Temperate Fruits

- The each layer of fruit in carton is separated by a fruit trays which are different for different size grades.

### (c) Storage

- Apple fruit has long storage life and shelf life of fruits can be prolonged by providing optimal storage conditions.
- The cold storage retards fruit deterioration and reduce decay from pathogen and to prevent shrivel ness resulting from water loss.
- Apple fruits can be stored for 4-6 months after harvest in cold storage at a temperature of -1.1 to 0 oC with 80-90 per cent relative humidity.

### (d) Processing

- About 30 per cent of apple fruits are rejected as cull fruits before packaging for fresh fruit market.
- The culled fruits can be processed and preserved as fruit pulp for making various value added products like jam, fruit leather, fruit toffees and fermented products like wine can be prepared from preserved pulp.
- From fresh fruit juice can be made.



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### Lecture 4: Insect pests, diseases and special production problems of apple.

#### INSECT-PESTS AND DISEASES

##### 1. Insect-pests:

- The insects like san jose scale, woolly apple aphid, red spider mite, tissue borers and defoliating beetles and caterpillars in apple are important insects, which causes great damage to plants.

##### (a) San Jose Scale (*Quadraspidiotus perniciosus*) :

- It is polyphagous pest which feeds on apple plants. The insect is covered with deep grey armature.
- By lifting armature, a yellow coloured insect underneath is seen. The nymph and adults suck sap from aerial parts.
- Heavily infested trees have bark covered with deep grey overlapping scales. The plant vigour is reduced which results in poor fruit setting and quality.

##### Control:

- Spray 2 per cent dormant oil ( Servo orchard spray oil/ Hindustan petroleum spray oil ) or 1.5 per cent summer oil like orchaks 796/ IPOL/shelter909 at half leaf to tight cluster stage.
- If oil spray is not applied then spray with 0.04 % chlorpyrifos ( 200ml durmet in 100 L water) after petal fall to kill the crawlers and newly settled scale.

##### (b) Woolly apple aphid (*Eriosoma lanigerum*) :

- It feeds on apple and lives in colonies on the aerial parts and roots of plant.
- On the aerial parts, it is seen as white woolly mass.
- Damage is caused by sucking of sap from stem, twigs and roots resulting in gall formation, plant remains stunted.
- Fruit set and quality also reduced under severe infestation.

##### Control:

- Spray infested trees with 0.04% chlorpyrifos ( 200ml durmet in 100 L water) during May-June and again in October.
- Aphid infestation on roots can be reduced by drenching the collar region of tree with chlorpyrifos (0.1%) in October- November using 10-15 litre solution per tree.
- Use Mulling Merton (MM) series clonal rootstocks for raising nursery plants, which are resistant to woolly aphid.

##### (c) European red mite (*Panonychus ulmi*):

- This is a serious pest in apple and causes damage by feeding on green matter of leaves. The leaves turn bronze in colour and upward cupping, followed by leaf drop and weakening of fruit bud.
- The maximum population is observed during May-July. The mite completes 5-7 generations in a year.

## Temperate Fruits

### Control:

- Spray 2 per cent dormant oil ( Servo orchard spray oil/ Hindustan petroleum spray oil ) at half leaf to tight cluster stage. Dormant oil spray as suggested for scale is effective against mites.
- Spray of 1 per cent summer oils like orchaks 796/ IPOL/shelter909@ 1 % at petal fall and again at walnut stage of fruit.
- If population is high, spray with fenazaquin ( 25 ml Magister 10 EC/100 L) or propargite (100 ml Omite/ 100 L water) twice at 20 days interval in June- July.

### (d) Defoliating Caterpillars:

- They feed on newly emerged leaves and defoliate the trees. The growth of plants is retarded .

### Control:

- Spray 0.05% Endosulfan ( 150 ml Thiodon or endocil 35 EC in 100 L water)15-20 days before flowering or when caterpillars appear.

## 2. Diseases

Diseases also cause a great damage to the apple trees. Apple scab, powdery mildew, premature leaf fall, canker and root rot are major diseases of apple plantation.

### (a) Apple scab:-

- This is caused by fungus *Venturia inaequalis*.
- Light brown or olive green spots which soon turn musty black appear on either or both sides of the young leaves in spring.
- Young lesions are velvety brown to olive green becoming more distant with age, leading to curling of leaves.
- On the fruits, small lesions develop and slowly increase leading to misshapening and cracking of fruits.



Plate. Scab symptom on leaves



Plate Symptoms on fruit

### Control:

- Follow the spray schedule of dodine (0.1%) or mancozeb (0.3%) at silver tip to green tip, mancozeb (0.3%) + carbendazim (0.05%) at pink bud, benmyl/ carbendazim (0.05%) at petal fall, zineb (0.3%) or dodine (0.075%) at pea size fruit, mancozeb + carbendazim in June-July and urea 5% spray after fruit harvest to control the disease.

## Temperate Fruits

### (b) Powdery mildew:-

- This disease is caused by fungus *Podosphaera leucotricha*, which survive as mycelium on dormant buds.
- The young leaves show white mildew growth on its surface and also on twigs and look silvery white.

#### Control:

- Prune off affected twigs .
- Spray during dormancy, green tip, petal fall and two weeks after petal fall with fungicides like wettable sulphur (200-300 g/100 L) or contaf (50 g / 100 L) or Baycor (50 g/ 100 L).



**Plate Powdery mildew**

### (c) Canker:-

- Many fungi have been reported to be involved in canker complex.
- Symptoms appear on trunk and branches, resulting in the production of wounds which develop length wise more rapidly.
- These are normally elliptical and the wound may increase up to a meter in length.
- The bark beneath the rough exterior becomes hard, dry and tough.



**Plate Canker**

**Plate Pasting with chaubattia paste**

#### Control:

- Cut and burn the badly cankered portion of the tree.
- Scarify the cankered portions up to healthy portions and paint with Chaubattia paint.
- Immediately after pruning, apply chaubattia paste or copper oxychloride paint on cut portions of the shoot.
- Spray copper oxychloride (300 g) or captan (200 g) in 100 L of water after fruit harvest.

## Temperate Fruits

### (d) White root rot:

- This is caused by *Dematophora necatrix* fungi.
- Affected trees shows sparse foliage, slow growth, bronzing or yellowing of leaves. Such trees ultimately die. Root turns brown and remain covered with white cottony mycelial of fungi in rainy season.



Plate White root rot

Plate Root rot affected tree

### Control:

- Improve the drainage of an orchard.
- After leaf fall, remove the infected roots and apply Chaubattia paste ( Red lead, copper carbonate and linseed oil (1:1:1.25) or copper oxychloride (300 g/100L) in Nov- December on cut ends of the roots.
- Give at least four drenching of Carbendazim (100 g) along with mancozeb (300 g) in 100 L of water during April, June, July and September in infected trees.

SPECIAL PROBLEMS: Low Productivity in apple

### Low Productivity in apple

- Decreased productivity of apple orchards in the recent years has become a serious concern of the growers in all the apple growing areas.
- The apple productivity has been fluctuating year to year between 2 MT to 8 MT/ ha.
- The factors which influence yields are climate, soil, cultivar, rootstocks and cultural management practices.
- Most of factors influencing yield are manageable to a large extent but the climatic factors are beyond the control.
- The appearance of certain diseases and pests in epidemic form has also adversely affected yield in recent years.
- The out break of red spider mite attack and premature defoliation of apple in the past 9-10 years has remained persistent problem in apple orchards.

### Causes of Low productivity

#### 1. Climatic factors:

- The low temperature at the time of flowering and fruit setting adversely affects production of fruits.
- The areas most vulnerable to the influence of low temperature are located between 5000 to 6000 feet elevation where good spring season with adequate sunshine promote apple flowering during mid March to mid April

## **Temperate Fruits**

- Fluctuating temperature during this period particularly rains accompanied by low temperature inhibits the cross pollination due to restricted bees activity and washing off pollen and poor pollen tube growth.
- It is well established that the flowers are killed below 2.20C and bee activity is completely inhibited below 4.4oC.

### **2. Varietals factors:**

- In Himachal Pradesh, Delicious group of apple varieties constitutes more than 80 per cent of the total production of apple.
- The predominant varieties like Starking Delicious, Red Delicious, Rich-a-red and certain improved bud sports and spur types are self unfruitful and require cross pollination for fruitfulness.
- Moreover, these varieties have strong tendency of alternate bearing ,which is also one of the reasons for low production during the off years.

### **3. Inadequate pollinizer:**

- In Himachal Pradesh, 25 to 33 per cent proportion of pollinizing varieties in orchards is recommended for adequate fruit set.
- But actual proportions of these varieties is only 5-10 per cent. The problem is further compounded due to predominance of Golden Delicious as a pollinizing variety, which does not synchronize in flowering of the Delicious varieties in many agro climatic situations, and strong tendency of alternate bearing.

### **4. Lack of pollinators:**

- Honey bees are the major agents besides other wild pollinators for effective pollination in apple.
- Over the years the population of honey bees and other pollinators have declined due to indiscriminate use of pesticides.
- Placement of honeybees in the orchards has also not picked up due to scarcity of beehives.

### **5. Inadequate nutrition:-**

- Apple cultivation is mostly done on the slopes which poses serious problem of water and nutrient losses.
- Frequent dry spells during April-June and September -November make the nutrients unavailable to the plants even if applied adequately in the soil.
- Contrarily leaching of the nutrients during rainy season from July -August further affects the health of the trees.
- It has also been noticed that the fertilizers are not applied according to the requirement of the trees.

### **6. Poor soil conditions:-**

- In orchards which are planted on the slopes, run off losses render the soils nutritionally and structurally poor. In many orchards, soils which do not have adequate drainage, temporary water logging conditions develop during the rainy season killing feeder roots and temporarily restricting the uptake of the nutrients. All these factors adversely affect the plant health and productivity.

### **7. Poor canopy management:**

- Dependence of the orchardists on hired pruners is increasing day by day. The plants are not properly trained and pruned by these untrained pruners resulting in poor canopy development.



## Temperate Fruits

- At lower elevation where the vegetative growth is excessively more due to warm conditions, hard pruning promotes more vegetative growth and reduces reproductive growth is considered a wrong orchard practice.
- In such conditions lesser heading back and more thinning out of shoots as per tree behavior is required to balance cropping and growth.

### 8. Senile orchards:

- Orchards more than 40 years of age face the problem of unfruitfulness more seriously than the young orchards.
- Such orchards do not produce adequate annual extension growth and usually have foliage of small size.
- The old orchards have also been planted under traditional systems of planting at a spacing of 20-25 feet, which take 15-20 years to come to commercial fruiting after planting.
- Use of ethephon for early maturity and colour improvement at lower elevation has also proved counter productive. Continuous use of ethephon beside poor orchard management practices is a cause of senility and poor shelf life and quality of the fruits.

### 9. Pathological factors:

- The number of disease has been found affecting the apple orchards. The most serious among these is apple scab .Besides apple scab others diseases are premature leaf fall, root rot, color rot, replant problem. Powdery mildew, cankers and viruses. Most of the pollinizing cultivar like golden Delicious and Red Gold have been found to be higher susceptible to scab.

### 10. Entomological factors:

- The magnitude of pest in incidence varies from region to region and orchard to orchards. Aphid is most dominant one affecting 82 per cent orchards followed by San Jose Scale (71%), blossom trips (70%), European mite (62%), apple leaf roller(43%) root borer(26%) stem borer(9%), defoliating beetle(6%) and hairy cater pillar (5%).

### Suggested Remedial measures:

1. Among the standard varieties there should be more proportion of regular bearing varieties than the Delicious cultivars.
2. Adequate proportion of pollinizing varieties should be compensated with has not been provided, top working of the trees with pollinizing varieties.
3. Proper orchard soil and canopy management practices should be given adequate priority.
4. There is an urgent need to go for high density plantation in different temperate fruit crops.
5. Indiscriminate use of insecticides, pesticides and fungicides should be avoided in order to maintain the population of natural predators and avoid problem of tolerance by pests.

### SPECIAL PROBLEMS: Premature leaf fall

#### Premature leaf fall

- Apple plantations in Himachal Pradesh have been ravaged by a unique phenomenon of leaf shedding in mid-summer for the last few years.
- The problem starts in the month of June-July and by mid August majority of orchards affected and severe cases only fruits are seen hanging on the defoliated branches near maturation.

## Temperate Fruits

- The disease which was first noticed in 1995 in some orchards, which now spread to all apple growing districts of the State.
- All the commercial Delicious cultivars are susceptible. Premature leaf shedding has also been reported recently from Kashmir, neighboring Uttaranchal and Bhutan.

## Symptoms

- Disease symptoms first appear as dark green circular patches on upper surface on the mature leaves giving rise to 5-10 mm size brown leaf spots especially in the months of June and July, which turn dark brown in the due course.
- When lesions are numerous they coalesce to form larger dark brown blotches and the surrounding areas turn yellow.
- Severe leaf shedding follows these symptoms in the following weeks quite a head of natural leaf fall in autumn.
- In affected orchards, fruits nearing maturity are commonly seen hanging on the defoliated branches.
- Symptoms also appear on the fruit as clear brown spots, which are initially circular (3-5 mm in diameter) and become oval, depressed and dark brown later.
- Numerous small black colour pinhead specks, the acervuli are visible in the affected tissues.

## Casual organism and disease development

- This disease is caused by *Marssonina coronaria*, but *alternaria* leaf blight is also involved in this malady.
- This fungus is reported to perennate in the fallen leaf litter on the orchard floor. The seeds of the fungus are mature by the time of blooming in the spring and they are liberated in the orchard for a quite long period.
- In Himachal Pradesh, the perfect stage of this fungus is not frequently intercepted.
- This fungus was found to perennate in the infected leaf litter in the form of acervuli which produce fresh conidia in early summer to start primary infections.
- Frequent rains are helpful for disease development. Infections first appear on mature leaves turning yellow and abscise prematurely.
- Countless conidia and microconidia are formed on diseased leaves which cause secondary infections leading to epiphytotic development in favorable humid conditions.

## Management

- This disease can be controlled effectively integrating different technologies like field sanitation, proper pruning and judicious use of fungicides as follows:
- The orchardists are advised to collect and destroy the fallen leaves from the orchard floor in winter. Urea (5%) spray on the leaf litter is also helpful in reducing the primary inoculum by enhanced decomposition of leaves.
- Proper pruning allows adequate air circulation in the tree canopy thereby modifying the microclimate and reducing disease development.
- Protective 3-4 sprays of fungicides like mancozeb (0.3%), carbendazim (0.05%), thiophanate methyl (0.05%), benomyl (0.05%), propineb (0.3%), dodine (0.075%), ziram (0.3%), dithianon (0.05%) and zineb (0.3%) are effective in controlling the disease.

## Temperate Fruits

### SPECIAL PROBLEMS: Replant Problem

#### Replant Problem

- Replantation pertains to the plantation of new plants of apple in the fields vacated by removal of old and declining trees.
- In India old trees in many apple orchards have either outlived their economic bearing life or declined due to the adverse effects of non-curable insect pests/diseases problems and/or natural calamities.
- Moreover, many growers want to introduce new improved and highly productive varieties in their old orchards, that too, sometimes under high density plantations.
- Because of land limitations, the growers the growers are mostly compelled to plant new apple trees on the old apple sites.

There has been increasing concern about poor growth, delayed fruiting and short life of apple trees planted in the old apple sites.. This problem being faced by the growers is termed as 'Replant Problem'. It is also, sometimes, termed as 'Replant Disease' when only biotic causes are involved to develop such situation.

#### Causes of Replant Problem

- There are many causes of poor growth of young trees of apple and these vary from region to region or even orchard to orchard in a particular region. These can include weak or diseased nursery stock, poor planting and management techniques, water deficiencies or excessive, spray injuries or damage from insects, diseases, rodents etc. But our concern here is only with the soil related causes, which include biotic (harmful microorganisms) and a biotic (nutritional deficiencies or excessive soil pH, phytotoxins) factors in the soil.
- Various types of micro-organisms like fungi, bacteria, actinomycetes, nematodes and their interactions causes replant problem.
- When we remove the old plants, some of the root system (mainly fine roots) are left behind in the old site.
- The soil adhered to such roots consists a good population of micro-organisms which later almost rob the newly planted trees of their vital elements, thereby adversely affecting their growth.
- These micro-organisms can also directly affect the newly planted trees by causing some kind of maladies in their root system.
- A number of fungi belonging to oomycetes, hypomycetes and basidiomycetes have been reported as causal agents of replant disease.
- In England, Canada and U.S.A., many investigators have shown that species of Phytophthora and Phythium are the primary causes of replant disease, Phythium sylvaticum has been identified as cause associated with apple replant disease in Canada.

#### Management of Replant Problem

- Liming has been found effective in soils where Dermatophthora and Phytophthora are the causes of replant problem.
- The elements, N and P have been reported to suppress the growth of replant disease caused by fungi and bacteria and subsequently to promote the growth of bacteria antagonistic to these usual organisms.
- Replacing the soil at a replantation site with the steamed/fumigated old apple soil or some non-apple soil or potting soil mixture (containing peat, sand or soil, dolomite, lime, NPK fertilizer, minor elements) have also been reported as effective in attaining good growth of replanted apple trees.

## Temperate Fruits

- Inter-cropping with herbaceous crop and growing mustard and radish before planting greatly improved the growth of newly planted apple seedlings. Antagonistic crops like marigold (*Tagetes pastula*) successfully reduced the population of nematodes, *Pratylenchus penetrans* and the fungus, *Phythium* spp. In replant soil. Cultivation of red fescue (*Festuca rubra*) and red top (*Agrostis alba*) also reduces *P. penetrans* population.
- Soil sterilization by fumigation, steaming or even solarization checks the population of soil borne pathogens. Generally pre-plant treatments are more useful than the post-planting treatments.
- The recommendations to manage the replant problem in Himachal Pradesh include:

i) Dig out and destroy the stumps and roots of old/dead apple trees.

ii) The fresh layout of the orchard be done by avoiding frequently/possibly the old pit sites.

iii) New pits of bigger size (5 x 3 ft) should be dug and kept open for exposing to sunlight for about one month.

iv) Pre-plant soil sterilization by fumigation (early winter) or solarization (during summer) to check the population of soil borne micro-organisms. For fumigation, make 9 inch high heap of pit soil outside the pit, drench with formalin solution (1 litre of commercial formalin in 9 litres of water) and cover with transparent thin polyethylene sheet for atleast 48 hours. Remove the sheet and turn the soil daily for about a week so that formalin fumes escape from the treated soil. In case of solarization, 9 inch high heap of pit soil is covered with transparent polythene sheet for 2 months during summer before filling the pits.

v) Incorporate well rotten FYM along with 1 kg SSP fertilizer and 200 g Kanadane dust in treated pit soil and fill the pit upto one foot above ground level.

vi) Always use the healthy and strong rooted plants for replantation. In high problem areas preferably use tolerant rootstocks of apple like Merton793

vii) To improve the growth of newly planted apple seedlings, grow mustard, radish, marigold and red fescue (*Festuca rubra*) and red top (*Agrostis alba*) as decoy/biofumigation crops

### SPECIAL PROBLEMS: Unfruitfulness in temperate fruits

#### Unfruitfulness in temperate fruits

- Unfruitfulness is a serious problem in apple, cherry, almond and walnut and is associated with both internal and external factors.
- The sterility is mainly due to (i) Impotence, (ii) incompatibility and (iii) abortion of embryo.

**(1) Impotence:** It relates to the condition when either one or both the sex organs fail to develop to required stage and fails to form flowers or abortion of male and female flower organs occur.

**(2) Incompatibility:** It relates to the condition, where both male and female flowers develop and their organs are functional but sterility is due to the incompatibility.

(3) In some cases both the male and female flowers are formed and function but embryo abortion occur.

- Sterility associated with internal functions may be related to evolutionary tendencies due to factors associated with constitution of protoplasm, genetic influence and physiological reasons,

#### A. Evolutionary tendencies:

##### a. Defective flowers:

- Self fertilization is not possible in many temperate fruit species due to imperfect flowers, heterostyly, dichogamy and pollen impotence.

## Temperate Fruits

- In most of temperate fruit plants like apple, pear, stone and nut fruits, flowers are perfect and present on the same plant (monoecious) but problem of unfruitfulness still occur due to incompatibility ( apple, cherry and almond) and dichogamy (walnut , pecan nut and chestnut).
- In kiwifruit the male and female flowers are present on different plants which restrict self pollination.
- In apple, cherry and almond the cross incompatibility results in unfruitfulness.
- Some varieties of persimmon are staminate constant ( bear staminate flowers every year) and pistillate constant
- The presence of short styles with long filaments or long styles and short filaments is dimorphism, a type of heterostyly and basal gap between filaments is more which allow the bees to enter without touching the stigma to collect nectar ( in some apple varieties) results in unfruitfulness.

### Abortiveness leading to impotence:

- Interference either in the development of flowers or in the full development of sex elements and their functions may lead to unfruitfulness.
- In certain varieties of plum pistil is degenerated and unfruitfulness results. In pecan and walnut the terminal clusters consisting of pistillate flowers fall off before pollination leads to unfruitfulness.
- In strawberry also late flowers are abortive and no fruit set occurs in these flowers.
- In some temperate fruits there are some varieties having defective pistil (plum), defective embryo and embryo-sac (apple) which also leads to unfruitfulness.

### Non-viable pollen:

- When the pollen is not viable the production of fruit is not possible. Pollen of some varieties of plum, peach, pear and cherry are non-viable due to their abortion leads to unfruitfulness in these fruits.

### Genetic factors:

- Hybridity is associated with sterility as well as unfruitfulness. Hybridity is also responsible for seedlessness in some varieties of temperate fruits.
- Hybridity and incompatibility are two type of sterility which are directly due to genetic factors.
- Self sterility depends on inheritance but its development is controlled by environment. Peach- plum hybrids known as Blackman are completely sterile. Similarly, Peach- sour cherry hybrid Kamdesa is completely sterile. Pyronia (Pear x quince) flowers and fruits freely but is always seedless.
- Incompatibility between pollen and ovule is one of the causes of unfruitfulness in apple, cherry, almond, pear, apricot, plum .

### Physiological causes:

- Poor growth rate of the pollen tubes in the styles, possibly due to hormonal or chemotropic control ( apple, pear, cherries) is known.
- The pollen tube growth is slow due to low temperature.
- Unfruitfulness can also results from difference in the stage of maturity of pollen grain vis a vis the pistil and embryo.
- The proper development of the flowers, its maturity and fertilization leading to development of a fruit with viable seeds is controlled by the abortive condition within plant existing at the time of pre-blooming and post-blooming stages.
- The nutritive status of the plant determines the time taken by the pollen to fertilize. Fertilization takes in shorter time in strongly vegetative condition then those in poorly vegetative condition.
- Defective pistils are formed in exhausted or weakned trees caused by overbearing, drought and poor nutrition.

## Temperate Fruits

### External factors:

(1) **Environment:** the climatic conditions at the time of flowering affect pollen germination, pistil formation and transfer of pollen , pollen tube growth and ultimately on fruit set. Low temperature and rainfall at the time of flowering adversely affect the transfer of pollen and pollen tube growth thereby results in poor fruit set in most of temperate fruits.

(2) **Nutrition:** Proper nutrient supply affect fruit setting as well as unfruitfulness. Jonathan apple which is self sterile become self fruitful in rich soils having optimum level of nutrients in the soil. Infected high nitrogen content in plant at the time of flowering encourages fruitfulness.

(3) **Pruning:** Moderate heavy pruning induces good setting and yield.

(4) **Age and vigour of plant:** Very young and vigorous tree set less fruits than the moderate vigorous and old trees.

(5) **Water relations:** Moisture stress promote the formation of abscission layers leading to flower and fruit drop.

### Control :

- Pollination management by planting pollinizing varieties, placement of bee-hives .
- Proper nutrient management
- Irrigation
- Proper pruning



### LECTURE 5 – Pear cultivation

#### INTRODUCTION

##### Taxonomical classification

Order = Rosales

Family = Rosaceae

Sub-family = Pomoideae

Genus = *Pyrus*

Species = *communis*

Basic chromosome = 17

Somatic number = 34

##### Introduction

- Pear (*Pyrus communis*) is next only to apple in importance, acreage, production and varietal diversity amongst the temperate fruits.
- The genus *Pyrus* has probably originated in the mountainous regions of Western China.
- Vavilov (1951) proposed three centres of origin for the cultivated pear.
  1. **Chinese centre:** It is primary gene center comprising the regions of north and central China, Japan and Korea. The important species which originated in this track are *P. pyrifolia*, *P. ussuriensis*, *P. betulifolia* and *P. calleryana*.
  2. **Central Asiatic centre:** Western Tian-shan, Uzbekistan, North-west India and Afghanistan are included under this centre. The indigenous species *P. communis*, *P. paishia*, *P. salicifolia* originated under this centre.
  3. **Near Eastern centre:** Asia minor and Caucasus mountains are the tracks where great variability exists in *P. communis*, *P. syriaca* and *P. caucasica* are the important species found in this centre.
- There are 22 primary species, which are classified in to 4 groups on the basis of geographical distribution.
  1. **European group:** *P. communis*, *P. nivalis*, *P. cordata*, *P. caucasica*
  2. **Asian group:** *P. calleryana*, *P. betulifolia*, *P. dimorbhophylla*, *P. Koehnei*
  3. **North Africa group:** *P. longipes*, *P. memorensis*, *P. gharbiana*
  4. **East Asian group:** *P. pyrifolia*, *P. ussuriensis*, *P. hodoensis*
- Both European and Asian pears were domesticated by hybridization and selection from local wild species in prehistoric times.
- Chinese and Japanese migrants took Asian pear to USA as seed and scion material.
- In India, various English missionaries introduced pear along with other fruits some times during 1970 and planted them in Kullu, Shimla in Himachal Pradesh and Kumaon hills in Uttarakhand.
- After this many varieties of pear were introduced from England, France, Italy and Japan.
- Pear in temperate areas of the state are mostly grown as intercrops in apple orchards.
- However, in recent years some compact orchards of pear have been established in Kullu and Shimla districts of Himachal Pradesh and Kashmir valley.

## Temperate Fruits

### Area and Production:

- Due to wide genetic variability pear is cultivated in many temperate and tropical countries of the world.
- In the world the area under pear is 1580876 ha and production is 22460529 MT.
- In India, pear is
- HP has the grown in more than 9 states and area is 38160 ha, production is 317244 MT.
- Himachal Pradesh has maximum area of 7382 ha with a production of 17381 MT.

### Plant description:

- Plant is a deciduous, tree or shrub, leaves serrate, crenate rarely lobed.
- Flowers are with or before leaves, in umbel like raceme, white rarely pinkish, sepals reflexed or spreading.
- Petals suborbicular to broad oblong, stamen 20-30, anthers red to purple, style 25, free, closely constricted at base.
- Ovules 2 per locule.
- Fruit- a globose or pyriform, pome with persistent or deciduous calyx.



**Plate 1. Pear tree in fruiting**

### Climate and Soil :-

- Pear can be grown in wide range of climatic conditions, as it can tolerate as low as  $-26^{\circ}\text{C}$  temperature during dormant season and as high as  $45^{\circ}\text{C}$  during growth period.
- A large number of pear cultivars require about 1200 hour below  $7^{\circ}\text{C}$  during winter to complete their chilling requirement to flower and fruit satisfactorily.
- However, Bartlett needs about 1500 hours compared to other temperate pears
- Pear variety Patharnakh needs only 150 hours of chilling and also with stand high temperature and hot winds during summer.
- The medium chilling requiring pear cultivars. like Le Conte, Kieffer, Gola perform well in areas experiencing mild winter.
- Spring frosts are detrimental to pear production and temperature at  $-3.3^{\circ}\text{C}$  or below kills the open blossom or flowers. Therefore, low lands should be avoided for its planting.
- North eastern slopes are better for pear plantations because warmer aspects have a problem of spring frost which kills the bloom.



## Temperate Fruits

- Pear grows best in deep, well-drained, fertile medium textured loamy soil. It is more tolerant to wet soils but less tolerant to drought than apple .
- Pear even do well on poorly aerated heavy soil with high water table which is heavy in texture for most of deciduous fruits.
- A pH range of 6.0 to 7.5 is desirable because Fe deficiency appears in alkaline soils.

### Varieties:

- Pear varieties belongs to 2 groups:- European Pears and Asian Pears
- European pears fruits are pyriform in shape without any grit cells, whereas asian pears are roundish in shape with grit cells.

(1) **European Pears:** Bartlett, Clapp's Favourite, Anjou, Conference, Winter Nelis, Flamish Beauty, Doyenne du Comice, Max Red Bartlett, Red Bartlett, Starkrimson, Laxton's Superb.

(2) **Asian Pears:** Shinseiki, Chojuro, Kosui, Nijisseiki, Kikisu, Yali

**Table 1. Recommended varieties for different states.**

Early season	Mid season	Late season
<b>(A) Himachal Pradesh</b>		
<b>High hills:-</b>		
Early China, Laxton's Superb, Fertility	Bartlett, Red Bartlett, Max Red Bartlett, Starkrimson, Flamish Beauty, Clapp's Favourite, Dr. Jules Guyot	Conference, Doyenne Du Comice, Kashmir pear.
<b>Low and valley areas:</b>		
Sand pear, Kieffer, China, Punjab Beauty, Punjab Nector, Punjab Gold		
<b>(B) Jammu and Kashmir</b>		
China pear, Beurre d' Amanlis	Citron-do-carne, Bartlett, Ghoshbugh, Clapp's Favourite, Fertility, Chinese sand pear	Beurre Hardy, Vincor of Winkfield.
<b>(C) Uttarakhand</b>		
Thumb pear	Doyenne Bursoch, Docteur Dr. Jules Guyot, Baggughosha, Clapp's Favourite, Pathernakh, Le-Conte, Flamish Beauty	Winter Nelis, Conference.
<b>(D) Punjab</b>		
Le-Conte, Kieffer, Punjab Beauty, Punjab Nector		

## Temperate Fruits



Plate 2. MAX RED BARTLETT



Plate 3. STARKRIMSON



Plate 4. Conference

### ROOTSTOCKS AND PROPAGATION

- Pear is commercially propagated through grafting on seedling or clonal rootstocks
- Seedling rootstocks are seedlings of Kainth (P pashia) and Shiara (P serotina).
- Clonal rootstocks are Quince A (vigours), Quince B (Intermediate) and Quince C (dwarf) and BA 29.
- In Punjab, root suckers of cultivated pear are also employed as a rootstock
- Some clonal rootstocks like OH X F-230 (semi-dwarf), Oregon 211 (dwarfing), Oregon260 have been recently released and found promising.

#### Propagation of seedling rootstock:-

- For raising seedling rootstocks, seeds are extracted from fully mature fruits of Kainth and Shiara.
- For good germination, the seeds are stratified for 30-40 days in alternate layers of moist sand at low temperature (4-5°C) during December- January.
- The pre-stratified seeds are sown in the nursery beds at a distance of 6-10 cm seed to seed and 10-15 cm in rows at a depth of 3-4 cm.
- In very cold areas, the seeds are directly sown in the nursery beds during December. After sowing of the seeds in the nursery beds, the beds are mulched with grass mulch and light irrigation is given.
- When the seeds start germinating and attain 2-3 inch growth mulch material is removed.
- Regular weeding, hoeing and irrigation is required for proper growth of the seedlings. About 80-90% seedling are ready for grafting within a year.

#### Clonal rootstocks:

- Clonal rootstocks are multiplied through mound or trench layering as discussed under apple.

#### Raising rootstocks from root suckers:

- In plains, the root suckers from pear trees are separated during October-December along with its roots. These suckers are planted in the nursery beds at 15-20cm distance in rows 30cm apart.

## Temperate Fruits

### Own rooted:

- Hard-wood cuttings are taken during dormant season from one year old shoot. Before planting, the cuttings are treated with 100ppm IBA for 24 hours.

### Propagation of scion:

- The seedling and clonal rootstocks are grafted with tongue or cleft method of grafting during February.
- The clonal rootstock Quince is not compatible with most of varieties, particularly with Bartlett group, therefore Beurre Hardy and Old Home are used as interstock.
- T-budding during April-May also gives good bud-take success.

### Planting and planting density:

- The land selected for pear plantation should be cleared off and all the old stems and roots of earlier growing trees and shrubs need to be removed.
- After cultivating the soil thoroughly, green manuring crops are grown to improve the soil fertility.
- A planting plan is prepared adopting a particular layout system before actual planting.
- The layout system depends on the plant density to be adopted and topography of the land.
- Generally square and rectangular system of planting is followed in flat land, while terrace and contour system in sloppy lands.
- Under high density, hedge row and bed system is used for pear plantation.
- The planting distance ultimately depends upon the soil fertility, cultivars, rootstock and training system.

**Table 3. Grading and packing of pear**

Grade	Equatorial diameter (mm)	Size of box (inner in cms)	No. of layer
Extra large	<75	45.5 x 30.5 x 30.5	4
Large	70-75	45.5 x 20.5 x 20.5	3
Medium	65-70	Do	3
Small	60-65	Do	3
Extra small	55-60	Do	4
Culled	<55	45.5 x 30.5 x 30.5	Loose

- Planting is done during December- January.
- Pits of 1x1x1 m size are dug and filled with a mixture of soil, 50-60kg FYM and one kg of single super phosphate about one month before planting..

## CULTURAL PRACTICES

### Training and Pruning:-

Pear are usually trained according to modified Central leader system.

### Modified central leader system:

- Generally, one - year - old whip without a single branch is planted in the dormant season.

## Temperate Fruits

- Immediately after transplanting the tip of plant is headed back to 60 to 75 cm above the ground level.
- In the following summer, most of the buds on main branch will sprout. In order to develop clean stem up to 30 cm from the ground the sprouted buds are pinched off soon after their appearance.
- Three or four well spaced buds projecting in spirally around the trunk are retained.



Fig 1. Pruning at planting

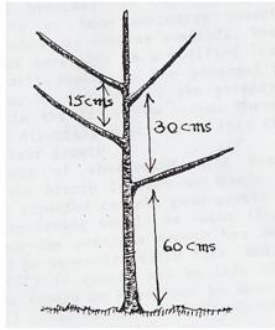


Fig 2. Selection of primary branches

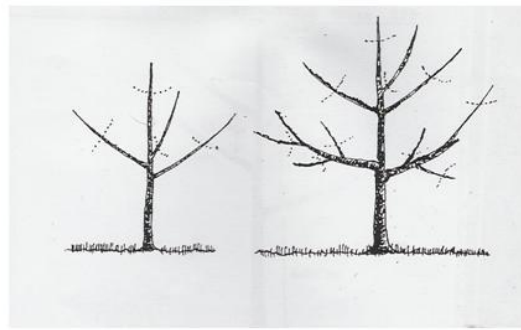


Fig 3. First year pruning



Fig 4. Second year pruning

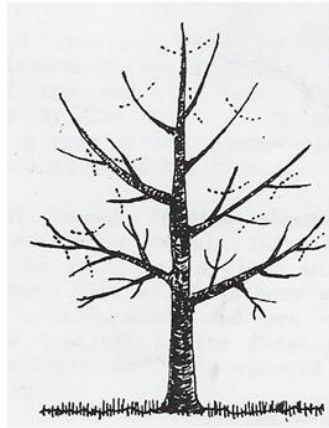


Fig 5. Third year pruning



Fig. 6. Fourth year pruning

### Modified Leader System of Training

- If summer pruning is not done, then 3-4 well spaced primary branches having wider crotch angle are selected during dormant pruning. The lowest branch should be selected at least 30 cm above the ground and other branches spaced vertically 10-15 cm apart in spiral fashion.
- The branches emerging below 30 cm from ground level and other undesirable branches are pruned off. The selected branches are headed back to  $\frac{1}{4}$  of growth to a bud projecting in the outer direction.
- The leader is also headed back to 30 cm above the last branch.
- During the second dormant pruning, 2-3 well spaced primary branches are selected on the leader.
- On the primary branches selected during previous year, two secondary branches which are growing in outward direction should be selected. The selected primary and secondary branches are headed back to  $\frac{1}{3}$  or  $\frac{1}{4}$  of the growth.
- The third year training consists of thinning out of unwanted branches and heading back of desirable side branches.
- The central leader should be headed back to a bud or weak shoot, which will develop in the form of a side branch. By fourth year training should be completed.

### Pruning:-

- In pruning of bearing tree, certain amount of thinning out and heading back of outward growing laterals is followed.

## Temperate Fruits

- Pruning intensity varies with the bearing habit of cultivars and vigour of the tree.
- Pear bear fruits mostly on spurs or sometime on 2 years old wood. Spurs continues to bear for 6 years. The limbs with spurs over 6-8 years old need to be removed in a phased manner.
- The branches and new shoots are headed back to induce new growth. Old planting branches and spurs are thinned out to maintain the vigour of the retained ones.
- The pruning is done during the winter.

## Manuring and Fertilizers:-

- The fertilizer dose depend upon the soil fertility, type of soil, kind and age of trees, cultural practices, climate and crop load.
- The dose of manure and fertilizer should be determined on the basis of soil and leaf analysis.
- In an orchard of optimal fertility, nitrogen, phosphorus and potassium are applied in the ratio of 70:35:70g per year age of tree and which is stabilized after 10 years of age (700: 350: 700g N: P: K per tree).
- These application may be supplemented by FYMat the rate of 10 kg per year age of tree with the maximum of 100kg for 10 year old tree.
- N, P and K is applied in the form of calcium ammonium nitrate, single super phosphate and muriate of potash, respectively.
- Since, the response to phosphorus application is poor in phosphorus rich acidic hilly soils, it would be better to apply phosphorus after every 2-3 years or reduce the dose to half annually in such conditions.
- In bearing trees, FYM along with phosphorus and potash should be applied during December-January.
- Nitrogen is applied in the month of February-March in two split doses. Half of N is applied 2-3 weeks before bud break and second half dose one month after flowering, where the irrigation facilities are available.
- The fertilizers should be broadcasted in the tree basins 30 cm away from tree trunk to the canopy drip line and mixed well in the soil. In high rainfall areas with steep slopes having small basins, a band application of nitrogen is preferred.

## After care:-

- Immediately after planting, the basins should be prepared around the plants. The level of the soil near the trunk should be kept slightly higher than the level at basin to avoid direct contact of water with the trunk.
- Irrigation should be given immediately after the planting. Second irrigation is given after 2-3 days of first irrigation and subsequent irrigation is given as and when required.
- The young plants are staked after planting to keep their stem straight.
- The trunk of these plants are white washed to avoid sunburn. The surplus shoots from the plants which are not required for primary frame work should be removed. The sprouts on the rootstock and root suckers should also be removed.

## Orchard floor management and weed control

- Pear orchard should be managed with clean basin management system. In this system, the basin of trees are kept clean and free from weeds either by hand weeding, use of mulches and weedicides.
- In the initial years of plantation, the intercrops like peas, beans, cabbage, cauliflower and ginger are grown in the vacant area in between the trees but not in basin area.
- In bearing orchard, the basin area of trees should be mulched with 10-15 cm thick dry grass mulch or black alkathene mulch.

## Temperate Fruits

- Sod grasses like white clover, red clover, orchard grass and rye grass are grown in the vacant area between the trees.
- The mulches helps to conserve soil moisture and control the weeds in the basin area.
- To control weeds, both pre-emergence and post emergence weedicides are used. Spray of simazine at the rate of 4 kg/ha in March, followed by two sprays of glyphosate @ 800 ml/ha at monthly intervals in July and August have been found very effective to control the weeds in pear orchards.

### Use of growth regulators:-

- Paclobutrazole (PP-333) @ 500 to 1000 ppm restrict the vegetative growth, increased fruit set in pear. Cv. Flamish Beauty.
- GA3 at 10-20 ppm applied 10-14 days after full increased fruit set, fruit retention but it reduced flower bud differentiation in the following year.
- NAA 5-10 ppm control fruit drop in pear.

### Irrigation:-

- Most of the pear orchard in India established in rain fed sloppy areas where irrigation facilities are inadequate. During the summer month, there is very less and low rainfall resulting in drought like conditions.
- The soil moisture stress affects the fruit growth and development. Therefore, irrigation is essential in pear orchards. The most critical period of water requirement in pear is April to June months and peak requirement is after fruit set.
- Irrigation applied at 80% of field capacity increased fruit set and yield, tree growth and reduces fruit drop in Flamish Beauty cultivar.
- In lighter soils, more frequent irrigation and heavier application of irrigation water is required. During the summer month, tree should be irrigated at 8-10 days intervals, while after harvesting the irrigation at 20 days intervals is required till October.
- No irrigation is required during winter months as plants under goes dormancy.

### Harvesting and Post-harvest management:-

- Fully mature fruits are harvested for fresh consumption, while firm and green fruits for canning and distant markets.
- For local consumptions, fruits are picked slightly later stage because fruits hanging on trees make considerable gain in size weight and overall fruit quality.
- Fruit weight may increase up to 20% in delayed picking, however, it reduces the storage life.
- The ease with which the stem can be separated from the spur by an upward twist is used as an index of maturity.
- Number of days from full bloom to maturity is fairly consistent in a region but vary between regions.
- In Washington (USA), harvest maturity for pear variety varies from 110 to 115 days for Bartlett, 130-135 days for Bosc and 145-150 days for Anjou.
- Besides this, change in surface colour from green to yellow is also taken as a maturity index for harvesting.
- Generally, Bartlett pear is harvested at 19 pound pressure.
- After harvesting, pre-cooling treatments are given to fruits to remove field heat and arrest ripening.
- Pear fruits are picked individually by giving a gentle twist rather than direct pull.
- Harvesting should be done in 2-3 picking at 3-4 days intervals rather than single picking
- In India, no specific grading and packing standards have been fixed for pear, but the farmers grade pear fruits according to fruit size as under.

## Temperate Fruits

**Table 3. Grading and packing of pear**

Grade	Equatorial diameter (mm)	Size of box (inner in cms)	No. of layer
Extra large	<75	45.5 x 30.5 x 30.5	4
Large	70-75	45.5 x 20.5 x20.5	3
Medium	65-70	Do	3
Small	60-65	Do	3
Extra small	55-60	Do	4
Culled	<55	45.5 x 30.5 x 30.5	Loose

- Pear is packed in boxes either in offset or in diagonal styles.
- Stems in first row next to packer should point away from packer, Stems in first fruit in other rows point toward packer.
- Pear are either placed in paper folds or wrapped in individual papers. The wooden, plastic or cardboard boxes are generally used for packing pears.
- The fruits are packed in layers. The bottom and top of the boxes is properly cushioned with newspaper or dry grass for avoiding bruising of fruits.
- Pear can be stored for 120-180 days at- 1oC and 85% relative humidity in cold storage.

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### Lecture 6 - Peach cultivation

#### INTRODUCTION

##### Taxonomical details

Order = Rosales  
Family = Rosaceae  
Sub-family = Prunoideae  
Genus = Prunus  
Sub genus = Amygdalus  
Species = persica  
Basic chromosome = 8  
Somatic number = 16



##### Introduction:

- Peach along with its smooth-skin mutant, the nectarine, is a temperate juicy fruit of excellent appearance and quality.
- It comes to the market early in the season, particularly the low chilling peaches and growers get remunerative prices due to non availability of other fresh fruits in the market.
- It has high nutritive value being rich in protein, essential amino acids, minerals and vitamins.
- Peaches originated in China, where its culture dates back to 3000 years. Although it is not exactly known that how and when the peach reached in India but it is opined that some traders might have carried over the stones of peaches from China to Kashmir.
- Peaches were introduced by Mr. Alexander Coultts in Himachal Pradesh in 1870. Later on, its cultivation was initiated in mid hills of Himachal Pradesh on the advice of an American Horticulturist Prof. R W Hodgson.
- Some low chilling varieties of peach were also introduced at Punjab Agricultural University, Ludhiana during 1968 from California.

##### AREA AND PRODUCTION

- Peach is basically a temperate zone plant and its commercial production is confined between the latitude of 30 and 40° N and S, although it is now grown almost all over the world.
- The major peach producing countries are Italy, USA, Spain, China, France, Greece and Japan.
- In India, peach is grown on a commercial scale in mid hills of Himachal Pradesh, Jammu and Kashmir, Uttarakhand, as well as in a limited scale in north-eastern states.
- In Himachal Pradesh, peaches are commercially grown in Rajgarh area of District Sirmour, which is also known as peach bowl of India.
- Low chill varieties of peaches are commercially grown in Punjab, Haryana and Eastern U.P.



## Temperate Fruits

- In India, peach occupies an area of 35531 hectares with a total production of 237921 MT (FAO, 2010-11). In Himachal Pradesh the area under this fruit is 5195 ha and production is 5162 MT (Annon. 2010).

### Morphological characters of plant:

- Peach is a small to medium sized upright spreading, open topped deciduous tree.
- The trunk bark is dark brown, rough and young shoots are smooth and pinkish in colour.
- The leaves are simple, large, oblong lanceolate, glabrous above, pubescent beneath.
- Vegetative and flower buds are borne in the axil of leaves.
- Flower are numerous, sessile, white or pink appearing before leaves.
- The flower is of perigynous type as the perianth surrounds the pistil but is not fused to it.
- The floral configuration is : five sepals, five petals, 30 stamens and single ovary.
- Fruits are fuzzy with free or cling stone, however, the nectarines are fuzzless peaches.



**Plate 1. Peach tree**



**Plate 2. Flower and leaf bud**



**Plate 3. Flowers**

### Climate and Soil

- Peaches require humid climate with cold winter and dry summer.
- It is moderately winter hardy and sensitive to low temperature injury. Swelling buds are injured at -6.5°C.
- Sites free from early spring frost are more suitable as peaches bloom early in the season.
- Peach needs about 500 to 800 hours of chilling during winter to break bud dormancy.
- Chilling requirement is easily met in areas located between 900 to 1600 m above mean sea level.
- There are some low chilling varieties, which require 250 to 300 chilling hours. These varieties are grown successfully in sub-montane tracts of Punjab, Haryana, UP and Jammu., where summer temperature reaches 45 oC with very low humidity.
- The limiting factors in peach cultivation are the minimum winter temperature, chilling hours, spring frosts, hailstorms, high humidity and desiccating winds during summer.
- Deep sandy loam soil rich in organic matter is best for its successful cultivation.
- Peaches are highly susceptible to water logging and prefer perfect drainage.
- The pH of the soil should be between 5.8 and 6.8.

### VARIETIES

- Peaches are used for table as well as for canning purposes.
- The choice of suitable varieties for any region depends up on the type of market to be served and adaptability to the local soil and climatic conditions.
- The varieties used for table purposes should be yellow fleshed, freestone and relatively free from fuzz.
- For canning purpose, the fruits should have yellow flesh, clingstone, non splitting pit, good symmetrical size.

## Temperate Fruits

**Table 1. Promising varieties of peach recommended for different states**

State	Early	Mid season	Late
Himachal Pradesh	Alton, World's Earliest, Early White Giant, Redhaven, May Fire and Silver King (Nectarine)	July Elberta, Kanto 5, Shimizu Hakuto, Sunhaven, Snow Queen (Nectarine)	J H Hale
Uttarakhand	Early Candor, Redhaven, Sunhaven	July Elberta, Alexander, Crawford Early	Parrot Deluxe, J H Hale, Peregrine
Jammu and Kashmir	Peshwari, July Elberta, Quetta, Saharanpur, Prabhat	J H Hale, Alexander, C O Smith	-
Punjab	Shan-e-Punjab, Flordasun, Prabhat, Sun Red, Florda Red	Sharbati	



**Plate 4. July Elberta**



**Plate 5. Redhaven**



**Plate 6. May Fire**



**Plate 7. Snow Queen**

### ROOTSTOCKS AND PROPAGATION

#### Rootstocks

- Peach seedlings are generally used as rootstock, though plum, apricot and almond seedlings can also be used.
- Since wild species produce more vigorous and hardy seedlings than the cultivated varieties, thus wild peach seedlings are preferred in the hills.
- In the plains, seeds of Sharbati, Sufeda and wild apricot is used to grow the rootstock for peach propagation.

## Temperate Fruits

- Clonal rootstocks are precocious, size controlling, very productive and resistance to insect pests and diseases. Due to these plus points, clonal rootstocks are preferred over seedling rootstocks for raising nursery plants of these fruits.



**Plate 8. Wild peach**



**Plate 9. Wild Apricot**



**Plate 10. Grafted Nursery plants**

- For peach, peach x almond hybrid GF677 clonal rootstock is commercially used. This rootstock is useful on alkaline soil due to resistance to chlorosis.
- The other important clonal rootstocks are Siberian C ( cold hardy), St. Julien hybrid No.1 and 2 and Damas GF677 ( resistant to water logging and alkaline soil), Nemagaurd and Shalil ( nematode resistant).

## Propagation

- Peach is commercially propagated through grafting or budding on seedling or clonal rootstocks.
- For raising seedling rootstocks seeds of wild peach are used.
- Before sowing, seed is first stratified at 4-5°C or below for 10-12 weeks in the moist sand.
- Pre-sowing treatment of seed with certain agro-chemicals and plant bio-regulators viz; thiourea (0.5%), GA (200ppm) or BA (100ppm) not only reduce the stratification period required and enhance seed germination but also improves the seedling growth.
- The stratified seeds are sown in well-prepared beds about 5 cm deep and 15 cm apart at a row spacing of 20cm.
- Seed beds are mulched with 6-10 cm thick dry grass and light irrigation is must after sowing to avoid desiccation of seeds.
- Seed start germinating in March and the seedling become graftable in one year.
- The clonal rootstocks are multiplied through mound and trench layering.
- The commercial methods of propagating peach are tongue or cleft grafting and T budding.
- In the hills, tongue grafting during February and T budding during May- June are recommended.
- In plains, grafting is performed during November-January and budding during April- June and in September.

## Planting/ Planting Density:

- The plantation operation is carried out in the winter season.
- Before planting, the site of an orchard should be leveled, bushes and weeds are cut down and proper planning of layout is adopted.
- In plains, square system of planting is common, while in hills layout of an orchard is done with contour and terrace system.
- Pits of 1 x 1 x 1 m at a distance of 4.5 m in hills and 6.5 m in the plains, are dug in the month of September - October, which are refilled with soil and 40-50 kg of well rotten Farm Yard Manure and 1 kg single super phosphate.
- In high density planting, the spacing is reduced to 3x 3 m. and 5 x 1 m in tatura trellis (2000 trees /ha).



**Plate 11. High density planting**

### TRAINING AND PRUNING

#### Training

- Pruning of young plants for developing frame work in initial 3-4 years of planting is termed as training.
- Training is mainly done to give a proper shape and to build a strong framework of trees.
- Another benefit is to utilize the available space and sun light to the maximum extent for the production of quality fruits.
- Peach is generally trained in the form of open center. However, in the plain area where plenty of sunlight is available, trees are trained on modified central leader system with 4-5 scaffold branches.
- In high density, peach are trained with tatura trellis system .

#### Open Centre System

- After planting, the plant is cut back to 40-60 cm above the ground level.
- During the growing season, about 3 to 6 laterals, in addition to the central leader are produced on the tree.
- In the first winter pruning, 3 to 4 scaffold branches which are well located and have wide angle should be selected and remaining unwanted branches are removed.
- The central leader is also completely removed. The selected branches are headed back to  $\frac{1}{4}$  to  $\frac{1}{2}$  of the growth.
- During the second dormant pruning, 2-3 secondary branches are selected on the primary branches.
- The major consideration in selecting secondary branches should be their location so that after pruning, the tips of primary and secondary leaders are about 30-40 cm apart from each other.
- The height of secondary branches is staggered in different years by pruning all branch leader more severely. The vertical ones are pruned more severely. This will produce branch leaders at different heights and prevent overcrowding when the tree is mature. In the following years, the head should be fully formed and selection of secondary branches are completed.

## Temperate Fruits



Fig. 1. Pruning at planting

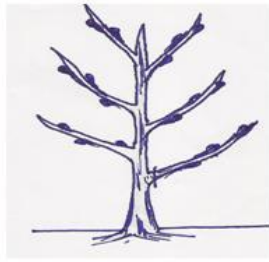


Fig. 2. Shoot development during first year



Fig. 3. First year dormant pruning



Fig. 4. Second year dormant pruning



Fig. 5. Third year dormant pruning

Figures 1-5: Open centre system of Training



Plate 12. Pruning at planting



Plate 13. First year training



Plate 14. After 1<sup>st</sup> year pruning



Plate 15. Second year training

## Tatura trellis system

- In high density planting, this system of training of plants is very popular being very yield efficient. Trees are planted at a spacing of 5x1m or 6x1m.
- At the time of planting, one year old plant is headed back to 20 cm above the ground level.
- In next growing season two limbs or branches are selected in opposite directions and these branches are trained across the inter row space at an angle of 60 degree from the horizontal, forming V-shaped canopy.

## Temperate Fruits

- The canopy is supported by a permanent trellis constructed of high tensile galvanized steel fence posts.
- The secondary branches are developed along each primary branches forming fruiting canopy.



**Plate 16. Tatura trellis system of training**

## Pruning

- The main objective of pruning is to maintain balance between vegetative growth and fruiting.
- Bearing peach require heavy and regular pruning because it bear fruits laterally on the previous season growth.
- It is known, once a growth has fruited will never bear again in its life. Therefore, pruning is done to remove the unproductive parts which in turn will form new fruiting branches in the following season.
- In peach pruning, thinning and heading back of shoots are two basic components. Pruning should be done so as to produce 30-70 cm of growth under subtropical conditions and 25-30 cm under mid hills, annually, which is sufficient for optimum fruit production,



**Plate 17 Pruning of peach tree**

- For good quality fruit production, 40-50 per cent of thinning out and 75% heading back of shoots is suggested under mid hills conditions.

## Temperate Fruits

- At the time of pruning , dead ,diseased and broken branches should be pruned off.

### CULTURAL PRACTICES

#### Orchard Floor management

- In the initial years of plantation, the intercrops like peas, beans, tomato, cabbage, cauliflower and ginger are grown in the vacant area in between the trees but not in basin area. Besides these, some green manuring crops like bean, peas and gram should be grown which helps in improving soil texture and nutrient status.
- In bearing orchard, the basin area of trees should be kept clean either by manual weeding or use of weedicides.
- Sod grasses like white clover, red clover, orchard grass and rye grass are grown in the vacant area between the trees.
- Basins are mulched with 10 cm thick dry grass mulch or black alkathene mulch The mulching helps to conserve soil moisture and efficiently control the weeds in the basin area.



**Plate 18. Mulching black alkathene**



**Plate 19 Grass mulch**



**Plate 20 Intercropping**

#### Manure and fertilizers

- Nutritional requirement of peaches is comparatively higher than other stone fruits because it bears on one years growth making the production of annual growth imperative for fruit production. Recouperment of the wood removal every year in pruning is also necessary.
- Fertilizers are therefore applied every year. A large number of factors like the type of soil, its fertility, climate, cultivar, planting density, shoot growth and irrigation facilities determine the amount of fertilizers to be applied.

Table 2. Manuring/ fertilizer schedule for peach tree /year in different states.

State	FYM (kg/tree)	N (kg/tree)	P (kg/tree)	K (kg/tree)
HP	40	500	250	700
Punjab	26	500	200	600
UP	25	300	500	300
Arunachal Pradesh	50	350	210	210
Haryana	35	540	180	540

## Temperate Fruits

**Table 3. The manure and fertilizer schedule for peach in HP.**

Age of tree (yr.)	FYM (kg)	N (g)	P <sub>2</sub> O <sub>5</sub> (g)	K <sub>2</sub> O (g)
1	10	70	35	100
2	15	140	70	200
3	20	210	105	300
4	25	280	140	400
5	30	350	175	500
6	35	420	210	600
7 & above	40	500	250	700

- The farmyard manure along with full dose of P and K should be applied during December and January. Half dose of N is applied in spring before flowering and remaining half dose a month later.

### Irrigation

- Irrigation is very essential for harvesting the peaches of better size and quality.
- A sufficient moisture in the soil before the emergence of leaves and flowers is required for proper fruit-set and growth.
- Frequent irrigations are needed during the fruit development. Lack of irrigation, particularly, during dry and hot summer result in fruit drop, reduced fruit size and quality.
- In the hills, at least two- three irrigations and in plains, weekly irrigation should be given during the fruit development period.
- In general, for quality fruit production irrigation at 80% of field capacity is recommended.
- Orchard soil management and weed management
- During initial 3-4 years after planting, the intercrops like peas, beans, tomato, cabbage, zinger and colocacia are grown in between the peach trees and basin area is mulched with hay or alkathene mulch.
- In fully grown trees, sod grasses are grown in vacant areas and basin area is mulched with suitable mulch materials.
- Weedicides like simazine and atrazin at 2.0 kg/ha, terbacil at 0.8 kg/ha as pre-emergence and paraquat at 4.0 litre/ha and glyphosate 4.32 kg/ha as post-emergence herbicide proved to be most effective to control the weeds in peach orchards.

### Crop Regulation

- Heavy flowering and fruiting are the characteristics features of peach trees resulting in small sized, poor quality fruits and reduction of flowering in the subsequent season. Hence for production of quality fruits crop regulation through thinning is essential in peach.
- The criteria for fruit thinning in peach are based on leaf to fruit ratio, spacing between fruits per tree. Generally 30-40 leaves per fruit is the appropriate ratio.
- Application of Ethephon (300 ppm) at petal fall in July Elberta is recommended for optimum fruit thinning. However, in Redhaven peach, Ethephon (600ppm) 20-30 days after fruit set when the fruitlets are 20-25 cm in diameter, should be used for thinning.
- Hand thinning at 5-7.5 cm fruit spacing before pit hardening stage is equally effective.



## Temperate Fruits

### Maturity, Harvesting . Storage and post- harvest management

- Harvesting of peaches at proper stage of maturity is essential as the post harvest quality and storage life of fruits are controlled by maturity.
- Various indices for judging fruit maturity used are days from full bloom, calendar dates, fruit size, firmness, pit discoloration, freeness of pit and change of ground colour.
- Days required from flowering to maturity vary in different cultivars varies from 78 to 127 days. Early season varieties like Flordasun takes 81 days, Alexander 86 days, mid season July Elberta 101 days and late season cv. Elberta takes 127 days from full bloom to harvest. Ground colour variation in conjunction with flesh firmness is one of the best maturity indices in peaches.
- Peach fruits do not mature uniformly and hence several pickings are needed during harvesting.
- Hand picking is the standard method for harvesting fruits.
- The picking containers are lined with cushion materials to avoid cuts and bruises.
- Immediately after harvesting, fruits are stored at a cool place or marketed. Pre-harvest application of calcium nitrate at the rate of 1.5 per cent increases storage life of peaches.

**Table 4. Grade and packing specification for peach fruits**

Grade	Fruit size (cm)	No of layers	No of fruits / layer	Box inner size(cm)
Special	55 and above	3	28-32	43.2 x25.4 x 20.3.
Graded	46-55	4	35-38	43.2 x25.4 x 20.3
Grade-II	Below 46	4	38-45	43.2 x25.4 x 20.3
Extra large	65 and above	3	28-30	47.0 x 28.0 x 26.0
Grade A	60-65	4	36-40	47.0 x 28.0 x 26.0
Grade B	55-60	4	46-50	47.0 x 28.0 x 26.0

### Storage

- Peaches have a shorter storage life than most other temperate fruits. The recommended cold storage conditions are 0-0.3°C and 85-90% relative humidity.
- In these conditions, free stone peaches and nectarines can be kept for two weeks and clingstone for 4 weeks.
- Pre cooled peaches can be stored for 28-36 days.
- In controlled atmosphere storage containing 5% CO<sub>2</sub> 1-2 % O<sub>2</sub> at 0°C peaches can be stored up to 42 days.
- The peaches came into bearing after 2 years of planting in the field. The economic bearing life of peach plant is about 20-30 years. The yielding capacity increases with the age of the plant.
- The average yield fully grown trees of different varieties varies from 50 to 125 kg in hills. In conventional plantation, 7-10 tones/ha and under high density with Tatura Trellis system of training about 23 tones per ha yield has obtained

### Diseases

#### (1) Peach leaf curl aphid (*Brachycaudus helichrysi*) :

- This is most serious pest of peach. They also infest plum plants.
- The aphid sucks sap from the buds and sprouting foliage causing curling, yellowing and thickening of leaves.
- The activity of aphid is seen with the emergence of new growth during March .Floral buds also become weak and result in poor setting.

### **Temperate Fruits**

**Control:** The pest is controlled by spray of 0.025 % methyl demeton ( 200 ml metasystox 25 EC) or dimethoate 0.03% ( 200 ml Rogar 30 EC) in 200 litres of water 7-10 days before flowering. The spray should be repeated after 5 days.



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### LECTURE - 7 Cultivation of apricot

#### INTRODUCTION

##### Taxonomical details

Order = Rosales

Family = Rosaceae

Sub-family = Prunoideae

Genus = Prunus

Sub genus = Prunophora

Species = armeniaca

Basic chromosome number = 8

Somatic chromosome number = 16

##### Introduction

- Apricot is an important fruit crop of mid-hills and dry temperate regions of the country.
- Its fruits are attractive, delicious and highly nutritious.
- It is very rich in Vitamin- A and also contains more carbohydrates, proteins and phosphorus than majority of common fruits.
- They are mostly used as dessert, and because of perishable nature it can be canned, frozen and dried.
- The fruits are also processed into jam, nectar and squash.
- The kernels which are either sweet or bitter depending upon the variety, is a valuable byproduct.
- Sweet kernels are used in confectionary, while bitter kernels are used for oil extraction and raising rootstocks.

##### ORIGIN AND DISTRIBUTION

- The cultivated apricot has its origin in Western China.
- The apricot fruit moved westward from central Asia through Iran and transcaucasus region and reached Italy during first century , to England in 13th century and to North America by 1720.
- The major apricot producing countries are China, USSR, Turkey, Italy, Spain, Greece, France and USA.
- Commercial cultivation of apricot in India is at recent origin and was started by European settler and missionaries after 1870.
- Presently, apricot is grown commercially in hills of HP, J & K, Uttarakhand and to a limited extent in North-Eastern hills.
- Some drying type of apricots are also being grown in the dry temperate regions of J & K, Kinnaur & Lahaul spiti in HP.
- In India, it occupies an area of 13115 ha with a production of 17894MT (NHB.2010).

##### VARIETIES

- In India, apricot is grown in mid and high hills and dry temperate areas having variable climatic conditions. Varieties which are suitable for mid hills are not suitable for high hills or dry temperate region.
- About 100 varieties of cultivated apricot are available in India and most of them are of exotic origin.

## Temperate Fruits

- The promising varieties recommended for different regions of the country are as under:

### A. Himachal Pradesh Early Late

Mid hills New castle, Early Shipley, Kaisa Shakarpara

High hills Kaisa, Nugget, Royal Suffaida, Charmagz, St.Ambroise, Moorpark. Nari

Dry Temperate Charmagz, Suffaida, Shakarpara, Kaisha, Halman, Nari.

### B. UTTARAKHAND

Charmagz, Kaisha, Moorpark, Turkey, St.Ambroise, Shipley's Early, Chaubattia Alankar, Chaubattia Madhu, Chaubattia Kesri

### C. Jammu and Kashmir:

Ladakh:

Halman, Rakcha Karpu, Tokpopa, Narmu and Khante

Kashmir -

Turkey, Australian, Charmagz, Rogan and Shakarpara.

### New Varieties for mid hills.

Early Maturing - Baiti, Beladi. Early maturing Apricot

Late - Farmingdale, Alfred.

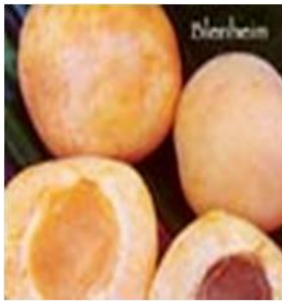


Plate 1. Royal



Plate 2. Nugget



Plate 3. New Castle

## CLIMATE AND SOIL:

- Apricot can be successfully grown at an altitude between 900 to 2000 m amsl.
- The white fleshed sweet kernelled apricots require cooler climate and are grown in dry temperate regions up to 3000 m amsl.
- The long cool winter (300-900 chilling hours), frost free and warm spring are favorable for fruiting.
- Average summer temperature between 16.6 to 32.2°C is suitable for growth and quality fruit production.
- In general, the sites located on North-Eastern aspect at lower elevation and South-Western at higher elevation are suitable for its cultivation.
- Spring frost causes extensive damage to the blossoms, which are killed when temperature falls below 4°C.
- An annual rainfall of about 100mm, well distributed throughout the season is good for normal growth and fruiting
- Apricot is quite hardy and can grow in most of the soils, but deep, fertile and well drained loamy soils are much suitable for its growth and development.
- The pH of the soil should be 6.0-6.8. In Ladakh and Kinnaur, large wild apricot trees are found growing in sandy well drained soil which is not very fertile.

#### ROOT STOCK AND PROPAGATION

- Apricots are commercially propagated by grafting or budding on rootstocks. The multiplication through cuttings is rarely done as it gives very low rooting success.
- Wild apricot (Chulli) and wild peach seedlings are commercially used as a rootstock. However, wild apricot seedlings are generally preferred as rootstocks because the graft union is good and the trees are more vigorous than on plum and wild peach seedlings.
- Peach is a satisfactory rootstock for light soils and dry conditions, but sometimes the graft union is enlarged or rough.
- In heavy soils under excessive soil moisture conditions apricot on Myrobalan plum makes better growth.
- Different clonal rootstocks have been recommended in different regions .i.e. Myrobalan 29C and Marianna 2624 for California; GF 31, GF 8-1 for France and Marianna 7/7 for South Africa.
- For raising the seedling rootstocks, the seeds are collected from fully ripe wild apricot fruits.
- Seeds are stratified for 45-50 days at 4°C to break dormancy.
- Pre-stratified seeds are sown in nursery beds, which attain a graftable size after one year.
- The seedlings which attain pencil thickness in one year are grafted with tongue method in the month of February., while the seedlings of less thickness are T- budded in the month May-June.
- Chip budding performed in the month of September also gives good success.

#### PLANTING AND PLANTING DENSITY

- The apricot plants are planted during the dormant season i.e. end of December to February, but early planting gives better establishment of plants.
- Undesirable trees and shrubs should be removed from the land during its initial preparations by digging and ploughing.
- On the flat land, a regular planting layout system such as square and triangular is followed, while on the hill slopes, contour system is generally practiced
- The spacing of plants varies with the soil, climate and vigour of variety and rootstocks.
- The plants are generally planted at a spacing of 6m x 6m
- The pits of 1x1x1m dimension are dug about a month before planting and are filled with a mixture of soil and 50-60 kg well decomposed FYM. About 1 kg SSP and 10 L. of Chlorophosphorus (4ml/ 1 litre of water) is also added to each pit.
- In comparison to other temperate fruits, high density planting in apricot has begun rather late as there are very few dwarfing rootstocks.
- A density of 7200 trees/ha has been reported in Cv. Canino.

## Temperate Fruits



**Plate 4. Planting and planting density**

### TRAINING AND PRUNING:

- The apricot is trained to open vase and modified centre leader system of training though the open vase system of training is more popular in hilly regions.
- One year plant is headed back at about 60-70cm above the ground and 3-5 well spaced shoots are allowed to grow in all the directions, while undesirable shoots are pinched off during summer.
- In first dormant season 3-5 primary scaffold branches arising at proper angle of 45°, well spaced (10-15cm apart) and spirally arranged around the tree trunk are selected.
- The lowest branch should be 40-45 cm. above ground level. All the primary scaffold branches are headed back to half of their growth to get the secondary branches on them.
- During the second dormant pruning, 4-5 well spaced secondary branches are selected on each primary branches and other are removed.
- At the end of the third year the pruning is confined to the thinning of branches which are crossing or crowding each other.
- Apricot bears on spurs and laterally on one year old shoots. The spurs have a short life of 3-4 years and many of them also get broken during the fruit plucking.
- The production of young growth is therefore essential for the initiation of new spur's which generally takes place at the base of the growing laterals.
- In young bearing trees pruning should be light and of corrective type but in older trees heavy pruning should be done to maintain balance between growth and fruiting.
- In new castle apricot, 25-30 percent thinning of one year old shoots and 1/3rd heading back is recommended to improve size and fruit quality.
- After pruning, Mashobra or Chaubattia paste is applied on the cut end of the shoots.

### FLOWERING

- In apricot, usually three buds develop in the axil of a leaf at each node on a shoot and spur. The central one being a vegetative bud, the two side buds are floral.
- Time of flowering and its duration varies with the variety and the prevailing weather conditions.
- Under mid hills condition the flowering in apricot comes in the month of March and higher hills at the end of March and April.

## Temperate Fruits



**Plate 5. Flowering in apricot**

### Pollination and fruit set

- Most of the commercial as a apricot are self fruitful and set fruits without pollinizer.
- However, varieties like Charmagz and Perfection have been reported self incompatible.
- There is generally a good fruit set in the apricot Cvs growing in appropriate climatic conditions.
- There is 40-60% fruit set in the cultivars commercially grown in mid hills, but fruit drop is to the extent of 79% in these cultivars, which occurs mostly in second week after fruit set.
- A spray of 10ppm NAA at the beginning of pit hardening reduced the pre- harvest drop.

### MANURING AND FERTILIZERS:

- Apricot trees remove large amount of nutrients from the soil and require organic organic manures as well as chemical fertilizers for normal growth and fruit production.
- The manurial requirements depend upon age of tree, type of soil, climate conditions and cultural practices, which vary from region to region.
- FYM is applied during December-January along with full dose of P and K by broadcasting method.
- Nitrogen is applied in 2 doses via first half dose of N is spring 2-3 weeks before flowering and remaining half N a month later ,if irrigation facilities are available.
- Under rain-fed conditions the second half dose of N should be applied at the onset of monsoon rains or through one or two foliar sprays of urea 0.05% after fruit set
- Fertilizers should be broadcast on the soil surface under the spread of the trees and mixed with the soil.
- It should not be applied in too wet or too dry soil. In high rainfall areas with steep slopes, the band application of nitrogenous fertilizers should be preferred over broadcasting.

## Temperate Fruits

**Table 1: Recommended fertilizers schedule for apricot in Himachal**

Age of the tree (year)	FYM (kg)	CAN (g)	N (g)	SSP (g)	P <sub>2</sub> O <sub>5</sub> (g)	MOP (g)	K <sub>2</sub> O (g)
1	10	280	70	220	35	165	100
2	15	560	140	440	70	335	200
3	20	840	210	660	105	500	300
4	25	1120	280	880	140	670	400
5	30	1400	350	1100	175	835	500
6	35	1680	420	1320	210	1000	600
7 and above	40	2000	500	1560	250	1170	700

### AFTER CARE/CULTURE

#### Thinning: -

- Fruit set in apricot is rather heavy which results into under sized fruits and also increases the tendency of biennial bearing.
- Fruit thinning improves fruit size, promotes regular bearing, decreases limb breakage due to heavy crop load and maintains the tree vigour
- Fruit thinning should be done within forty days after full bloom i.e. during the last week of April or first week of May, because this is the effective period influencing fruit bud formation.
- Both hand and chemical thinning method are employed.
- Depending upon the crop load, the fruit may be thinned till the fruit are 6-10cm apart. A spur should have not more than two fruits.
- Foliar spray of 25 to 50ppm NAA 20 days after fruit set is best for thinning.

#### ORCHARD SOIL MANAGEMENT AND WEED MANAGEMENT

- Sod culture plus mulching of basin with dry grass or black polythene is the common orchard floor management practice followed in apricot orchards.
- In apricot orchards atrazine or diuron @ 4.0kg/ha as pre-emergence and gramoxone @ 2kg/L or glyphosate @800ml/ha as post-emergence has been found effective and economical in controlling weeds.
- Mulching of trees basin with 10-15cm thick dry grass also checks the weed growth.
- During the initial 3-4 years of orchards life when the plants are young, intercropping with leguminous crops like pea, bean, soyabean, cowpea, and also tomato and strawberry is recommended as they enrich the soil and also give economic returns.

#### IRRIGATION

- Though apricot is tolerant to dry atmosphere yet require irrigation water especially during critical periods of fruit growth and development.
- Water requirement varies with the soil, tree age, climatic conditions and irrigation method. The peak water use period is from end of April to mid of June, which coincides with fruit development period.
- Irrigation at 20 per cent depletion of soil moisture from field capacity improves fruit size and yield. Irrigation interval should be 10 days during May and 6-8 days during June.
- In all, eight irrigations in a season are sufficient for apricot in mid hill of Himachal Pradesh..



## Temperate Fruits

### MATURITY INDICES. HARVESTING AND YIELD

- Change of surface colour, days from full bloom to harvest and fruit T.S.S are considered to be the best indices of maturity.
- For fresh market, the fruits are plucked when surface color turn green to yellow.
- Fully ripe fruits are, however, harvested for freezing, canning and drying.
- In Himachal Pradesh, days from full bloom to harvest and fruit T.S.S. have been standardized for different varieties to judge the optimum time of harvest.
- Since apricot fruits are very perishable, due care is required during harvesting, packing and transportation.
- The fruits should be harvested in the morning hours and direct exposure of fruits to sun are avoided during grading and packing.
- Apricot trees start fruiting at the age of 5 years and give economic yield up to 30-35years. Apricot attains full bearing age at about 8-10 years and yield about 50-80kg fruits per trees.

**Table 2. Maturity indices for judging optimum fruit maturity of apricot**

<b>Name of variety</b>	<b>DFFB to harvest</b>	<b>TSS ° Brix</b>
Shipley's early	73 ± 4 days	15-16
New castle	84± 4 days	12-15
Blenheim	85± 4 days	15-16
Shakapara	96± 4 days	14-17
Royal	100± 4 days	12.5-15
Kaisha	92± 4 days	12-15
Alfred	86± 4 days	13-16
Baiti	82± 4 days	11-13
Beladi	81± 4 days	12-14
Farming dale	84± 4 days	12-15

### POST HARVEST MANAGEMENT

- Before packing, the fruits are graded according to the size of the fruit.
- Fruits are packed in the wooden boxes or CFB cartons. Each box is lined inside with newspaper sheets keeping the margins for over hanging the flaps.
- The boxes are initially padded with pine needles at the bottom to avoid brushing of the fruits.
- Wrapping of individual fruits is not done in apricot. Then fruits are arranging in layers and top layer is covered with paper by bringing together over hanging flaps.
- The top of the box is nailed in case of wooden boxes whereas CFB carton are sealed with adhesive tape.

## Temperate Fruits

**Table 3. Grading and packing of apricot fruits**

Grade	Fruit size (mm)	No. of layers	No. of fruit per layer	Size of box (cm) Inner size
Special	42 and above	3	28-32	37X16.5X16.5
Grade-1	36-42	4	38-43	37X16.5X16.5
Grade-11	L 36	4	50-56	37X16.5X16.5

- In order to save wood, small sized CFB cartons can also be used for packing of apricot fruits. These are lighter in weight easy to handle and in packing and harvesting no extra labour and expenditure like wrapping material, nails, padding material etc are required. However, they are slightly more expansive than wooden boxes and need protection from direct rains but fetch better prices because of lesser bruising damage.
- Apricot fruits can be stored at 0oC for 1-2 weeks with 85-95 per cent relative humidity.



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### LECTURE -8 Cultivation of plum

#### INTRODUCTION

##### Taxonomical details

Order = Rosales

Family = Rosaceae

Sub-family = Prunoideae

Genus = Prunus

Sub genus = Prunophora

Species = salicina and domestica

Basic chromosome number = 8

#### INTRODUCTION

- Plum is an important temperate fruit, which is used as fresh as well as in preserved form.
- It is next to the peaches in economic importance amongst the stone fruits.
- It requires certain period of chilling during winters to break dormancy, thus cultivated in areas where winters are cool.
- Fruits are rich source of minerals, vitamins, sugars and organic acids in addition to protein, fat and carbohydrates.
- The types of plums with high sugar content above 18% are known as prunes which can be dried with pit
- In India, plum was introduced by Alexander Coultts in 1870 in Himachal Pradesh.
- After evaluation, only Japanese plum has been recommended for commercial cultivation in mid hills of the temperate region of north-western Himalayas.
- Some low chilling varieties of plum were also introduced at Punjab Agriculture University, Ludhiana.

#### AREA AND PRODUCTION

- Plum are grown in the temperate zone of all the countries of the world.
- The main plums and prunes producing countries of the world are Africa, Algeria, Morocco. South Africa, North and Central America.
- In India these fruits are grown on a commercial scale in mid hills of Himachal Pradesh, Jammu and Kashmir, Uttarakhand, but on limited scale in north-eastern states.
- In Himachal Pradesh, plums are mainly grown in Solan, Sirmour, Shimla. Mandi districts.
- Low chill varieties are also grown in Punjab, Haryana and Eastern U.P. The area under plum in our country is 14000 ha. and annual production is 57143 MT (FAO,2010-11).

#### Morphological characters :

- Tree medium to large, upright growth and deciduous.
- Leaves alternate, serrate, sharp pointed , medium sized and glabrous.
- Flowers are produced three in a bud on one year shoot or on spur.
- Flowers perfect, solitary or raceme, sepals 5, petals 5, usually white , stamens numerous, perigynous, pistil 1 with elongated styles, 2 ovuled and fruit drupe usually single seeded.

## Temperate Fruits



Plate 1. Flower



Plate 2. Plum tree in bloom

### Climate and Soil

- Plum requires varying types of climate and is grown from subtropical plains to the temperate high hills
- The European type of plums require temperate climate and are grown in high hills at an elevation of 1300-2000 m a m s l. It requires about 800-1000 hrs of chilling below 7°C during winter to break rest period.
- Japanese plum requires 100-800 hrs chilling, which is met in mid hill areas located at an elevation of 1000-1600 m a m s l.
- Plums can be grown in areas where winters are cold and summers are hot. Cold, wet and windy weather during bloom is detrimental for good fruit set as spring frost injury causes damage to bloom.
- A northern slope is preferred particularly for Japanese plum, which tend to delay the bloom period and thus avoid early frost injury.
- Plum requires 90- 110 cm well distributed rainfall throughout the year.
- Prolonged drought during fruit growth and development and excessive rains during fruit maturity hamper fruit quality..
- Although plum can grow on a wide range of soils, yet, deep, fertile and well-drained loamy soils with a pH of 5.5-6.5 are most suitable.
- The soil should be free from hard pan, water logging and excessive salts.
- Very heavy or light soils are not suitable.
- The Japanese plums do well on average soils having high pH.

### SPECIES AND VARIETIES

- The cultivated plums belong to two species

**(1) *Prunus domestica* (European plum):** It is a hybrid of diploid myrobalan plum (*Prunus cerasifera*) and tetraploid black thorn (*Prunus spinosa*). It is hexaploid. Fruits are larger in size than Japanese plum. Fruit is oval or round having both yellow and green ground colour and also both red and blue skin colour. The cultivated varieties of European plum is classified in to three main groups:

**(a) Prunes:-** Fruit is oval in shape with bulging ventral side and compressed bilaterally. It is blue or purple in colour , high in sugar content which makes them suitable for drying without removal of pit. All prunes are plums but all plums are not prunes. Varieties are Italian prunes, Giant prune, President.

**(b) Reineclaud and green gage plum:-** This is hybrid of *Prunus domestica* with *Prunus insititia* . Fruit is greenish yellow in colour and round in shape having yellow skin and flesh.. Important varieties are Golden Drop, Green gage, Golden transparent,

**(c) Lombard plum:-** The colour of fruit is purplish red. Varieties are Lombard, Victoria.

**(2.) *Prunus salicina* (Japanese plum):-** Originated in china but introduced in Japan from where it is disseminated around the world. Plant is more vigorous, productive, precocious and resistant to diseases

### Temperate Fruits

than European plum. The fruits are large and heart shaped with pronounced apex.. A few cultivars are oblate or round.

(3.) *Prunus insititia*:- This is a small fruited European plum, hexaploid and grows wild in Europe and Western Asia. Plums of the species are known as Damson and Mirabelles. Fruit are small and purple (damson) yellow (mirabelles). Plant small and compact and form excellent hedge rows.

### European plum cultivar

California Blue, Washington, French Prunes, Early Italian, Stanley, Grand Duke, Victoria, Damson.

### Japanese plum Cultivar

Beauty, Methley, Santa Rosa, Kelsey, Mariposa, Satsuma, Burbank Red Beaut, Fronteir

**Table 2. Manurial and fertilizer schedule recommended for plum in different states**

State	FYM (kg/tree)	N (kg/tree)	P (kg/tree)	K (kg/tree)
HP	60	500	250	700
Punjab	36	180	90	720
Uttranchal	-	300	500	300
Arunachal Pradesh	50	300	210	210
Tamilnadu	30	250	1000	1000
Haryana	35	540	190	540



**Plate 3. Frontier**



**Plate 4. Santa Rosa**

## ROOTSTOCKS AND PROPAGATION

### Rootstocks and propagation

- **Seedling rootstocks:** The plum grown mostly on plum rootstocks though seedling of peach, apricot and almond can be used. In India plum is propagated mainly on seedlings of wild apricot (Chuli)
- **Clonal Rootstocks for plum:** Myrobalan B, Myrobalan 29C, Mariana GF 8/1, Mariana 2624, Mariana 8-6. Mariana 9-25, Pixy, St. Julien A, GF-667

## Temperate Fruits

### Propagation

#### Rootstock :

- Plums are propagated vegetatively by budding and grafting on rootstocks.
- These can also be propagated by hard wood cutting and by leafy soft wood cuttings under intermittent misting. Cuttings taken from hard wood and semi hard wood treated with IBA (2000-5000ppm) for better rooting..
- For raising the seedlings, the seeds of wild apricot are stratified under alternate layers of moist sand for 45 to 50 days at temp 3-5°C to break the rest.
- The stratified seeds are sown in nursery beds 6-10 cm deep in row 25-30cm apart with a distance of 10-15 cm from seed to seed.
- The seedling attain graftable size in a year
- In Punjab, own rooted plants of Kala Amritsari are generally used for planting.
- Clonal rootstocks of plum are multiplied commercially by layering.
- It has been observed that most of clonal rootstocks of plum are difficult to root. Application of 2500ppm IBA to stool shoot helps to improve rooting.
- Clonal rootstocks are also propagated by hardwood cuttings. The hardwood cutting should be taken during dormant season and dipped in 2500ppm IBA solution for 30 seconds. Then these cutting are planted in mist propagation chamber for rooting.

#### Propagation of scion

- Seedling as well as clonal rootstocks which are 0.8 to 1.2 cm in thickness are grafted in February with tongue and cleft method of grafting.
- The seedling which do not attain graftable size in February, they should be budded with T- and chip methods of budding in June- July.
- For grafting the scion wood should be collected from healthy, disease free, true to variety trees during January. The scion wood is collected from one year old shoots. They are packed in moist sphagnum moss, which are properly labeled for variety. These bundles of scion wood are stored in cold storage or buried deep in the soil at shady place till grafting is done.
- The best time of grafting of these fruits are February in lower elevation and in March at higher elevations.
- Chip budding can also be done in March, July and September..

#### PLANTING AND PLANTING DENSITY

- Planting of plum is done December -January when the plant is in dormant conditions.
- Before planting, site of an orchard should be properly cleared off the bushes and weeds. It is advisable to plough the plantation area.
- In hilly area, terraces should be kept inwards to facilitate soil conservation.
- The orchard area should be properly laid out about two month before planting. In sloppy land, layout of an orchard should be done with contour or terrace system, while in flat land square system is followed.
- The planting distance varies according to the varieties, rootstocks and fertility of soils. Plums are generally planted at a distance of 6 m x 6 m.
- In high density plantation, the plum plants raised on semi-dwarfing clonal rootstocks should be planted at 4m x4m distance.
- Pits of 1 m x1 m x 1 m size are dug in October – November. Pits should be filled with fertile top soils mixed with 40 kg of well rotten FYM and 1kg of single super Phosphate.

## Temperate Fruits

- To avoid any damage from insects, the pits are drenched with 10 litres of chlorpyrifos (4ml/L) solution. The graft union should be kept 10-15 cm above the ground level at the time of planting to avoid any scion rooting.
- Young plants should be watered regularly and basin area is mulched with 15 cm thick dry grass.

## Pollination and Fruit Set

- Most native American plums are self unfruitful and need pollinizers be inter planted in the orchard. The partial self fruitful cultivars such as Santa Rosa and Beauty are also benefited in fruit set with the pollinizers.
- The European plum in view of the fruit set are categorized in to self fruitful varieties in which 30% of the flowers set fruit and self unfruitful varieties in which 1.5 to 2% of the flowers set fruits which need pollinizer.
- For proper pollination and to obtain good harvest, at least every third tree in every third row, a pollinizer should be planted with the strong beehives per acre.
- In case, the cultivars produce little or no pollen, a pollinizer branch should be grafted on every tree.

## CULTURAL PRACTICES

### Training and Pruning

- Plums are generally trained on the open center system or to modified central leader system depending upon the varietal growth habits.
- The varieties with spreading habits of growth as in Japanese plum should be trained to open center system.
- In HP open center system is followed irrespective of variety. However, in the plains, where plenty of sunlight is available, trees should be trained in the form of modified central leader system with 4-5 scaffold branches

### Open Centre System

- After planting, the plant is cut back to 40-60 cm above the ground level. During the growing season, about 3 to 6 laterals, in addition to the Central leader, are produced on the tree.
- In the first winter pruning, 3 to 5 scaffold branches which are well spaced and have wide angle should be selected and remaining branches are removed. The Central leader is also completely removed.
- The selected branches are headed back to  $\frac{1}{4}$  of the growth. During the second dormant pruning, 2-3 secondary branches are selected on the primary branches.
- The major consideration in selecting secondary branches should be their location so that after pruning, the tips of primary and secondary leaders are about 30-40 cm apart from each other.
- The height of secondary branches is staggered in different years by pruning all branch leader more severely. The vertical ones are pruned more severely. This will produce branch leaders at different heights and prevent over crowding when the tree is mature.
- In the following years the head should be fully formed and selection of secondary branches are completed.

### Pruning

- In plums, thinning and heading back of shoots are two basic components of pruning.
- Most of plum varieties bear on spurs on two years old wood. The life span of these spurs is 5-6 years. It is necessary to prune for some spur renewal each season .
- The extent of pruning is done such a way to induce an annual shoot growth of 25-50 cm.

## Temperate Fruits

- In bearing plum trees, 25-30 percent thinning of shoots and 50-75 per cent heading back of shoots is suggested for proper fruiting.
- At the time of pruning, dead, diseased and broken branches should be pruned off.



**Plate 5. Unpruned tree**



**Plate 6. Pruning of tree**

## Nutrition

- Plum requires adequate amount of nutrients for better growth and quality fruits.
- Application of manures and fertilizers depend upon soil fertility, type of soil, topography, age of tree, cultural practices and crop load.
- The requirement of fertilizers varies from region to region.

**Table 2. Manurial and fertilizer schedule recommended for plum in different states**

State	FYM (kg/tree)	N (kg/tree)	P (kg/tree)	K (kg/tree)
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Punjab	36	180	90	720
Uttanchal	-	300	500	300
Arunachal Pradesh	50	300	210	210
Tamilnadu	30	250	1000	1000
Haryana	35	540	190	540

- The farmyard manure along with full dose of P and K should be applied during December and January. Half dose of N is applied in spring before flowering and remaining half a month later.

## Irrigation

- Plum is mostly grown under rain fed conditions. However, in order to produce a fruits of good fruit size and better quality irrigation is essential.
- Various methods of irrigation are adopted to irrigate plum orchards but in hills basin and drip irrigation methods are more popular and are widely used and recommended.
- After fruit setting, the plum trees are irrigated at weekly intervals and 6 to 8 irrigations are recommended for higher production of quality fruits in Santa Rosa plum.

## Orchard floor management and Weed management

- In plum orchard, sod culture and mulching of tree basin area with hay mulch or black alkathene mulch is the most common method of orchard floor management.



## Temperate Fruits

- During pre-bearing stage, intercropping with leguminous and vegetable is also practiced in orchards planted in flat and less sloppy land.
- The weed removal manually is one of the practices employed in the orchards besides inter cultivation and cover crop growing. In rainy seasons, the weeds in plum orchard is controlled with the post-emergence sprays of glyphosate at the rate of 800 ml/ hectare.

## Crop regulation and Quality improvement

- Generally plum tends to bear heavy crops and bear under sized fruits of low-quality, thinning therefore, is necessary to increase the fruit size and uniformity in colour of fruit and to stimulate flower initiation for the regulation of next year's crop.
- Various methods viz; hand, mechanically and use of chemicals are used but chemical thinning has superiority with respect to thinning cost, fruit size and quality. NAA at 20 to 40 ppm sprayed after petal fall resulted in good fruit thinning.

## Maturity, Harvesting and Yield

- It has been observed that plum usually ripen unevenly over the tree. Fruits, therefore, are harvested in two or three pickings and it is very important to find out the exact stage of picking when they are mature.
- Among various indices of maturity, most commonly used are flesh firmness  $5.9 \pm 0.45$  kg, days from full bloom (94±3), TSS 13.5-14.5 and TSS acidity ratio 1.2: 1.5.
- The fruits are harvested with stalk intact avoiding any skin injury.
- Fruits are very delicate and perishable, therefore picking baskets should be lined with soft material on the inner surface.
- Immediately after plucking the fruits should be kept under the shade of the tree to remove field heat.

**Table 3. Maturity standards of commercially varieties of plum**

Variety	Days from full bloom	Firmness	TSS (%)
Red Beaut	88+3	5.60+0.5	15-16
Santa Rosa	94+3	5.90+0.5	16-17
Frontier	105+3	6.30+0.5	16-18
Kala Amritsari	85+3	5.40+3.0	13-14

## Grading and Packing

- To obtain high price in the market the grading of the fruits is done to have uniform size and better quality. The packing and grading standards of the plum are:

**Table 4. Grading and packing of plum fruits**

Grade	Fruit Size diameter (mm)	Box Size (Inches)	No of Layers	No of fruits/layer
Special	42& above	14.5x6.5x6.5	3	28-32
Grade I	36-42	-do-	4	38-42
Grade II	Below 36	-do-	4	50-56

## Temperate Fruits

### Storage and Marketing

- Plum being perishable have very short shelf life.
- In India work in HP has revealed that plum can be stored for 1 to 2 weeks at 0°C with 80-90% humidity.
- The CA storage has been practiced overseas by maintaining 2-3% oxygen and 2-8% CO<sub>2</sub> and the fruits can be retained for a duration of 2-3 months.



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### LECTURE - 9: Cultivation of cherry

#### INTRODUCTION

##### **Taxonomical classification**

Order = Rosales

Family = Rosaceae

Genus = Prunus

Sub genus = Cerasus

Species = avium

Basic chromosome = 8

Somatic number =16

##### **Introduction:**

- Cherries occupy an important position among temperate fruits all over the world.
- The cultivated cherries are divided into two main group i.e. sweet cherries ( Prunus avium) and sour cherries (P.cerasus).
- The sweet cherry is mainly used for table purpose and sour cherries for processing.
- Cherries are rich in protein, sugar, potassium, calcium, iron and zinc.
- Sweet cherries are believed to have originated between in area between black and Caspian sea in Southern Europe.
- The earliest records indicate that it was first domesticated in Greece around 300 BC. It spread to Italy from Greece where it was established as a fruit crop by 37 BC. Early settler's brought seeds to North America and part of South America.
- In India, it was introduced by british settler's in Kashmir, Kullu and Shimla hills during pre - independence era.

##### **Area and production:**

- The cherries are extensively grown in all the temperate countries.
- The leading cherry producing countries area USSR, USA, West Germany, Italy and France.
- In the world, it is grown in 381482 ha and fruit production is 2196537 MT (FAO,2009-10).
- In India, it occupies an an area of 3264 ha with a production of 12690 MT and is extensively grown in the state of Jammu and Kashmir, in area of 1110 ha with a production of 605MT and in HP in an area of 453 ha and production is 419 MT (Annon., 2009-10).

## Temperate Fruits

### Morphological Characters:



**Plate 1. Cherry tree**



**Plate 2. Flowering in cherry**

- Sweet cherry is a tall tree, branches are erect, leaves are large, thin, pubescent beneath and serrated.
- The petioles are long having two or more swollen glands.
- The fruit is cordate in shape, has deep cavity and apex is rounded or pointed
- The floral buds are borne on 2 year old shoot or at the base of 1 year old shoot and found only on lateral, simple flower buds.
- Flowers are white in colour and have 5 petals, numerous stamens, single style and an ovary with a single carpel containing two ovules.
- The fruit colour of cherry varies with varieties and may be yellow, red or purplish black.
- The texture of the flesh is tender or firm, sweet and yellow or red or dark purple in colour.
- On the bases of flesh, sweet cherries have been divided into two pomological groups : Heart Group and Bigarreau Group.
- The Heart cherry varieties. have soft and tender flesh and heart shaped fruits. The fruit colour varies from dark with reddish juice to light coloured with colour less juice.
- The Bigarreau Group of cherries is usually roundish. The colour of fruit and juice also varies from dark red to light red.

### CLIMATE AND SOIL

- Sweet cherry requires cool climate.
- It is grown successfully in areas between 2,000 and 2,700m above mean sea-level, requiring 1,000-1,500hr chilling period during winters.
- Cherry blossom is very sensitive to spring frost; therefore frost-free sites of hill slope and valley areas with and an drainage of cold air are preferred.
- Since southern and south -western aspects are warmer, they should not be selected for cultivation at lower elevations.
- Generally, North-East or North-West aspects are most suitable for cherry cultivation.
- An annual rainfall of 100-120 cm, well-distributed throughout the year is desirable but high rainfall during flowering results in heavy blossom wilt.
- At the time of fruit ripening heavy rains causes fruit cracking. Therefore, weather should be dry at the time of fruit ripening and locations having early on set of monsoon should be avoided.
- A well-drained deep sandy loam soil with pH 6.5-7.0, which can hold, moisture during summer are most suitable.
- The cherry plant is very sensitive to water logging and therefore so heavy soil should be avoided.

## Temperate Fruits

### VARIETIES:

- About 120 varieties are available in germplasm repository. Most of them belong to sweet cherry group. All varieties are divided into 2 groups.



**Plate 3. Mature fruits of light and dark coloured varieties**

### 1. Heart Group

Fruit is heart-shaped having soft and tender flesh. Colour of fruit varies from dark with reddish juice to light coloured with colorless juice. Red Heart, Black Heart are important varieties of this group.



**Plate 4. Black Heart**

### 2. Bigarreau group

Fruit roundish, colour of fruit and juice varies from dark to light red. Sam, Summit, Sue, Sunbrust, Lapins, Compact Stella and hybrid (13-17-40) are new promising varieties.



**Plate 5. Stella**

## Temperate Fruits

**Table 1. Recommended varieties of sweet cherry for different states**

State	Varieties
Jammu and Kashmir	Black Heart, Early Purple Black Heart, Guigne Noir Gross Lucenta, Guigne Noir Hative, Guigne Pour ova Precece, Bigarreau Napoleon and Bigarreau Noir Gross
Himachal Pradesh	Black Tartarian, Bing, Napoleon White, Sam, Sue, Stella, Van, Lambert, Black Republican, Pink Early, Black Heart, Early Rivers, Sunbrust, Dero-nero II and Merchant
Uttar Pradesh	Bedford Prolific, Black Heart and Governor's Wood



**Plate 6. Black Heart**



**Plate 7. Bing**



**Plate 8. Stella**

### ROOTSTOCKS AND PROPAGATION

Cherry is propagated by grafting on seedling as well as on clonal rootstocks.

#### 1. Seedling rootstock

Seedling rootstocks of cherry are paja (*Prunus cerasoides*), bird cherry (*Prunus paddum*), mahaleb and mazzard.

#### 2. Clonal rootstocks

- Clonal rootstocks are commercially recommended for raising its plants as trees on paja show symptoms of delayed incompatibility.
- Clonal rootstocks are Colt, Giesela, Charger, SL64 and Mazzard F 12/1.
- Colt is semi-dwarf, compatible with almost all varieties of sweet cherry, has good anchorage, and is tolerant to gummosis, crown-rot, moderately resistant to stem-pitting virus and bacterial canker but susceptible to oak-root fungus.
- Mazzard F 12/1 is semi-vigorous and difficult-to root rootstock.

#### Propagation of seedling rootstocks

- Seeds of paja do not require chilling treatment to break dormancy. It has now been discouraged as rootstock due to delayed in ompatibility, although most of earlier plantation existed on paja rootstock only.
- Seeds of mahaleb and mazzard require stratification before sowing..
- Seeds are soaked in 500 ppm GA3 for about 24hr, then they are stratified by placing between the layers of sand in a cool place at 2 -4oC for 80-120 days for mahaleb and 120-50 days for mazzard to break seed dormancy.
- During stratification, the medium is kept moist.
- As the embryonic root comes out from seed coat, these are transplanted 6cm deep and 10-15 cm apart in rows spaced at 20-25 cm in nursery beds.
- The nursery beds are mulched with 10-15 cm thick hay and irrigated lightly.
- Mulch material is removed when seedlings attain 5-6 cm height.

## Temperate Fruits

- The nursery should be regularly watered and kept free from weeds. The seedlings attain graftable size in a year.

### Propagation of Clonal rootstock

- Mound layering or trench layering is the common method of clonal rootstock multiplication.
- The stool beds are established during December by planting healthy mother plants 30-45 cm apart in row spaced at 60-70 cm.
- Before new growth starts, the mother plants are cut back to 2.5 cm above the ground level.
- New shoots develop on the stub in the spring. When the shoots are 25-30 cm long, their bases are covered with a mound of soil or saw-dust, building the mound to a height of 20-25 cm as the shoots grow during spring.
- The suckers are ringed at the base and then covered with soil to encourage rooting.
- In difficult-to-root Mazzard F12/1 root stock, IBA (7,500 ppm) is applied to the ringed portion of the shoots during summer.
- The shoots are separated in winter and then lined out in the nursery beds.
- If the suckers are well-rooted and more than 0.8 cm in diameter, they are grafted in the spring, otherwise they are kept in the bed for a year to produce strong plants for grafting.
- Colt rootstock is easy to root and can also be multiplied through cuttings.
- Hardwood cuttings of 30-45 cm length and of pencil thickness are taken in February.
- Cuttings are treated with IBA (2,500ppm) for 10 seconds and planted in nursery beds for rooting.
- Rooted cuttings are lined out in December and grafted with scion variety in March.

### Propagation of scion:

- Cherry plants are propagated mainly through grafting.
- Tongue grafting during February-March is recommended, which gives a bud-take of more than 90%.
- For grafting, the scion wood is collected during winter when the buds are dormant.
- Scion wood is packed in moss grass and then wrapped in moist gunny bags.
- These packed bundles of scion wood are stored at 2-4 C till these are used for grafting.

### Planting and planting density

- In India, cherry cultivation is confined to hilly areas on sloppy lands so the planting is done on contour or terrace system. However, in valley areas, square system of layout is recommended for the establishment of an orchard.
- The planting distance depends upon the soil fertility and the rootstock used.
- A spacing of 6m x 6m is recommended for plants raised on seedling rootstock in Himachal Pradesh.
- For semi-dwarfing rootstock like colt, spacing can be reduced to 4.5 x 4.5 m.
- Pits of 1m x 1m x 1m size are dug and filled with a mixture of 35-40 kg farmyard manure and half kg super phosphate one month before planting.
- The pits are filled at last up to 15 cm above the ground level.
- The best time of planting is December-January.

### Pollination

- Since most of the cherry varieties are self-incompatible as well as cross-incompatible therefore compatibility of varieties is required for cross-pollination.
- There are many cross-incompatible groups and cross compatible varieties within a group should be planted in the orchard for proper fruit set.
- Care should be taken to see that not only their flowering period overlaps, but they also do not have the same sterility alleles.

## Temperate Fruits

- The varieties which have the same sterility alleles if planted together will not set fruit and require at least one other variety having different sterility allele for better fruit set.
- The universal donor varieties like Stella, Vista, Vic, Seneca and Vega are good cherries as pollinizer to be planted with any variety to get good fruit set provided their flowering period overlaps.

**Table.2. Incompatibility groups of some important varieties of sweet cherry**

Group	Variety	Sterility allele
I	Bedford Prolific, Black Downton, Black Eagle, Black Tartarian and Early Rivers	S <sub>1</sub> S <sub>2</sub>
II	Bigarreau Schrecken, Black Elton, Black Heart, Clauster Black Victoria Black Waterloo, Merton Bigarreau and Van	S <sub>1</sub> S <sub>3</sub>
III	Bigarreau Napoleon, Emperor Francis, Bing, Lambert and Star	S <sub>3</sub> S <sub>4</sub>
IV	Kentish Bigarreau, White Bigarreau, Sue, Victor, Merton Heart and velvet	S <sub>2</sub> S <sub>3</sub>
V	Bohemian Black, Late Black and Turkey Heart	S <sub>3</sub> S <sub>5</sub>
VI	Elton Heart, Governor Wood and Early Amber	S <sub>3</sub> S <sub>6</sub>
VII	Hedelfingen Monstreuse Mezel, Black Republican and Vic	S <sub>4</sub> S <sub>5</sub>
VIII	Noir de Schmidt, Peggy Rivers, Schmidt and Giant	S <sub>2</sub> S <sub>5</sub>
IX	Red Turk, Black Giant and Ursula Rivers	S <sub>1</sub> S <sub>4</sub>
O	Stella, Vista, Vega and Seneca	Universal donors

- For good pollination, planting should be done in such a manner that plants of one variety adjoins the other in the planting arrangement (Table 3.)

**Table.3. Different planting plans for an effective pollination**

(a) Planting plan for fully compatible cultivars of groups VI, VII and IX where A is an important common cultivar

A	A	A	A	A	A	A	A	A	A	Proportion of plants (%)
B	C	B	C	B	C	B	C	B	C	
A	A	A	A	A	A	A	A	A	A	A=60
A	A	A	A	A	A	A	A	A	A	B=20
B	C	B	C	B	C	B	C	B	C	C=20

(b) Planting plan for fully compatible cultivars of groups VI, VII and IX where A is less an important common cultivar

A	B	A	B	A	B	A	B	A	B	Proportion of plants (%)
B	C	B	C	B	C	B	C	B	C	
A	B	A	B	A	B	A	B	A	B	A=40
C	A	C	A	C	A	C	A	C	A	B=40
A	B	A	B	A	B	A	B	A	B	

(c) Planting plan for partially compatible cultivars of groups I, II and III

A	B	C	A	B	A	B	C	A	Proportion of plants (%)
B	C	A	B	C	B	C	A	B	
C	A	B	C	A	C	A	B	C	A=34
A	B	C	A	B	A	B	C	A	B=34
B	C	A	B	C	B	C	A	B	C=21



## Temperate Fruits

- The placement, 2-3 bee hives/ha is required in a cherry orchard at balloon stage for better pollination and fruit set.

## CULTURAL PRACTICES

### Training

- Cherry trees are trained on modified leader systems.
- Plants are headed back at about 60-80 cm at the time of planting.
- The central leader is retained and 3-5 wide-angled branches, 20-25 cm apart spirally around the tree are selected in first dormant pruning.
- The lowest branch should be 40-60 cm above the ground level.
- The selected scaffold branches are headed back to minimum and only one-fourth of the growth is pruned off.
- In second dormant pruning, 3-4 well-spaced main branches are selected whose one-fourth growth is pruned off and on each main scaffold well-spaced 3-4 secondary branches are selected.
- After 3-4 years, central leader is headed back and lateral branches are allowed to grow, resulting in the development of strong and moderately spreading tree.



**Plate 9. Modified leader system of training**

### Pruning

- Cherry plants require more corrective pruning rather than too much heading back of the branches.
- Bearing trees need some pruning to keep the centre of the tree open. The top is kept fairly low, to generate new growth.
- Pruning is restricted to eliminating the dead, diseased and intercrossing branches.
- Fruits are borne laterally on spurs of one-year-old shoot. The average productive life of fruiting spurs is 10-12 years, requiring less super renewal pruning.

### Manuring and fertilization

- Cherry requires all the essential nutrients for better growth and quality fruits. Since fruit development and vegetative growth occurs simultaneously, it has high demand for mineral nutrients.
- The amount of manure and fertilizer to be applied is influenced by the age or size of tree, soil types and fertility, cultural practices and anticipated fruit yield.

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**Table 4. Manure and fertilizers schedule for sweet cherry in Himachal Pradesh**

Age of tree (years)	Farmyard manure(kg/tree)	Calcium ammonium nitrate(g/tree)	Single Super phosphate (g/tree)	Muriate of potash (g/tree)
1	10	200	160	100
2	15	400	320	200
3	20	600	480	300
4	25	800	640	400
5	30	1,000	800	500
6	35	1,200	960	600
7	40	1,400	1,120	700
8	45	1,600	1,280	800
9	50	1,800	1,440	900
10 and above	60	2,000	1,600	1,000

- Farmyard manure should be applied in December along with a full dose of super phosphate and muriate of potash.
- Half dose of N is applied in spring before flowering and the other half dose of N is applied in spring before flowering and the other half one month later.
- Fertilizers are broadcast in tree basin about 30 cm away from the tree trunk.

### Aftercare

- Cherry orchards are maintained under permanent sod with a clean basin management.
- The basins are kept clean by hand-weeding or using weedicides.
- Application of Diuron 4kg/ha as pre-emergence and Paraquat (0.5%) as post-emergence are recommended to suppress the growth of weeds for 4-5 months.
- Mulching tree basin in April with 10-15 cm thick hay also helps control weeds and conserves soil moisture.
- Green manuring crops-bean, pea, red clover and white clover-can also be grown in tree basins to improve soil texture and fertility.

## Temperate Fruits

### Irrigation

- Due to sloppy lands and non-availability of irrigation water, cherry is grown under rain fed conditions in our country.
- The distribution of rainfall throughout the year is uneven and owing to less rainfall during April-May, the plantations should be irrigated frequently.
- Irrigating cherry trees at weekly intervals during fruit growth and development is recommended for better fruit size and quality.

### Fruit cracking

- Fruit cracking is a serious problem in cherry, which causes 50 to 80 per cent losses.
- Sweet cherry cultivars differ in the susceptibility in cracking because of differences in the rate of water absorption and capacity for expansion of the peripheral tissues to accommodate the increased fruit volume that results when water is absorbed.
- The cultivars with a rapid rate of absorption and a low capacity for expansion tend to be immune.
- Any treatment that decreases the rate of water absorption or increases the capacity of fruit tissues to stretch without rupturing reduces the amount of cracking.
- Spray of calcium chloride at 300g per 100 litre water or GA3 at 2000 ppm or NAA 10 ppm at 25-30 days before harvest checks fruit cracking.



Cracking of cherry fruits in Van cultivar on Colt rootstock

### Plate 10 Fruit cracking

## MATURITY INDICES, HARVESTING AND POST-HARVEST MANAGEMENT

- The yield and quality of cherry is appreciably affected by the stage of maturity at which fruits are harvested.
- Early-picking results in flat fruits with less yield as cherries usually develop rapidly in the last few days before maturity is reached.
- Harvesting of over-ripe fruits results in loss of weight, volume and quality.
- Colour development, TSS and flavour are the best standards for judging the optimum time of harvesting.

### Temperate Fruits

- Fresh fruits are picked with stem when the surface colour changes from green to red.
- The fruits are packed in boxes lined with paper. Generally, 1 kg cardboard boxes are used for packing now a days.



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### LECTURE - 10: Cultivation of almond

#### INTRODUCTION

##### Taxonomical classification

Order = Rosales

Family = Rosaceae

Sub-family = Prunoideae

Genus = Prunus

Species = amygdalus

Basic chromosome number = 8

Somatic chromosome number= 16

##### Introduction

- Almond is an important temperate fruit with widespread popularity for its kernels throughout the world.
- It is a native to central Asian mountain areas (India, Iran and Pakistan).
- Apart from raw consumption as an edible kernel of the drupe, it has also industrial applications as a major ingredient in many manufactured products.
- The kernels are rich source of fat (54%), proteins (19%) minerals and vitamins.
- Its oil called badam roghan is considered to have high nutritional, medicinal and industrial value.
- Almond oil is used in confectionary and also for pharmaceutical and cosmetic preparation.
- Kernels after blanching, roasting, frying and salting are very delicious and in great demand.
- Green almond kernels are also consumed in the milky stage.

##### Area and Production:

- Almond is cultivated mainly in regions situated between 360 and 450 N latitude.
- The major almond producing countries are USA (48500MT) and Spain(21700MT), which account for about 50 per cent of the total world almond production. Other leading almond producing countries are Italy (119000MT), Iran (76000MT) Syria (67000MT), Morocco(66000MT), Greece(35000MT) and Turkey (34000MT).
- In the world it occupies an area of ..... ha and production is 144737 MT(1999-2000).
- In India, almond cultivation is confined mainly to Jammu and Kashmir, high hills of Himachal Pradesh and Uttarakhand.
- The state of Jammu Kashmir is the major almond producing state in the country.
- The area under almond cultivation is 18000 ha and the production was 9700 MT in Jammu and Kashmir, where as in HP the area is 5610 ha and the production is 1345MT (Annon, 2009-10).
- In Himachal Pradesh almond are cultivated in Shimla, Mandi, Kinnaur, Chamba, Kangra and Sirmaur districts.

##### Morphological characters:-

- The cultivated almond is a tree of medium height , branches are glabrous and one -year- old shoots are pale green to reddish brown in colour.

## Temperate Fruits

- Flowers usually develop laterally on short spurs and have 1-5 flower buds, flower is perigynous with a single ovary enclosed in the floral cup that bears 30-40 stamens.
- Flowers are hermaphrodite with white or pink petals, 5 sepals a single and unicarpel pistil which usually contain 2 ovules.

### Varieties :-

- Almost all cultivars of almond are self sterile and require pollinizer. Even a few cultivars like IXL and Non Pareil are cross sterile.

### Recommended varieties for different states of India

**Varieties for J & K :-** Makhdoom, Parbat, Waris, Shalimar, Afghanistan Seedling, IXL, Merced and Non Pareil.

### Himachal Pradesh

High and mid hills :- Merced, Non Pareil, IXL.

Valley areas:- :- Drake, Katha, Peerless, Ne Plus Ultra.

Dry temperate zone :- Ne Plus -Ultra, Texas, IXL

- The almonds of seedling origin are classified in four groups viz. (i)paper shelled, (ii)soft shelled, (iii) semi- soft shelled and (iv) hard shelled.

### Climate and soil :-

- Among the various temperate nut and dry fruits, almond is the most exacting in its climatic requirement, favorable environmental conditions are essential for success in the cultivation of almond.
- Among the various climatic factor, cool climate during winters plays a important role in flowering and regular sprouting in spring.
- The chilling requirement for normal bud sprouting depends on the cultivars and are relatively low, ranging from 200 to 700 hours below 7.20C.
- However, for successful cultivation, almond require cool winter, frost free spring and warm dry summers.
- The limiting factor in almond cultivation is the spring frost, especially during full bloom or fruit set.
- The tolerance to low temperature during bloom depends upon cultivars, Non Pareil and Ne Plus Ultra are highly tolerant to low temperature.
- South facing slopes are considered the best for almond growing.
- Rains during spring and summer cause blossom and fruit infection by brown and green rot organisms, while foggy and rainy weather during summer result in brown strains on the shells (due to stagmini blight) of ripening nuts.
- Almond can be grown on all type of soils, but well drained loamy soils having pH of 5.5 to 6.8 are most suitable for its cultivation.

#### Rootstocks and propagation:-

##### A. Seedling rootstocks

- In India seedlings of bitter almond, wild peach and behmi ( *Prunus mira*) are used as a rootstock. Almond seedling rootstock from the bitter or sweet cultivars are used because of longevity and tolerance to drought, lime soils and iron chlorosis
- In winter climate and irrigated areas peach seedling are used.

##### B. Clonal rootstocks

- The clonal rootstocks like GF 677, GF 557, Marianna 2624, Myrobalan 2032 and Marianna GF 8/1 are being used world over.

#### Propagation:

- Bitter or sweet almonds seeds are sown either directly in the nursery beds during December or stratified in the moist sand for 50-60 days and then sown the nursery beds.
- The pencil thickness seedling are grafted with tongue grafting method in Feb – March or budded with T method in May.

#### Planting

- One-year- old grafted or budded plants having good growth and well developed root system are planted in a square, contour or terrace system at a spacing of 5x5 meter depending upon the rootstocks and soil fertility.
- The planting should be done in December – January.
- Since almond is a highly cross pollinated crops, thus every third row should be planted with a pollinizer variety to provide 33 % pollinizer.

#### Training and pruning

- Almond plants are generally trained with open centre system.
- After planting, the plant is headed back 70-80 cm above the ground level.
- In the summer 3-4 well spaced branches on trunk in different direction are selected while other unwanted branches are pinched off.
- The lowest branch should be selected not below 0.6 m from the ground level.
- If these branches are not selected during summer than they must be selected during dormant pruning.
- The primary scaffolds (3-4) developing within 10-15 cm from the top will form the tree crotch.
- After selecting the primary branches the leader is removed and primary branches are headed back to  $\frac{1}{2}$  to  $\frac{1}{3}$  of the growth.
- Summer pruning is carried out 2-3 times in order to retain shoots for main branches and to eliminate unwanted branches and water sprouts.
- The summer pruning should also be carried out in the second year to form the secondary framework scaffold.
- In the third year dormant pruning, 2-3 secondary branches on each main branches are selected.
- The shoots growing inward and interfering with the main branches are pruned off.
- Almond bears fruits mostly on spurs which remain fruitful for about 5 years and these spurs should be renewed by regular pruning after 3-4 years.
- Pruning should be done in such a manner that one fifth of fruiting wood is removed every year .

## Temperate Fruits

- Unwanted water sprouts and suckers should be removed .
- Trees with less than 10-12 years of age should make 22-25 cm annual growth and older trees should produce 15 cm of new shoot growth each year, therefore. pruning is done by heading back of new shoots and thinning out of unwanted shoots.

### Manuring and fertilizers :-

- Almond is a heavy feeder and thus requires proper fertilization.
- The application of manure and fertilizer depends upon the soil fertility and age of tree proper fertilization schedule is formulated after leaf and soil analysis.
- The manure and fertilizer schedule recommended for bearing almond trees of 7 years or more years old are 50-60 kg FYM, 500g N, 350g P<sub>2</sub>O<sub>5</sub> 700 g K<sub>2</sub>O per plant.
- FYM along with full dose of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O are applied in Dec- Jan and half dose N one month before flowering and remaining half after one month of first application.

### Irrigation :-

- Irrigation is most important practice to improve the growth and yields of almond trees because summer rainfall is insufficient in the areas where almonds are grown.
- Almond trees should be irrigated at weekly intervals during April, May and June.

### Orchard soil management :-

- Sod culture plus mulching of basin area is the best soil management system for almond orchard.
- The ground should be cultivated to a depth of 10-15 cm during winter and repeated in spring.
- After cultivation 10-15 cm dry grass or black alkathene mulch is used on the basin for weed control and moisture conservation.
- The weeds can also be controlled with the application of weedicides like glyphosate or paraquat.

### Pollination

- Most of the cultivars are self unfruitful and require cross pollination for good fruit set.
- Only a few varieties like Drake and Dhaber are self pollinated and capable of setting fruits with their own pollen.
- It has been observed that in even in self fruitful cvs. Cross pollination increases fruit set.
- In almond all the cultivars are not cross compatible usually two pollinizer varieties, possibly of commercial importance are used, one flowering slightly before and the other just after the main cultivars.
- Good pollination can be achieved by single row of the main cultivar and pollinizer.
- Pollination is mainly done by honey bees usually 4-5 colonies/ha are placed for effective pollination.

### Harvesting and post harvest management :-

- Almond can be harvested green or dry. Nuts of thin shelled variety are also harvested at the green stage for direct consumption..
- Almonds are ready for harvesting when they change from green to yellowish with cracks or when splitting at suture starts from pedicel end.
- For dry nuts the harvesting is done from August to October
- Nuts are harvested by knocking the limbs with long wooden poles. The polythene sheet should be spread beneath the tree prior to harvesting.
- The nuts should be placed in a shady place for dehulling where these can be dried as well.
- The yield of 10-12 quintals/ ha of shelled almonds are obtained.



### LECTURE - 11: Kiwifruit cultivation

#### INTRODUCTION

##### Taxonomical details

Family = Actinidiaceae

Genus = Actinidia

Species = deliciosa

Basic chromosome number = 29

##### Introduction

- The kiwifruit (*Actinidia deliciosa* Chev.) is a deciduous fruiting vine native to Yangtze river valley of south and central China.
- This is known as “China’s miracle fruit” and “Horticulture wonder of New Zealand”.
- Although this fruit vine is originated in China, yet its full economic potential was exploited by the New Zealanders, which accounts for over 70 per cent of world trade.
- In other countries of the world, its cultivation gained momentum after 1960 and now it is cultivated on a commercial scale in USA, Italy, China, Japan, France, Germany and Australia.
- In India, it was first introduced at Lal Bagh garden, Bangalore, but the plant did not come in to bearing due to lack of chilling requirement during winter for its bud break.
- Later on, in 1963, it was introduced in Shimla hills, where the plant came in to bearing in 1969.
- Kiwifruit is rusty brown with hairy surface and looks like a spota fruit. Fruit has refreshing and delicate flavour, pleasing aroma and high nutritive and medicinal value.
- It is rich in Vitamin-C and contain more of potassium, phosphorus and iron and low in calories.

##### Area and Production

- Kiwifruit is mainly grown in New Zealand, China, USA, Italy, France, Australia and Israel.
- In the world, it occupies an area of 88012 ha. with a production of 1377233 MT (FAO,2009).
- In India it is grown in mid hills of Himachal Pradesh, J&K, Uttarkhand, Sikkam, Arunachal Pradesh, Meghalaya, Nagaland and Nilgiri hills of south India.
- In HP it is grown in 128 ha and production is 154 MT ( Annon, 2009-10)

##### Soil and climate:-

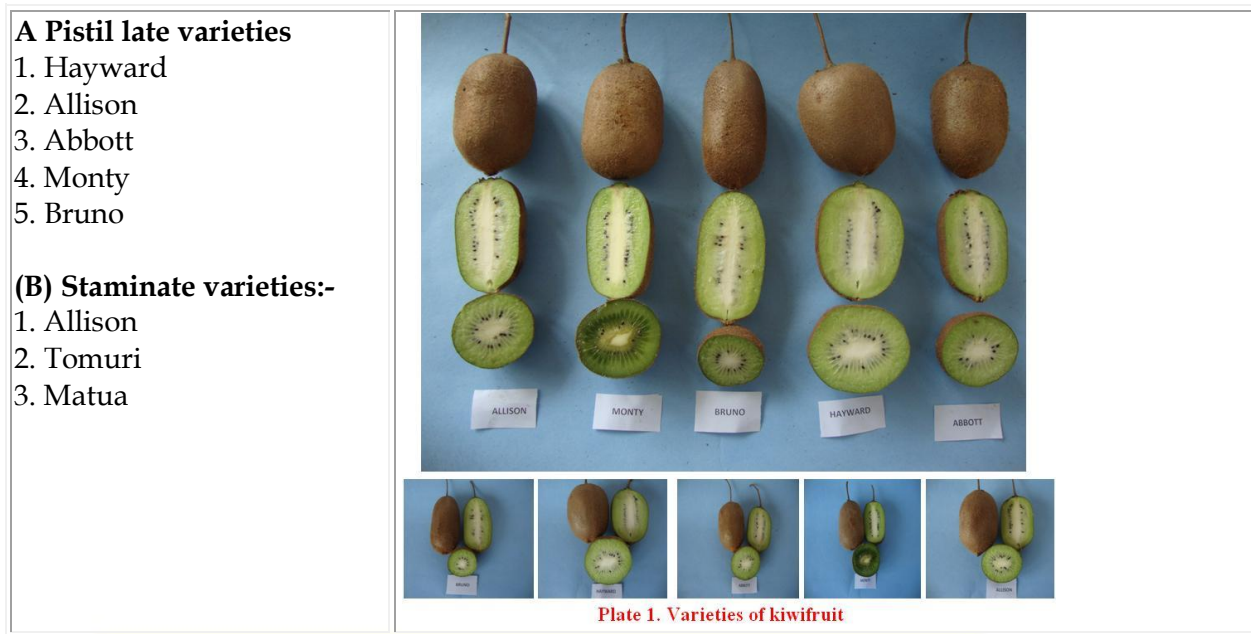
- Kiwifruit can be grown in almost all types of soil provided adequate soil moisture is available.
- Deep well drained, sandy-loam soil with good amount of organic matter is ideal for its cultivation. Heavy clay soil with poor drainage is not suitable.
- A soil pH 5.5 to 6.5 is considered ideal for vine growth and fruit production.
- Although, kiwifruit is very hardy deciduous vine can withstand a wide range of climatic conditions, yet for the production of good crop of quality fruits it has specific climatic requirements.
- It can be grown successfully in warm temperate to sub-tropical regions lying between 3000 to 5500 feet a.m.s.l, which provide 600-800 chilling hours to break dormancy.
- Low temperature (-2.5oC or below) and frost during spring and autumn is very injurious, which kills immature shoots and fruit buds.
- In summer, high temperature >38oC accompanied by high insulation (loo) and low humidity may cause scorching of leaves and sunburn of fruits and even death of the plants.

## Temperate Fruits

- A rainfall of about 120-150 cm, well distributed throughout the growing period is sufficient for proper growth and development.
- High velocity of wind during April and May cause breakage of young tender flowering shoots, whereas low temperature, hails and rainfall during flowering hamper the fruit set.

### Varietal status

- Kiwifruit is a dioecious plant, bears staminate and pistillate flowers on separate plants.



## PROPAGATION AND CANOPY MANAGEMENT

### Rootstock and propagation:-

- Seedlings of some cultivated cultivars like Bruno and Abbott are commonly used as a rootstock in kiwifruit. Seeds of these two cultivars are preferred because of good germination and strong seedling vigour.

### Propagation:

- Kiwifruit is commercially propagated through cuttings, grafting and budding and tissue culture.

#### A. Propagation through cutting :

- This is the most rapid and easiest method.
- Softwood, semi hard and hard wood cuttings are used to raise own rooted plants.
- The ideal cutting is 0.5 to 1.0 cm thick with relatively short internodes, about 10-15 cm in length having at least 4-5 buds.
- Cutting should be taken from middle portion of current season's growth shoot in June-July in case of semi-hard cuttings and from one year old shoot during January-February in case of hard wood cuttings.
- After preparation, the cuttings are dipped in 4000-5000 ppm IBA solution for 10-15 seconds and then planted in mist propagation chamber or in open field conditions for rooting.

## Temperate Fruits

### B. Propagation through grafting and budding :

- Kiwifruit vines are also propagated by grafting and budding on seedling rootstock. Although this method takes two years to develop a nursery plant, yet is easiest, economical and used for large scale multiplication.
- Before sowing, seeds are stratified in alternate layers of moist sand for 30-35 days at 0-5o C to break dormancy.
- Stratified seeds are sown in the seed beds during February. Germinating and baby seedlings are very sensitive to direct sunlight so they must be protected by creating a shade or using shade nets.
- At three leaf stage the seedlings are transplanted in polybags and then in nursery beds during July-August.
- The seedlings attain a graftable size within a year. Tongue grafting and Chip budding done in last week of January to end of February gave 90-95 % bud-take success.
- Nursery management practices like weeding, irrigation, staking of grafted plants are done at regular intervals.



Plate 2. Propagation through cutting



Plate 3. Propagation through grafting and budding

### Planting:-

- Flat land with gentle slope is ideal for planting of kiwifruit.
- Plant spacing varies according to cultivars being grown and training system adopted.
- In general, planting is done at a spacing of 6 m from plant to plant and 4 m from row to row in varieties like Allison, Abbott and Monty trained on T- bar Trellis system.
- Whereas, Hayward is less vigorous and is planted at a spacing of 5m x 5m. In pergola system of training, a spacing of 6m x 6m is recommended for getting better fruit production.
- Planting is done during dormant season ( December to January)
- While planting, the male plants are spread throughout the block with every female adjacent to a male. This is achieved by 1:8 or 1:9 male to female ratio.

## Temperate Fruits

### Canopy management:-

#### (A) Training:-

- Kiwifruit is a vine like grape, thus require similar training structure but more stronger than grapes.
- A number of training structures are used for training a vine, but T- bar trellis and pergola systems are more popular.
- In T- bar trellis system, the pillars of iron and concrete about 1.8m in height above the ground level are erected at a distance of 6m from each other in a row in straight line.
- A cross arm (1.5m) is fixed on each pole, which carries five outriggers wire at a distance of 45 cm each.



**Plate 4. T Bar trellis system**

- Vines are trained upto wire as single stem then two leaders in opposite direction along the center wire are selected or developed . From these permanent leaders, temporary fruiting arms 25-30 cm apart are selected at right angle along both sides of each leader.
- Training of vines on pergola system is similar to that of T-bar. A flat topped network of criss-cross wire is prepared on the erected pillars. This systems is costly to prepare but vine trained on this system gives higher yields.

#### (B) Pruning:-

- The main objective of pruning is to obtain high yield of quality fruits and to manage excessive vegetative growth.
- The following principles should be kept in mind at the time of pruning.

(1) The fruit is developed on current season's growth arising from one year shoot.

## Temperate Fruits



**Plate 5. Unpruned vine**



**Plate 6. Pruned vine**

(2) Only the basal buds of the nodes 4-12 on current season growth are productive.  
(3) Vines grow 2-3 m every year, which become overcrowded if not controlled by summer and winter pruning.

(4) The shoots developed on older wood by heading back will not fruit normally in the first season.

- Keeping in mind these principles, the vine pruning is carried out in such a way that the fruiting areas are available every year requiring the wood to be young.
- This is achieved by 3-4 years lateral replacement system. In dormant pruning, the fruiting lateral is cut back to 2 vegetative buds beyond the last fruit.
- In the second year, these vegetative buds produce the fruiting shoots, which are pruned again.
- The arm on lateral shoots are pruned and allowed to fruit for 3-4 years.
- After this the lateral is removed from the main branches and other laterals are selected and pruned accordingly so that the balance between vegetative and reproductive growth is maintained for the continuity in the fruit production.
- In summer pruning shoot is cut beyond 6-8 buds from the last fruit during June-July.

### Pollination requirement and role of Pollinators

- The Kiwifruit crop is highly dependent on pollination as the plants are functionally dioecious.
- For effective pollination, one male plant is planted for every 9 pistil late plants.
- Wind and insects play a very significant role in pollination, however, introduction of honeybees in the orchard further increase fruit set and size of the fruit.
- Honeybees colonies about 8-9 per hectare are required in kiwifruit orchard for effective pollination.
- Besides, insect pollination, hand pollination is essential to get fruits of better size and quality.

### CULTURAL PRACTICES

#### Orchard Floor Management:-

- Clean cultivation with mulching of the tree basin area with 15 cm thick hay grass or black polythene mulch is recommended for kiwifruit orchards.
- During the initial two years, intercrops like strawberry, peas, beans, cowpeas and vegetable crops like tomato, ginger etc. can also be grown in the vacant area between the trees.

## Temperate Fruits



Plate 7. Black polythene mulch



Plate 8. Hay mulch

### Nutrition:-

- The vines make much vegetative growth, yield heavily, thus requires adequate amount of manures and fertilizers for normal vine growth and fruit production.
- The quantity of fertilizers to be applied vary with soil fertility and age of the vine.
- In general, a basal dose of 20 Kg FYM alongwith 0.5 Kg of NPK fertilizers mixture containing 15 per cent N be applied each year of age.
- For fully bearing vines (8 years and above) 60-80 kg FYM, 800g N, 560g P<sub>2</sub>O<sub>5</sub> and 1200 g K<sub>2</sub>O/vine is applied every year per vine.
- FYM along with full dose of P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O is applied during December-January, while N fertilizer is applied in two equal dressing, half before bud-burst and remaining full dose at the onset of monsoon i.e. in July.
- Application of 2/3rd dose of recommended NPK fertilizers through drip irrigation in eight equal split doses from bud burst at 10 days intervals is recommended which results 25 per cent saving of fertilizers and increase yield of quality fruits over traditional method of fertilizer application.

### Irrigation:-

- Water requirement of kiwifruit is very high because of vigorous vegetative growth and larger leaf surface area.
- In general, fully grown vines require 80-100L of water for total daily transpiration from 16-17 m<sup>2</sup> canopy area during summer.
- Due to irregular distribution of rainfall in most of kiwifruit growing areas, the supplemental irrigation is important for improving productivity of fruits.
- Young vine should be irrigated at 2-3 days intervals, while bearing vines are to be irrigated at 20% depletion of soil moisture from field capacity (5-6 days intervals) during summer to get better size fruits.
- Drip irrigation at 100 per cent ET<sub>c</sub> gave higher yield of quality fruits.

## Temperate Fruits

### Crop and quality regulation:-

- All the cultivars of kiwifruit except Hayward bears heavily every year. This heavy crop create a severe competition between the fruits for water, nutrients and photosynthates, which leads to production of small size fruits. Therefore, to harvest quality crop of good size hand thinning is essential as chemical thinning is ineffective.
- In a study on thinning in kiwifruit, hand thinning ( 20% thinning) to the extent of retaining 4-6 flower buds or fruits/ flowering shoot produced more fruits of A grade without any adverse effect on total yield as chemical thinning was found ineffective in kiwifruit.
- In hand thinning only lateral flowers or fruits are removed .



**Plate 9. Flower or flower bud thinning**



**Plate 10. Fruit thinning**

**Plate 11 Retaining 6  
fruits/shoot**

**Plate 12 unthinned**

### Maturity indices, Harvesting and Marketing:-

- In kiwifruit, determination of optimum fruit maturity is difficult because no change take place into the skin or flesh colour or size of fruit at fruit maturity.
- A maturity index of 6.20B TSS is considered is satisfactory for fruit harvest.
- Days from full bloom to harvest along with TSS was found the best index to judge the optimum harvesting time.
- Beside this, at maturity the hairs present on the fruit skin are removed very easily
- and can be used to judge the harvesting or maturity.
- Harvesting is done manually by giving gentle twist to fruit and fruits are plucked without stalk,

### Grading and Packing:-

- There is no standard for grading and packing in India, However, following grades are under 'A' grade >70g, 'B' grade (50-70g), 'C' grade <50g. but international standard of grading is 'A' grade is above 100g, B 70-100g. <70g is C grade.

## Temperate Fruits

	DFFB to harvest (Lower elevation)	Harvesting Dates	DFFB to harvest at higher elevation	Harvesting Dates
Allison	193 +- 4	20-25 Oct.	209 +-4	4-6 Nov.
Abbott	190 +- 4	20-25 Oct.	211 +- 4	8-12 Nov.
Bruno	182 +- 4	15-20 Oct.	205 +- 4	1-3 Nov.
Monty	192 +- 4	20-25 Oct.	-	6-10 Nov.
Hayward	201 +- 4	1-5 Nov.	223+- 4	18-20 Nov.



**Plate 14. Packing of kiwifruit**

- In India kiwifruit is packed in 3-5 Kg boxes of Cardboard. However in other countries the kiwifruit are packed in tray packs.
- Standard tray consists of an out case of cartboard or plastics, a performed plastic packet tray-packs, a polliners corrugated strawboard and a cardboard lid. In a tray 33 fruits of 100 g/fruit weight are accommodated.
- Kiwifruit has excellent keeping quality, storage of fruits should be done with hours of picking.
- Fruits can be stored at ambient temperature for 6-7 weeks, but for good commercial storage refrigeration is necessary. It can be stored for 4-6 months in cold storage at 0oC and 90% relative humidity.
- Fruits are eaten fresh or combined with other fruits in sealed.
- A large number of processed products such as jam, jelly, candy, squash and wine are prepared from kiwifruit.





## LECTURE - 12: Cultivation of strawberry

### INTRODUCTION

#### Taxonomical classification



Order = Rosales

Family = Rosaceae

Sub-family = Rosoideae

Genus = *Fragaria*

Species = *ananassa*

Basic chromosome = 7

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Cultivated strawberry is octaploid having chromosome number 56

#### INTRODUCTION

- The cultivated strawberry is one of the most important soft fruits of the world.
- Fruit is technically known as an accessory fruit in that the fleshy part is derived not from the ovaries (achenes) but from receptacle.
- It can be grown in different climate ranging from temperate to tropical.
- Strawberry is very nutritive fruit. It is a rich source of vitamins and minerals. Strawberry fruit contains about 0.5% pectin. The flavor of the fruit is due to presence of volatile esters.
- Most of the fruits are consumed fresh and some are processed into Jam, chutney, squash and other food stuffs.. It is used in large scale ice cream making. The fruits are canned and shipped in frozen conditions in western countries.

#### AREA AND PRODUCTION

- Strawberry is a native of temperate regions, but varieties are available which can be grown in subtropical areas

## Temperate Fruits

- The cultivated strawberry (*Fragaria x ananassa*) was first tried in Europe in the early 18th century and represents the accidental cross of *F. virginiana* from eastern North-America, which was noted for its fine flavor and *F. chiloensis* from Chile and noted for its large size.
- Strawberry industries in America was started in the beginning of 18th century, and today nearly 50% of worlds production is in Europe.
- The strawberry is commercially grown on large scale in Europe and North America. Among the European countries, France, Italy, Poland and Spain are the major producers. The other countries having a sizable production of strawberries are Russia, Japan and Turkey.
- The total world production of strawberry is 3822987 MT .
- In India strawberry is commercially grown in plains mainly for fruits and in hills for raising planting material production. The major strawberry growing states in India are Punjab, Haryana, Uttar Pradesh, Himachal Pradesh, Uttarakhand, Jammu and Kashmir and Maharashtra (Mahabaleshwar).

## Morphological description



Plate 1. Strawberry plant

- Strawberry is perennial herb, petiole mostly long and channled above, stipules adnate at the base of petiole.
- Leaves 3-foliolate, leaflets sharply denate, but entire at the more or less wedge shaped base.
- Flowers polygamo-dioecious, rarely hermaphrodite, the male flowers larger, all 5-parted, central flower open first.
- Calyx lobe form flat hypanthium, stamens about 20 or less, filament mostly shorter than receptacle, anthers oblong, receptacles roundish or conic bearing numerous pistils with lateral styles.

## Varieties

- Several varieties have been bred in different countries and evaluated under local condition. The varieties recommended for Indian conditions are : Chandler, Camarosa, Sweet Charlie, Ofran, Oso Grande, Gorella, Selva., Sanga Sangana, Belrubi, Shasta, Fern, Tioga and Pajaro

## Temperate Fruits

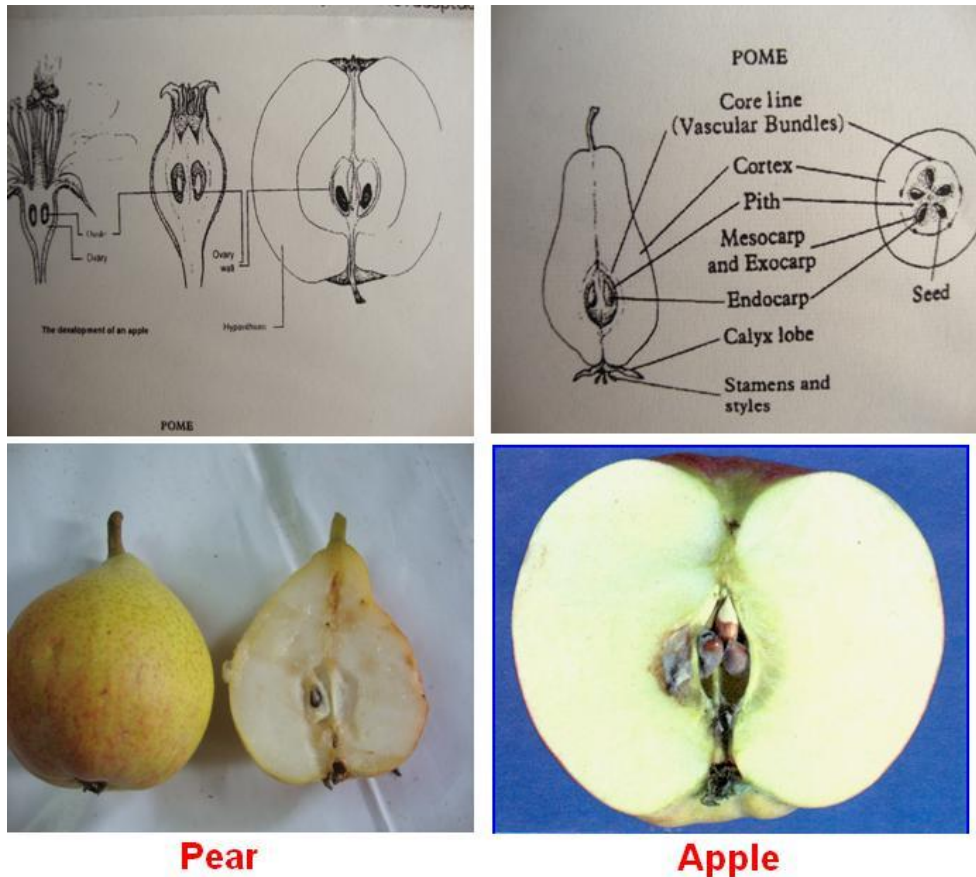


Plate 2. Chandler

### Climate and Soil:-

- Strawberry can be grown in all types of climate, but thrives best in temperate climate. It is grown in temperate to sub tropical areas.
- Some cultivars (Gorella, Chandler, Senga Sengana) are adapted to septentrional culture i.e. short days in autumn and hard winter, or to meridional conditions i.e. long days in autumn and moderate winter (cv. Tioga).
- The day neutral cultivars (Selva and Fern) can be grown all around the year.
- Strawberry requires certain minimum amount of dark period (8 hours) for flower bud initiation, but better flowering and fruiting can be achieved if plants are chilled. Under normal conditions flowers are initiated in autumn.
- A temperature of about 22-30°C is considered optimum for plant growth. In cold climates, frost damage and winter injury are major constraints for strawberry cultivation. Blossoms of most June bearing cvs are damaged at -2°C.
- The optimum temperature for period between onset of flowering and onset of ripening should be 14 to 16°C.
- Strawberry thrives best in light soil as heavy soil inhibits root growth and development.
- Sandy loam soils rich in organic matter (4-5%) is best for strawberry cultivation.
- Most of the roots found in the top 15-20 cm of soil, therefore it is essential that top layer of soil should be porous and rich in humus.
- Strawberry is not very sensitive to soil reaction, yet it prefers a light acidic soils (pH 4.6 to 6.4).

#### Propagation:-

- Strawberry is commercially propagated by runners.
- Nowadays, tissue culture techniques has been adopted for mass multiplication.
- Propagation by seed is not suitable as the seedling do not come true to type.
- Runners produced from stolon of established plants are commonly used for propagation of strawberry. Although, propagation by runners perpetuates the character of the parent but viral diseases are also transmitted through runners from infected mother plants. Therefore, virus tested clonal material should be selected and planted at 1.2 x 1.2 to 1.8 x 1.8 m distance in land where strawberry had not been grown during past few years.
- For higher runner production, the inflorescence must be removed by hand in order to prevent fruiting.
- Application of GA3 at 50-100 ppm and N at 60-120 ppm increases runner production.



Plate 3 Propagation through runner

#### Planting:-

- Land to be used for strawberry cultivation should be prepared by repeated ploughing and removal of weeds and stubbles.
- The roots of strawberry are confined in the top 40 cm of the soil, therefore 40 cm soil surface should be fertile and friable.
- A good practice in preparing the soil for strawberry planting is to grow green manuring crops like clover, soyabean and plough them in the soil which helps to increase organic matter.
- Manure and fertilizers should be mixed during land preparation. High level of phosphorus and potash are desirable for best fruit production.
- Strawberry can be planted on flat beds, in the form of hill rows or matted rows or can be planted on raised beds of 4x4 meters.
- Strawberry is planted at a spacing of 25-30 cm plant to plant and 45-50 cm apart in rows during September to mid of October.

## Temperate Fruits

- Plants are to be set with a crown at the soil surface. If the plants are set too shallow, roots tend to dry out and the plant may die. Irrigation with sprinkler is given after planting.



Plate 4. Systems of Planting

### Manures and fertilizers:-

- Strawberry requires both organic and inorganic fertilizers for growth and fruit production.
- Apply 50-60 tones/ha well rotten FYM at the time of preparation (pre planting) along with 40 kg P<sub>2</sub>O<sub>5</sub> and 30 kg K<sub>2</sub>O/ha. Apply 80 Kg of N/ha in two split doses. Half N should be applied after month of planting, and remaining half before blossoming.
- Foliar application of urea (0.5-1.0 %) and micronutrient formulation (0.3%) should be applied 3-4 times before flowering, fruit initiation and fruit enlargement.

### Irrigation:-

- It is a shallow rooted plant and grown in sandy loam soil thus require more frequent light irrigations.
- Excessive irrigation is however detrimental which encouraged growth of leaves and stolons at the expense of flower and fruit and also increases incidence of Botrytis rot.
- Irrigation is applied in furrows below the rows.

## Temperate Fruits

- The use of sprinkler and drip method of irrigation are more convenient for irrigating strawberries. The results of various studies reveals that irrigation should be given at 100% ET with drip method.



Plate 6. Irrigation with sprinkler method

## Mulching:-

- After one month of planting, the plants are mulched with black polythene or grass mulch, which will protect the berries from the direct contact with the soil.
- Mulching of strawberries in fall has been found useful as it minimizes winter freezing injury to plants, and suppressing early spring growth, thereby reducing fruit bud frost injury.
- Mulching also suppresses weed growth and reduces soil erosion.



Plate 7. Mulching of strawberry & Plate 8. Use of poly tunnel

- Poly tunnels can also be used to protect the strawberry fruit from frost in winter.
- Wheat straw and paddy straw can also be used as mulch material.
- Black polythene mulch is very beneficial which is placed after planting by creating the holes at the point of plant.
- Alkahene mulch can also be used over the beds to maintain more favorable soil environment and to protect the plant from cold injury.

#### Weed control:-

- Weed control is one of the most serious and expensive management practices in strawberry. The weeds pose a great problem and sometimes become unmanageable specially during rainy season.
- Both chemical and hand weeding is used to control the weeds.
- Application of venzar (lenacil) at 1.5-2.0 kg/ha as pre-planting gives good control of weeds.
- Use of mulches also help in controlling the weeds in strawberry plantations.
- Hand weeding should be done at regular intervals to keep field free from the weeds.

#### Flowering:-

- Flowering is controlled by photoperiod. Increasing the light intensity in greenhouse- forcing cvs, reduced time of flowering, increased number of inflorescence and fruit set.
- The everbearing cvs (Ozark Beauty, Geneva, Superfaction) initiate and produce flowers throughout the growing season.
- Day neutral strawberry (Tribute, Brighton, Hecker ) have gained popularity in different geographical regions.
- Strawberry production may be limited by low temperature during autumn, winter or spring in many temperate regions. Low temperature during bloom, and in the fall and winter can destroy the flowers and buds.
- Flowering in short day cvs. can be induced in long days so long as the temperature is sufficiently low.
- Some cvs have specific temperature requirement for flower bud initiation
- Purner et al. (1984) studied the effects of photoperiods and temperature on day neutral, June bearer ( Red chief and Guardian) and everbearer ( Qurown and Ozark Beauty) strawberries, They were grown at constant temperature 21 oC 16 hour long days (LD) 9 hours short days (SD) or 9 hour with the dark period interrupted (NI) by 3 hours of low level incandescent radiation. Flowering in day neutral was unaffected by photoperiod, in June bearing flowering was inhibited with NI and LD compared with SD, flowering of ever bearer was promoted by LD compared with SD.

#### Pollination:-

- Most cultivars produced hermaphrodite flowers. However, imperfect, pistillate and strictly female cvs require cross pollination.
- The anthers open at the sides, sometimes under tension so that pollen is transferred onto pistils.
- Pollens are initially heavy and sticky but later become dry and are carried by wind. However, bees and flies are important agents in strawberry pollination.
- Incomplete pollination results in developing irregular and poorly shaped berries.
- Placement of 2 honeybees hives /hectare is recommended for effective pollination and good fruit set..

#### Harvesting:-

- Fruits are usually harvested when half to three quarters of skin develops colour.
- A delay in picking increases the percentage of overripe and rotten berries.
- It is conventional practice to harvest the strawberries every third day..

## Temperate Fruits

### Pests and diseases

#### Pests:-

##### (i) Red spider mite (*Tetranychus urticae*):-

- They are red in colour, present on the under side of the leaves.
- They are controlled with the spray of Chlorpyrifos (1ml/L) and acaricide like dienochlor and amitraz.

##### (ii) Leaf roller :-

- *Eiphyas postvittana* and *Ctenopsestis obliquana* are common leaf roller, affecting strawberries.
- The caterpillars fold the leaves across the midrib.
- Two sprays of endosulfan (1ml/L) in August September controls the pest.

#### Diseases:-

##### Gray mold: (*Botrytis cinerea*)

- Light brown soft spot appear on fruits, the berries dry out and covered by a dusty fungus growth.





### LECTURE - 13: Persimmon cultivation

#### INTRODUCTION

##### Taxonomical classification

Family = Ebenaceae

Genus = Diospyros

Species = Kaki

Basic chromosome = 15

Somatic nos = 60, 90

##### INTRODUCTION

- Persimmon (*Diospyros Kaki* L.) is considered as the national fruit of Japan.
- The genus *Diospyros* contains approximately 400 species, most of which are native to tropical and sub-tropical regions.
- It is probably originated in China, where it has been cultivated for centuries. It was introduced from China into Japan in ancient times, where most of its improvement work has been done.
- In nineteenth century, it was introduced from China to many other countries namely USA, Brazil, Italy, New Zealand, Israel, Australia and South East Asia.
- In India, the European settlers introduced persimmon in hilly states namely Himachal Pradesh and Jammu and Kashmir somewhere in 1921.
- At present, it is grown on a limited scale in Jammu and Kashmir, Himachal Pradesh and Uttarakhand.
- No organized plantation of this fruit has get been done in India but with the diversification in fruit culture, it cultivation is gaining importance.
- Ripe fruit is delicious, flesh is sweet and jelly like. The entire fruit is edible except seed and calyx.

##### Area and Production:

- China and Japan are the main countries where commercial cultivation of persimmon is done. These two countries contribute major share to the global market.
- In recent years, its cultivation is also done in Brazil, Italy, New Zealand, Korea, USA and Australia.
- In the world it occupies an area of 312974 ha with a production of 23335607 MT.

##### Climate and soil:

- Persimmon can be grown in a wide range of subtropical and warm temperate climate.
- The areas 1000 to 1500 m amsl that have moderate winter and relatively mild summer are ideal for its cultivation
- It is a deciduous tree and can tolerate low temperature of -15°C during dormancy, but its chilling requirement is less (less than 200 hrs), bud sprouting occurs early in the spring.
- These buds are damaged by the spring frost.
- During the maturation period, temperature is the most important factor for obtaining quality fruits. Non astringent cultivars require warmer condition for fruit maturation than the astringent type.

## Temperate Fruits

- Although persimmon can grow on a wide range of soil types yet it thrive best on deep, well drained loamy soil.
- A pH range of 6.5 to 7.5 is ideal for its growing.

### Varieties:

The fruit of Japanese persimmon shows wide variations in size, shape, and colour, and are broadly classified into two major groups.

- (1) Non astringent
- (2) Astringent group

### Varieties are also divided on their response to pollination.

- (i) Non-astringent and pollination constant (PCMA)
- (ii) Non-astringent and pollination variant (PVHA)
- (iii) Astringent and pollination constant
- (iv) Astringent and pollination variant

**Astringent cultivars:** - Eureka, Hachiya, Honan Red, Triumph, Saijo

**Non-astringent cultivars:** - Fuyu, Jiro, Hana Fuyu, Suruga, Goshō

**Pollination variant cultivars:** Chocolate, Gailey, Hayakume, Maru.



**Plate 1. Haichya**



**Plate 2. Fuyu**

## ROOTSTOCKS AND PROPAGATION

### Rootstock

- D. kaki, D. lotus and D. virginiana are used as a rootstocks for persimmon
- In India, Diospyros lotus is used as the rootstock.
- The D. virginiana is used as rootstock for Japanese persimmon in Israel and USA.
- The seeds are extracted from fully ripened fruits during late-October.
- The stratification of seeds for 60-90 days improved seed germination.
- The stratified seeds are sown in the nursery beds.
- The best seed germination is obtained at 28°C. The seeds at this temperature take about 2-3 weeks to germinate.
- Young seedlings usually take a year to be of suitable size for grafting.

## Temperate Fruits

### Propagation

- Propagation is done by grafting the scion on seedling rootstocks, using the tongue graft for smaller diameter stocks and the cleft and veneer grafting on the larger stock.
- Veneer grafting is generally more successful than budding and should be carried out in September with the start of sap movement.
- Tongue grafting is also done with a success rate of 60-65%.

### Planting and planting density:

- In India, winter planting during January-February is recommended when trees are dormant. Planting after bud sprout generally results in poor survival.
- The trees are planted at a distance 5.5-6.0m.
- The pits of 1m x 1 x 1m are dug. Well rotten farmyard manure is mixed while filling the pits in the same manner used for other deciduous trees.
- At the time of planting the bud union should be kept 75 mm above the ground level.
- The planting density for persimmon depends on cultivar, rootstock and soil type. Dwarfing cultivars (Jiro) can be closely planted at 5m x 2.5m (800 trees/ha), semi-dwarf cultivars Fuyu at 5m x 3m (660 trees/ha) and vigorous cultivars at 6mx 4.5m (370 trees/ha).

## CULTURAL PRACTICES

### Training and pruning:

- The trees should be trained to form a low head. To achieve this, the plants are headed back at 60 cm from the ground at the time of planting to develop a frame work of strong branches.
- The dwarf and semi-dwarf cultivars are best trained to a modified central leader system. The more vigorous, upright, narrow crotch angle types should be trained to a vase or palmate system.
- The pruning is done during winter when the trees are dormant in January. Since flowers of D. kaki are borne on current season's wood, heavy pruning reduces crop setting by forcing excessive vegetative growth.
- Summer pruning of mature trees may thicken laterals and increase fruit size and colour. With more vigorous and less precocious cultivars, techniques such as cincturing and limb spreading may be beneficial to achieve higher and earlier fruit production.
- In case of grown up trees, practically no pruning is done except for removing weak, interfering, discarded or insect damaged shoots and branches.

### Manuring and fertilization:

- Persimmon does not require high fertilizer doses.
- An application of balance fertilizer (10:10:10) at a rate of one pound per inch of trunk diameter at ground level is recommended before bud-break.

### Aftercare:

- After planting, young plants need a continuous care for their survival.
- The plants need staking to keep them in a straight position which helps in selecting the well spaced laterals in the coming growing season.
- Watering at 7-10 days interval is essential.
- The plant basins are kept free of weeds.
- During hot summers, when the evapo-transpiration rate is high, the plants require mulching with dry grass/dry leaves. Mulching needs to be done in the first week of March.

## Temperate Fruits

### Irrigation:

- Irrigation is considered essential for the successful production of persimmon.
- Dry periods during fruit growth reduce the size, quality and number of fruits carried to maturity.
- Moisture deficiency during early summer may increase fruit drop.
- The peak water requirement periods are in mid summer. Due to high evaporation during summer months the irrigation is very essential to maintain uniform soil moisture.
- The young and bearing trees are irrigated at 6-7 days intervals during summer months.

### Maturity indices, Harvesting and Post harvest Management

- Persimmon fruits are harvested when they have attained yellow to reddish colour but are still firm.
- The fruits are clipped from the trees with shears leaving the calyx attached to the fruit together with a short stem.
- More care is needed to avoid bruising.
- Persimmon fruits mature in mid September, although the period of maturity varies among the different varieties.
- If fruits are harvested too early, they develop poor colour, sweetness and flavor.
- Fruits after harvesting should be wrapped individually in paper and packed in a single layer crate.
- Persimmons soften at room temperature.
- Ripe persimmons are delicious. Flesh is sweet and jelly like.
- Brix level at maturity in different varieties varies between 14- 170C.
- The persimmon trees start bearing 4-5 years after planting. However, dwarf and semi-dwarf cultivars start bearing 2-3 years after planting.
- Mature trees of Fuyu are capable of producing 50 kg fruit/plant.
- Jiro cultivar has recorded over 80 kg/plant, whereas in the Hachiya, the yield is over 100 kg/plant.
- The decrease in astringency during growth and maturation of astringent cultivars and disappearance of astringency from non-astringent varieties are most striking.
- Various methods have been suggested to remove the astringency from the astringent cultivars, however, most of these result in partial softening of fruits. Treatment of the fruit with carbon dioxide has been the most successfully developed technique till date. Dipping of fruits in 500 ppm Ethephon solution for 2 minutes helps in removing the astringency in cultivar Hachiya and the fruits are ready for consumption with 2-3 days of storage.
- The persimmons are also allowed to sweeten naturally after harvesting from the plants at room temperature, although they can be held in firm conditions for 2-3 months at 30-320C and 85-90% relative humidity. Average freezing point of flesh is 28.20C.
- Persimmon is graded by size and quality. During grading and packing, handling should be kept minimum to avoid bruising. The most popular packages for persimmons are single layer trays commonly used for stone fruits.



### Lecture - 14: Walnut cultivation

#### INTRODUCTION

##### Taxonomical classification

Family = Juglandaceae

Genus = Juglans

Species = regia

Basic chromosome = 16

##### INTRODUCTION

- Walnut is one of the important nut fruit of the world cultivated mostly in semi-cold regions.
- The wild seedling of walnut have been found in growing in vast regions right from the Carpathian mountains in Eastern Europe across Turkey, Iraq, Iran, Southern USSR and Afghanistan to the North-Western Himalayas.
- It is e believed to have originated in Iran and the areas surrounding it.
- The returning army of Alexander brought it to Europe from Iran.
- Almost all plant parts of walnut are utilized in one way or the other.
- The fruit has excellent flavor and is mainly consumed as a dry fruit being eaten for table purposes.
- The Kernels contains about 60-75% fat and oil, 16% carbohydrate, 15% Protein.
- Wood is used for making valuable furniture.

##### Area and production

- It is grown extensively in USA, China, France, Italy, Turkey, Poland, Yugoslavia, Rumania, Iran.
- In India, it is grown in the state of Jammu and Kashmir, HP and Uttarakhand and occupies an area of 41840 ha. with a production of 32000 MT.
- In HP the area under walnut is 46282 ha. and production is 1294MT (Annon., 2009-10).

## Temperate Fruits



**Plate 1. Walnut tree**



**Plate 2. Walnut fruit**

### Climate and Soil:-

- Walnut is grown successfully in all parts of the Himalayan region between the elevation of 1200 to 2150 m a m s l.
- The main climatic limitations for climatic limitations for walnuts are

- (a) Spring and fall frosts.
- (b) Extreme summer heat and
- (c) In- sufficient winter chilling.

- The plants can tolerate as low as  $-11^{\circ}\text{C}$  during deep dormancy with out serious damage but as soon as growth commences after dormancy, the temperature even 2 or 3  $^{\circ}\text{C}$  below freezing point ( $0^{\circ}\text{C}$ ) kills leaves, shoots and flower thus resulting in crop failure.
- Like wise the plants which continue to grow till late during fall are subjected to serious foliage damage by frost.
- High temperature more than  $38^{\circ}\text{C}$  causes sun burning of hulls and shriveling of kernels resulting into blank nuts. The damage are further aggravated if the humidity is low and temperatures exceeds above  $40^{\circ}\text{C}$ .
- Persistently lower summer temperature is not favorable for proper filling of the nuts.
- The cool growing season delay harvest. Like other temperate fruits, walnut require certain amount of chilling period to break bud dormancy.
- In the absence of adequate chilling, the bud opening and blooming are irregular and delayed resulting in poor crop.
- The chilling requirement varies with the cultivars and ranges from 700 to 1500 hrs.
- Walnut do well in mild climate with moderate rainfall. An annual rainfall of about 80-90 cm, well distributed throughout the season. is considered sufficient for the cultivation of walnut.
- Walnut grows well on fertile, well drained sandy loam or silt loam soil with a depth of 5-6 feet.
- The soil pH should be 5.5 to 6.5.

### Varieties

- The walnuts plantation in India are of seedling origin, however some cultivars introduced from USA and France are under test. The survey of walnut germplasm in the e states of Jammu and Kashmir,

## Temperate Fruits

Himachal Pradesh and Uttarakhand have resulted in identifying potential seedlings which have been released as cultivars.

### Exotic varieties

Hartley, Payne, Franquette, Serr, Sunland, Chico, Vina, Howard, Chandler, Tehana, Tulari, Lara

### Local selections

Gobind, Pratap selection, Solding selection, Kotkhai Selection, Kashmir budded, Wilson Wonder, Chakrata Selection, Sulaman and Hamdam.

## PROPAGATION AND CANOPY MANAGEMENT

### Rootstock and Propagation:-

- Walnut seedlings of *Juglans regia* are generally used as a rootstock for walnut in all over the world, however, in USA seeds of *J. hindsii*, Paradox (*J. hindsii* x *J. regia*) are used for raising seedling rootstocks.
- Traditionally, walnut in India is propagated by seed. Although sexual method is the most efficient and economical but not satisfactory, because the seedlings are highly variable, having long juvenile period, producing the nuts with inferior quality and with low shelling percentage.
- In India, Persian walnut known as akhrot is most common source of seed.
- The seeds are stratified for 90-110 days at low temperature 4-5°C to break the seed dormancy.
- Various pre-sowing treatments with growth regulators, scarification and water soaking etc. not only reduce the stratification requirement and improve seed germination but also enhance seedling growth.
- Soaking of seed in 750- 1000ppm GA3 or 1000 ppm ethe-rel solution for 24 hours after stratification is very effective in stimulating seed germination.
- The stratified seeds are sown in line 30cm apart at a distance of 15-20 cm and at a depth of 10-15 cm in February - March.
- The nursery beds are covered with mulching and regular irrigation and weeding is done so that seedling become graftable or buddable in one year.



Plate 3. Seedling rootstock Plate 4. Chip budding Plate 5. Annular Plate 6. Patch



Plate 7. Chip budded nursery plants

## Temperate Fruits

### Propagation

- The seedlings are grafted with tongue method during February in mid hill and in March in high hill conditions.
- Side veneer grafting gives best results when performed during July- August.
- Walnut is very difficult to propagate and gives low success with grafting.
- Budding with Chip method in mid May to first week of June, and annular budding and patch budding performed in end June to mid July gave 80-85% bud-take success.

### Planting:-

- Planting distance and density varies with the soil, rootstock, topography and nature of bearing habit of varieties.
- On flat land, square or rectangular system and on sloppy land contour and terrace systems of layout are adopted.
- The planting is done any time from December to March but establishment of plants are better in early planting.
- In general, the planting is done at a spacing of 10-12 meter in grafted plants and for seedling plants the spacing of 15 x 15 meter is recommended.
- However, lateral bearing varieties raised on clonal rootstocks like paradox are planted at a spacing of 8 x 8 meter.

### Training and Pruning:-

- Walnut trees are mainly trained according to modified leader system.
- After planting, the plants are headed back to 60-70 cm above graft union.
- The most vigorous upright limbs is selected after one year growth, removing the other shoots but leaving one or two small lower limbs on South West side to protect the tree from sun burn.
- The first main frame work branch should be 4-5 feet from the ground. The frame work of the tree is made in such a way that branches are spaced far, both vertically and horizontally.
- Care should be taken that in the cultivar which fruits laterally, a large number of new shoots are headed back on the periphery to reduce fruit and increase vigorous shoot growth throughout the tree periphery.
- In contrast, on the terminal bearing cultivars, pruning consists of heading back of selected framework branches and thinning out of competing limbs.
- Shading become a problem in a mature tree, hence thinning out of limbs in the top and sides of the tree should be done.
- The best method of pruning of tree of age below 16-35 years old is to cut back to 4-5 years old shoots.

## CULTURAL PRACTICES

### Manure and Fertilizers:-

- The walnut is grown as scattered trees and not in the form of well laid out regular plantation as such they are not fertilized.
- Virtually no information is available on the fertilizer requirements, however, the walnut trees should be fertilized with ½ kg of 15:15:15 NPK fertilizer mixture/year/tree up to 16 years age.
- The fertilizers dose is stabilized after 16years and full bearing tree should be fertilized with 8 Kg of NPK mixture along with 100 Kg FYM.
- The full dose of manure and fertilizer is applied during December - January



## Temperate Fruits

### Orchard Soil management:-

- Sod plus clean basin management is the best orchard floor management in walnut.
- The basin area can also be mulched with dry grass to conserve moisture and to control weeds.

### Irrigation:-

- Walnut trees require adequate moisture especially 5-6 weeks immediately following bloom. A water deficit prior to shell hardening result in small nuts and in mid summer results in stick tight hull.
- The critical periods for water requirement is from full bloom to shell cracking. Therefore, walnut tree should be irrigated at weekly intervals during the summer months for higher fruit production..

### Pollination:-

- Winds plays an significant role in pollination and fruit set.
- Pollen of *Juglans regia* variety is capable of fertilizing the eggs of same variety and any other variety as well.
- In walnut dichogamy is the main problem, which is further aggravated by short period of both pollen viability and stigma receptivity.
- However, pollen germinate on stigma in 1-3 days after pollination. Pollen viability last for 100hours at 14-15oC and 55 hours at 22-25 oC, however above 25oC and humidity below 33% during pollination results in pollen sterility.
- Adverse weather conditions like snowfall, hail, frost and rain during flowering results in crop failure due to inadequate pollination.
- Improvement in pollination and fruit set can be made by (1) hanging of catkins of male flowers (2) planting of 3-4 varieties in the orchard.

### Maturity and Harvesting:-

- Harvesting at proper maturity and subsequent handling of the produce are of prime importance. Any delay in picking after maturity of kernels, deteriorates the quality and increases the incidence of mould and pests.
- The maturity indices are commonly used for determining the harvesting dates of walnut are cracking of hulls from nut and change in colour of packing tissues between the kernels.



**Plate 8 Splitting of husk from fruit**

- When about 80% of the hulls have cracked from the nuts, it is a time of walnut picking.
- Secondly the proper maturity is also assessed by observing the packing tissue between and around the kernel halves which turn brown on maturity.
- Depending upon the climate, the harvesting is usually done after two weeks of browning.
- The kernel become dark if the further harvesting is delayed.

## Temperate Fruits

- The spray of ethephon 200-500 on kernel maturity advancing harvesting by 10 days, makes harvest of entire crop at a time and promotes hull splitting.
- Walnut is normally harvested from August to October.
- Maturity is earlier in lower altitudes but late at higher altitude.
- Walnut drop naturally over about one month period after splitting of hull in a natural way, while others are forced to drop down by splinting with long poles.
- The nuts should be gathered , hulled and dried immediately.
- The fallen nut are collected in huge heaps in the orchards and covered with wet leaves and grasses for hull fermentation taking about 10-15 days.
- Dehulling, washing and cleaning of nuts are done manually in India and mechanically in other advanced countries.
- Application of nuts in ethephon at 1500 ppm when hull are still on loosen the hull in 3-4 days.

## Post- Harvest Management:-

- After cleaning, the nuts are dried with the help of drier at 32-30oC temperature till the moisture content in nut is about 8%.
- The nuts can be dried in the sun for many days by spreading them on a canvass sheet or hand floor.
- After drying the nuts are started the gunny bags in small ventilated rooms.



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### Lecture - 15: Pecan nut cultivation

#### INTRODUCTION

##### Taxonomical classification

Order = Fagales  
Family = Juglandaceae  
Genus = Carya  
Species = illinoensis  
Basic chromosome = 16

##### Introduction:-

- Pecan is a valuable horticultural gift of North America to the world.
- In USA, it is considered as “Queen of nuts” because of its value both as a wild and as a cultivated nut.
- As compared to other nut fruits, which have been grown since time immemorial, pecan has been under cultivation only for about one hundred years but has gained enormous popularity.
- Pecan occupying fifth rank among leading tree nuts because of its excellent nutty flavor.
- Pecan nut is a rich source of fat (72 g) protein (9 g), carbohydrates (15 g) and minerals.
- Pecan is usually taken roasted or salted to supplement normal diet.
- Almost 90% of the nuts are sold shelled and rest in shell.
- The nuts are commonly used to add aroma, flavor and crispness, a rich colour or to garnish a large number of dishes.
- However, most commonly it is used in baking dishes and in ice creams.
- Pecan shell, a by product is also used to manufacture tannin, charcoal and abrasives in hand soap.
- The pecan tree has a value as a timber too, due to its strength and hardness. There is a great demand for its veneer and lumber in decorative paneling, fine furniture, and flooring and in pallet manufacturing.

##### Origin and Distribution:

- Pecan is said to be native of North America but it was also opined that it originated during Cretaceous period in Canada and moved south in recent geological times.
- Spanish explorers found pecan growing along the Mississippi river and its tributaries.
- The native habitat of pecan ranging from Texas in the southwest to Alabama in southeast extending up to Southern Illinois.
- Besides USA, the world wide distribution of pecan confined to Australia, Canada, Egypt, India, Israel, Mexico, Peru, Turkey and South Africa.
- In India it is grown in Himachal Pradesh, Jammu and Kashmir, Uttarakhand and in the Nilgiri hills where it was introduced in mid-thirties.
- In Himachal Pradesh, its plantation remained confined to the areas of Kangra, Mandi, Solan and Kullu districts, which constitutes approximately 700 ha area.

## Temperate Fruits



Pecan tree



Male catkin



Female flower



Pecan fruits

### Soil and climate:-

#### Soil:

- Pecan tree can be grown on varied soil conditions ranging from the sandy loam to clay loam and alluvial soil of river and small streams but they all have certain common characteristics.
- The soil should be deep, loose, well drained and well aerated to a great depth.
- Soil that is deficient in any of these requisites may support young trees but fail when the trees attain greater age and size with corresponding greater requirements..
- Pecan can be grown satisfactory where pH ranges from 5 to 8.

#### Climate:-

- The climate is probably the main constraint in the expansion of pecan cultivation.
- It needs warm temperate climate meaning thereby that the extreme of both temperate and sub-tropical climates are undesirable.
- The pecan requires a long frost-free period from the time when growth starts in the spring until the nut matures in the fall.
- It is influenced by minimum temperature and number of chilling hours during winter.
- An ideal climatic environment for pecan cultivation consists of growing season of 240-280 days, mean temperature above 26.70C, heat unit accumulation (base 100C) of 5000 degree days for 7 months, nut growing period, mean temperature for three coldest month between 7.20C and 12.80C with at least 400 h of chilling.
- High humidity affects adversely the growth, fruiting and regularity of bearing in plant by preventing pollination, increasing the incidence of diseases on leaves and nuts.
- Hailstorms and winds of high velocity are harmful to the trees.

#### Varieties:

- In pecan nut size, shell thickness and cracking attributes are desirable for selecting a variety.
- Some important pecan varieties grown in country and other parts of the world are Mahan, Nellis, Stuart, Western Schley, Mohawk, Cheyenne, Chicksaw, Desirable

## Temperate Fruits



### PROPAGATION AND CANOPY MANAGEMENT

#### Rootstocks and Propagation

- Seedlings of various cultivars like Burkett, Nellis and western Schley are generally used as rootstock for pecan nut as there is no clonal rootstock.
- The bitter pecan (*C. aquatica*) is adapted to poor drainage, flooding condition and low pH but gives low yield.
- For raising the seedlings rootstocks, the seeds are stratified at 4°C for 70-90 days.
- Cold stratification of the nuts for 70 days followed by soaking in GA3 (500 ppm) for 48 hrs gives good germination and subsequent seedling growth.
- After stratification, the nuts are sown in well prepared nursery beds at a spacing of 15 cm from seed to seed and 20 cm apart in rows.
- After sowing of seeds, the nursery beds are mulched with 10 cm dry grass and light irrigation is given.
- As the seeds start germinating, mulch is removed and proper weeding, irrigation and hoeing is done at regular intervals so that seedlings attain graftable and buddable size in a year.
- Pecan is commercially propagated by budding and grafting onto seedling rootstocks
- The seedling rootstocks are budded with patch and annular method in July and tongue grafted in Feb- March.

#### Planting:

- The best time of planting for pecan is dormant season, late winter or early spring just before bud swelling..
- In flat land, the pecan nut is planted in square system at 10-12 m spacing.
- In sloppy lands contour and terrace layout of planting system are adopted.
- The plant spacing depends on the cultivar and fertility of the soil.
- The distance can be reduced to 8-10 m on soil with low fertility.

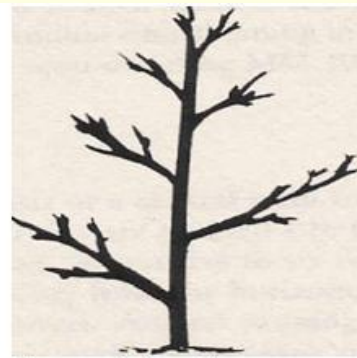
## Temperate Fruits



Pecan nut planted at 10 x 10 m spacing

### Training and Pruning:

- The training in pecan begins with the planting when 1/3 of the top is removed and branches are allowed to emerge as high as 1-1.5 m from the ground level.
- The pecan trees are trained in central leader system and from the second year onwards the subsequent branches should be spaced spirally at 30-35 cm from one above the other.
- As the pecan trees advance in age, they become larger and get crowded making pruning, spraying and harvesting operations difficult.
- Pruning of pecan nut trees is, therefore, desirable but is often neglected.. Once the framework is established very little pruning is done mature trees . Dried and broken and over crowding branches are removed.



Central leader system

CULTURAL PRACTICES

### Aftercare:

- Pecan has very long growing season and requires proper management throughout to ensure good plant growth and productivity.
- Mulching the basins with dry grass helps in conserving the soil moisture, control of weeds and adds organic matter on decomposition.
- Rats poses big problems to pecan plantations and require protection by baiting against rats and keeping basins free from weeds and cultivation regularly.
- Pre emergence and contact herbicides are generally used to control the weeds. Diuron and simazine (2.5 kg/ha) are widely used herbicides besides, paraquat @ 1 kg/ha can also be used as contact herbicide.

## Temperate Fruits

- Cover crops can also be grown during summer and winter especially on hilly slopes to check soil erosion and leaching of nutrients. Crops like soyabean, beans, cowpea and clover can also be grown in summer in young orchard before they come into bearing.
- Since pecan is planted at greater spacing and come into bearing late, it is advisable to grow intercrops till it starts bearing. Besides the seasonal crops filler trees such as peach can also be grown as an intercrop in the orchard.

## Pollination:

- Pecan is a monoecious tree. The staminate and distillate flowers are borne separately on the same tree and organized into catkin and spikes respectively.
- The pecan has compound buds enclosing floral and mixed buds in separate bud scale but with a common outer scale. The floral bud develop to produce catkin but mixed bud grow either into a vegetative shoot or in a single pistillate inflorescence.
- There is complete or less complete dichogamy in pecan which often poses main difficulty in pollination especially in isolated plantings.
- The most pecan cultivars requires cross pollination for good fruit set.
- Wind is pollinating agent which carry pollens for about 900 meters.
- For good fruit set in pecan, planting should have 3-4 cultivars well dispersed in the orchard or at least 10 per cent pollinizer cultivar should be planted in the orchard.



Male catkin

## Manures and Fertilizers:

- Pecan responds to fertilizer applications very slowly and effects on growth and yield are observed after two to three years. Thus the leaf analysis may not hold good in determining the nutritional status of the plant.
- Pecan tree should be manured with 100 kg of farmyard every year in the month of December. In addition, apply 500 g N:P:K mixture (15:15:15) per year age of the tree up to 16 years.
- The full bearing trees of 16 years and above should be given 8 kg of NPK fertilizer mixture every year.
- Pecan trees are prone to zinc deficiency which can be corrected with foliar application of zinc sulphate @ 0.5 per cent.

## Temperate Fruits

### Irrigation:

- Adequate moisture is required to improve growth and productivity of pecan.
- Irrigation improves kernel yield, nut weight and diameter, appearance and oil content.
- Pecan needs proper soil moisture all the year and requires irrigation even before shuck opening and it reduces the stick tight and viviparous nuts.
- The pecan trees are commonly irrigated through flood, basin, and drip irrigation methods at 6-7 days intervals during critical periods i.e flowering, fruit set, fruit and nut growth of water requirements.

### Maturity and Harvesting

- The nuts are harvested when the husk or hull covering the shell becomes fairly loose.
- A single shaking will bring down the bulk of the matured nuts which can be collected on a plastic sheet.



**Ready for harvesting**



**Nuts and kernels**



**Drying of nuts**

- To enhance splitting, the hulled nuts may be dipped in water to moisten the shell and spread out in the sun to dry.
- One method of salting the split nuts is to boil them in salt solution for few minutes, then re dry and store them.
- If stored in plastic bags, nuts will last for at least 4 to 6 weeks in the refrigerator.
- Frozen nuts will last for several months.





### LECTURE - 16: Chestnut and Hazelnut cultivation

#### CHESTNUT

##### Taxonomical classification

Family = Fagaceae

Genus = Castanea

Species = dentata

Basic chromosome = 12

##### Introduction

- The chestnut is similar to the acorn of oak. The chestnut trees are growing in temperate climate of the world for more than 4000 years for beauty, fuel and shelter.
- The sweet chestnut is a nutritious low in fat and rich in vitamin B.
- Freshly harvested nuts contains about 50 per cent moisture, 40-42 per cent carbohydrates, 2.9 per cent proteins and about 1.5 per cent fats.
- In addition to good food source to human being, chestnut also provides food for number of wild life species. Its wood is durable and used for timber and furniture work
- Chestnut and chinquapins are exception to all other nut trees in that they contain little oil and are high in carbohydrate particularly in starch.

##### Area and Production

- There is no organized plantation of chestnut in India, Only stray plantation exist and some plants grows wild in the forest of Himachal Pradesh, Darjeeling and Khasi hills.
- Leading countries in the chestnut production are USA 526000MT, China 101000MT, Turkey 99000MT; Korea 70000MT Italy 53000MT; Japan 48000MT and Spain 31000MT;
- Total world production of chestnut is nearly 477,568 metric tons in an area of 18430 ha plantation with average productivity of about 1.84 T/ha (FAO,2008).

##### Flower and fruits

- The Chinese chestnut is latest tree to bloom. The flowers are produced in two kind of catkins borne on current season shoots near the terminal portion of the shoot.
- The fruit of the Chinese chestnut is borne in a spiny involucre known as bur.
- Three nuts are usually produced in each bur (upper, left and right )
- The bur is a vegetative structure that encloses the nuts or fruits. Botanically, each nut is a complete fruit
- The shell of the nut develop from the ovary wall.
- The kernel of the nut is a young embryo plant that develops from the fertilized eggs of ovule.
- The edible portion of the kernel is made up of two fleshy cotyledons and minute internal growing points of shoots and root.
- The kernel is enclosed in a membranous covering called the pellicle, which originate from the integument of the ovule.

## **Temperate Fruits**

### **Soil and climate**

#### **Soil:**

- Chestnut can be grown in all types of soil but it grows best in well drained sandy or sandy loam soil.
- The soil should be moderate to slightly acidic. The chestnut trees withstand moderate drought after well establishment.

#### **Climate:**

- The chestnut can be grown in a wide range of climate in temperate areas.
- It is as hardy as peach and can withstand as low as -29°C temperature in deep dormancy.
- It requires less chilling to break bud dormancy in spring. Buds respond quickly to warm temperature and thus become subject to damage by late spring frosts.

## **ROOTSTOCKS AND PROPAGATION**

### **Rootstocks:**

- Some species of chestnut are used as rootstock for propagation.
- Chestnut are highly cross pollinated and hybrid seedling used as rootstock is a possible cause of graft union failure in chestnut. Therefore mixed hybrid strains should not be used as rootstock.

### **Propagation:**

- Chestnut seeds planted immediately after harvest showed poor germinate.
- The seeds are stratified for 50-60 days in moist sand at 0 to 2.2 °C to break dormancy of chestnut embryos and ensure uniform germination.
- The chestnut stratification in moist sand kept in wooden boxes at cool shady place proved better than in refrigerator because of fluctuating temperature under field condition help in promoting the seed germination.
- The stratified seeds are sown in nursery beds in the month of March.

### **Grafting and Budding:**

- The chestnut has only one bud at each node and if it is killed by spring frost bud break fails. So early grafting should be avoided.
- Splice grafting and tongue grafting done in March are generally used for the propagation of chestnut. Chip budding also perform well.

### **Varieties**

- Most of nurserymen in Western countries grow only seedling plants because of their easy availability at lower price, however, grafted trees are superior to seedling in nut production.
- The cultivars which are of commercial importance are :Abundance, Crane, Kuling, Meiling, Nanking, Orrin, Colby and Hemming :

### **Planting density:**

- The planting is done during winters.
- Before planting, the site should be properly laid out with contour or terrace systems.
- The pit should be prepared well in advance and refilled with soil mixed with 60 kg well rotten FYM.

## Temperate Fruits

- Plants should be spaced about 30 feet apart as trees are very large in canopy.

### Pollination:

- All cultivars and species of chestnut are self sterile. Two or more cultivars and seedling must be planted in the orchard to ensure cross pollination.
- Young orchard trees may not set nuts when the first flowers are formed because of lack of pollination.
- When young trees start flowering the few staminate catkins apparently do not produce enough pollen to fertilize the pistillate flowers.
- Chestnut is wind pollinated as well as insect pollinated.

## CULTURAL PRACTICES

### Canopy Management:

- The Chinese chestnut form a low headed tree if left unpruned. Unpruned tree start bearing earlier than severely pruned ones.
- Early pruning stimulates vegetative growth. Hence, for early nut production orchard trees should not be pruned for few years.
- An ideal practice is to allow the trees to come into bearing before any pruning is done, then remove only a few of the lowest branches each year until the tree is properly headed. Lower limbs are removed gradually from the tree and the practice is continued.
- The lowest branch should be kept at a height of one meter from the ground and therefore branches should be spaced spirally at a distance of 40 cm from one another.

### Nutrition:

- The chestnut trees are mostly planted on eroded upland soils, so it is important to fertilize trees regularly.
- At least ½ kg 15:15:15 NPK mixture per year age of tree should be applied before sprouting or in early spring.
- The full bearing trees should be supplied with 100 kg FYM and 6-8 Kg of NPK mixture during December – January.

### Irrigation:

- Well established trees can withstand a moderate amount of drought
- Chestnut is generally grown under rain-fed conditions but needs adequate moisture for at least 2 months after blooming.
- Irrigation at fortnightly intervals after blooming is desirable for better fruit size, yield and nut quality.

### Inter culture:

- Row crops such as corn, soyabean or other pulses can be grown between the trees for the first few years.
- Filler trees of stone fruits can be planted for supplementing income in the early years and should be removed later on after chestnut plants start bearing full crops.

## Temperate Fruits

### Maturity and Harvesting

- The chestnut mature in the first fortnight of October in Himachal conditions.
- The bur colour changes from green to light brownish and split open during maturity releasing the nuts.
- Chestnut are very perishable crop that require prompt harvesting every third days.
- Traditionally, chestnut are hand gathered from ground after falling naturally.
- In USA and other developed countries the chestnut are harvested mechanically by shaking the burs from the trees and using mechanical pick up device together the nuts.
- The harvested chestnuts are treated with fungicides to prevent spoilage. These nuts are then cured for 5 days at 21oC. on an average, the harvest period of each tree is 23 days as maturity is not uniform in chestnuts.

### Yield:

- Seedling tree yielded 26 kg of nuts at 12 years of age.

### Storage:

- Fresh chestnut contain 40-45per cent carbohydrates, mostly in the form of starch, about 5 per cent oil and about 5 per cent moisture. These are highly perishable because the nuts loose moisture rapidly at room temperature, causing the kernel to become hard and inedible.
- For storage, the moisture of nuts must be less than 10 per cent and relative humidity of storage atmosphere must be 70 per cent or lower and storage temperature must be 0oC or lower.
- Mold on chestnut can be destroyed with hot bath (57.7oC for one hour).
- The best way of drying chestnut is to put them in bags at 4.4oC with well circulated air at 70 per cent relative humidity.
- Under these conditions the nuts will cure and dry to the optimum moisture content.

## HAZELNUT CULTIVATION

### INTRODUCTION AND ORIGIN

- Hazelnut (*Corylus avellana* L.) belongs to the family Betulaceae is typically a temperate zone nut crop and mostly grown in Turkey, Italy, Spain, Germany, France and England.
- Turkish hazelnut production of 625,000 tons accounts for approximately 75 % of worldwide production.
- The common hazel (*Corylus avellana*) is native to Europe and Western Asia.
- In Himachal Pradesh, it is found growing wild in Pangi region of Chamba district and locally known as Thangi.
- Hazelnut is also known as cobnut and filbert.
- In UK, a distinction is made between filbert, which have the husk longer than the nut, and cobnut, in which the husks are shorter than the nut. Hazelnuts are extensively used in confectionary to make praline and also used in combination with chocolate truffles.

### CLIMATE

- The hazelnut tree is quite hardy but only produces satisfactory crops under moderate climate conditions.
- Temperature of minus 10 0C is critical, especially if accompanied by wind, which may kill both pistillate and staminate flowers.

## Temperate Fruits

- The chilling requirement of hazelnut is about the same as that of most commercial cultivars of apple and thus it can be grown successfully in the apple growing regions of Himachal Pradesh, Jammu and Kashmir and Uttarakhand and North-Eastern Himalayan regions of India.

## SOIL

- Hazelnuts are more shallow rooted than most fruit and nut trees, and do not tolerate wet soils. However moisture retention in the soil is important since the tree can not tolerate excessive dry summer heat and hot winds.
- Soils must be moderately fertile and heavy clay soils should be avoided. Hazels will grow in pH ranging from 4.5 to 8.5, but around pH 7 is ideal.

## VARIETIES

- There are more than 200 cultivars of hazelnut world over but only a dozen or so having the commercial importance.
- Important varieties are Tonda Romana, Barcelona, Negret, Tonda Giffoni, Tonda Gentile delle Langhe, Pautet, Tombul

## PLANTING AND PLANTING DENSITY

- The area for planting should be marked and cleared or sprayed with herbicide.
- Tree spacing is highly variable in the different countries, as they depend on the fertility of the soil, rainfall and variety vigour.
- A planting density of 860 trees/ha is recommended with rows 4m- 5m apart (to allow machinery access) and 2m- 3m within row spacing.
- To ensure adequate pollination it is advisable to plant atleast 10% of other varieties, evenly distributed throughout the stand.
- Planting is usually done during winter months.
- In the orchards of Oregon (USA), trained in vase, tree density normally varies from 270 to 400 trees/ha (6x6m or 5x5m), while in the South-West of France they oscillate between 666 (5x3m) and 800 trees /ha (5x2.5m)..

## MANURES AND FERTILIZATION

- Prior to planting and up to bearing age, organic and inorganic fertilizers should be applied according to soil analysis as follow:
- Organic fertilizers like FYM should be applied at around 30 tons/ha if the soil organic matter is below 2 per cent. Where, the soil pH is around 5.5, it should be raised to 6.5 by liming but not more than 5 t/ha should be given in a single dressing.
- Fertilizer application to mature trees should be based on leaf and soil analysis. The fertilizer recommendations for hazelnut is 120 to 150 Kg/ha of N, 60 to 70 Kg/ha P and 100 Kg/ha of K.

## TRAINING AND PRUNING

- The traditional training system in hazelnut orchards in the main production areas (Turkey, Italy and Spain) has been a multistem bush, according to its normal tendency of bushing growth.
- However, the training system used in the new orchards of United States, France, Italy and Spain is in vase with only one stem..
- Pruning systems

## Temperate Fruits

- Hazelnut bear its fruits laterally and terminally on wood of the previous season's growth and the pruning after the tree has come into bearing should be such as to stimulate a moderate amount of new growth each year.

## WEED CONTROL

- Weeds compete the crop for moisture and nutrition and adversely affect the nut yield and quality, thus planting should be kept free of weeds manually or through the use of herbicides .
- The most used herbicides in mature orchards according their application time, are: Simazine, Diuron, Napromide, Oxifluorphen, Propyzamide, Trifluraline in pre emergency and Paraquat, 2,4-D, Aminotrizol, Glyphosate, Ammonium gluphosinate, Terbutilazine + Terbumeton etc. in postemergency.

## HARVESTING AND YIELD

- When nuts change from green to brown and the abscission starts, is the best time of harvesting. Usually it comes in mid aut
- Hazelnut trees reach maximum production between fifteen and twenty
- Five years of age and the average yield per plant ranged from 2-2.5 Kg.



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# EXERCISE



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### EXERCISE 1: Preparation of seed and nursery beds

**Materials :** Spade, khurpa, measuring tap, rope, sand, farm yard manure

#### (i) Seed bed preparation

- The soil of the nursery should be friable, well drained and fertile to produce vigorous seedlings.
- Soil is well pulverized before the seed beds are prepared. Each seed bed should be raised 15-20 cm above the general level of the plot to facilitate drainage.

#### Procedure:

- Select a sunny side for preparing seed or nursery beds.
- Mark out the area required for nursery. Dig the soil about 25 to 30 cm deep with the help of a spade.
- Remove weeds and stones and level the land with the help of a rake.
- Spread dry leaves in a thin layer and burn it. This helps in destroying diseases and pests.
- If the soil is heavy clay or silt then mix coarse sand @ 3 to 4 kg per square meter.
- After this, spread well decomposed farm yard manure @ 5-6 kg per square meter and 120 kg of N, 50 to 60 kg of P and 80- 90 kg of K per hectare nursery area. Mix all these well and leave the land for few days.



**Plate 1. Land preparation for nursery**



**Plate 2. Seed beds**



**Plate 3. Nursery beds**

- Prepare beds of 120 cm wide and 2 meter in length. In between two beds leave space of 25– 30 cm. The beds should be kept 5-10 cm high from the soil surface.
- In the prepared beds the seeds be sown about 2 to 4 cm deep and 8 to 10 cm apart. The depth of the furrow will depend upon the size of seeds. Bolder the seeds deeper the furrow.

## Temperate Fruits

- After sowing the seed in the furrow, the seeds be covered with a mixture of farm yard manure and coarse sand in the ratio of 3:1 and beds are covered with grass mulch.
- Sprinkle water as and when necessary. Over watering should be avoided as excessive moisture encourages foot-rot diseases.
- The young seedlings cannot tolerate strong sun or rain. Therefore, it is essential to protect the young seedlings against sun and rain by a thatch or with polythene films.

### ii) Preparation of nursery beds

- The seedlings at 3 to 4 leaf stage are transplanted from seed beds to nursery stage at proper spacing. Before transplanting, the soil is thoroughly ploughed and then nursery beds are prepared.

#### Procedure :

- Nursery beds should be bigger than seed beds. It should be located in open space and nearer to water source.
- The soil is made friable by 3-4 ploughing and 60-80 tones well rotten FYM, 120 kg of N, 50 to 60 kg of P and 80- 90 kg of K per hectare nursery area is mixed in the soil.
- In the prepared bed, lines (30 x 30 cm apart) should be marked for planting the seedlings. After four rows, 45-60 cm space is left to facilitate the movement for operations like hoeing, weeding, propagation and lifting of plants.



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### EXERCISE 2: Propagation of temperate fruits

**Materials required:** Seed. Wooden box, moss grass, bavistin, sand, refrigerator

- Temperate fruits are commercially propagated through asexual method of propagation, however, sexual method is generally employed for raising seedlings rootstocks.
- The propagation is classified in two broad categories.

(1) Propagation of rootstocks

(2) Propagation of scion cultivars

- The rootstock propagation is accomplished through seed in case of seedlings rootstock and through layering, cutting and tissue culture in case of clonal rootstock.
- The scion cultivar is propagated through grafting and budding.

#### 1. Propagation of rootstock

##### (i) Seedling rootstocks: -

- Seedling rootstocks are commercially used on which scion variety is grafted or budded.
- In apple, seeds of crab apple (*Malus baccata*) or self pollinizing varieties like Golden Delicious and Granny Smith are used for raising seedling rootstocks.
- Seedlings of Kainth (*Pyrus pashia*) and Zarainth (*Pyrus serotina*) are used as a rootstock for pear.
- For peach, wild peach, for plum and apricot wild apricot called chulli and for almond bitter almond and behmi seeds are used for raising seedling rootstocks.
- Cherry plants are raised either on Paja (*Prunus cerasoides*) seedling or on clonal rootstocks. Seeds of wild persimmon called khau for persimmon are used.
- Seeds of katha walnut for walnut, Burkett variety of pecan for pecan nut and Bruno variety of kiwifruit for kiwifruit are used for raising seedling rootstocks.
- Seeds should be collected from fully ripened fruits, extracted by hand or machine should not contain flesh on the skin and dried under shade.
- Seed are treated with Bavistin (3g / Kg seed) to be stored for some time before sowing.

#### Seed stratification

- Seeds of deciduous fruit trees generally do not germinate until they get chilling treatment. Exposing the seeds to low temperature (0 to 5°C) for a considerable period helps in breaking the dormancy thus resulting in stimulation of germination.
- Seeds are placed in alternate layers of moist sand either in wooden box for small seed like apple, pear and kiwifruit and in pits for bold seed like peach, apricot, walnut and almond.
- This box is kept at low temperature a little above the freezing point for specific period depending upon the type of seed (Table 1).

## Temperate Fruits



Plate.1 Seed stratification in wooden box

Table 1. Stratification period for different temperate fruits seed

Seed of fruit plant	Effective temperature C°	Time period (days)
Apple	3-5	70-80
Apricot	3-5	45-50
Cherry	2-5	90-100
Peach	2-4	70-90
Pear	2-5	45-50
Pecan nut	2-5	90-100
Walnut	2-5	70-75
Kiwifruit	2-4	40-50

- In addition to low temperature treatment there are other methods to improve germination like soaking seeds in water, scarification mechanical as well as acid treatment and by chemical treatments such as GA 200-400 ppm, thiourea 0.25 to 5% or KNO<sub>3</sub> 0.2%.

### Seed sowing

- Pre-stratified seeds are sown in nursery beds during March at a spacing of 8-10 cm from seed to seed and 15-20 cm from line to line at a depth of 3-5 cm.
- After sowing, the nursery beds are mulched with 10 cm thick dry grass and light irrigation is given to avoid desiccation of stratified seeds.
- As the seeds start germinating, mulch material is removed. Cultural operations like weeding, hoeing, irrigation and spray of insecticide and fungicides are done at regular intervals.
- The seedling rootstock attain graftable size in a year.

## Temperate Fruits



**Plate.2.Seed sowing in seed beds**

- In high hills areas experiencing sufficient snowfall in winter, seeds are sown directly in the field during December, however, some times poor germination occurs due to heavy rainfall.

### **(ii) Clonal rootstocks :-**

Clonal rootstock of temperate fruits are propagated through layering, cutting and tissue culture, however, through layering (mound and trench layering) is the most common method.

#### **(A) Mound and trench layering:-**

##### **(i) Establishment of stool beds:-**

###### **(a) Selection of site:-**

- The site for the establishment of mother stool beds of clonal rootstocks should be selected at an isolated place where the soil are fertile and well drained.
- The land should be prepared by deep ploughing and soil is made leveled, free of stones and weeds.

###### **(b) Selection of mother plants:-**

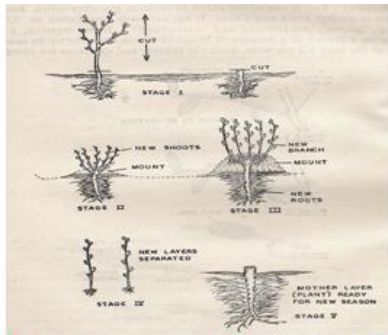
- The main consideration in the selection of mother stock for the establishment of stool beds are (i) Quality (ii) Trueness to type (iii) Disease, insect and virus free.
- The mother plant should be elite material taken from a single indexed mother plant and should be free from diseases, insects and viruses.
- The mother plant material selected for the establishing stool beds should be 8-10 mm in diameter, 60-70 cms in length and have well-developed root system.

#### **Mound Layering:-**

- Mound layering is a method of propagation where the plants are established vertically and plant shoots are stimulated to develop roots at their bases as a result of etiolation caused by mounding of the soil or rooting medium around the base of such growing shoots.
- For the establishment of mother stool beds for mound layering, the planting of mother stock is done at a distance of 40 to 45 cm plant to plant and 1.5 meters from rootstock to rootstock during the month of December - January.
- At planting, the plants are headed back 45 to 60 cm and allowed to grow for one year. The mother beds are irrigated after planting and proper aftercare like weeding, irrigation, fertilization, pest and disease control is followed during establishment phase of mother stool.
- In the second year, stooling cycle starts and in the month of Jan-Feb before new growth start in the spring the plants are cut back to about 2.5 inches above the ground level.

## Temperate Fruits

- In the spring two to five shoots will develop from the stub in the first year and more in later years. As these shoots attain 10-15 cms height, first earthing up with a media containing soil: FYM/ Vermicompost: Sand : Coco peat (1:1:1:1) is done to cover the half of height of shoots.
- In difficult to root clonal rootstocks like M-9 and Merton -793 of apple and Gisela and F 12/1 of cherry, 5000 ppm IBA as linolin paste is applied at the base of shoot by removing some bark before earthing up of shoots.
- When the shoots attain 25-30 cm height, second hilling operation, followed by third hilling is done in the mid summer when the shoots have grown 45 cm.
- In the month of December, the soil around the stool beds are removed and rooted layers are cut close to their base from the mother plants and transplanted in the nursery beds for grafting and budding.
- After the harvest of the rooted layers, the mother stool beds are kept exposed until the new shoots have grown.



**Fig. 1. Different steps for mound layering**

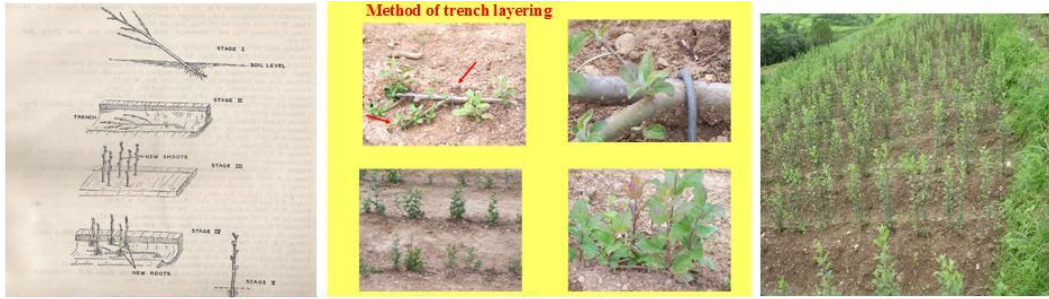


**Plate 3. Mound layering**

## Trench Layering:

- In trench layering, the mother plants are established in a horizontal position in the trenches.
- Trench width should be 70 cms, depth 14 cms, distance between branches 150 cms and effective distance between stool bed 80 cms, distance between plant to plant 40-45 cms. and angle between plant and trench 45o.
- The healthy, diseased free and elite mother plants are planted in dormant season at an angle of 45o in the trenches. The ideal length of mother stock for plantation in the trench beds is 50-60 cm. Each mother plant should be planted as to overlap the previously planted mother stock by approximately 20 cms.
- After planting, the stool beds are well irrigated and further irrigation is given as an when required during the entire growing season.
- The mother stock is allowed to establish for one years. The proper management practices like weeding, irrigation plant protection measures are followed at a regular intervals.
- In the next dormant season, training and bending of mother stock is done. The main mother plant is bend horizontally along the bottom of the trench putting iron hooks and wooden pegs. Two to three suitable side shoots on either sides of main mother stock plant are selected while remaining unwanted side shoots are pruned off.
- In the first season, the buds from the pinned down main stem as well as from shoots will break. As these shoot attain 10-15 cm height, the first earthing up is done with a medium containing sand:soil:FYM:cocopeat and saw dust.
- The earthing up operations are done 3 times in a season.
- In the dormant season, the medium is removed and stool shoots are cut from the parent plants and planted in the nursery beds for grafting and bud.

## Temperate Fruits



**Fig 2 and Plate 4. Different steps of trench layering Plate 5. Trench layered**

### Propagation through cuttings:

- Clonal rootstocks can also be propagated through hard wood and semi hard wood cuttings. The ability of cuttings to regenerate through cuttings varies with the rootstocks.
- Use of special techniques like pre-planting and post-planting treatments of cuttings have helped in rooting of cuttings in difficult to root clonal rootstocks.
- Hard wood cuttings of 15-20 cm long and 0.8 to 1.0 cm in diameter are taken during dormant season (January).
- Cuttings are dipped in 2500 ppm IBA solution for 15-20 second and then transplanted in mist propagation chamber or in open field conditions in rooting medium of sand: cocopeat: vermicompost :soil (1:1:1:1).
- The semi hard cuttings along with leaves are taken during July, dipped with 2500 ppm IBA solution and planted in mist propagation chamber for rooting.
- In the month of December and January, the rooted cuttings are transplanted in nursery beds for further grafting and budding.



**Plate 5. Hard wood cuttings Plate 6. Dipping of cuttings in IBA solution**



**Plate 7. Planting of cuttings in the field and polyhouse**

### Propagation through tissue culture:

- Clonal rootstocks of apple can be multiplied on large scale through tissue culture. The commercial micropropagation is achieved following a series of steps.

## Temperate Fruits

### (I) Explant source :

#### Collection and preparation:

- Explant used for initiating shoot culture of clonal rootstocks of apple can be obtained either from actively growing shoots or dormant shoots.
- The shoot tip is better explant source but axillary buds can also be used.
- About 5-8 cm long shoots from actively growing branches are collected and stored in polythene bags to prevent wilting until they can be processed in the laboratory.
- The best time of collection of explant is March-April, because it shows less contamination and initiate growth in vitro quickly.
- The leaves along with stipules are removed from the collected shoots ensuring that no damage is done to axillary buds. Axillary buds are excised from shoots with sharp blade in a beaker containing water.
- One drop of liquid detergent is added to it and stirred gently to wash out the debris. The beaker with explant is covered with muslin cloth and kept under running water for about a hour.
- In case of the dormant shoot, they are cut into pieces of 2-4 cm long with bud near the distal end. These sections are kept under running tap water.

#### 2.Surface sterilization:

- Surface sterilization is carried out in laminar air-flow cabinet. First the buds are dipped in 70% ethanol for 40 second and washed 3-4 times with sterile distil water, last rinse is for 5-10 minutes.
- Once the sterile distil water completely rinsed from the explant, they are inoculated as such or 2-3 outer leaflets are dissected away in 25 mm diameter test tubes.

#### 3.Excision of meristem as explant:

- After sterilization of axillary and terminal buds, they are dissected by removing bud scale, leaf primordia carefully to expose the growing point.
- The growing point together with 2-4 leaf primordia is excised and explant with the base resting on the surface of the medium.



Plate 8. Propagation through tissue culture



## Temperate Fruits

### 4.Establishment of explants:

- Smaller explant can be used to initiate culture because they are relatively free from contamination .
- The best sprouted explant should be selected for transfer to fresh medium.
- Growth of buds usually begins 10-15 days after cutting. By 3-4 weeks, leaf primordia developed into long leaves .
- The sprouted explant are transferred to fresh medium for growth of stem and axillary buds.

### 5.Shoot multiplication :

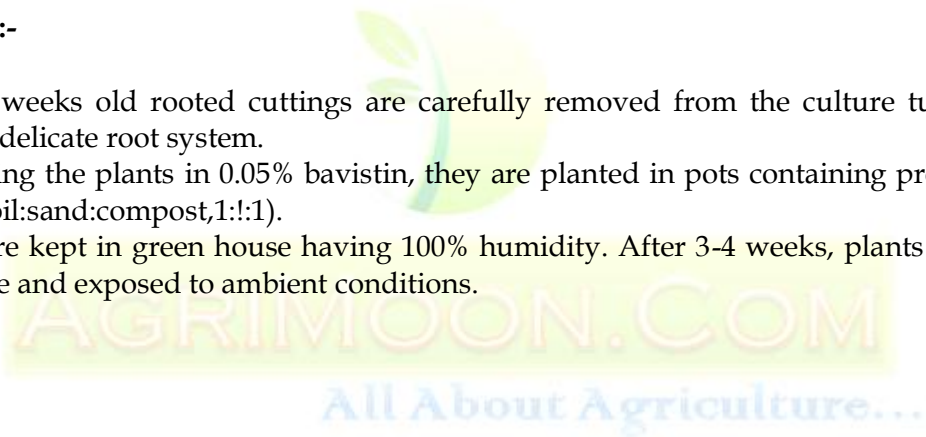
- Once culture are established ,shoots will proliferated in MS medium. The presence of leaves on explant is followed by growth of shoot and stem formation, then axillary bud develop from primary shoot give rise to secondary shoots.

### 6.Rooting: -

- Vigorously growing 2-3cm long shoots from proliferating cultures are selected for rooting.
- These cuttings are then rooted in MS medium containing Auxin (IBA 1.5um) but no cytokinin and GA3. The concentration of auxin varies depending upon the rootstock.

### 7. Acclimatization:-

- About 4-6 weeks old rooted cuttings are carefully removed from the culture tubes to avoid any damage to delicate root system.
- After dipping the plants in 0.05% bavistin, they are planted in pots containing presterilized potting mixture (soil:sand:compost,1!:1).
- The pots are kept in green house having 100% humidity. After 3-4 weeks, plants are transferred to soil mixture and exposed to ambient conditions.



## Temperate Fruits

### EXERCISE 3: Propagation of scion cultivars and Nursery management

**Materials required:** Rootstocks, scion, grafting knife, scateure, polythene strip,

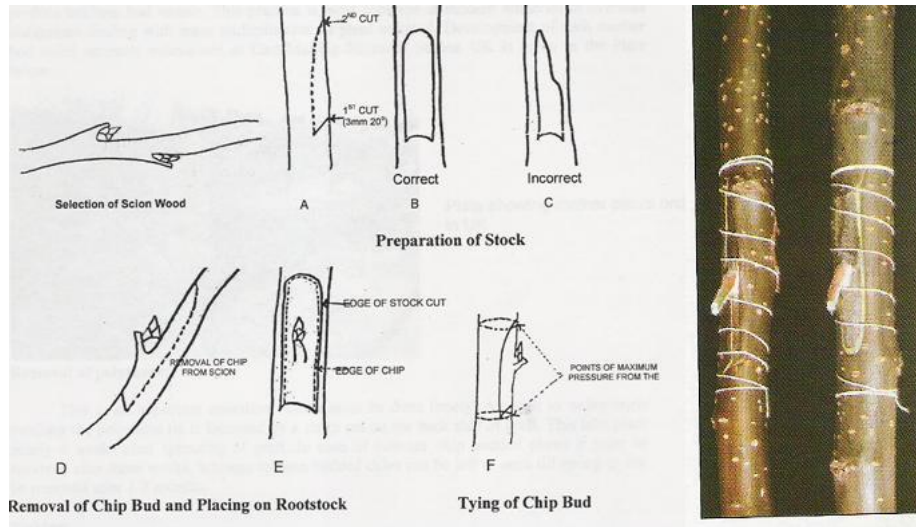
**Procedure:**

- Temperate fruits are commercially propagated through grafting and budding of scion cultivars on to a rootstock, which are raised by seeds or asexual method.
- Tongue method of grafting done in March gave good bud take success and is used commercially for multiplication of nursery plants of apple.
- However, in grafting more scion wood is required which induces early maturity of the plants and there are more chances of transmission of disease pathogens.
- Budding in summer is highly successful for all those problems. Among the various methods, T-budding is done in June gave good success but T-budding frequently resulted in some bud failure and connection between cambium of rootstock and scion is not always affected completely with the result the union are slowly formed.
- In recent years, chip budding have become very popular method of propagation in apple. In this method cambium of scion and rootstock unite very quickly and union is very perfect. It is easy to perform and it can be done any time, however, the highest success is obtained in Mid Feb and July-August.

**Table 1. Time and method for commercial propagation of different temperate fruits**

Kind of fruit	Recommended propagation method	Time of operation
Almond	1. Tongue Grafting 2. Chip budding	February Mid-March
Apricot	Tongue Grafting T- budding	February May-June
Cherry	1. Tongue Grafting	February- March
Peach	1. Tongue Grafting 2.T-budding	February May-June
Plum	1. Tongue Grafting 2. Chip budding	February February
Apple	Tongue grafting Chip budding	February – March March and July
Pear	Tongue grafting	February- March
Kiwifruit	Tongue grafting and chip budding Hard wood cuttings	February February
Walnut	Chip budding  Tongue grafting Patch budding	Mid May to first week of June March July
Pecan nut	Patch and Annular Budding	July

## Temperate Fruits



**Fig.1 Chip budding**



**Plate 1. Chip budding**

**Plate 2. Patch budding**



**Plate 3. Annular budding**



**Plate 4. Chip budded plants of walnut**

### Collection and treatment of scion wood:-

- For grafting, the scion wood are collected during dormant season from the identified and labeled mother trees.

## Temperate Fruits

- Generally one year old shoots are collected and each separate bundles must be carefully labeled for variety.
- The scion wood is to be stored for one or two months, therefore, labels and marking must be durable. Scion woods are stored in moist chamber or in cool chamber at 0-20C.
- Sticks can also be packed in moist sphagnum moss buried in soil or in the trenches at cool and shady place.
- Before grafting, the scion wood are dipped in a solution of tree spray oil, bavistin, chlorpyrifos and then dried in the shady place, which helps to disinfect the scion wood.
- For summer budding, shoots are collected from healthy, disease and virus free mother plants at the time of budding.
- Remove all the leaves immediately to reduce water loss. For longer distance transportation, the scion wood are wrapped in thin polythene and no wet material is used for internal wrapping. such bundles are again covered in other material against bruising..

### Aftercare and management of nursery plants:

- Nursery management practices play an important role in the production of healthy and quality nursery plants. The important operations followed after grafting and budding are:-

#### (i) Removal of polythene:

- This is an important operation, which must be done timely. After 4 weeks of sprouting as the grafted plants attain 30-40 cm height and the graft union start swelling, polythene strips is loosened by the sharp cut on the back side of the graft.
- In case of chip budding, it must be removed after 3 weeks.

#### (ii) Deshooting:

- After grafting and budding, the shoots generally arise from the rootstocks below the graft union.
- These shoots should be removed immediately after sprouting at a regular intervals, otherwise it result in failure of grafting and budding.

#### (iii) Staking:

- After removal of polythene, staking is must since the union are tender in summer and the plants blown off with higher wind velocity. Wooden sticks are generally used for staking of grafted plants.

#### (iv) Single stem:

- The Indian orchardists need single straight stem nursery plants for plantation, whereas in european countries feathered two years old grafted plants are preferred for plantation. In grafted or budded plants no scion shoots are allowed to grow and they are pinched off from the growing scions

#### (v) Mulching:

- Mulching of nursery plant is very essential especially in nursery established at water scarce areas to promote growth of plants.
- Immediately after grafting, nursery plants are mulched with 10 cm thick dry grass or with black polythene, which helps in soil moisture conservation and control weed population in the nursery.

## **Temperate Fruits**

### **(vi)Irrigation:-**

- Irrigation is very essential for good growth of nursery plants of apple.
- Irrigation should be given at frequent intervals or alternate days.
- Watering should be done in evening time to avoid evaporation. Irrigation should be given through sprinkler systems.

### **(vii)Manuring and Fertilizations:-**

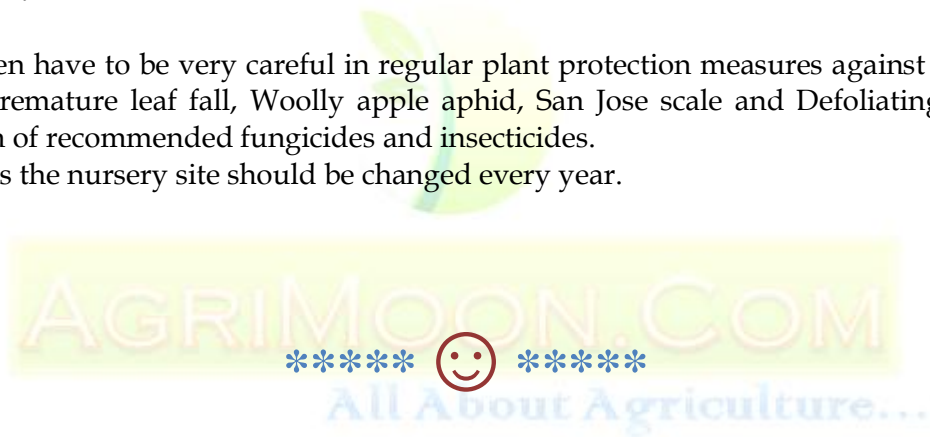
- The requirement of manure and fertilizers depends largely on the type and fertility of soil.
- Well rotten FYM at the rate 60-80 tonnes per hectare along with 30 Kg of P<sub>2</sub>O<sub>5</sub>, 60 Kg K<sub>2</sub>O and 60 Kg of N per hectare is applied in the nursery beds before sowing of seeds or transplanting of seedlings.
- Remaining half dose of nitrogen (60Kg/ha)is applied with the onset of rains (July).

### **(viii)Hoeing and weeding:**

- The nursery beds should be kept always clean or free from weeds by manual weeding.
- Nursery beds should be dug 5-10 cm deep at least 3-4 times with the help of forks to loosen the soil.

### **(ix)Plant protection:**

- Nurserymen have to be very careful in regular plant protection measures against powdery mildew, root rot, premature leaf fall, Woolly apple aphid, San Jose scale and Defoliating beetles with the application of recommended fungicides and insecticides.
- Besides this the nursery site should be changed every year.



### EXERCISE 4: Identification and description of varieties of apple and pear

#### Red Delicious

Originated as chance seedling in the orchards of Josse Hiatt near Paru in USA (Hiatt, In 1894) Later named as Red Delicious by Stark Brothers Nurseries. Fruit large sized and oblong conical in shape. Ground colour is greenish-yellow with red streaks. The colour of flesh is creamish. Fruit ripens in third week of August.



#### Starking Delicious

Also known as Royal Delicious, is a Limb Sport of Red Delicious in Monsoville, New Jersey, USA (1921) Tree moderately vigorous, fruit large, conical in shape with prominent calyx lobes, skin colour yellow with red stripes all over the surface, flesh firm, sweet, juicy. Fruit mature earlier than Red Delicious and ready to picking in 130-140 days from full bloom.



#### Rich-a-Red

In 1919 Rich-a-red was discovered as a whole tree mutation in the orchard of LJ Richardson, Monitor Washington, USA. Fruits are large sized and oblong conical. Ground colour greenish yellow with red wash all over, Lenticels are conspicuous.



## Temperate Fruits

### Top Red Delicious

A bud mutation of Short Well Delicious. Standard type. Fruits conical with predominant lobes. Fruits large, medium with dark red streaks over yellow background. Flesh yellowish cream sweet, aromatic and juicy, matures 10-15 days earlier than the Starking (Royal) Delicious



### Red Chief:

Bud sport of Starkrimson. Tree size small, compact and forms number of spurs, very productive and regular in bearing. Fruit medium to large, conical in shape with prominent calyx lobes. Fruit colour dark red with prominent stripes. Colour development 10-15 days earlier than Starking Delicious. Flesh creamy, crisp and juicy.



### Vance Delicious

A limb sport of Delicious. Standard type. Fruits medium to large, conical with prominent lobes with dark red stripes over yellow background. Better and early colour and gives higher yield than Royal Delicious. Flesh is yellowish cream sweet and juicy, matures 15-20 days earlier than Starking Delicious



### Hardeman

A whole tree mutation of Delicious. Standard type and vigorous. Fruits medium to large, conical with prominent lobes. Dark red stripes over yellow background. Matures at the same time of Starking Delicious



## Temperate Fruits

### Skyline Supreme Delicious

A whole tree mutation of Starking Delicious. Standard type. Fruits medium to large, conical in shape with five prominent lobes and surface colour is red wash. Fruits develop early and better colour and matures 10-15 days earlier



### Bright-N-Early

It is a semi spur types strain of Red Delicious a limb sport. Fruits are conical in shape with deep bright red stripes. Fruit flesh light cream sweet and juicy. Fruits mature 7-10 early early Starking Delicious.



### Real Mecoy Red Delicious

A mutation of Red Delicious. Standard type. Fruits are conical with prominent lobes. The fruit colour is red wash over yellow background. Fruit matures 10 days early than Starking Delicious, sweet and juicy.





## Temperate Fruits

### Well Spur

A whole tree variation of Starking Delicious. Spur type variety and fruits are more conical with deep red wash, covering whole surface. Five lobes are prominent. Fruits mature 15-20 days early than Starking Delicious. Flesh is yellowish cream, sweet and juicy.



### Silver Spur

A whole tree variation of Hi Early Red. A spur type cultivar and fruits are conical with deep red submerging streaks. Fruits mature 15 days early than Starking Delicious.



### Starkrimson Delicious

A whole tree mutation of Starking Delicious. Fruits are more conical with prominent lobes with scarlet red wash, covering whole surface. Flesh is yellowish cream, sub-acidic and juicy. Spur type. At higher elevations fruit size remain small and over coloured (black). This cultivar is suitable for lower and valley areas in the state.



## Temperate Fruits

### Red Spur

A whole tree mutation of Starking Delicious. Tree growth spur type. Fruits are conical in shape with prominent lobes at calyx and deep red wash with conspicuous dots (lenticels) over whole surface and resemble Rich-a-red. Flesh yellowish cream, sub acidic and juicy, regular and prolific bearer. Fruit matures 10-15 days earlier.



### Criterion

A hybrid between Golden Delicious and Starking Delicious and was found to be superior to Golden Delicious. The shape resembles to Starking Delicious and colour is golden yellow with red cheeks. The tree is standard type



### Mutsu

This cultivar is originated in Aomori by the Aomori Apple Experimental Station, Japan from the cross between Golden Delicious and Indo. This cultivar was selected in 1939. This cultivar was registered and introduced commercially in 1949.

Heavy producer and moderately biennial bearer. Fruit is medium to large, round to oval in shape and resembles to that of Golden Delicious. Fruits are green which becomes yellow later on. Skin is thin. The flesh is yellowish white fine and juicy.



## Temperate Fruits

### Granny Smith

Trees vigorous upright and spreading. Fruits are medium to large in size. Ground colour of fruit is green, turns greenish yellow at maturity. Lenticels are conspicuous, skin is smooth. The shape is round conical. Flesh is greenish white, firm juicy, good of blend of sugar/ acidity. A very late variety, good pollinizer and regular bearer.



### Black Ben Davis

Popularly known as Kalidevi is Kullu Valley of Himachal Pradesh. The trees are very vigorous and fruits are medium to large in size. The fruits are round conical little flattened. The colour is striped dark red. Flesh is creamish white, firm juicy, aromatic sweet and mildhy acidic. Bennial is bearing. A good pollinizer.



### Golden Delicious

It is partly self fruitfull. A chance seedling, heavy bearor and used as pollinizer variety. Fruit round to conical oblong, greenish yellow which turn golden yellow at ripening. Late maturing variety, takes 150-160 days from full bloom to harvest.



### Red Gold

A pollinizer variety for Red Delicious and its sports. The fruits are small to medium size of dark, dull red colour. The fresh is white, sub acidic and juicy. It is a heavy and regular bearer but tends to develop biennial bearing habit it allowed to over-crop. It suffers from a mosaic virus which tends to restrict fruit size. After the initial years of cropping the free produces very small sized fruit.



## Temperate Fruits

### Tydeman's Early Worcester

A pollinizer for Delicious and its sports. (McIntosh and Worcester Pearmain) and was evolved at East Malling Research Station in 1929. The tree is vigorous and spreading. It is difficult to train because it has few laterals. The fruit is medium sized, greenish yellow covered with bright red colour. The flesh is white, juicy, fairly firm with a pleasant flavour. It matures early in 80-90 days from full bloom to maturity.

### Manchurian

It has compact, upright growth and bears six medium sized cupped white flowers per cluster and attracts good bee activity. Tip bloom continues throughout most of the bloom period and also has good return bloom



### Red Flesh

This variety tends to be more leggy in its growth habit unlike Manchurian, which is compact and upright. The flowers are off red colour and because of this bee activity is poor. It is also highly susceptible to powdery mildew



### Snow Drift

A very profuse bloomer on first or second year wood having five small to medium sized, cupped, white flowers per cluster. If not trained, it attains bushy oval shape, leaves are small and glossy.



## Temperate Fruits

### Golden Hornet

It has drawn attention for strong pollen viability and a longer period of dehiscence. Flowering is alternate or biennial on spurs. This tendency, however, can be checked by post blooming pruning. It has 5-6 medium sized cupped white flowers per cluster



## PEAR VARIETIES

### Bartlett:

It is known as William's Bartlett. This variety originated in England. Tree large, prolific and regular bearer. Fruit medium to large, ovate-pyriform, green when picked, which turns bright yellow on ripening.



### Max Red Bartlett :

Bud mutant of Bartlett. Tree and fruit character resemble with parent except that fruit colour is dark cranberry red.



### Red Bartlett:

Fruit medium to large in size, obovate - acute- pyriform, greenish with red blush on one side, flesh white with fine melting texture, crisp, juicy, ripen from end of june to mid july



## Temperate Fruits

### Starkrimson :

It originated in Michigan, USA as an all-over red bud sport. Tree large and heavy bearer. Fruit large, colour rich crimson all over the fruit, flesh white. It is early maturing variety and matures 10-15 days before Bartlett.






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**EXERCISE 5: Identification and description of varieties of stone fruits**

**PEACH AND NECTARINE VARIETIES**

<p><b>July Elberta :</b> This is most important and commercially grown variety in mid hills. Fruit medium to large, skin smooth, pale yellow with red splash. Flesh firm, yellow, juicy, sweet in taste, freestone. This is good for canning</p>	
<p><b>Redhaven:</b> A cross of Halehaven and Kalhaven. Fruit medium in size, round, suture prominent, skin yellow overlaid red to deep red clour, attractive, pubescence light to medium, flesh yellow red at pit, very firm, freestone, early maturing.</p>	
<p><b>Shan-e-Punjab:</b> This is one of lading low chill variety and grown commercially in sub- tropical climate. Fruit matures in the first week of May. Tree vigorous and prolific bearer. Fruit yellow in colour with red blush. Flesh yellow, freestone, juicy and sweet.</p>	
<p><b>Prabhat:</b> This is another important low chill variety. Tree medium and very heavy yielder. Fruit colour yellow with red blush. Flesh yellow with red coloration, firm and slightly acidic.</p>	

## Temperate Fruits

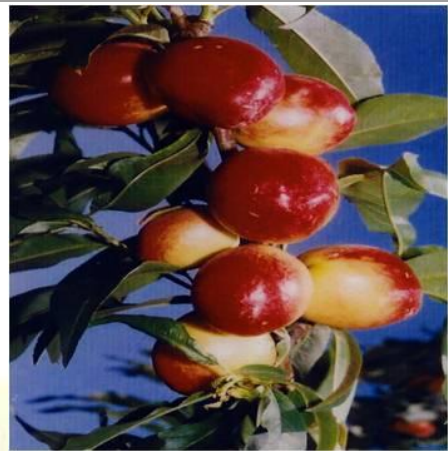
### Snow Queen (Nectarine):

Tree heavy bearer. Fruit medium in size, skin colour white with shining red overcolour., smooth without fuzz. Flesh white, good flavor, clingstone.



### May Fire:

Fruit medium , smooth ,skin colour green to white with deep red overcolour. Flesh white, attractive, juicy, clingstone and sweet. Fruit matures very early in mid May.



## PLUM VARIETIES

### Santa Rosa:

Tree upright, vigorous and very productive. Fruit large, heart shape, purplish crimson in colour. Flesh amber in colour with red near the skin. Fruit juicy and flavored, It is self fruitful variety.





## Temperate Fruits

### Fronteir:

Tree semi-vigorous, upright in growth and productive. Fruit large, skin purplish red, fruit heart shape, Flesh deep red, very sweet, juicy, firm and freestone. Fruit matures 10-15 days after Santa Rosa.



### Mariposa:

An upright growing tree,. Fruit heart shape with greenish yellow skin mottled with red. Flesh red in colour, juicy and firm. Late maturing variety



## APRICOT VARIETIES

### Royal :

The fruit is large in size, yellow with red spot, flesh yellow, juicy, and sweet. Kernel sweet, late maturing variety, good for dessert and canning.



## Temperate Fruits

### New Castle Apricot:

Early maturing variety. Fruit round, medium sized and barium red yellow. The flesh is sweet and juicy, mature in May and suitable for warmer areas.



### Moorpark

Self-fruitful, this large apricot was developed in the eighteenth century. Considered one of the best. Juicy and aromatic; sweet rich, plum-like taste. Brownish-red skin with specks and dots; yellow to orange flesh. Midseason harvest.



## CHERRY VARIETIES

### Black Heart:

Tree is upright. Fruit large size and heart shape. Colour of fruit dark red.



### Bing

Tree is upright and spreading. Moderate to heavy yielder, fruit size large, fruit heart shaped, susceptible to fruit cracking



### Stella:

Tree vigorous and spreading, heavy bearer, self incompatible variety. Fruit large to medium, black in colour, heart shaped to oval.



**EXERCISE 6: Identification and description of varieties of strawberry and persimmon Strawberry**

**STRAWBERRY**

**Chandler:**

Chandler variety was originally developed in California. The vigorous, high-yielding, June-bearing Chandler strawberry plants produce very desirable strawberries. Fruit is very large, firm, and produce early-season to mid-season . The strawberries vary from being long and wedge-shaped to large and conical. They are a brilliant red color, glossy, and have an exceptional flavor profile.



**Camarosa:**

Camarosa is typical of short-day types. Plants are larger, more erect, and more vigorous than plants of `Chandler`, and are generally similar in form to plants of `Oso Grande. `Camarosa` are larger, somewhat longer and more narrow than for ` The fruit shape for `Camarosa` is very flat conic, and is easily distinguished from `Chandler` (flat conic, with some long conic) and `Oso Grande` (rounded or blocky conic).. Achenes vary from light red to dark red.

**Sweet**

**Charlie:**

‘Sweet Charlie’ was developed at the University of Florida’s Gulf Coast Research and Education Center in Hillsborough County, Florida. After The Sweet Charlie cultivar was hand pollinated as a cross between FL 80-456 and Pajaro. Sweet Charlie strawberry plants are small and compact making picking relatively easy. The Sweet Charlie strawberries are medium in size, deliciously sweet. Sweet Charlie is June-bearers, but an excellent short-day variety in warmer climates. They produce about a week before chandler and have a relatively low acid level Sweet Charlie is a vigorous plant. Fruits are firm, can tolerate gentle shipping over short distances, and have deep red mature strawberries.

**PERSIMMON**

**Hachiya:**

It is an-astringent variety with oblong pointed fruits. The fruits are of very high quality and bearing is fairly good.



**Fuyu:**

It is a non-astringent variety with tomato-shaped fruits. This is a raw eating type and the fruits can be eaten hard.



**Hyakume:**

Fruits, roundish oblong to oblate, large, skin buff yellow to orange, flesh dark, crimson, firm, good quality.



EXERCISE 7: Identification and description of varieties of nut crops

**PECAN NUT**

**Western Schley:**

This variety originated as a cross between Seedling and Texas. Nut size medium, pointed both ends. High kernel percent (54-59) and good kernel quality.



**Burkett:**

Good variety, plants are vigorous. Nut small to medium size, high kernel percentage (%2-57).



**Mahan:**

This variety introduced by F A Mahan. The tree is vigorous, precocious, prolific bearer with good foliage. The leaves fall late in the season. The nuts are extra large, thin shelled and tend to poor filling on older trees. It has given highest yield among various cultivars in India.



## Temperate Fruits

### Nellis:

A regular bearing variety with oblong, cylindrical nut tapering towards the end, shell light brown and has stripes at the base. Amber colored kernel constitutes 49.4% of nut, moderately filled and easily separated.



### Cheyenne:

This is a cross of Clark x Obom and released from Brownwood. Tree is very precocious, very productive, and pruning can control scab resistant and being recommended for high-density purpose at its size. It is protandrous type and need to be grown with protogynous varieties. Medium size nuts are slightly wrinkled, loose in shell but has excellent flavour.

## WALL NUT

### Hartley:

This was selected from seedling by John Hartley. The colour of kernel is light, heavy yielder, tolerant to codling moth and blight. The shell is light colour, thin and filling good.



### Serr:

Trees very vigorous. It is lateral bearing variety. The kernel percentage is 59 of nut, light in colour

### Chandler:

It is lateral bearing variety. Trees are moderate in vigour and sem-upright. The nut is large, oval, smooth with good seal and bright colour. Kernel percentage is 49

### EXERCISE 8: Identification and description of varieties of kiwifruit

#### Hayward:

Selected as a chance seedling by Hayward Wright This is most popular variety throughout the kiwifruit growing regions of the world because fruits have large size and more keeping quality. Length and breadth ratio is about 1.3:1, oval in shape and fruit weight ranges from 80-120g/fruit. It bears late than other cultivars and bear solitary flowers on fruiting canes. This is comparatively shy bearer and has a tendency towards biennial bearing. This variety require more chilling hours and can be grown at slightly higher elevation



#### Allison:-

This is most popular varieties in India as it gives higher production. It resemble very much to cultivar Abbott, except that its fruits are slightly broader in proportion to the length. Length in to breadth ratio is about 1.6:1 and Fruit weight ranges from 40-90g/fruit. It is an early flowering and maturing , heavy and regular bearing variety.



#### Abbott:-

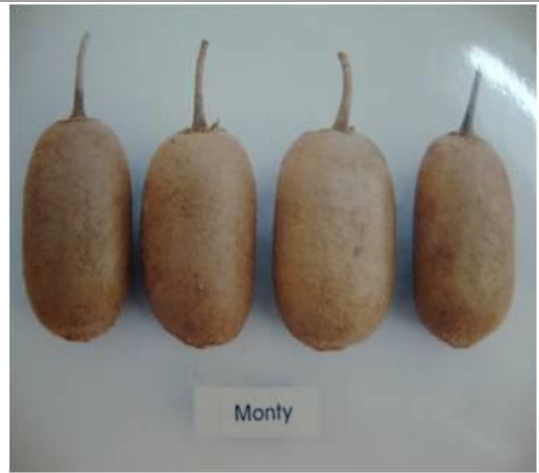
This is an early flowering and maturing varieties. Fruit medium size, Oblong and covered with dense hairs. Very sweet in taste with lower ascorbic content, heavy yielder and regular in bearing.



## Temperate Fruits

### Monty:-

This is a good variety for lower elevation, prolific bearer late maturing variety. Fruits are oblong and resemble with those of Abbott and Allison, but some what wider towards the blossom end.



### Bruno:-

Fruits are largest among the cultivars and slightly tapering towards stem end. Fruit length and breadth ratio is about 1.9:1 and fruit weight ranges from 40-70g/fruit. Fruits are very rich in ascorbic acid . Early flowering and maturity variety, heavy yielder and suitable for lower hills and valley areas.



### Allison Male-

It flowers earlier than Tomuri and is a best pollinizer for cvs. Allison, Bruno, Monty and Abbott, regular with profuse flowering.

### Tomuri:-

It is late flowering and it appears usually in groups of 5 (1-7). It is a good pollinizer for cultivars Hayward

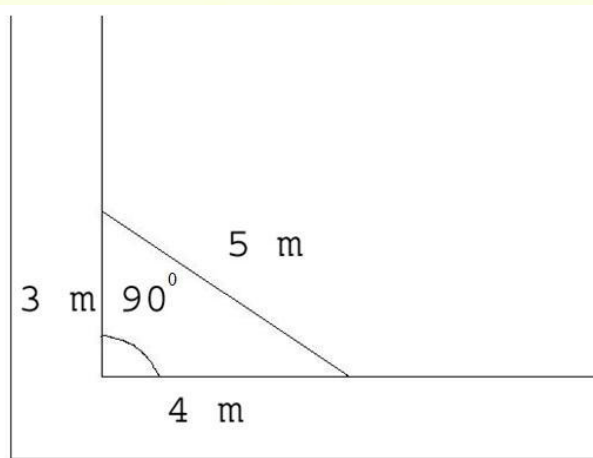




### EXERCISE 9

#### Lay-out

- Lay-out means locating the position of trees in an orchard.
- For laying out an orchard, the baseline is first selected parallel to an adjacent orchard or the main road.
- At least three points are marked at proper distance from the boundary and ranging rods are fixed.
- The rope is stretched across the field along one side of the ranging rods. This represents the first row as well as the base line.
- Now stretch the measuring tape along this row and fix wooden pegs to locate the position of trees leaving proper distance from the ends.
- Another row or base line at right angle to the first base line is then marked along with other edge of the field with the help of carpenter square or cross-staff.
- The right angle can also be drawn with the help of measuring tape.
- One end of this tape is fixed at 3 metre distance along the first row and then the tape is stretched along the second row for a distance of 4 metres.
- The diagonal distance between these two points should be 5 metres (Fig.1). Similarly, right angle is made at the last point of the base line. Then, the positions of the rows towards either side of the boundary and trees on the first and last rows are marked.
- The rope is stretched across the corresponding points to get the positions of the plants and finally, wooden pegs are fixed in these positions.



**Fig. 1. Checking the right angle with measuring tape**

#### Systems of lay-out

- System of lay-out refers to the orderly way of planting the trees. An orchard lay-out system should have suitability to a particular site of an orchard with respect to its elevation and topography.

**Materials required:** Rope and iron chain, measuring tape, ranging rods, cross staff and wooden pegs.

## Temperate Fruits

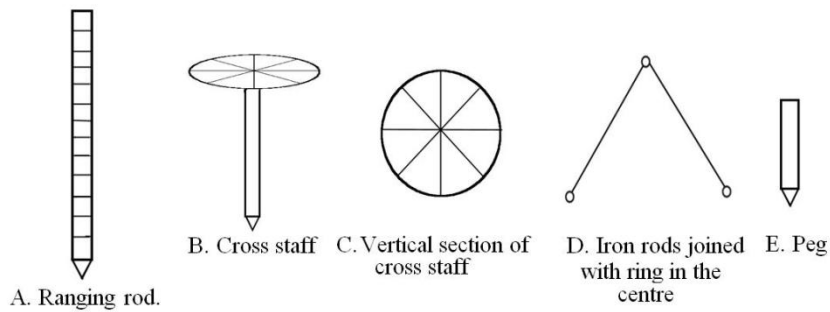
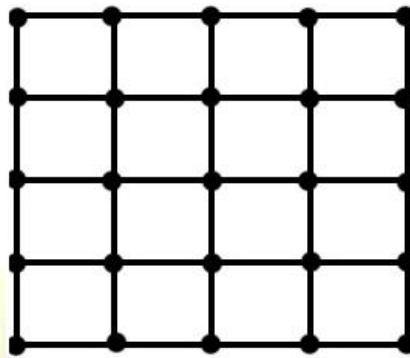


Fig. 2. Tools used for layout of an orchards

- The following seven layout systems are usually followed for planting of temperate fruits orchard.

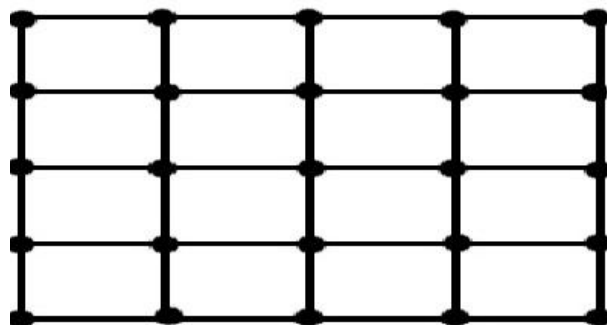
### Square system :

- In this system, as the name indicates, the distance from plant to plant and row to row is the same.
- The plants are at right angle to each other so that every units of four plants forms a square.
- This is the most common system and is easy to layout. This facilitates interculture in two directions.



### Rectangular system:

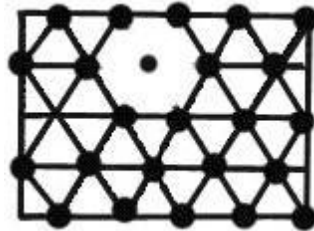
- The trees are planted in straight rows running at right angles on one side of the field.
- The distance from plant to plant and row to row is not the same and four trees joined at the base give a rectangle.
- Like square system, cultivation, irrigation and other intercultural operations can be done in two directions.



## Temperate Fruits

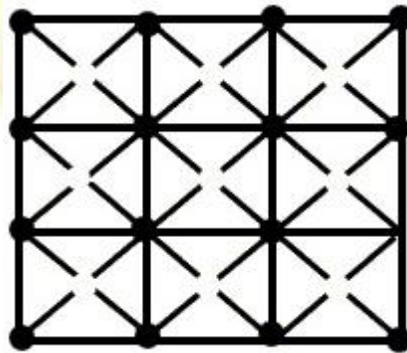
### Hexagonal system:

- In this system, the trees are planted in each corner of an equilateral triangle, thus six trees in a hexagon and seventh in the centre.
- This system differs from a square system in a way that the distance between the row is less than the distance between the trees in a row, but distance from tree to tree in six directions remains the same.
- This permits cultivation in three directions.
- This system can be employed where the land is very fertile with assured irrigation.



### Diagonal or Quincunx system:

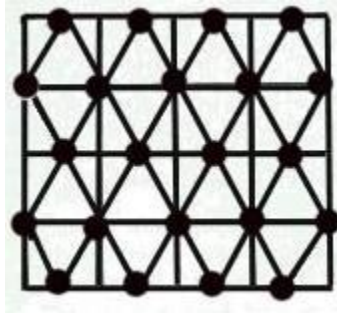
- It is the same as the square system with an additional plant in the centre of a square.
- The central tree is usually not a permanent tree and is planted to fill the central space.
- This is known as filler. Filler serves as a source of additional income till the main trees come into bearing. Papaya in mango and peach in apple orchards can be planted as filler trees.
- For laying out this system, the field is laid out in similar ways as in square system. Then, the rope is stretched through the diagonal points of the squares and additional pegs are fixed at the points where diagonals cross each other.



### Triangular system:

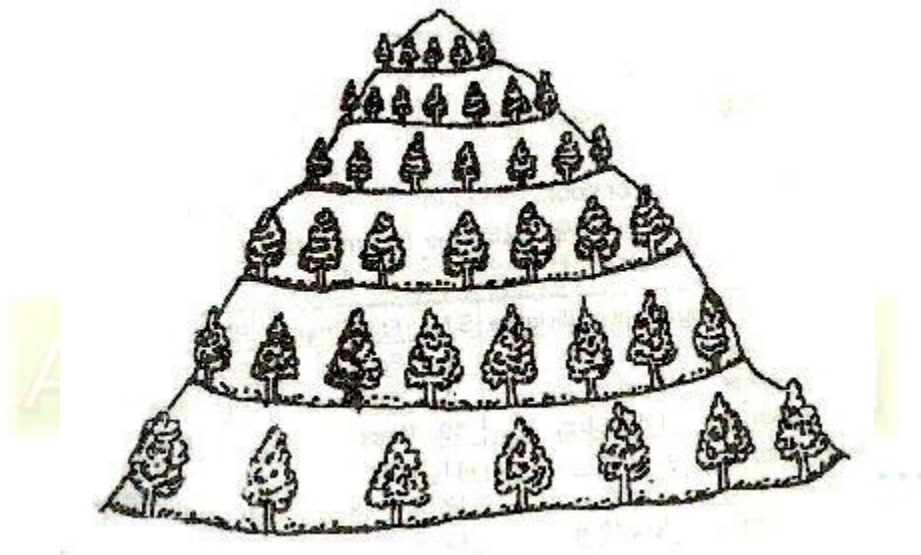
- The trees are planted as in the square system except the plants which are in the even numbered rows are midway between, instead of opposite to those in the odd numbered rows.
- Every second row accommodates one plant less than the square system.
- For laying out an orchard according to the triangular system, a large triangle with a ring in each corner as used in hexagonal system.
- The sides of this triangle are equal to the distance to be kept for the plants in the orchard.
- Two of these rings are placed on the stakes of base line.
- The position of the third ring indicates the position of plant in the second row. This row is then used as a base line.
- The whole area is laid out in this manner. However, this system is not of practical importance.

## Temperate Fruits



### Contour system:

- This system is usually followed in the hilly areas with undulating topography.
- The positions of plants are marked at various heights from mean sea level.
- The points having the same altitude are connected together by a line and trees are given spacing on this line.
- The rows are represented by line passing through the same contour.



### Terrace planting:

- This is also commonly followed in hilly areas.
- On the steeper slopes, terraces are made along the contour and then planting is done.
- The width of contour terrace varies according to the nature of the slope. If the slope becomes steep, the width of terrace is narrower and vice versa.
- Bench terracing is the most popular system in hilly areas.

## Temperate Fruits



### Spacing of temperate fruit plants

- The planting distance for a particular fruit tree is determined by various factors like kind of fruit tree and its growth habit, rootstock used, pruning and training needs, rainfall of the area and soil conditions etc., but the common distance for most of the fruit trees is given here under :
- The best time of planting of temperate fruits are January and February..
- Before planting, orchard site is properly laid out After layout of an orchard , the pits of 1x1x1 m size are dug one month before the planting.
- The pits are filled with soils in which 40-50 kg well rotten FYM and 1 kg single super phosphate are mixed.



### EXERCISE 10: Training and pruning of pome (apple and pear) fruit trees

**Objectives :** To learn and practice different systems of training and pruning in apple and pear trees.

**Materials :** Secateurs, pruning saw, branch spreader, Bordeaux paint or Chaubattia paste and ladder.

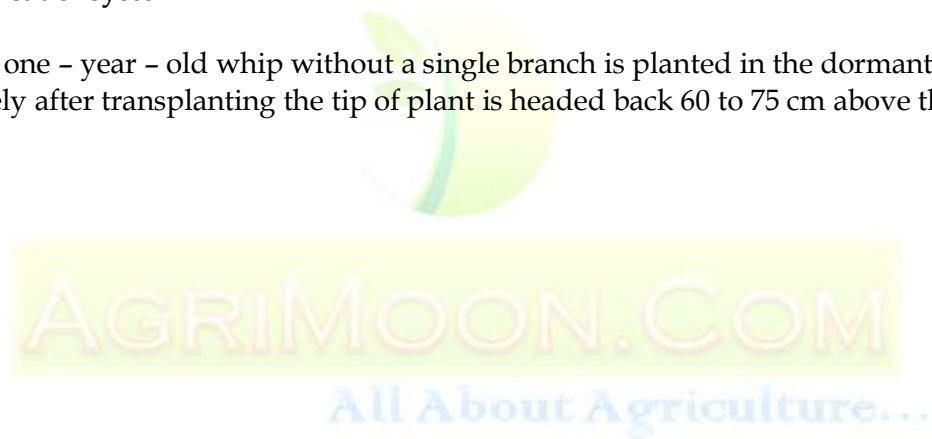
**Procedure :**

**Training**

- Training is done to shape or build a strong framework of the trees in order to support maximum crop when plant reaches bearing stage.
- There are several systems of training in apple especially for dwarf plantations like spindle bush, dwarf pyramid and cylinder spindle etc., but modified central leader system is most suitable for standard plantation.

**Modified central leader system**

- Generally, one - year - old whip without a single branch is planted in the dormant season.
- Immediately after transplanting the tip of plant is headed back 60 to 75 cm above the ground level.



## Temperate Fruits



Fig 1. Pruning at planting

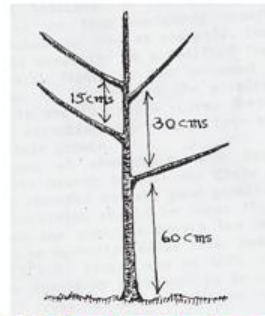


Fig. 2. Selection of primary branches

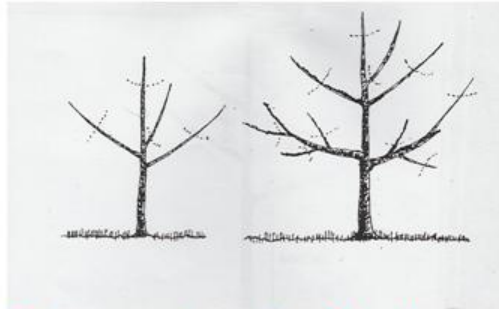


Fig. 3 First year pruning

Fig. 4. Second year pruning



Fig. 5 Third year pruning



Fig. 6 Fourth year pruning

**Fig.1-6 Modified Leader System of Training**

- In the following summer, most of the buds on main branch will sprout.
- In order to develop clean stem up to 45 cm from the ground the sprouted buds are pinched off soon after their appearance.
- Three or four well spaced buds projecting in opposite directions are retained with lowest one 45 cm above ground . If summer pruning is not done, then 3-4 well spaced primary branches having wider crotch angle are selected during dormant pruning.
- The selected branches should be spaced 10-15 cm apart in spiral fashion. The branches emerging below 30 cm from ground level and other undesirable branches are pruned off.
- The selected branches are headed back to  $\frac{1}{4}$  of growth to a bud projecting to the outer direction.
- The leader is also headed back to 30 cm above the last branch.
- During the second dormant pruning, 2-3 well spaced primary branches are selected on the leader.
- On the primary branches selected during previous year, two secondary branches which are growing outward direction should be selected.
- The selected primary and secondary branches are headed back to  $\frac{1}{3}$  -  $\frac{1}{4}$  of the growth.
- The secondary and tertiary branches selected should be spreading horizontally and upright or downward growing branches should be removed.
- The third year training consists of thinning out of unwanted branches and heading back of desirable side branches.

## Temperate Fruits

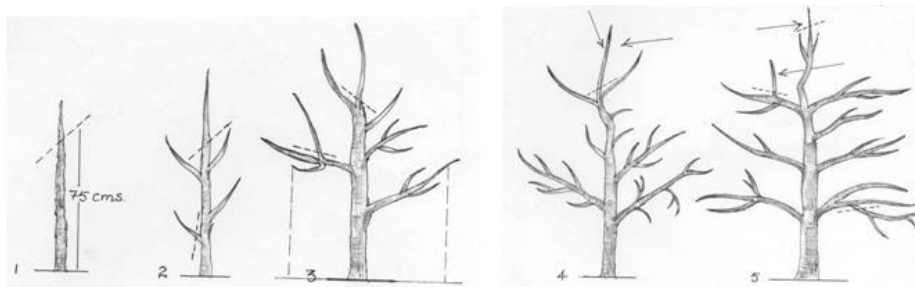
- The central leader should be headed back to a bud or weak shoot, which will develop in the form of a side branch.
- By fourth year training should be completed.

### Training of dwarf apple tree

- With the introduction of clonal rootstocks and spur type cultivars of apple the tree trunk of the plants is short and head is close to the ground.
- Various methods of training viz. spindle bush, dwarf pyramids, cordons, palmette and espalier have been developed in different countries of the world but Spindle bush system of training is commonly followed for apple in India.

#### Procedure:

- One year old apple plants are cut back to a bud about 60 cm above the ground.
- During the first summer 2 to 3 laterals or feathers 30 cm above from the base may be used to form the main scaffold branches such branches should be well spaced all around the stem.
- If the growth is moderate to weak during the first summer, tying down of feathers/branches are not required.
- If they are vigorous then can be tied in August when the growth has stopped. Tying is done by putting loops around the shoot and tightening the other end to pegs pushed into the ground.
- For spreading since they are tender can be made by cloth pins at this stage. During first winter season, 2 to 3 well spaced laterals should be retained and unwanted branches arising on the main stem should be cut out.
- The weak scaffold old branches may be cut back by  $\frac{1}{3}$  to  $\frac{1}{2}$  of their length to a downward growing stem, whereas if healthy should be thinned out.
- During the August of the second year when growth has stopped, strong growing laterals are tied down to form branches. In second winter season to check excessive vigour of the central leader, it may again to be cut back to the next suitably placed rather weaker growing lateral which is tied and trained again into take the place of the central leader.
- Delaying pruning until late winter or early spring will also help check vigour.
- During subsequent growth the branches are allowed to grow from the central leader at regular intervals, choosing wide angle shoots.
- The higher placed branches must be kept shorter than the lower ones to allow sufficient light to reach the lower parts of the tree.



**Fig 7. Development of a spindle bush tree**

1. At planting time 2. After one year 3. After two year 4. After three year 5. Subsequent Years

- In order to keep sufficient wood in the spindle bush while it is being built up a small surplus of the wide angled branches is retained which may cut out as they require more space.
- The main branches should be trained and spaced so that there is plenty of room for fruiting laterals.



## Temperate Fruits

### Treatment of Wounds:

- The cuts less than 2.5 cm in diameter heal themselves, but there is a danger of infection in the bigger cuts which should be covered with Bordeaux paste or Chaubattia paste.

### Pruning of apple and pear tree

#### Pruning

- The objective of pruning is to maintain a proper balance between vegetative growth and spur development.
- The training is completed during initial 4-5 years after planting of plant, but pruning is continued after training throughout the life of tree.
- In pruning, thinning out and heading back are two basic components. The pruning consists of thinning out of all upright laterals and those growing inside the trees and heading back of leaders and laterals.
- In apple, the fruit is obtained not only spurs but also on fruit buds on young laterals. Therefore, pruning should be done in such a way that continuous supply of new, healthy shoots, spurs and branches are maintained.
- While pruning, some part of tree is pruned and some left unpruned. The pruned parts produce shoot growth and unpruned parts will produce fruit buds.
- The laterals which have left unpruned in one year, may be either shortened or left unpruned in the next year depending on the growth, spur formation and crop load.
- Once the laterals have cropped and become weak, they must be severely shortened leaving them 5-6 cm long.
- The severe shortening will promote the production of new growth from these stubs, which in two years will give a crop.
- The whole cycle is accordingly repeated every year to ensure regular growth, spur formation and cropping.
- At the time of pruning dead, diseased and broken branches are removed and on the cut surface Chaubattia or Bordeaux paste is applied to avoid any fungal infection.
- The best time of pruning is during dormant season (December to January).



**Plate 1. Pruning of apple tree**

### EXERCISE 11: Training and pruning of stone fruits

**Objectives :** To learn and practice different systems of training and pruning in stone fruits.

**Materials :** Secateurs, pruning saw, branch spreader, Bordeaux paint or Chaubattia paste and ladder.

**Procedure :**

**Training**

- The stone fruits are mostly trained to open centre system of training, however, under high density plantation tatura system is adopted.

**Open Centre System**

- After planting, the plant is cut back to 40-60 cm above the ground level.
- During the growing season, about 3 to 6 laterals, in addition to the central leader are produced on the tree.
- In the first winter pruning, 3 to 4 scaffold branches which are well located and have wide angle should be selected and remaining unwanted branches are removed.
- The central leader is also completely removed. The selected branches are headed back to  $\frac{1}{4}$  to  $\frac{1}{2}$  of the growth.
- During the second dormant pruning, 2-3 secondary branches are selected on the primary branches.
- The major consideration in selecting secondary branches should be their location so that after pruning, the tips of primary and secondary leaders are about 30-40 cm apart from each other.
- The height of secondary branches is staggered in different years by pruning all branch leader more severely. The vertical ones are pruned more severely. This will produce branch leaders at different heights and prevent overcrowding when the tree is mature. In the following years, the head should be fully formed and selection of secondary branches are completed.

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## Temperate Fruits



Fig. 1. Pruning at planting



Fig. 2. Shoot development during first year



Fig. 3. First year dormant pruning



Fig. 4. Second year dormant pruning

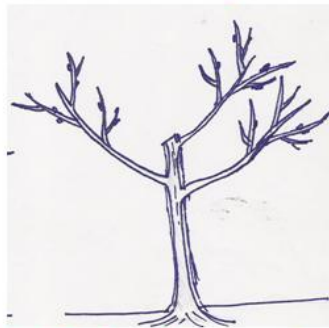


Fig. 5. Third year dormant pruning

Figures 1-5: Open centre system of Training



Plate 1. Pruning at planting



Plate 2. First year training



Plate 3. After 1<sup>st</sup> year pruning



Plate 4. Second year training

## Temperate Fruits

### Tatura trellis system

- In high density planting, this system of training of plants is very popular being very yield efficient. Trees are planted at a spacing of 5x1m or 6x1m.
- At the time of planting, one year old plant is headed back to 20 cm above the ground level.
- In next growing season two limbs or branches are selected in opposite directions and these branches are trained across the inter row space at an angle of 60 degree from the horizontal, forming V-shaped canopy.
- The canopy is supported by a permanent trellis constructed of high tensile galvanized steel fence posts.
- The secondary branches are developed along each primary branches forming fruiting canopy.



**Plate 5. Tatura trellis system of training**

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### EXERCISE 12: Training and pruning of stone fruits (Cont...)

#### Pruning

- The main objective of pruning is to maintain balance between vegetative growth and fruiting.
- Bearing peach require heavy and regular pruning because it bear fruits laterally on the previous season growth.
- It is known, once a growth has fruited will never bear again in its life. Therefore, pruning is done to remove the unproductive parts which in turn will form new fruiting branches in the following season.
- In peach pruning, thinning and heading back of shoots are two basic components. Pruning should be done so as to produce 30-70 cm of growth under subtropical conditions and 25-30 cm under mid hills, annually, which is sufficient for optimum fruit production,



**Plate 6. Pruning of peach tree**

- For good quality fruit production, 40-50 per cent of thinning out and 75% heading back of shoots is suggested under mid hills conditions.
- At the time of pruning , dead ,diseased and broken branches are pruned off.

#### Apricot

- In young bearing trees pruning should be light and of corrective type but in older trees heavy pruning should be done to maintain balance between growth and fruiting.
- In new castle apricot, 25-30 percent thinning of one year old shoots and 1/3rd heading back is recommended to improve size and fruit quality

#### Plum

- In plums, thinning and heading back of shoots are two basic components of pruning.
- Most of plum varieties bear on spurs on two years old wood. The life span of these spurs is 5-6 years. It is necessary to prune for some spur renewal each season .
- The extent of pruning is done such a way to induce an annual shoot growth of 25-50 cm.
- In bearing plum trees, 25-30 percent thinning of shoots and 50-75 per cent heading back of shoots is suggested for proper fruiting.
- At the time of pruning , dead ,diseased and broken branches should be pruned off.



**Plate 7. Pruning of plum tree**

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### EXERCISE 13: Training and pruning of kiwifruit

#### (A) Training:-

- Kiwifruit is a vine like grape, thus require similar training structure but more stronger than grapes.
- A number of training structures are used for training a vine, but T- bar trellis and pergola systems are more popular.
- In T- bar trellis system, the pillars of iron and concrete about 1.8m in height above the ground level are erected at a distance of 6m from each other in a row in straight line.
- A cross arm (1.5m) is fixed on each pole, which carries five outriggers wire at a distance of 45 cm each.



**Plate 8. T Bar trellis system of training**

- Vines are trained upto wire as single stem then two leaders in opposite direction along the center wire are selected or developed . From these permanent leaders, temporary fruiting arms 25-30 cm apart are selected at right angle along both sides of each leader.
- Training of vines on pergola system is similar to that of T-bar. A flat topped network of criss-cross wire is prepared on the erected pillars. This systems is costly to prepare but vine trained on this system gives higher yields.

#### (B) Pruning:-

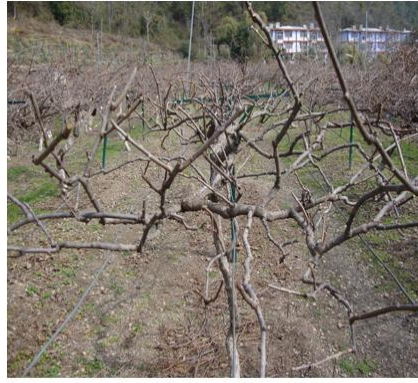
- The main objective of pruning is to obtain high yield of quality fruits and to manage excessive vegetative growth.
- The following principles should be kept in mind at the time of pruning.

(1) The fruit is developed on current season's growth arising from one year shoot.

## Temperate Fruits



**Plate 9. Unpruned vine**



**Plate 10. Pruned vine**

(2) Only the basal buds of the nodes 4-12 on current season growth are productive.

(3) Vines grow 2-3 m every year, which become overcrowded if not controlled by summer and winter pruning.

(4) The shoots developed on older wood by heading back will not fruit normally in the first season.

- Keeping in mind these principles, the vine pruning is carried out in such a way that the fruiting areas are available every year requiring the wood to be young.
- This is achieved by 3-4 years lateral replacement system. In dormant pruning, the fruiting lateral is cut back to 2 vegetative buds beyond the last fruit.
- In the second year, these vegetative buds produce the fruiting shoots, which are pruned again.
- The arm on lateral shoots are pruned and allowed to fruit for 3-4 years.
- After this the lateral is removed from the main branches and other laterals are selected and pruned accordingly so that the balance between vegetative and reproductive growth is maintained for the continuity in the fruit production.
- In summer pruning shoot is cut .beyond 6-8 buds from the last fruit during June-July.

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**EXERCISE 14: Preparation and uses of plant growth regulators in temperate fruits**

**Calculating the strength of growth regulators:**

Strength of growth regulators is calculated in ppm (part per million). ppm is the mg of chemical dissolved in one liter of water e.g. 5 ppm means 5 mg salt dissolved in one liter of solvent. Following table will tell the interconversion of hormonal strength:

Per cent solution (%)	Miligram/litre (mg/l)	Parts per million (ppm)	Grams/litre (g/l)
100	1,000,000	1,000,000	1000
10	100,000	100,000	100
1	10,000	10,000	10
0.1	1,000	1,000	1
0.01	100	100	0.1
0.001	10	10	0.01
0.0001	1	1	0.001

Percentage =	ppm
	10,000
or ppm = %age x 10000	
or ppm = % x 10 <sup>4</sup>	

**Preparation of growth regulator solution**

- Weigh the required quantity of growth regulator. The quantity of chemical required will depend on volume and strength of the solution to be prepared and the purity of chemical used. In case the chemical is liquid, measure the required quantity with the help of a pipette or syringe.
- It is always desirable to prepare the solution of higher strength as the lower concentration can be prepared easily by dilution.
- After weighing the chemical transfer it to a beaker and dissolve it with the suitable solvent.
- Shake the beaker till the chemical is fully dissolved. Now transfer it into volumetric flask and at necessary quantity of distilled water. For every use prepare a fresh solution.

## Temperate Fruits

The common uses of PGRs in fruit crops are as under:

**Propagation :** PGRs are being used commercially for rooting of cuttings, layering and seed germination.

### Rooting of cuttings:

- The prepared cuttings should be treated with the growth regulator solution as soon as possible.
- Put the growth regulator solution in the beakers. Label the beakers properly with glass marking pencil.
- Make bundles of 10 or more cuttings for each concentration of individual growth regulator solution. Put the basal ends of cuttings in the solution.
- At least 2-3 cms of cuttings must be dipped inside the solution. Leave the cuttings in the solution to the desired time. In one beaker take distilled water and keep same number of cuttings for same duration of time as allowed in growth regulator solution.
- After the specific duration remove the cuttings from the solution and wash them with plain water and plant them in the medium already prepared. Commonly used hormones for rooting are as:

Sr. No.	Name of growth regulator	Suggested concentration (ppm)		Remarks
		Quick dip	Prolonged dip	
1	Indole acetic acid (IAA)	500-1500	100-500	Roots produce are thicker and shorter
2	Indole butyric acid (IBA)	500-1500	100-500	More fibrous roots are produce hormones not toxic even at higher concentrations. Move slowly within the plant and destroyed slowly by auxin destroying enzymes. Excellent rooting hormones
3	Naphthalene acetic acid (NAA)	500-1500	100-500	This hormone is toxic if used at higher concentration

### b) Treating cuttings with growth regulator powder :

- Take distilled water in a beaker. Dip the basal end of the cuttings in water.
- Only one to two centimeter basal end of the cuttings should be moistened.
- Dip the moistened end of cuttings directly in the growth regulator powder and immediately planted in rooting media in usual manner.
- Treating cuttings in talc powder is not satisfactory because the growth regulators is not evenly distributed in the talc powder.

## Temperate Fruits

### Use of growth regulators in layering:

- First weigh the watch glass. Then put lanolin paste on the watch glass with the help of a glass rod.
- Weigh it again to get the weight of the lanolin paste.
- Weigh the growth regulator and dissolve it in suitable solvent. Heat the watch glass by putting it on a low flame.
- As paste melts add the growth regulator solution.
- Mix the solution with glass rod till homogenous mixture is formed. Remove it from the flame and let it cool.
- Prepare the air layer and apply the paste with the help of a glass rod on the upper side ringed area. The following growth regulators and their mixtures have been found to be effective on large number of plants in inducing rootings in layering:

Sr. No.	Name of growth regulator	Suggested concentrations (ppm)
1	Naphthalene acetic acid (NAA)	1000-10000
2	Indole butyric acid (IBA)	1000-10000
3	Indole acetic acid (IAA)	1000-10000
4	2,4 Dichlorophenoxy acetic acid (2,4-D)	250-500
5	NAA+2,4-D	5000+250
6	IBA + 2,4-D	5000+250

### Germination :

- GA3 200 ppm has been successfully used for enhancing seed germination in apple, pear and stone fruits..

### Fruit set :

- In apple, spray of miraculan 0.75 ml/l and paras 0.6 ml/l or biozyme or protozyme 2 ml/l at bud swell stage and repeated after petal fall stage improve fruit set and yield.

### Fruit drop :

- In apple and pear spray of 10 ppm NAA about a week before expected fruit drop prevent fruit drop.

### Fruit Thinning

- It has been observed heavy bearing in apple, pear and stone fruits during !on year!, results in small sized poor quality fruits.
- Therefore, judicious thinning at proper stage of fruit development is must to regulate cropping and improving fruit size and quality.
- The thinning can be achieved either by manually or with the use of growth regulators.

### Temperate Fruits

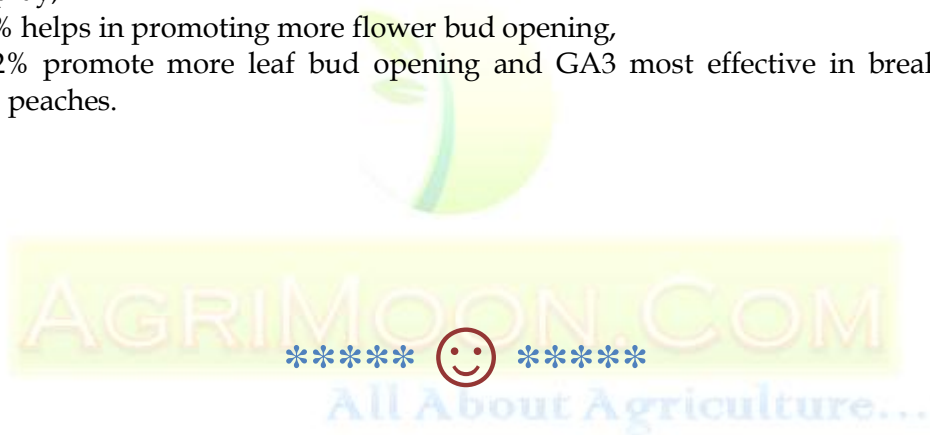
- Foliar sprays of 20 ppm NAA at petal fall results in optimum fruit thinning In peaches application of Ethephone (2-Chloromethyl Phosphonic Acid i.e. CEPA) 300 ppm at petal fall in July Elberta is recommended for optimum fruit thinning.
- However, in Red haven peach, Ethaphone (600ppm) 20-30 days after fruit set when the fruit lets are 20-25 cm in diameter, should be used for thinning.

### Improvement of fruit colour and enhancement of maturity:

- In apple spray of 1200 ppm ethephone about a week before expected harvest improve fruit colour in mid hills and enhance fruit maturity in high hills. 25 ppm NAA should also be mixed with ethereal to prevent excessive fruit drop caused by ethereal.
- In plum spray of 500 ppm ethereal about a week before harvest improve fruit colour. In apricot and peaches 2,4,5-T, 2,4-D, NAA or TIBA enhances fruit ripening and improve fruit colour and flavour.

### Dormancy :

- Benzyl adenine (BA) 500 ppm and gibberellins 50 -200 ppm are effective regulators in breaking dormancy.
- Other chemicals used to break dormancy in fruit crops are Dinitro-ortho-cresol DNOC 1.5% as dormant spray,
- KNO<sub>3</sub> 2-5% helps in promoting more flower bud opening,
- Thiourea 2% promote more leaf bud opening and GA<sub>3</sub> most effective in breaking dormancy in cherry and peaches.



### EXERCISE 15: Manuring and fertilization of temperate fruit crops

- The temperate fruit trees like other plants remove large quantities of mineral elements from soil for growth, development and fruit production.
- Fruit trees being perennial stay in soil for a number of years and continuous removal without adequate replenishment of these elements cause partial or complete depletion of available nutrients in the soil. This lag causes reduction both in rate and amount of uptake of these nutrients, growth and productivity of plants.
- It is, therefore, obvious that a fruit grower needs to replenish these nutrients externally through the application of manures and fertilizers.
- But each type of fruit species has its own nutrient requirement, so the doses of manures and fertilizers also varies. This will also vary with the inherent capacity of soil to supply nutrients
- Under average conditions of the soils of the orchards, the recommended doses of manures and fertilizer are given in the table.

#### Objectives :

- i) To acquaint the students with different types of fertilizers
- ii) To know the fertilizer and manure requirements for different fruit species, their time of application and method of application

**Material :** FYM, Fertilizers, Spade, Basket and Weighing balance

#### Methods of application

- For efficient uptake and utilization of nutrients, the method of application of fertilizers to the soils plays an important role.
- Method depends upon the age of the plant, type of fertilizers and gradient of orchards.
- The fundamental methods of fertilizers to orchard soil are; broadcasting and placement of fertilizers in bands, strips and basins.
- When the land is flat and, fruit trees have grown large and their roots have occupied the entire space, the broadcasting method can be followed.
- The fertilizers are well mixed in the soil and light irrigation is given. Trees with basins, require basin application. In sloppy orchards the fertilizers can be applied by band or dibbling so that the fertilizers are not eroded.
- In sloppy land, the phosphate fertilizers should be applied in holes. Care should be taken while making holes/bands that roots are not damaged.
- The fertilizers are applied at least 30cm to 60 cm away from the stem depending upon the age of the plant.

## Temperate Fruits

Table 1: Recommended fertilizers schedule for Pome fruits in Himachal Pradesh

Age of the tree(year)	FYM (kg)	N (g)	CAN (g)	P <sub>2</sub> O <sub>5</sub> (g)	SSP (g)	K <sub>2</sub> O (g)	MOP (g)
1	10	70	280	35	220	70	115
2	20	140	560	70	440	140	230
3	30	210	840	195	660	210	350
4	40	280	1120	140	880	280	470
5	50	350	1400	175	1100	350	585
6	60	420	1680	210	1320	420	700
7	70	500	1960	245	1540	500	820
8	80	560	2240	280	1760	560	935
9	90	630	2520	315	1980	630	1050
10 and above	100	700	2800	350	2000	700	1170
Off year	100	500	2000	250	1560	400	670

Table 2. The manure and fertilizer schedule for Stone fruits in HP.

Age of tree (yr.)	FYM (kg)	N (g)	P <sub>2</sub> O <sub>5</sub> (g)	K <sub>2</sub> O (g)
1	10	70	35	100
2	15	140	70	200
3	20	210	105	300
4	25	280	140	400
5	30	350	175	500
6	35	420	210	600
7 & above	40	500	250	700

Table. 3. Doses of manures and fertilizers and their time of application

Fruit plant	Age of plant (years)	FYM (kg / plant)	Doses of fertilizers (g/plant)		
			CAN (25% N)	SSP (16% P <sub>2</sub> O <sub>5</sub> )	MOP (60% K <sub>2</sub> O)
Pome fruits (apple and pear)	Per year of age	10	280	220	115
	10 years and above	100	2800	2200	1150
Stone fruits	Per year of age with increment of five years	10	280	220	165

## Temperate Fruits

(peach, plum, apricot) almond and cherry	7 years and above	40	2000	1560	1200
Kiwifruit	Per year of age with increment of 8 FYM	10	400	450	350
	8 and above	80	3200	3600	2800
Nuts	Per year of age with increment of 5 FYM	10	2 Kg NPK mixture fertilizer (15:15:15)		
	16 and above	100	8 kg NPK mixture fertilizer		

CAN = Calcium Ammonium Nitrate, SSP = Single Super Phosphate, MOP = Muriate of Potash

### Time of application

- In temperate fruits, apply all FYM, SSP and MOP during December after pruning.
- Apply half dose of CAN 2-3 weeks before flowering and remaining dose one month after the first application or just after fruit set.

### Methods of Application

- Method of application depends up on age of the plant, type of fertilizers and gradient of the orchard. The fundamental methods of fertilizer application to the orchard soils are; broadcasting and placement of fertilizers in bands, strips and basins.

#### Broadcasting Method:

- It is a cheapest method and consists of spreading the fertilizers uniformly over the entire floor of orchard, where the fruit plants have grown to large size and their roots have occupied the entire space in the orchard.

#### Basin Method:

- In this method, the manure and fertilizers are applied in the basins of the fruit trees. This method is applied when the plants are young and/or basins have been prepared.

#### Band Method:

- The placement of fertilizers is made in bands or trenches around a tree. Care is taken to avoid root injury while digging the bands or trenches. The method is followed in orchards with steep slope and when the fertilizers are applied in small quantity.

## Temperate Fruits

EXERCISE 16: VISIT TO PRIVATE ORCHARDS TO DIAGNOSE NUTRIENT DEFICIENCY AND OTHER MALADIES

VISIT TO PRIVATE ORCHARDS TO DIAGNOSE NUTRIENT DEFICIENCY AND OTHER MALADIES

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### GLOSSARY

**Abscisic acid (ABA).** A complex natural growth inhibitor, thought to be the principle inhibitor in the dormant (resting) stage of buds.

**Achene.** A dry, hard, one seeded indehiscent fruit in which the seed is attached to the ovary wall at one point.

**Anthocyanin.** A class of water soluble pigments, including most of those imparting red or blue colour to fruits or flowers.

**Asexual.** Without sex. Asexual propagation is the production of a new plant by vegetative means by budding, grafting, rooting of cuttings or division.

**Axil.** The angle between a petiole and the stem it is attached to.

**Basic Number.** The number of chromosomes found in gametes of a diploid plant or a diploid ancestor of a polyploid level.

**Bud sport.** A new strain or clone arising from a bud in which a mutation occurred in the bud initial.

**Callus.** Wound healing tissue, arising first as undifferentiated parenchyma tissue at the edges of a bud, graft or other wound.

**Carpel.** A modified leaf forming the structure enclosing the seed.

**Chromosome.** Rod like structures in the cell nucleus that contain the genes, the units of heredity.

**Compatible.** (1) Of sex cells, the ability to unite and form a viable embryo. (2) Of grafting, the formation of a successful, long lived stock/ scion union.

**Cytokinins.** A class of plant hormones that stimulate cell divisions and delay senescence, eg., benzyl adenine, zeatin and kinetin.

**Deciduous.** Falling off, as the calyx of some fruits and leaves in autumn.

**Dehiscence.** The natural bursting of anthers or other organs to release the contents.

**Dichogamy.** The condition in which the male and female flower of a plant flower at different time.

**Dormancy.** The condition of a bud or seed characterized by lack of visible growth. Deciduous plants not in leaf are said to be dormant.

**Epigynous.** Flower type in which the floral parts arise conjointly from above the ovary (in apple and pear).

**Gibberellic acid (GA3).** Gibberellin A3 one of the related group of plant hormones found in fungi and higher plants.

**Hermaphrodite.** A flower with both stamens and pistil.

**Imbricate.** Curved and overlapping like roof tiles (eg., bud scales of a flower bud, scales of a fir cone).

**Mutation.** The spontaneous change in a hereditary unit, commonly called a bud sport.

**Mycorrhiza.** A fungus on the surface or within the tissue, usually roots, of higher plants in a symbiotic relationship.

**Nut.** A hard, indehiscent, usually one seeded fruit, derived from carpels plus stem axis plus accessory parts.

**Ovary.** The enlarged lower part of the pistil, enclosing the ovules or young seeds.

**Ovule.** The portion of the ovary that contains the embryo sac and the egg cell, and which after fertilization develops in to a seed.

**pH.** The symbol for the logarithm of the reciprocal of the hydrogen ion concentration in gram atoms per litre ( eg.,  $\text{pH} = \text{H}^+ 10^{-5}$ ).

**Pollen tube.** The growth extension in the style following the germination of the pollen grain (the male gametophyte is a part of the pollen tube).

## **Temperate Fruits**

**Pollinator.** The agent of pollen transfer, usually bees.

**Pollinizer.** The producer of pollen, the variety used as a source of pollen for cross- pollination.

**Pome.** The fruit type derived from the fusion of the ovaries, calyx cup, and floral tube, produced by apple, pear, quince, and other members of the sub family Pomoideae.

**Protandry.** The shedding of pollen before the stigmas are receptive.

**Protogyny.** The stigmas being receptive before pollen is shed.

**Pubescent.** Covered with down or fine, short hair.

**Receptacle.** The modified or expanded portion of an axis that bears the organs of a single flower or the florets of a flower head.

**Scion.** A detached stem, usually dormant and used in asexual propagation by grafting.

**Self- fertilization.** The fertilization of the egg of a variety by its own pollen.

**Self- pollination.** Pollination by pollen from the same flower of a tree.

**Somatic.** In plants the diploid body cell; vegetative rather than reproductive cells.

**Stamen.** A male portion (of a flower) that produces pollen; a stamen consists of an anther and filament.

**Staminate flower.** A flower producing pollen but not pistils.

**Sterility.** The inability to produce viable seeds.

**Stolon.** A slender branch, as a runner or prostrate stem, which takes root at the tip, developing a new plant.

**Sucker.** An undesirable sprout from the roots or crown of a tree.

**Triploid.** An individual with three sets of chromosomes.

**Variety.** A clone, sort, or cultivar that is propagated asexually.

**Waterlogged soil.** An improperly drained soil in which water content remains too high for normal plant growth.

**Wilting coefficient.** The percentage of moisture in the soil when permanent wilting of plant takes place.

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### SUGGESTED READINGS

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### QUESTION BANK

- Q.1 What are characteristics of temperate fruits?
- Q.2. Classify temperate fruits based on plant stature.
- Q.3. What are pome fruits? Give suitable examples of temperate pome fruits.
- Q.4. Differentiate between drupe and nut fruits.
- Q.5. Classify temperate fruits according to bearing habits.
- Q.6. Classify temperate fruits based on fruit growth pattern.
- Q.7. Write area and production of apple in India
- Q.8. Write down soil and climatic requirements of apple
- Q.9. Give detailed account of varietal status of apple in India
- Q.10. What are clonal rootstocks and how they differ from seedling rootstocks? Write down methods of propagation of clonal rootstocks.
- Q.11. Explain training and pruning of apple.
- Q.12. Explain the role of growth regulators in apple
- Q.13. Give manure and fertilizer schedule along with method and time of application for apple
- Q.14. What is pollination problem in apple? Write in details pollination management in apple orchard.
- Q.15. Discuss the maturity, harvesting grading and packing of apple
- Q.16. What are major insect pests of apple? Suggest the suitable control measure.
- Q.17. Give causal organism, symptoms and control of canker, apple scab and white root rot of apple
- Q.18. Discuss in brief causes of low productivity of apple.
- Q.19. What are symptoms premature leaf fall in apple and suggests control measure.
- Q.20. Explain replant problem of apple.
- Q.21. Write taxonomical classification of pear.
- Q.22. Write different centres of origin of pear.
- Q.23. Differentiate between European and asian pear . Give varietal status of both the pear.
- Q.24. Give manure and fertilizer schedule of pear.
- Q.25. Explain orchard soil and weed management of pear.
- Q.26. Write down maturity indices used for judging optimum maturity. Explain harvesting , grading and post harvest management of pear. are maturity.
- Q.27. Write soil and climatic requirement of peach.
- Q.28. Differentiate between peach and nectarin. Give varietal status of peach and nectarin in India.
- Q.29. Explain training and pruning of peach.
- Q.30. What are adverse effect of drought in peach tree? Give irrigation scheduling in peach orchard.
- Q.31. Write short notes on peach leaf curl and harvesting of peaches.
- Q.32. Give taxonomical classification of apricot.
- Q.33. Writ rootstock and propagation of apricot.
- Q.34. Give maure and fertilizer schedule for apricot.
- Q.35. Explain harvesting, grading and packing of apricot.
- Q.35. Discuss orchard soil management in apricot orchard..
- Q. 36. Explain species of plum
- Q 37. Write climatic and soil requirement of plum
- Q.38. Differentiate between Japanese and European plum. Give varietal status of Japanese plum in India.
- Q.39. Discuss propagation of rootstocks and scion of plum.
- Q.40. Write manure and fertilization of plum.
- Q.41. Give orchard soil and weed management of plum.
- Q.42. Write climatic requirement of cherry
- Q.43. Differentiate between heart and Bigarreau groups of cherry and give their varieties.
- Q.44. Explain training and pruning of cherry.
- Q.45. Write rootstock status of cherry and give methods of propagation of clonal rootstocks of cherry.

## Temperate Fruits

- Q.46. Discuss fruit cracking of cherry and its control measures.
- Q.47. Suggest the suitable climate for kiwifruit cultivation.
- Q.48. Write down methods of propagation of kiwifruit.
- Q.49. Explain training and pruning of kiwifruit vines.
- Q.50. What are pollination problem in kiwifruit. Suggest suitable methods to improve pollination in kiwifruit.
- Q.51. Why thinning is essential in kiwifruit? Write short note of thinning in kiwifruit.
- Q.52. Explain irrigation and orchard soil management in kiwifruit.
- Q.53. Discuss harvesting, grading and packing of kiwifruit.
- Q.54. Give taxonomical classification of strawberry.
- Q.55. Write down soil and climatic requirements of strawberry.
- Q.56. Explain planting and mulching in strawberry.
- Q.57. Discuss manuring and fertilizer application in strawberry.
- Q.58. Write soil and climatic requirements of persimmon
- Q.59. Enlist astringent and non astringent varieties of persimmon
- Q.60. Explain rootstocks and propagation of persimmon.
- Q.61. Write harvesting, grading and packing of persimmon.
- Q.62. Give climatic requirements of walnut
- Q.63. Write propagation of walnut
- Q.64. Write fertilization, harvesting and dehulling of walnut.
- Q.65. Give varietal status of walnut.
- Q.66. Give taxonomical classification of pecan nut
- Q.67. What are soil and climatic requirements of pecan nut
- Q.68. Explain planting and planting density of Pecan nut
- Q.69. Write propagation techniques of pecan
- Q.70. Give manuring and fertilization in pecan orchards.
- Q.71. Explain harvesting and shelling of pecan.
- Q.72. Explain manuring, orchards soil management and propagation of chestnut
- Q.73. Write harvesting of chestnut
- Q.74. Explain pollination problem and its management in chestnut
- Q.75. Give origin and introduction of Hazelnut
- Q.76. Write soil and climatic requirement of Hazelnut
- Q.77. Write propagation and varietal status of Hazelnut
- Q.78. Explain Harvesting of Hazelnut.
- Q.79. Give varietal status of chestnut
- Q.80. Discuss manuring, weed control and training of Hazelnut.
- Q.81. Write down the soil and climatic requirement of chestnut.

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