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.

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

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 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 as 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.

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 develop. 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 mesocarp which is fleshy and hard and stony endocarp, enclosing 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.

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 involucres (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).

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

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.
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.

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, apple and pear (occasionally)
   (c) Flower buds mixed, flowering shoot with lateral inflorescences e.g. persimmon, chestnut, pistachio nut, cranberry.
Chapter: Apple

Taxonomic classification of apple
Order = Rosales
Family = Rosaceae
Sub-family = Pomoideae
Genus = Malus
Species = domestica
Basic chromosome = 17
Somatic no’ts = 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 Nadu.
- 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

<table>
<thead>
<tr>
<th>State</th>
<th>Area (000 hectares)</th>
<th>Production (000 MT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jammu and Kashmir</td>
<td>138.10</td>
<td>1373.000</td>
</tr>
<tr>
<td>Himachal Pradesh</td>
<td>99.6</td>
<td>280.10</td>
</tr>
<tr>
<td>Uttarakhand</td>
<td>32.4</td>
<td>114.0</td>
</tr>
<tr>
<td>Arunachal Pradesh</td>
<td>12.8</td>
<td>10.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>283</strong></td>
<td><strong>1777.10</strong></td>
</tr>
</tbody>
</table>
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 21-240C during active growth period.
- Low temperature below 150C, rains and cloudy weather during bloom restrict the bee activity, which is completely inhibited below 50C and adversely affect fruit set.
- The optimum temperature for pollination, pollen germination and fruit setting is 18 to 220C.
- 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.

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

<table>
<thead>
<tr>
<th>Season</th>
<th>Jammu and Kashmir</th>
<th>Himachal Pradesh</th>
<th>Uttarakhand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early season</td>
<td>Irish Peach, Benoni</td>
<td>Tydeman’s Early Worcester(P), Michael, Mollies Delicious, Schlomit, Starkrimson, Anna</td>
<td>Early Shanburry(P), Fenny, Benoni, Chaubattia Princess</td>
</tr>
<tr>
<td>Mid season</td>
<td>American Mother, Razakwar, Jonathan(P) Cox’ Orange Pippin(P), Queen’s Apple, Rome Beauty, Scarlet Siberian</td>
<td>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.</td>
<td>Red Delicious, Starking Delicious, McIntosh(P), Cortland, Golden Delicious(P)</td>
</tr>
<tr>
<td>Late season</td>
<td>King Pippin, American Apirouge, Kerry Pippin, Lal Ambri, Sunheri Chamure, Golden</td>
<td>Golden Delicious(P), Yellow Newton(P), Winter Banana, Granny Smith(P), Red Fuji, Coe Rymer, Buckingham(P)</td>
<td></td>
</tr>
</tbody>
</table>
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

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

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

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

Pollinating 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

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).

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 pollinating 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.
- Seeds are stratified for 60-70 days in alternate layers of moist sand at 4-6 °C 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

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.

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 at least 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.

Table 3 Spacing and planting density for different scion stock combinations

<table>
<thead>
<tr>
<th>Fruit crop</th>
<th>Scion/variety</th>
<th>Rootstock</th>
<th>Tree size</th>
<th>Spacing (m)</th>
<th>Density (trees/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>Standard</td>
<td>Seedling</td>
<td>Vigorous</td>
<td>7.5 x 7.5</td>
<td>178</td>
</tr>
<tr>
<td></td>
<td>Standard</td>
<td>MM111 and Merton 793</td>
<td>Semi vigorous</td>
<td>6.0 x 6.0</td>
<td>278</td>
</tr>
<tr>
<td></td>
<td>Standard</td>
<td>MM106, M7</td>
<td>Semi dwarf</td>
<td>4.5 x 4.5</td>
<td>494</td>
</tr>
<tr>
<td></td>
<td>Standard</td>
<td>M9 and M26</td>
<td>Dwarf</td>
<td>1.5 x 1.5</td>
<td>4444</td>
</tr>
<tr>
<td>Spur type</td>
<td>Standard</td>
<td>M111, Merton 793</td>
<td>Semi dwarf</td>
<td>3.5 x 3.5</td>
<td>816</td>
</tr>
<tr>
<td>Spur type</td>
<td>MM106, M7</td>
<td>Dwarf</td>
<td>3.0 x 3.0</td>
<td>1111</td>
<td></td>
</tr>
</tbody>
</table>

**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.
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 crock 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 ¼ 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 ⅓ - ¼ of the growth.
The secondary and tertiary branches selected should be spreading horizontally and upright or down ward 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.
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 produced 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).

**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.

**Pollination and Pollinizers:**

• 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.
• The cross pollination and fruit set in apple can be improved by planting at least 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

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- 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.
- For ten or more than ten year- apple tree, 100 kg FYM, 700 g N, 350 g P2O5 and 700 g K2O should be given annually.
- 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 P2O5 and K2O 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 ZnSO4 (0.5%) and boric acid (0.01%) before flowering and in May-June.
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.
- 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.

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.

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 Nepthalene 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 triacontanol (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.

6. **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.

7. **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.

**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 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).

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.

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 pests 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 result 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 % chlorpyriphos (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 remain stunted.
- Fruit set and quality also reduced under severe infestation.
Control:
- Spray infested trees with 0.04% chorpyriphos (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 chlorpyriphos (0.1%) in October- November using 10-15 litre solution per tree.
- Use Malling 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 cause 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 complete 5-7 generation in a year.

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.

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, benmethyl/ carbandazim (0.05%) at petal fall, zineb (0.3%) or dodine (0.075%) at pea size
fruit, mancozeb + carbandazim in June-July and urea 5% spray after fruit harvest to control the disease.

(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).

(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.

Control:
- Cut and burns 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.

(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.

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 outbreak 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
   - 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.
• 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 caterpillar (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 pollinating varieties should be compensated with has not been provided, top working of the trees with pollinating 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.
- 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 from 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 epiphytitic 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 be helpful in reducing the primary inoculums 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.

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 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 cause 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 a 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.
- 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 at least 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 up to 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.
- 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 weakened trees caused by overbearing, drought and poor nutrition.

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. Infect 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