

POLLINATION AND UNFRUITFULNESS

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- ❖ Pollination refers to transfer of pollen grains from anther to stigmatic surface.
- ❖ It is of two types viz., **self-pollination** and **cross-pollination**.
- ❖ If the transfer is from stamen to stigma of the same flower or to the stigma of another flower on the same plant or to the stigma of a flower on any plant of the same clonal variety, then this type of pollination is known as 'self-pollination'.
- ❖ If it is effected without the aid of any outside agency, such as wind or insect, then this process is known as '**autogamy**'
- ❖ If the pollen is to be transferred to the flower of another individual or in the case of pomological varieties, to the flower of another variety, this process is known as 'cross-pollination'.

Cross-pollination may be required for a number of reasons in Horticultural crops.

1. Due to the dioeciously nature (eg. Papaya, Datepalm, Nutmeg) or monoecious nature (Cucurbits)
 2. Due to the peculiar flower structure, (eg. Brinjal, Delicious apples, Vanilla)
 3. Due to the dichogamy nature (Onion, Carrot, Sapota)
 4. Due to the behaviour of bisexual flowers as functionally unisexual (eg. Avocado and Allspice)
 5. Due to self-incompatibility or self-sterility factors (eg. Apple).
- ❖ The pollen may be transferred from the anther to the stigma in a variety of ways. In most plants, pollen is shed at or after anthesis and is transferred to the stigmas by insects or by mechanical means primarily the wind.
 - ❖ In majority of the horticultural crops, pollination is effected by insects and pollination by wind is not a common one.
 - ❖ Fruit crops like sapota, jack and amla and nutcrops like walnut, chestnut and pecans are reported to be pollinated by winds.
 - ❖ They normally produce large quantity of pollen grains which are light in weight so that they can be carried to distance places. In these nutcrops, the stigma is also feathery to facilitate wind pollination.
 - ❖ Honey bees, ants and many insects aid in cross-pollination. Their activity is greatly affected by weather conditions especially low temperature and rain which sharply curtail their activity. Hence,

honey bee keeping is important.

- ❖ In apple orchards, each honey bee usually forages 2-3 trees and visits 50-100 flowers per trip. Thus in a day, it visits about 50000 flowers. Hence, 10-12 colonies per hectare at a distance of 150 metre are ideal for temperate fruit orchards.
- ❖ Recently, a chemical substance (proprietary product Name: Bee-Q) is used to attract the bees so as to increase the fruit set. It has been estimated that nearly double the number of flowers are pollinated in cardamom if such chemical is used at the time of early and mid flowering phases.

Artificial pollination

- ❖ Self-incompatibility is common in apple and pear. This has been recently overcome with the 'recognition' or 'mentor pollen' technique.
- ❖ In this technique, pollination is effected with a 2:1 mixture of Methanol killed or irradiated compatible pollen and self pollens which results in seed set.
- ❖ It is believed that the regulatory substance from the mentor pollen to the incompatible/incongruent pollen helps to overcome the crossing barriers.
- ❖ In emergent situations, when adverse weather conditions prevail or the orchard has inadequate pollinizers, hand pollination can be resorted to.
- ❖ This is much helpful in temperate fruit orchards and is being practised in European countries and not yet in India.

FRUIT SET

- In an orchard, all the fruit trees do not bear equally or regularly. Sometimes one fails to bear and at the same time, another tree of the kind under similar conditions produces a heavy crop.
- This problem may be due to failure to set the fruits, unfruitfulness and sterility.
- The following terminologies are useful in understanding the problem of unfruitfulness.
- Fruit setting refers to the initial setting of fruit at or just after the time of blossoming and to its remaining on the plant until maturity.
- A plant is said to be fruitful which not only blossoms and sets fruit but carries it through to

maturity.

- Plants which are unable to do this are also known as '**unfruitful**' or '**barren**'.
- '**Fertility**' on the other hand refers to the ability of the plant not only to set and mature fruits but to develop viable seeds.
- Inability of a plant to do this is known as '**infertility**' or '**sterility**'.
- Fertile plants are necessarily the fruitful and all the fruitful plants need not be '**fertile**'.
- '**Self fruitfulness**' indicates the ability of the plant to mature fruit without the aid of pollen from some other flower (or) plant and those plants are known as '**self fruitful plants**'

BEARING HABITS

Bearing habits

- Fruit trees may bear fruits either terminally on a long or short growth, laterally on current or past season growth or adventitiously from any point of the trunk.
- The relative position of a fruit with reference to its potential bud giving rise to flower or inflorescence in the shoot is often known as bearing habit.
- A knowledge on the bearing habit is a pre-requisite before resorting to pruning in any fruit crop.
- The position of flower or inflorescence on the shoot in relation to the growth of current season is characteristic of a species or variety.
- Position of fruit buds bears a relationship with the growth habit and the trees are rather compact when compared to plants having lateral fruit bud bearing habit since they force the development of laterals below rather than beyond the flowers or flower clusters.

Different kinds of flower bearing shoots

Based on the position of fruit bud and the kind of flower bearing shoots they produce, fruit trees can be classified into the following groups.

Group 1	:	Fruit buds borne terminally which unfold to produce inflorescence without leaves e.g. Mango.
Group 2	:	Fruit buds borne terminally which unfold to produce leafy shoots that terminate in flower clusters e.g. apples.
Group 3	:	Fruit buds borne terminally unfolding to produce leafy shoots with flowers or flower clusters in the leaf axils e.g. guava.
Group 4	:	Fruit buds borne laterally unfolding to produce flower parts only without any leaves e.g. citrus, coconut, papaya, coffee.
Group 5	:	Fruit buds borne laterally unfolding to produce leafy shoots terminating in flower clusters e.g. grapes.
Group 6	:	Fruit buds borne laterally unfolding to produce leafy shoots with flower clusters in the leaf axils, e.g. avocado.
Group 7	:	Fruit buds borne both terminally and laterally unfolding to produce inflorescence terminally, e.g. walnut.
Group 8	:	Fruit buds always borne adventitiously in old trunk or shoots. E.g., jack, cocoa, Indian star gooseberry (cauliflorous bearing)

Ability of a plant to produce optimum crop is **fruitfulness** and the inability to achieve this is referred to as **unfruitfulness**. This unfruitfulness is one of the serious problems of many orchards and its causes need to be understood properly for effective control and obtaining economically acceptable production level. The causes to this problem can be many and they have been broadly grouped into **two categories**

(A) Internal factors

(B) External factors.

(A) Internal factors associated with unfruitfulness: There are a number of internal factors which are associated with unfruitfulness or sterility. They have further been categorized into three major categories, those are

1. Evolutionary tendencies.
2. Genetic influence.

3. Physiological factors.

1. **Evolutionary tendencies:** In the process of evolution, a number of situations may lead to imperfect flowers or varied developmental periods leading to unfruitfulness unless suitable measures are adopted.

(i) Monoecious and Dioecious nature: A plant with stamens and carpels in different flowers on the same plant is **monoecious**. **E.g.** Coconut, Arecanut, Pecan nut, Capri fig and Hazel. In monoecious fruit plants in general there is no or very little problem of pollination, fruit setting and fruitfulness. Nevertheless, pollinators need to be ensured.

Plants which bear male and female flowers on different plants are known as **dioecious**. **E.g.** Papaya, Date palm and Strawberry. Likewise a few varieties of plum produce too little pollen to call them bisexual. Profuse flowering without fruit set in ornamental pomegranate is a result of their being unisexual. A number of sex forms have been reported in papaya by different

scientists. In case of figs two types of flower clusters are borne namely staminate and pistillate flowers. In Capri fig staminate flowers are borne near the eye and pistillate flowers are borne near the end. To ensure good fruit set, retention of a few staminate trees (9:1) is essential as pollinizers.

(ii) Heterostyly: A condition in the flower where length of the style, relative to other parts of the flower, differs in the flowers of different plants. In this case in some flowers styles are short with long filaments and in some of the flowers of some species or varieties styles are long with short filaments. Thus styles and stigmas at different height prevent self pollination.

In case of brinjal there are 4 types of flowers according to their length of style i.e. long, medium, pseudo short and true short. Out of these pseudo short and true short do not produce any fruit. Similarly in delicious group of apples extreme upright positions of the stamens accompanied by spreaded petals do not permit bees to do pollination while collecting nectar. When the pistils of heterostyled plants are pollinated with pollen from the same flowers or from other flowers containing stamens of an equal height the union may be fruitful but it is likely to be of varying degree of sterility. Here arrangement for cross pollination needs to be created.

(iii) Dichogamy: When stigmatic receptivity period does not coincide with pollen viability in monoecious plants it is known as dichogamy. In dichogamy self pollination is prevented in perfect flowered plants, due to maturity of two sex elements at different times. If the stamens ripe before the stigmas become receptive the flowers are known as **protoandrous** and if stigmas become receptive before the stamens produce viable pollens it is known as **protogynous**.

This results in low production of fruits. Protogyny is present in monoecious plants like walnuts, hazels, etc. whereas protandry is present in many coconut varieties. Majority of dioecious plants are also protogynous.

(iv) Abortive Flowers or aborted pistils or ovules: This occurs in the developing flower's pistils and stigmas of many species and is responsible for failure in fruit setting. Abortion of partially developed flower buds is common. Setting and maturity of two sexes depend on the erosion of two properly formed sex cells. Any interference with their development and functioning may lead to sterility or unfruitfulness; such things can be observed in some grape varieties and tomato varieties. The late flowers of strawberry cluster are always abortive. This is more common in indeterminate type of plants. Degeneration of pistils takes the form of abortion and it is more common in ornamental pomegranate. Certain olive varieties have 10-60% abortive embryos. It is also common in some apple varieties. Embryo sac abortion becomes a cause of seedlessness in certain instances than fruitfulness.

(v) Impotence of pollen - Many varieties of grapes produce non viable or impotent pollens though they appear as perfect flowers. Sterility in grape varieties was the result of impotent pollens. Sterile pollen in the grape results from degeneration processes in the generative nucleus or arrested development prior to mitosis in the microspore nucleus. This is also common in 'J.H. Hale peach, Washington Navel orange and 'Tahiti' lime.

2. Genetic influences

Self sterility is a condition determined by the inheritance received but can develop in favourable environment. Self sterility affects its off springs as well as hybrids .

(i) Sterility and unfruitfulness due to hybridity:

Generally wider the crossing, greater is the degree of sterility encountered. The cross between peach and plum bears abundance of flowers but they are without pistils with malformed stamens. Flower characteristics were constant sterile and barren. A

hybrid between the pear and the quince was seedless. Most of the citranges (cross between sweet orange and *Citrus trifoliata*) produce no fertile female gametes. Seedlessness in most of the banana and pineapple varieties is due to hybrid nature of their ancestors. Most of the triploid apple varieties produce aborted pollen. A number of hybrids between *Vitis rotundifolia* and *Euvitis* are completely sterile. Similar was the case with hybridization of *Vitis vinifera* and *Vitis rotundifolia*.

(ii) Incompatibility - One of the most common causes of self unfruitfulness and self sterility is due to incompatibility between the pollen and ovules of the same plant or of the same variety. Pollen and ovules are fertile but they fail to affect conjugation. In apple, pear, plum and aonla self incompatible varieties require another pollinizer varieties for fruit setting. Self incompatibility has been reported in some of the mango varieties like 'Langra', 'Dashehari' and 'Chausa'.

Self sterility and self unfruitfulness has been reported in apple, pears, plums, almond, apricot, the Clementine' mandarins, may be attributed to incompatibility where normal processes of fertilization fails somewhere between production of functional gametes and the fusion of sex cells.

3. Physiological influences:

(I) Slow pollen tube growth:

Slow growth of the pollen tube results in unfruitfulness. Differences have been found in the rate of growth in selfed and crossed apples, pears, cherries and certain citrus fruits. This may be considered one type of incompatibility due to chemotropic or hormone influences.

Besides this, fertilization should take place within a short time failing which abscission will take place at the base of the style, ovary pedicel or peduncle and fruit setting does not take place.

(ii) Premature or delayed pollination:

Premature or delayed pollination leads to unfruitfulness. Tobacco flowers are very susceptible to injury from premature pollination. When mature pollen grains are applied to immature pistils they germinate, penetrate the style, enter the ovule and if the ovules are not ready for fertilization the flowers fall. However, in case of oranges premature pollination did not have any deleterious effect whereas some injury was noticed in tomato. Lower setting due to premature pollination was noticed in persimmon, Pear, plum and peach.

Similarly, if pollination is delayed the flowers fall without setting. Delay in pollination for 1 or 2 days did not affect fruit set. However, further delaying may result into polyembryonic seeds in some species.

(iii) Nutritive Condition of Plant:

Nutritive condition of plant just before or at or and just after the time of blossoming is an important factor determining the percentage of flowers carrying for setting and for maturity. It may affect the pollen viability or fertility of pistils.

a. Effect on pollen viability - There was significant difference in germination percentage of pollen collected from old apple trees and from strong young trees of the same variety.

b. Effect on defectiveness of pistils: Exhaustion of tree by over bearing, drought or poverty of soil leads to production of defective pistils. Over bearing weakens the fruit tree and in coming season production is adversely affected. Close correlation was reported between defective pistils and unfruitfulness in American plums.

In case of *Vitis vinifera* carbohydrate deficiency is the common cause of flower drop. Due to carbohydrate deficiency flower abortion and ultimately unfruitfulness also occur in green house grown tomatoes.

(iv) Fruit setting of flowers in different positions:

Fruits borne on terminal growth have more competition in many fruit crops and mature and set under normal nutritional conditions but percentage of set is small. This positional competition takes place between fruits and branch as well as between different fruits influencing fruitfulness.

Strong and weak spurs - Nutritional condition of spurs has positive correlation with fruit setting in apple. Spurs on vigorous limbs with large leaves set more fruits than those borne on weak limbs. More flowers ultimately lead to more fruit set and more flowers are generally borne on strong limbs. Likewise flowers borne singly set fruits and mature as fruit and majority of those borne in clusters drop down.

Ringling or girdling also lead to accumulation of an extra store of food material leads to fruitset and develop parthenocarpically.

In the process of fruitifications the embryo is more important for development i.e. if nutritive condition is favourable, it accompanies the development of the seed coat and fruit wall, if not, only the latter portions are in high degree retardation in development. Under insufficient nutrient supply the number of seed forming ovules are diminished and under extreme nutrition deficiency both fruit wall and large number of ovules are diminished leading to enabling to form seed.

In case of green house cucumbers, nutritional deficiency leads to arrest of growth of growing fruits depending upon the position of the fruits and time of pollination. If a few of the cucumbers are harvested remaining fruits resume growth.

In case of strawberries producing bisexual flowers may lead to produce pistillate flowers if nutritional deficiency was observed.

However, nutritive condition has indirect influence on compatibility.

B. Unfruitfulness associated with external factors

1. **Nutrient supply:** In certain families like gramineae, cruciferae and leguminaceae sterility normally occur due to over feeding. 'Jonathan' apple self sterile in rich soil becomes self fertile in poor soils. High fertility level is generally associated with good pistil development and low level with poor pistils and good stamens in grapes. In olives low fertility leads to partial or complete degeneration of pistils.
2. **Pruning and Training:** Pruning tends to produce more true hermaphrodite condition in grape variety 'Hope'. If pruning is not done the variety tends to remain sterile and produces aborted pistils.
3. **Locality:** Jonathan apple which is sterile in one location is reported to be self fertile in another location.
4. **Season:** Hybrid grape 'Ideal' is self impotent early in season but becomes self potent later on.
5. **Temperature:** High temperature at flowering dries up stigmatic secretion and prevents pollination. Tomato varieties grown at high temperature do not produce any fruit.
6. **Light:** Exposure of strawberry plants to long photoperiod results in development of stamens and pistils in strawberry flowers.

7. **Pests and diseases:** Mango hopper, powdery mildew, etc. adversely affect the fruit set and development in mango and grape.

Spraying the trees when they are in bloom i.e. spraying at flowering reduces fruit set. Some of the fungicides gave inhibitory effect on pollen grains i.e. copper fungicides at 200 to 10000 ppm prevent the germination of pollen grains on the stigma.

Steps to overcome the problem of unfruitfulness:

Having known that there could be many reasons for unfruitfulness, it is necessary to make necessary corrective measures which should begin from planning level and extend to an established orchard.

(i) Choice of the crop and variety should be made on the basis of climatic and edaphic conditions of the site of orcharding.

(ii) Provision of windbreak and shelter belts for areas prone to wind damage.

(iii) Before planting an orchard soil should be brought to optimum by incorporating organic matter, amendments and nutrients based on soil analysis.

(iv) In case of problems of pollination due to heterostyly, dichogamy incompatibility, sterility, embryo abortion, hybridity, etc. a mixture of varieties should be grown by introduction effective pollinizer varieties and pollinators (Honey bees).

(v) Unfruitfulness due to slow growth of pollen tube, premature and delayed pollination, use of plant regulators can be affected after standardization in terms of chemical concentration and timing of application.

(vi) The problem due to old age could be overcome by replanting or rejuvenation of old trees.

(vii) Problem due to overbearing can be managed through thinning at appropriate stage.

(viii) Irrigation management would be key role in situations with drought and waterlogged conditions.

(ix) Problem due to uneven distribution of flowers on tree should be managed through thinning and crop regulation.

(x) Maintenance of critical nutrient status in tree leaves for optimum crop production by adopting correct nutritional programme based on plant and soil analysis.

(xi) In crops requiring regular pruning standard practices will have to be adopted based on crop, variety and its phenology.

(xii) Unfruitfulness due to pathogens should be managed through effective plant protection measures following integrated approach.

(xiii) Problem of unfruitfulness due to tendency of alternate bearing should be overcome through replacement of regular bearing varieties and crop regulation.