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Review

Unfruitfulness in fruit crops: Causes and remedies

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Unfruitfulness is a major problem in many fruit crops and their varieties result in huge loss to growers and make fruit cultivation less profitable. Unfruitfulness in fruit crops refers to the state where the plant is not capable of flowering and bearing fruit. However, the causes of unfruitfulness can be broadly grouped into two categories: Internal and external factors. Among the internal factors, dichogamy prevents self pollination in perfect as well as monoecious flowers. The occurrence of flowers with variable style length (heterostyly) is common in Prunus fruits. The proportion of aborted pollen grains varied from 22.5 to 48.0% in cashewnut. In apricot cv. 'Trevatt Blue', multiple ovules and anthers with degenerated microspores resulted in both female and male sterility and in 'Tokaloglu', the reason for unfruitfulness is self incompatibility (Gulcan and Askin, 1991). External factors, like temperature that is above 32°C, result in desiccation of stigmatic surface and more rapid deterioration of embryo sac occurrence. For high productivity in delicious apple plant diploid, self-fruitful and compatible varieties ensure cross pollination. Sequential introduction of honeybee increases fruit set and yield of 'Spadona' pear by about 50 to 80%. Foliar application of boron at a concentration of 200 mgl^{-1} increases pollen germination rate and tube growth in pear.

Key words: Unfruitfulness, fruit crops, internal factors, external factors.

INTRODUCTION

Unfruitfulness is a major problem in many fruit crops and their varieties result in a huge loss to growers and make fruit cultivation less profitable. 'Fruitfulness' refers to the state where a plant is not only capable of flowering and bearing fruit, but also takes these fruits to maturity. The inability to do so is known as 'unfruitfulness' or 'barrenness'. In spite of adequate flowering, low fruit yields in orchards have been experienced because of low initial fruit set and subsequently higher fruit-let abscission. In an orchard, all the trees do not bear fruits equally or regularly and sometimes fail to flower and bear fruit under similar conditions where another fruit tree bears heavily. This failure to fruit may be attributed to unfruitfulness. Any interference with the development of sex cells and organs leads to unfruitfulness.

Thus, unfruitfulness is one of the serious problems of orcharding and its causes need to be understood properly for effective control and obtaining of an economically acceptable production level.

CAUSES OF UNFRUITFULNESS

Unfruitfulness can be due to lack of balance between vegetative growth and fruiting, lack of flowering and poor fruit set, which is as a result of the unfavourable environment. It can also be due to heavy cropping, leading to inhibition of fruit bud production and poor crop in the following year.

Sterility also leads to unfruitfulness due to impotence, incompatibility or the abortion of embryo. The causes of unfruitfulness can be broadly grouped into two categories: (i) Internal factors and (ii) external factors.

Internal factors

There are a number of internal factors which are associated with unfruitfulness. They have further been divided or grouped into 3 major categories:

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(a) Evolutionary tendencies; (b) genetic influence (c) physiological factors.

Evolutionary tendencies

Due to evolutionary tendencies, cross fertilization must be done in order to maintain the vigour of the species. In these species, self fertilization is difficult or impossible. These factors help in maintaining these species, but in cultivation or from the growers' point of view, they limit its usefulness and range. The evolutionary factors leading to unfruitfulness are:

Imperfect/defective flowers: A perfect flower possesses both male (stamens) and female (pistil) parts, whereas an imperfect flower may be either staminate (functional male having only stamens) or pistillate (functional female having only a pistil or pistils). If staminate and pistillate flowers are borne on the same plant but in different locations, the species is termed as 'monoecious' for example, walnut, pecan nut, cashewnut and chestnut. If staminate and pistillate flowers occur on different plants, the species is termed 'dioecious' for example, pistachio nut, papaya, kiwifruit, fig and mulberry. One can see the ramifications for pollination and orchard design, in that a dioecious species such as pistachio or kiwifruit must be planted in an orchard with male plants near females for pollination. Aside pollination, the male plants are useless since they do not possess ovaries that will ripen into fruit.

Generally in monoecious fruit plants, there is no or very little problem of pollination, fruit setting and fruitfulness. A number of sex forms have been reported in papaya. The evolution of unisexual flowers cuts down chances of self fertilization completely. Of the unisexual plants, the pure staminate flowering ones are essentially barren.

Heterostyly: The presence of short style with long filaments (*Thrum*) for example, sapota and pomegranate, or long style and short filaments (*Pin* type) for example, almond and carambola is dimorphism, a type of heterostyly. The occurrence of flowers with variable length of styles is common in prunus fruit crops (Suranyi, 1976). Three types of flowers, namely thrum, homostylous and pin, were found in Pomegranate cvs. Ganesh-1 and Kandhari (Singh et al., 2006). The stigma is located above the superior plane of the anthers in some apricot cultivars which showed differences greater than 3 mm, and as such, cause problems in self-pollination (Ruiz and Egea, 2008). However, heterostyly is a relatively less important factor in dioecious plants.

Structural peculiarities: When stigmatic receptivity period does not coincides 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 organs at different times. If the stamens are ripened 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'. Dichogamy has been reported in hermaphrodite (avocado, mango, ber and annona), monoecious (cashew, pecan nut, walnut, chestnut) and dioecious (persimmon, fig and pistachio) species. In walnut, occurrence of both protoandrous and protogynous cultivars prevents self pollination, which warrants cross pollination.

In mango, the duration of stigma receptivity is only 2 to 4 h, following anthesis. Since pollen shedding does not start within few hours of anthesis, the periods of maximum male and female fertility in bisexual flowers fail to coincide (Verma and Jindal, 1997).

Stigmatic receptivity: It is the ability of the stigma to support pollen germination and it limits the effective pollination period (it is defined as the number of days during which the pollination is effective in producing a fruit and is determined by the longevity of ovules minus the time lag between pollination and fertilization) in fruit crops. Cessation of stigmatic receptivity has been associated with degeneration of stigma and rupture of papillar integrity in kiwi fruits (Sanzol and Herrero, 2001). In 'Agua de Aranjuez', pear stigmatic receptivity is a limiting factor for flower receptivity. The highest initial fruit set was recorded for flowers pollinated at anthesis and 2 days after anthesis. After 4 to 6 days, fruit set was significantly reduced. Thus, stigmatic receptivity could be an important factor limiting pear flower receptivity (Sanzol et al., 2003). Fruit set in kiwifruit after hand pollination was high, averaging 80% during the first 4 days following anthesis. However, when flowers were pollinated 5 days after anthesis, fruit set was decreased to 36% followed by 7 days after anthesis where fruit set was practically nil. Thus, the effective pollination period (EPP) was limited to the first 4 days and the stigmatic receptive averaged 84% and sharply reduced to nil after 7 days (Gonazel et al., 1995).

Abortive flowers or aborted pistils or ovules: This occurs in the developing flowers, pistils and stigmas. Interference either in the development of the flower or in the full development of sex elements and their function may lead to unfruitfulness. Floral abortion is more common in indeterminate inflorescence as compared to determinate inflorescence. Pistil degeneration leads to unfruitfulness in certain cultivars of plum and ornamental pomegranate, while in strawberry, pistil abortion is so late that unfruitfulness does not take place (Table 1). Certain

Table 1. Various causes of flower abortion in different fruit crops.

S/N	Fruit plant	Causes of abortion
1	Apple	Defective embryo, defective ovules
2	Almond	Defective embryo sac, gynoecium abnormality
3	Grapes	Degeneration of nucleus
4	Kiwi fruits	Pollen degeneration
5	Strawberry	Lower bud abortion, defective pistil
6	Sour cherry	Defective embryo
7	Mandarin	Abnormal pistil
8	Pecan nut	Defective pistil
9	Plum	Degeneration of pistil
10	Peach	Degeneration of nucleus, embryo abortion
11	Olive	Pistil abortion
12	Litchi	Embryo abortion

Table 2. Other sterile hybrids.

S/N	Cross	Hybrids
1	Troth early peach x Wildgoose plum	Mule
2	Peach x Sand cherry	Kamdesa
3	Pear x Quince	Pyronia
4	Persian walnut x California	Royal walnut
5	Persian walnut x Eastern black	Paradox walnut

Source: Gardner (1952).

olive varieties have 10 to 60% abortive embryos. Abnormal ovules and embryo sac appear to be the main cause of unfruitfulness of the olive cultivar, ‘Swan Hill’, even though perfect flowers are present (Rallo et al., 1981). The proportion of aborted pollen grains, varied from 22.5 to 46.8% in cashew nut showing a steady increase with plant age and reflecting an increase in the genetic load with plant age (Bhattacharya, 2005).

Non viable pollen: It is due to non-functional pollen or the ovule. Non-viability or impotence of pollen results in unfruitfulness. Unfruitfulness in the case of Muscadine grape is due to defective pollen. In grapes, sterile pollen results from degeneration processes in the generative nucleus or arrested development prior to mitosis in microspore nucleus. In general, late flowering in apricot genotypes showed lower pollen viability than early flowering genotypes (Ruiz and Egea, 2008).

Sterility: Some species have genes that prevent development of the pollen or the ovule. Generally, sterility is due to failure to obtain normal development of pollen, embryo sac, embryo and endosperm. Morphological sterility is due to rudimentary pistil or abortion of sex organs ovule degeneration. If one of the sexes is inactivated, then cross pollination has to take place. Pollen sterility is common in peach cv. J.H.Hale and many olive cultivars also. The proportion of sterile ovules varies between 22% in apricot and 98% in avocado (Verma and Jindal, 1997). In apricot, a clone of Trevatt variety, ‘Trevatt blue’, multiple ovules which were small and retarded in development were present in flower and anthers and they contain degenerated microscopes. This is the first report of simultaneous mutation in both female and male function (Lillecrapp et al., 1999). A high percentage of ovules in ‘Swan Hill’ olive cultivar contain poorly developed embryo sacs at anthesis and were not fertilized (Rallo, 1981).

Genetic influences

Unfruitfulness due to sterile hybrids: Hybridity is associated with sterility as well as unfruitfulness. The degree of sterility increases with wider crossing. Peach plum hybrids known as ‘blackman’ or ‘mule’ have complete sterile and barren flowers and are also present in ‘Kamdesa’, which is a hybrid between peach and sour cherry. The popular tangelo is a hybrid produced by crossing a grapefruit (*Citrus paradisi*) with a tangerine (*Citrus reticulata*). They are seedless or they produce seeds only with nuclear embryos (Gardner 1952; Table 2).

Incompatibility: Incompatibility is defined as failure of viable pollen to grow down the style of flower of the same variety (self incompatibility) or of the different varieties (cross incompatibility). Many cross-pollinating species exhibit self-incompatibility, so that fertilization by their own pollen is disfavored or prevented through physical or biochemical factors. There are different degrees of self-incompatibility, and many self-incompatible species will produce a few fruit even when self-pollinated. Thus, a single apple tree may have a bushel or so of fruit, since apples are not completely self-incompatible, but the same tree may produce several bushels if cross-pollinated. Horticulturists have coined the terms "self-fruitful" and "self-unfruitful" to describe cultivars that can set commercial crops or cannot set commercial crops (respectively) when self-pollinated. Thus, self-fruitful and self-unfruitful are economic or horticultural terms, whereas self-incompatible or cross-incompatible are botanical terms.

Self incompatibility is more common in fruit crops like apple, pear, sweet cherry, almond, avocado, fig, mango, citrus, olive, etc. than cross incompatibility (apple, pear, sweet cheery, European plums and almond). The sexual incompatibility is a genetic mechanism to ensure out-crossing of plants, thus it brings together germ cells of potentially greater genetic diversity. Incompatibility is a genetically controlled character manifested by the presence of multiple alleles at a single locus. In fruit production, incompatibility may create a platform to create variation leaving no scope for inbreeding. In mango, self unfruitfulness is reported in cvs. Dashehari, Chausa and Langra (Ram et al., 1976). Most pear (*Pyrus communis* L.) cultivars are impaired to set fruit under self-pollination because self fertilization is prevented by gametophytic self incompatibility system (Sanzol, 2007). In loquat varieties, improved golden yellow, pale yellow, golden yellow and the pollen tube penetrated the stylar canal up to 1/4 to 1/3rd of its length and did not go further below, even after 72 h of pollination. As such, this suggests incompatibility in loquat (Singh and Rajput, 1964). In pear cv. 'Agua de Aranjuez', 80% of the pollen tube reaches the base of the style and fertilized 70% ovules after cross-pollination, whereas only 10% pollen tube reaches the ovule and fertilized only 5% of the ovule which indicates a high degree of incompatibility in pear (Sanzol, 2007).

Physiological influences

Premature or delayed pollination: Premature or delayed pollination leads to unfruitfulness and is reported that premature pollination followed by germination and tube growth causes fruit drop due to toxicity in pistil. However, in case of oranges, premature pollination did not have any deleterious effect. Low setting due to premature pollination was noticed in persimmon, pear, plum and peach. Similarly, if pollination is delayed, the flower falls without setting.

Nutritive condition of plant: Nutrition of plant controls the percentage of defective pistils. Defective pistils are formed especially on exhausted or weakened plants caused by overbearing, drought and poor nutrition. Nutrition also determines the percentage of flower carried for setting, maturity and also pollen viability.

Fruit setting of flowers in different positions: Fruit borne on terminal growth have more competition in many fruit crops and its maturity is set under normal nutritional conditions, but the percentage of the set is small. This positional competition takes place between fruits and branches as well as between different fruits influencing fruitfulness. The apical (king flower) flower in the bud of apple (*Malus doestica*) develops first, followed by the lateral flower which develop in sequence, beginning at the base of the spur. Some fruits like plum and cherry, bear on both shoots and spurs and it is to be expected that slightly different nutritive conditions are obtained in the different tissues and a distinctly heavier June drop occurs in shoot borne fruits (Gardner, 1952). In apple, old spurs are less likely to initiate flowers than the young ones (Jackson, 2003).

External factors

Any external factor that affects the nutrition of the fruit tree is soil condition, water supply and cultural practices and is important on behalf of this.

Environmental factors

Temperature: Among the environmental factors, temperature has a great importance. It affects flowering and fruit set in several ways. It is a common knowledge that a period of cool, yet frostless, weather is conducive to better blossoming, fertilization and fruit set. However, the abscission of flower bud, fruit, etc. is a function of temperature.

High temperature: Above 32°C, desiccation of the stigmatic surface and more rapid deterioration of embryo sac occurs (Jindal et al., 1993). As temperature increases, ovule senescence become faster in 'Italian' than in 'Brooks' cultivar of plum. At 15°C, only one ovule per flower remains viable by 8 DAFB for Italian, whereas for 'brooks' cultivar, higher temperature results to a decrease in ovule longevity (Moreno et al., 1992).

Low temperature: In plum, cherry, apple, pear, etc., the

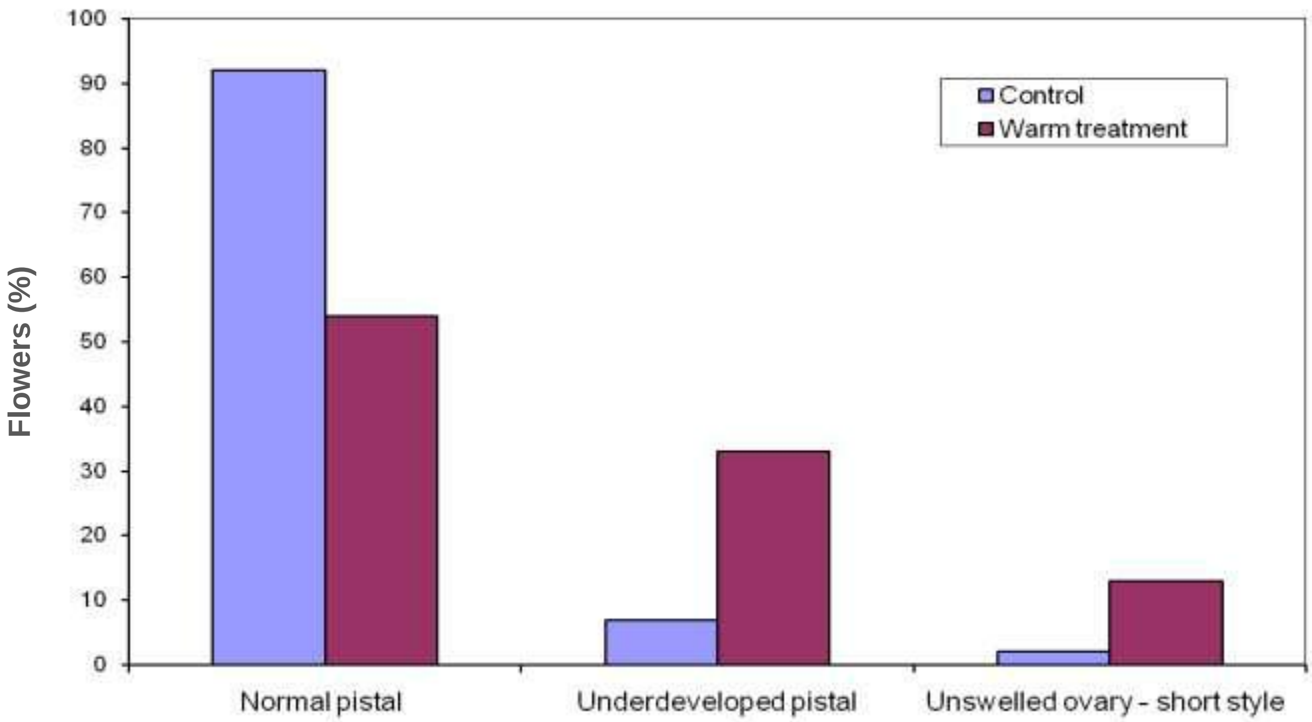

Figure 1. Percentage of flowers at anthesis with different pistil morphology in apricot cv. Moniqui in control and warm temperature.

temperature of 4.4°C or lower, completely check the blooming, fertilization and fruit set (Jindal et al., 1993). The polythene cage induced a mean increase in the maximum temperature of 7.6°C (warm treatment). In the control treatment, most of the flowers (92%) had morphologically well developed pistil, while in warm treatment, 33% of the flowers presented pistils that are not completely developed and 13% of the flowers shows short styles and unswelled ovaries (Rodrigo and Herrero, 2002) (Figure 1).

Fruit set and production of fruit in peach var. Granda were absent or very low in green house grown trees in orchards. Nava et al. (2009) found that a rise of the diurnal air temperature in the interior of the greenhouse promoted a significant reduction in the production of pollen grains.

Humidity: Low atmospheric humidity causes drying of stigmatic secretions. Wet and humid weather favours anthracnose and poor fruit set in mango. The poor germination of pollen in almonds is attributed to damp weather during fruit set.

Rain: It directly affects fruit setting by distributing the process of pollination and germination of pollen grains and staminal fertilization. In almond washing, treatment decreased the number of germinated pollen grains on the stigma mainly when the flowers were immersed before pollination and it seems to affect adhesion in forthcoming pollinations (Ortega et al., 2007). Rains at the time of blooming period causes unfruitfulness by washing pollen grains, inhibit pollinators and cause spread of diseases and pests. Every fruit species need a specific time period without rains at the time of blooming for successful pollinations.

Light: Light affects fruitfulness indirectly by its effect on photosynthesis. Light is a pre-requisite for photosynthesis and low light intensity or its duration reduces the carbohydrates reserves in the trees. In addition to this, poor light conditions promote fruit abscission.

Wind: Wind also affects the fruitfulness indirectly by its effect on the pollinating agents, that is, it controls pollination either by promoting wind pollination or by checking insect pollination. It is desirable in wind pollinated fruit trees like hazelnut and walnut, but if its speed is too high, it is harmful because it results in low fruit set on exposed sides and heavy crop on other sides. Excessively, speedy winds cause ovary abortion (Gardner, 1952) and also make the stigma dry.

Chemicals and pesticides

The use of pesticides can kill bees, therefore reducing

Table 3. Percentage fruit set after spraying captan and binapacry in apple.

Cluster treatment	Initial set (%)	Final set (%)
Exposed	0.3	0.3
Protected	23.3	12.6

pollination. Some pesticides can also be toxic to delicate flowers causing abortion and loss of fruit. Pesticides spray effects on receptive stigmatic surface, showed varying degree of injury and range from minor surface wrinkling to degeneration of stigma papillae. Controlled pollination for 1 h, after pesticides sprays, results in an inhibition of pollen germination and tube growth (Wetzstein, 1990). Commercial fungicides containing captan, dinocarp, sulphur and triforine sprayed on undehisced anthers of several apple cultivars reduced the viability of pollen, impaired pollen release, kill pollen when sprayed onto dehisced anthers (Ruth et al., 1978).

Pollen germination and tube growth were drastically suppressed by the spray and almost no fruit set was observed on the treated inflorescence and there was a highly significant difference between fruit set on exposed and protected cluster (Legge and Williams, 1975; Table 3).

REMEDIAL MEASURES

Balancing fruiting and vegetative growth

Pruning and thinning

The main techniques for controlling the vigour of fruit-trees and increasing their relative fruitfulness are the use of dwarfing rootstocks, compact, short-internode scions and of trees training and pruning system which give horizontal or wide-angled branches. As such, growth retardants are also used. The influence of pruning varies with the amount, season and kind of pruning. Judicious and proper pruning is needed to improve the fruit set and fruit retention on the trees and also on the removal of dead results in loss of carbohydrates reserves along with pruned wood. Also, severe pruning promotes too much vegetative growth and hence reduce the productivity. Experiments revealed that pear on *P. communis* and ‘E.M. Quince C’ rootstocks showed early fruit thinning to 1 fruit per cluster and increased the ultimate percent fruit set of ‘Comic’ girdling and cluster thinning in ‘Anjou’ set beyond either treatment (Westwood, 1974). In mango, the highest number of new flushes per shoot was achieved with severe pruning and spraying of GA_3 at 100 ppm (Sheban, 2009). Singh and Daulta (1986) found that pruning up to 12- bud, improve fruit set significantly and it is suggested that ‘Sharbati’ cultivar respond well to light pruning.

Control of pollination

Use of pollinizers

Pollen transfer may present an application problem in fruits which are self-incompatible. Many apple varieties are at least partially self-fertile, especially under warm weather, but in most cases, fruit-sets are improved by the use of pollinator varieties and bees. Cherries and plums also need cross pollination and should be interplanted with pollinizer varieties.

Breeding and selection of self-fertile cultivars or clones of cherry and apple may reduce difficulty or achieve satisfactory pollination, especially in cool marginal areas of fruit production where temperatures at blossoming time are sub-optimal both for bee activity and for pollen-tube growth. Until such improved varieties become available, provision of suitable pollinizer varieties and bee-hives can be of great help in ensuring satisfactory fruit-set. There is an increasing tendency for using crab-apples, as pollinizers of these occupy very little space in orchards. It is advisable to have a number of pollinizer varieties with widespread flowering dates to ensure cross-pollination.

One of the basic requirements for setting fruit is an adequate requirement of compatible pollen. With most tree fruit crops, the need for cross pollination is recognized. Pollinating insects are necessary for fruit set on all cultivars, and most cultivars will benefit from cross-pollination. Under general conditions, the closer a tree is to a pollinizer, the better fruit set will be. Cross pollination necessitates the availability of sufficient quantity of compatible pollen, as pollinizer cultivars flower synchronously the main cultivar and suitable agent for the successful and effective transfer of pollen. Therefore, suitable pollinizer cultivars must be interplanted at the time of orchard layout.

Desirable characteristics of pollinizers for delicious apple

1) The pollen of this variety should have the ability to fertilize the delicious flowers.

Table 4. Percentage of fruit set in loquat varieties, 'improved golden yellow' and 'pale yellow', by using different pollinizers.

Male / Female	Thames pride	California advance	Fire ball	Golden yellow	Improved golden yellow	Large agra	Large round	Pale yellow	Tanaka
Improved golden yellow	41.46	56.0	43.3	25.0	--	46.6	45.0	43.3	50.0
Pale yellow	43.3	50.0	41.6	40.0	45.0	53.3	45.0	--	46.6

2) It must flower with the main variety.
3) It must come into flower with the same age of delicious apple.
4) It should possibly be a commercial variety.
5) It should also be suitable for place and micro climate.
6) It should also be a long flowering season (Gautam, 2005).

In apple style, receptivity and pollen potency should be considered first during screening for effective pollinator. 'Redsleeves' is the most productive and it shows the highest style of receptivity. It gives the highest pollen germination at 8 - 10°C and at 5°C. As such, it is the most effective pollinator for Cox (Petropoulou and Alston, 1998). California advance variety was found to be the best pollinizers for improved golden yellow and pale yellow (Singh and Rajput, 1964; Table 4).

Introduction of pollinators

The population of natural pollinators has gone down due to indiscriminate use of pesticides and deterioration of the ecosystem. The managed bee pollination is very limited and the available bee hives, during bloom, hardy meet 2 to 3% of the demand. In spadona pear, introducing the colonies sequentially (sequential introduction means introducing half of the number of the recommended number of colonies at 10% FB and half at full bloom) increases the number of bees per tree and their mobility among the rows, and consequently, it increases fruit set and yield by 50-80 per cent (Stern et al., 2004). In red delicious apple, it was found that sequentially increasing the density of colonies increases the amount of cross pollination and a high proportion of top workers. However, the increased pollination efficiency results in high fruit set and higher yield (50 to 100%) in treated plots (Stern et al., 2001).

There was significant increase in fruit set in the apple orchard where bee colonies were kept for pollination and increase in fruit was significantly higher in orchard with sufficient pollinizer (>15%) than in orchards having insufficient pollinizers (<15%) (Sharma et al., 2004).

Control of frost damage

(1) In early stages, a temperature of about -15°C kills 50% of the bud, but at full bloom, the temperature of -3 to -4°C can have similar effect.
(2) This is due to increasing water content and decrease in their ability to supercool.
(3) Exposure to low temperature and dry conditions prior to the incidence of frost induces a degree of hardening and resistance to frost.
(4) Reduced by delaying bud break and blossoming.
(5) Repeated sprays of paclobutrazol at 250 g mg l^{-1} delayed flower initiation by about 13 days in pear cvs 'Doyenne du Comice' and 'Conference' (Dheim and Browning, 1988).
Ethephon delays bloom up to 16 days when applied at 10% leaf drop stage, but only up to 7 days when applied at 50% leaf drop stage in Italian prune tree. After frost (-2), during full bloom, damaged flowers were observed on control trees. Trees treated with ethephone escaped frost damage since they bloom 5 to 13 days later. As such, the higher yield was probably a result of avoiding frost (Crisosto, 1990).

Proper nutrition

Balanced supply of nutrients is always desirable for realizing optimum fruit production. Generally, it is advocated that for application of fertilizers, a few days before emergence of blossoms is generally believed to favour flowering and fruit set. Nitrogen application after terminal bud formation led to the development of flower with enhanced embryo sac longevity (Jackson, 2003). Pollen tube growth in pear was significantly stimulated by increasing concentration (25 – 200 mgl^{-L} of boric acid) and the values are significantly higher at 200 mg^{-L} concentration of boric acid (Lee et al., 2009). In walnut cv. Local selection, the highest fruit set (32.50), fruit retention (41.35) and nut yield (4.02 kg/tree) was recorded under foliar application of H_3Bo_3 + Paras (0.1 % + 0.6 ml/L) (Tomar and Singh, 2007). However, excess use of manures and fertilizers may produce abnormal flowers.

Application of plant growth regulators

The unfruitful behavior of several fruit plants can be overcome by the use of plant growth regulators which may be due to decreased fruit set and abscission at

Table 5. Findings on the use of plant growth regulator to overcome unfruitfulness in fruit trees.

Fruit crop	Growth regulator	Response	Reference
Litchi	TIBA, KNO_3	Increase pollen fertility	Sanyal et al. (1996)
Apple	Cultar (pactobutrazol)	Increase yield	Pant (2004)
	GA_3+NAA at petal fall	Increase fruit set and initiation	William et al. (1980)
	GA_{4+7} at any time between one and 40 days after blooming	Reduce June drop of fruitlets	Jackson (2003)

various developmental stages. Some of the recent findings on the use of plant growth regulator to overcome unfruitfulness in fruit trees are given in Table 5.

Use of suitable rootstocks

There can be as much as 50% or more difference in the yield of a given cultivar grown on different rootstocks. The reasons for such an effect can be traced to difference in tolerance to adverse soils, in resistance to pests or in uptake of nutrients. Four rootstocks namely: M_9, M_7, M_4 and M_1 induced 50% or more bloom in the fifth year in Starking delicious apple and resulted in higher yield efficiency by controlling tree size. (Robert and Mellenthin., 1964).

CONCLUSION

Unfruitfulness can be due to lack of balance between growth and fruiting and lack of flowering and poor fruit-set as the result of various internal and external factors in different fruits and their cultivars. So, it is necessary to make necessary corrective measures which should begin from planning level and extends to an established orchard. The crop/variety should be chosen on the basis of climate and adaphic factors. Different varieties should be cultivated and the introduction of effective pollinizers' varieties and pollinator (Honey bee) is necessary. While selecting pollinators for apple styler, receptivity and pollen potency should be considered first. Therefore, in order to obtain high productivity in apple plant diploid, self-fruitful and compatible varieties are used to ensure cross pollination. Also, old orchards should be rejuvenated. Thinning and crop regulation should be practiced and regular bearing varieties should be planted. So, it is important to analyze the problem and then corrective measures could be suggested. Basically, planning should be done, so that the future will be problem free, and then, adoption of correct package of practices should be followed.

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