NEW ERA AGRICULTURE MAGAZINE

Dichogamy in Fruit Crops

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Abstract

Dichogamy refers to the maturation of stigma and anthers of the same flower at different times, encouraging cross-pollination. It has two primary forms: protogyny and protandry. Fruit crops are highly heterozygous, with most being perennial. Cross-ability barriers and genetic makeup constrain productivity and advancement. Mechanisms like dichogamy, heterostyly, dioecy, and incompatibility act as crossing barriers, hindering trait-based crosses and achieving maximum productivity. Understanding these mechanisms is crucial for fruit crop improvement and yield maximization.

Introduction:

Dichogamy is the term for the maturation of the stigma and anthers of the same flowers at different times. It comes from the Greek words *dikho*-apart and *gamous*-marriage. Cross-pollination is encouraged by dichogamy, even in hermaphrodite species. There are two primary forms of dichogamy: (i) protogyny and (ii) protandry. Protogyny is the term for pistil maturing before anthers, as in the case of bananas, fig. Protandry is the term used to describe anthers that mature before the pistil.

Fruit crops are highly heterozygous in nature, with the majority of them being perennial. Both productivity and advancement are severely constrained. By multiple cross-ability barriers and the intricate genetic makeup. In fruit crops, many mechanisms, including dichogamy, heterostyly, dioecy, and incompatibility (self and cross), function as crossing barriers. These obstacles interfere not only with the process of improvement by making most trait-based crosses difficult or even impossible, but also with the achievement of maximum productivity by impeding

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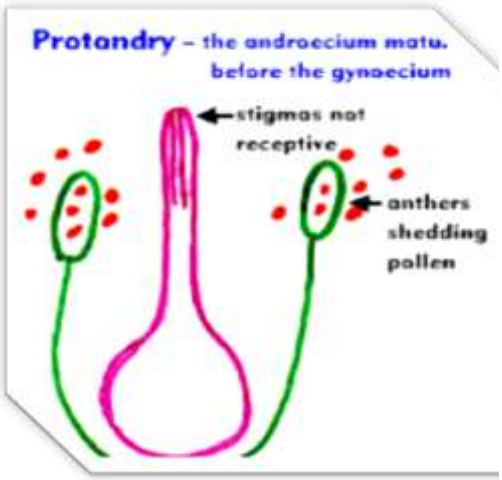
unhindered pollination. A thorough comprehension of these mechanisms is necessary for both fruit crop improvement and yield maximisation.

Types of dichogamy:

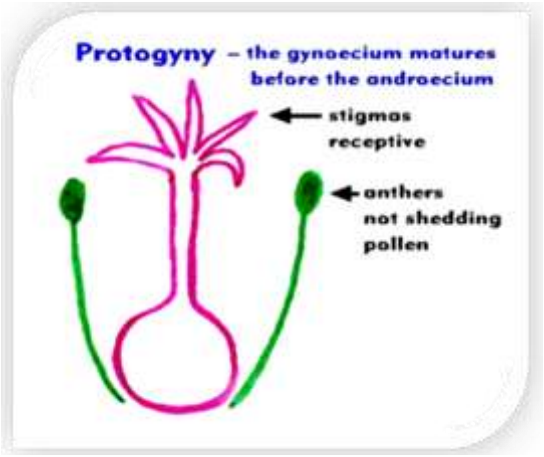
Protandry:

This kind of dichogamy occurs when pollens are discharged prior to the ovule maturing or when the anther matures before the stigma during the reproductive cycle. Cultivars of hazelnuts such as Palaz exhibit protandry (Bostan *et al*., 2009). The protandrous florets in macadamia nuts enhance nut output by outcrossing (Howlett *et al*., 2015). It is also seen in Aonla, where stigma becomes receptive on the second day of the anthesis, whereas anther dehiscence begins with the flower opening (Saini *et al*., 2020).



Protogyny:

In this kind, pollen is released during ovule maturity or stigma ages before anther during reproduction. The anthers of Cherimoya (*Annona cherimola*) do not mature and release pollen until the evening of the following day, yet the flowers open and the stigma becomes receptive in the morning. For good economic returns, this condition necessitates manual pollination and encourages outcrossing (Venkataratnam *et al*.,1996). Two days before the anthesis period, in sapota, the stigma emerges from the bud, reducing the likelihood of sexual interference between the stigma and anther and encouraging outcrossing.



Intrafloral Dichogamy:

Attainment of reproductive maturity of anther and stigma at different times within the single hermaphrodite flower is known as intrafloral dichogamy (Cetinbas *et al*., 2014).

Interfloral Dichogamy:

This type of dichogamy is mostly seen in diclinous species where anther and stigma are in separate flowers. In this case, reproductive maturity is achieved at different times in the stamens and pistils of male and

female flowers of dioecious or monoecious species (Cetinbas *et al*., 2014).

Complete Dichogamy:

It is a type of dichogamy in which reproductive period of male and female do not overlap. In other words, the hermaphrodite flower enters in the first phase (either male or female) and then enters the second phase (other than the first phase) when only the first phase is over (Cetinbas *et al.*, 2014). It always leads to complete outcrossing and prevents from inbreeding depression.

Incomplete Dichogamy:

In this type of dichogamy, male and female reproductive phases overlap at a particular period. The overlap might be slight to total as per condition (Lloyd *et al*., 1986). For example, in passion fruit, three floral stages occur: in the first and the third, only the anthers can be contacted by legitimate visitors while in the second, both the anthers and the stigmas are placed in the way of the pollinators (Amela García *et al*., 2011). In passion fruit, incomplete protandry is observed and it takes 30 to 90 minutes for style deflection in the flowers towards the lower position after opening of flower.

Asynchronous Dichogamy:

The most common form, in this group, is asynchronous dichogamy (Webb *et al*., 1983). In this case, pollen release in the flowers and the pollen acceptance phase of stigma occur at different times in each hermaphrodite flower or on the inflorescence of a plant. In most species of such type the pollinator can carry pollen from one flower to another flower of the same plant having a receptive stigma, so geitonogamous self-pollination and interference between androecium and gynoecium of different flowers can occur (Lloyd *et al*., 1986).

Hemi-synchronous Dichogamy:

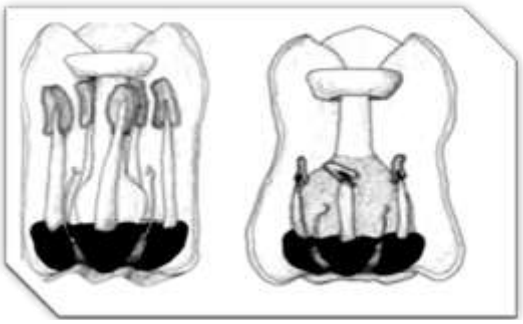
Hemi-synchronous dichogamy is a partial synchronization exists in a few or more flowers or only a portion of inflorescence. In this, there is synchronization among the sex organs of certain flowers, while there is no synchronization between these flowers and the sex organs of the rest of the flowers (Lloyd *et al*., 1986).

Synchronous dichogamy:

It occurs when all the flowers in an individual are in the same phase. This form of dichogamy is also seen in ***Ziziphus mistol*** where there is a high synchrony in flowering between individuals, as well as in floral anthesis between/ within inflorescences within individuals was observed (Cerino *et al*., 2015). High protandrous synchronous dichogamy was observed among the flowers of ***Ziziphus mistol*** which prevented self-pollination due to presence of complete intrafloral dichogamy.

Duodichogamy:

Duodichogamy was discovered by **Stout (1928)** in ***Castanea*** **(Chestnut).** It is another form of synchronous dichogamy and consists of 1.5 cycles during a flowering season. 1.5 cycles refer to consecutive switches between 3 different phases i.e. male phase - female phase - male phase.



In Chestnut, there are two types of inflorescences are seen- unisexual staminate catkins that develop on the previous season's shoot growth at the base of the flower branch and bisexual catkins that are found near the apex and develop on the current season's growth (Botta *et al*., 1995), the lower unisexual male catkin is the first start to open and the pistillate flower is next to open and not until 8-10 days after the anthesis of unisexual catkins, the male bisexual catkin flowers begin to open.

Heterodichogamy is the least common form of synchronous dichogamy and has two genetic variants. Heterodichogamous species include two types of hermaphrodite flowers: protandrous and protogynous. During blooming time, the first type of flower remains in the male phase while the second type of flower is in the female phase. As the two flower morphs exhibit male and female functions at different times among individuals within a population, this phenomenon promotes outbreeding through enhanced intermorph pollination (Watanabe *et al*., 2015).

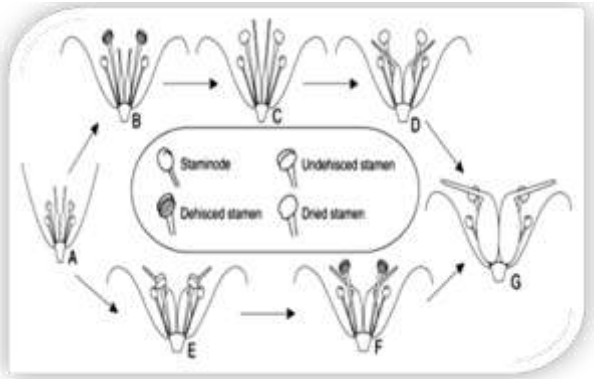


Fig.- Heterodichogamy in Kingdonia

Different types of dichogamy in fruit crops:

Protandry	Protogyny	Heterodichogamy	Duodichogamy
Walnut, Aonla, A. muricata, Hazelnut, Ber, Macademia nut, Pecanut, Passion fruit (Incomplete protandry), Coconut	Sapota, Fig, Banana, Strawberry, Pomegranate, Plum, Annona spp. Except A. *muricata*	Walnut, Pecanut, Pistachionut, *Ziziphus spinachristi* (Thorn jujube)	Chinese chestnut, *Bridelia tomentosa*, *Cleistanthus collinus*

Functions of dichogamy in fruit crops:

The widespread presence of dichogamy, *i.e*. a partial time separation between male and female phases in fruit crops, is a longstanding issue in floral evolution. It plays an important role directly or indirectly in fruit production. The functions of dichogamy are as follows-

I. **Avoidance of self–pollination and sexual interference:** It leads to the evolution of dichogamy. Avoidance of autogamy and geitonogamy depends on the form of dichogamy exhibited by the plant. incomplete protogyny is more efficient in reducing self –fertilization than incomplete protandry (Lloyd *et al*., 1986).

II. **Effect on floral longevity:** Floral longevity is defined as the length of time that the flower remains open and functionally active in the plant. Dichogamous flowers live longer compared to a dichogamous and male investment plays important role in it.

III. **Ease in doing controlled and efficient pollination due to complete outcrossing:** Dichogamy encourages outcrossing through temporary separation of male and female parts hence with the technique of controlled pollination it is easy to repair the crop load (Pinillos *et al*., 2008).

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