



**FACULTY OF AGRICULTURE SCIENCES AND
ALLIED INDUSTRIES**

(Crop Improvement I (Kharif))

For

B.Sc. Ag (Third Year)



RAMA
UNIVERSITY

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Course Instructor

Dr Shiv Prakash Shrivastav

FASAI(Genetics and Plant Breeding)

Rama University, Kanpur

Major Cereals, Pulses, Oilseed, Fodder, cash , **vegetable and horticulture crops** (*Kharif Seson*)

23. Breeding Fruit Crops MANGO *Mangifera indica* Family : Anacardiaceae Floral biology Flower starts opening early in the morning from 4-7 a.m. and maximum flowers open between 9.30-10.30 a.m. and complete 11.a.m. Dehiscence of anthers takes place at 11.30 a.m. and it continues up to 3.45 p.m. The pollen grains are oval, or triangular or oblong. Stigma becomes receptive even 18 hours before flower opening. Mode of pollination is entomophily; nectar is present to attract the insects. The flowering duration is usually of short i.e. 2 to 3 weeks. The mango inflorescence or panicle bears mainly two types of flowers – male and perfect. The number of flowers per panicle varies between 1000 to 6000 depending upon the variety and climatic factors. The percentage of perfect flowers varies between 0.74 per cent in Rumani, 16.41 to 55.7 per cent in Neelum and up to 69.8 per cent in Langra. Hybridization: Since a large number of male and perfect flowers are borne on a mango panicle, it requires a special crossing technique. The panicle should be bagged with a muslin bag (60 cm x 30 cm) fully stretched and fixed with two rings and a rod made of spliced bamboo. A piece of thick iron wire can also be made into a good frame for stretching the muslin bag over the panicle. Staminate flowers of the selected panicle to be used as female parent should be removed daily before dehiscence. Panicles of the variety selected as male parent should also be bagged before their flowers begin to open. Freshly dehisced male flowers should be carried in a small petridish lined with a filter paper and covered with another petridish to protect the flower from contamination with foreign pollen carried by insects. Perfect flowers should be emasculated early in the morning before dehisced. Freshly dehisced anther of the male parent should gently be brushed against the stigma which should then be examined under lens to see if pollen grains have adhered to it. As the pollination of flowers in any one panicle is carried over a number of days, only the pollinated flowers should be allowed to remain on the panicle. It has been found advantageous to keep the panicles enclosed in bags till the fruits set and develop slightly. The conventional method of pollination is time consuming, cost intensive and inefficient because of tallness and difficult to handle trees and poor fruit set. 'Caging technique' for crossing, developed at IARI following the discovery of self incompatibility in Dashehari, Langra, Chausa and Bombay Green, involves planting of grafted plants of the self incompatible varieties along with those of male parents enclosed in an insect proof cage and allowing pollination by freshly reared house flies and thus doing away with the tedious hand pollination.

BANANA *Musa* sp. Family : Musaceae Floral Biology Flowers are placed in the axils of the bracts, arranged biserially and number about 12 to 20 per node. Basal flowers behave as pistillate flowers while the terminal ones as staminate. At the bottom end, they form a bulbous male bud. Pistillate flowers are large in size and have well developed ovaries. Stamens (5) are reduced to staminodes, ovary inferior and trilobular. Style stiff and long, stigma club shaped and sticky. Staminate flowers have long stamens 5, filaments filiform, free, anthers two lobed. The female and male flowers open by 6.30-8.00 a.m. Hybridization Technique Undehisced anthers of male flowers are collected and twisted gently to force them to dehisce. Using a soft hairbrush, the pollen grains are taken out and smeared gently over the stigmatic surface of the female flowers, which opened on the day of pollination. The pollinated flowers are to be covered with soft cloth bag.

CITRUS *Citrus* sp. Family :Rutaceae Floral biology Flowers are produced on current season growth in cymes, both axillary and terminal position. Two types of flowers, perfect and imperfect are found. The flowers are white in colour in most of the species except lemon and citron where they are purplish on the outside. Flower opening, starts from morning and extends up to evening but maximum anthesis is between 11.00 a.m. to 12.00 noon. The viability of pollen grains varies from 45-80% depending upon the season. The dehiscence of anthers takes place

there 45 minutes before anthesis or within 45 minutes after anthesis. It varies up to 5 hours after anthesis. The receptivity of stigma starts either 15 minutes to 2 hours before anthesis or within 35 minutes to 5 hours after anthesis depending upon weather. The receptivity lasts for 4-8 days after anthesis. Hybridization Technique The mature flower buds on the female parent are emasculated early in the morning on the day of opening and are bagged. The flowers to be used as male parent are bagged the previous evening. The next morning as the day warms up; the anthers dehisce releasing the pollen grains when these flowers can be plucked to pollinate the receptive stigmas of emasculated flowers. The pollinated flowers are bagged, opened after about a week and allowed to mature into ripe fruits. In some cases, especially when the trifoliolate orange is used as male parent, difficulties are encountered as its flowering is over before other citrus varieties flower. Therefore, pollen has to be stored at low humidity and temperature. Seeds from mature fruits are extracted and sown immediately in sterilized sand and soil mixture. When seedlings are about 15 cm high, hybrid seedlings are identified. Particularly those showing some morphological characters of male parent and others are rejected. Electrophoresis methods can also be employed for identification of zygotic seedlings. Identification of hybrid seedlings having *P. trifoliolate* as male parent is easily done by looking for trifoliolate character. The hybrid seedlings parent is easily done by looking for trifoliolate character. The hybrid seedlings are grown to mature trees in the field and the seedlings raised from the fruits are evaluated for resistance to various disease, insect pests, nematodes and for suitability as scion or rootstock. SAPOTA *Achras sapota* Family : Sapotaceae. It is a wind pollinated one. Flowers are protogyny and the stigma grows out of the bud about two days before anthesis. Flowers open between 4-4.30 a.m. Anthers dehisce between 8-10 p.m. The flowers keep fresh for nearly two days. The stigma is found to be receptive two days before opening and continues to be like that up to 12 hours after opening. Peak receptivity is between 8-10 a.m. The total time taken from fruit set to maturity is 10-12 months under North Indian conditions but in Tamil Nadu it takes only 4-5 months. Flowers are emasculated and bagged before 4-5 p.m. and well before the stigma protrudes out of the bud. The actual procedure consists of making a circular incision around the flower bud with sharp knife or blade, so that 2/3 of the upper floral cup is removed including the portions of calyx, corolla and epipetalous stamens. The style is left in position in remaining 1/3rd of the floral cup. Stamens from male parent, which should shed their pollen in the early hours of next day, are collected in the previous day evening and kept over night in a petridish. These are used to pollinate the receptive stigma of the emasculated flower between 8-10 a.m. in the next day. POMEGRANATE *Punica granatum* Family:Punicaceae Floral biology The genus *Punica* belonging to the family Punicaceae has two species, *P. Protopunica* found wild in Socotra Island and the cultivated *P. granatum*. Both self and cross pollination were recorded in pomegranate. The pollen from male flowers gave higher fruit set than those from the hermaphrodite ones. PAPAYA *Carica papaya* Family :Caricaceae Hybridization Using a dioecious lines It has been established that female plants are more productive than hermaphrodite ones. Due to the crossing, most of the cultivars are highly variable. Hence it is considered appropriate to sibmate the selected female and male plants so as to bring homozygosity. Hence, suitable male plants are selected from the same progeny, which have resemblance to female plants in vegetative characters, such as stem and leaf colour, stem thickness and height at flowering etc. Progenies raised from S1 inbreds are screened and desired male and female plants are selected for further sibmating. This process is to be continued for 7-8 generations to achieve uniformity of a group a characters. Using gynodioecious lines It involves selfing regular and prolific bearing hermaphrodite and or crossing (sibmating) the female with hermaphrodite. Suitable hermaphrodite plants, which do not vary with climatic changes, are selected. Of the various types of the flower produced by a hermaphrodite plants 'elongata' and 'pentandra' types are selected for selfing. Selfing is to be continued in selected hermaphrodite plants for atleast three generations for uniformity of characters. In the case of female and hermaphrodite plants, sibmating between desired types of female plants are selected and sibmated with hermaphrodite plant. Seedling raised from S1 inbred is screened and desired female and

hermaphrodite plants are selected for further sibmating. This process is to be continued for 7-8 generations till homozygosity is achieved. Crossing between two or more parents and selecting the derived progenies with good attributes in the advanced generations has been employed as a method to develop new cultivar. CO.3. is a hybrid derivative between CO.2 x Sunrise Solo. Similarly, CO.7 is a gynodioecious cultivar developed from the crosses of CP.75 (Pusa Delicious x CO.2) x Coorg Honey Dew. Fruits are with red flesh and very sweet in taste.

GUAVA *Psidium guajava* Family : Myrtaceae
Floral biology The guava flower has a superior calyx with 5 lobes and the corolla of 6-10 petals arranged in one and two whorls. The androecium consists of 160 to 400 thin filaments carrying bilobed anthers closely packed together. The gynoecium consists of an inferior ovary, syncarpous with axile placentation and subulate terminal style. The style is smooth and red at the summit. It is larger than filaments but bent over stamens in bud stage . Three flowering seasons were reported in the peninsular regions of India, namely, ambe bahar, mrig bahar and hatti or hastha bahar. In north Indian subtropics, there are only two flowering seasons, however, have reported three distinct flowering and fruiting periods in spring, rainy and winter seasons in Delhi. The peak anthesis was found to be between 5.00 and 6.30 AM in most of the varieties. However, in Chittidar and Lucknow Round, it was observed between 6.30 and 7.00 AM The dehiscence of anthers starts 15 to 30 minutes after anthesis in all the varieties and continues up to 2 hours. After dehiscence, the anthers assume a whitish colour caused by the pollen. No fixed relation has been observed between the atmospheric temperature and humidity and the time of anthesis and dehiscence. Pollen fertility has been found to be high in all the cultivars of guava.

GRAPES *Vitis vinifera* Family : Vitiaceae
Floral biology Flowers are small, green, sweetly scented and are borne on panicles on current season growth. Three types of flowers viz., male, female and hermaphrodite occur in grapes. Varieties of *V. vinifera* are mostly hermaphrodite. Perfect Flowers : Pistil is functional; stamens are erect and produced fertile pollen. Female flowers: Pistil is well developed; stamens are reflexed and may produce abundant pollen, but remain sterile owing to the absence of germ pores. Male flowers: Stamens are erect and anthers produced well-developed fertile pollen but pistil is only rudimentary without stigma and style with only a small ovary containing incompletely developed ovules. The number of stamens varies from two to seven but majority of flowers have five stamens viz., 1. Stamens having upright filament and 2. Those in which the filaments are bent backwards and downwards soon after the cap fall. Petals and sepals are (five in number) fused and during anthesis the petals detach from the base forming a cap like structure called 'calyptra'. Anthesis starts early in the morning and continues beyond 5.00 p.m., the peak between 6.00 to 10.00 a.m. The time taken for completion of anthesis varies from half a minute to one day, depending upon the variety, temperature etc. Stigmatic receptivity has been characterized by the presence of sugary secretion on the stigma, giving it a bright appearance. Once the stigmatic surface dries, it becomes black, indicating the loss of receptivity. Stigma becomes receptive one day prior to anthesis and remains so, a day after, with maximum receptivity on the day of anthesis.

Hybridization Since most hermaphrodite vines are self-fertile, the buds must be emasculated for making desired crosses. Many female flowered vines, characterized by reflexed anthers and absence of germ pores in pollen, have complete pollen sterility and such male sterile line can be used to do away with the tedious process of emasculation. The calyptra (corolla), which is made up of five greenish petals, is united at the tip. Hence, the grape flower does not open from the tip, instead the calyptra become detached at the base and develops as a little cap at the time of blooming. This point should be taken into account, while doing emasculation or preparing a flower for hybridization programme. In practice, if a cross is to be made between varieties A x B, the following steps must be taken. Self-fertilization of variety 'A' must be prevented by doing emasculation. To begin with, the calyptra is carefully lifted with a pair of forceps exposing the stamens, stigma etc. Later, the stamens are gently removed before the pollen has been shed, several days before the flowers begin to open. Good number of flowers should be emasculated and the remaining flowers in the cluster are plucked off. Pollen from variety 'B' is then dusted over the pistils of variety 'A'. It is also necessary to have the clusters of variety 'B' bagged to

avoid contamination. Pollen may be collected in a vial or the entire cluster (pollen source) can be cut off for dusting. The treated cluster is then enclosed on a paper bag and tightly secured. Good germination of hybrid seed is the prime requisite in grape breeding programme to raise a large population for evaluation. In North India, a period of over 20 months is required to obtain transplantable seedlings of hybrids mainly because of seed dormancy and slow growth of seedlings. Grapes seeds are normally extracted manually from ripe berries and are stratified at 40C for 75 to 90 days before sowing to break the dormancy. Sand is proved to be a better medium than moss for keeping seeds for stratification.

ONION *Allium cepa* var. *cepa* *Allium cepa* var. *aggregatum* Family :Alliaceae Hybridization In onion, inflorescence is terminal umbel when flowering starts, umbels are covered with a butter paper bag. For emasculation, umbels having maximum buds at the emasculation stage are selected. Open flowers are removed and flower buds are emasculated in the usual manner and when a sufficient number of flowers are emasculated, the remaining small buds are removed.

AMARANTHUS *Amaranthus* sp Family :Amaranthaceae Floral biology Flowers are monoecious and the inflorescence is a branched compound spike, erect or pendulous, the spike is made up of a number of cymes. Each flower has 3-5 small bracteoles, male flowers with 3-5 stamens; female flowers with 2-3 styles and stigma. Flowers are protogynous; stigma becomes receptive several days before opening of staminate flowers. Dehiscence of anthers and release of pollen grains are maximum between 11 AM or 1 PM. Hybridization technique Arrangements and sequence of anthesis favours a combination of self and crops pollination. Maturation of flowers takes place from bottom to top. For crossing programme, only those flowers which are positioned in the middle portion of the inflorescence are selected. Male flowers which are situated above the middle portion are removed and are covered by a butter paper bag. Pollen is collected from the male parent and is crossed between 10-11 am for maximum seed set.

ANNUAL MORINGA *Moringa pterygosperma* Family : Moringaceae. Floral biology Anthesis has been reported to commence as early as 4.30 AM and continue till 6.30 AM peak. Observed at 5.30 A.M In another report the anthesis was found to be from 5 to 9 hrs. In association with temperature range of 27.3 to 29.20C and RH 68 to 78%. At Horticultural College and Research Institute, Periyakulam the anthesis was reported to commence as early as 2.30 AM and continue till 7.00 AM peak being 5.40 AM. Anthesis was irregular. However no flower was found to open after 7.00AM. The anther dehiscence starts around 4.00 AM and continues upto 6.30 AM the peak at 5.30 to 5.45 AM. In anther of longest stamen dehisces first followed by the stamens in the descending order of filamental length. At full maturity the anthers are greenish yellow and after dehiscence they turn to pale colour. On an average each anther has 7400 pollen and the diameter of each pollen measures 5-4 microns. The stigma becomes receptive a day prior to opening of flowers and continues to be receptive on the day of opening. The receptivity is lost on the next day of anthesis too. The flowers are good source of nectar and hence the pollination was predominantly by honeybees. Cross-pollination yields good fruit set and seed set than self-pollination. The pollen viability is 72% at anther dehiscence. Pollens stored beyond 66 hours were unable to germinate. By hand pollination using fertile pollens there was even 100 percent set. But under natural condition the fruit setting ranges from 11-15% depending upon the seasons.

Hybridization Techniques The flowers of same parent, which are going to open in next day, should be emasculated in the evening and bagged with butter paper cover next day morning pollen grains are collected and dusted on the emasculated flowers of female parent between 6.30-8.30 AM and immediately covered with butter paper cover. Flowers are again dusted in the next day morning for effective fruit setting. The paper covers are removed 45 days after pollination

Breeding Fruits and vegetables Crops

MANGO

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Citrus sp. Family :Rutaceae Floral biology Flowers are produced on current season growth in cymes, both axillary and terminal position. Two types of flowers, perfect and imperfect are found. The flowers are white in colour in most of the species except lemon and citron where they are purplish on the outside. Flower opening, starts from morning and extends up to evening but maximum anthesis is between 11.00 a.m. to 12.00 noon. The viability of pollen grains varies from 45-80% depending upon the season. The dehiscence of anthers takes place there 45 minutes before anthesis or within 45 minutes after anthesis. It varies up to 5 hours after anthesis. The receptivity of stigma starts either 15 minutes to 2 hours before anthesis or within 35 minutes to 5 hours after anthesis depending upon weather. The receptivity lasts for 4-8 days after anthesis. Hybridization Technique The mature flower buds on the female parent are emasculated early in the morning on the day of opening and are bagged. The flowers to be used as male parent are bagged the previous evening. The next morning as the day warms up; the anthers dehisce releasing the pollen grains when these flowers can be plucked to pollinate the receptive stigmas of emasculated flowers. The pollinated flowers are bagged, opened after about a week and allowed to mature into ripe fruits. In some cases, especially when the trifoliolate orange is used as male parent, difficulties are encountered as its flowering is over before other citrus varieties flower. Therefore, pollen has to be stored at low humidity and temperature. Seeds from mature fruits are extracted and sown immediately in sterilized sand and soil Breeding of Field & Horticultural Crops www.AgriMoon.CoM mixture. When seedlings are about 15 cm high, hybrid seedlings are identified. Particularly those showing some morphological characters of male parent and others are rejected. Electrophoresis methods can also be employed for identification of zygotic seedlings. Identification of hybrid seedlings having P. trifoliolate as male parent is easily done by looking for trifoliolate character. The hybrid seedlings parent is easily done by looking for trifoliolate character. The hybrid seedlings are grown to mature trees in the field and the

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ONION

Allium cepa var. *cepa* *Allium cepa* var. *aggregatum* Family :Alliaceae Hybridization In onion, inflorescence is terminal umbel when flowering starts, umbels are covered with a butter paper bag. For emasculation, umbels having maximum buds at the emasculation stage are selected. Open flowers are removed and flower buds are emasculated in the usual manner and when a sufficient number of flowers are emasculated, the remaining small buds are removed.

AMARANTHUS

Amaranthus sp Breeding of Field & Horticultural Crops www.AgriMoon.CoM Family :Amaranthaceae Floral biology Flowers are monoecious and the inflorescence is a branched compound spike, erect or pendulous, the spike is made up of a number of cymes. Each flower has 3-5 small bracteoles, male flowers with 3-5 stamens; female flowers with 2-3 styles and stigma. Flowers are protogynous; stigma becomes receptive

several days before opening of staminate flowers. Dehiscence of anthers and release of pollen grains are maximum between 11 AM or 1 PM. Hybridization technique Arrangements and sequence of anthesis favours a combination of self and cross pollination. Maturation of flowers takes place from bottom to top. For crossing programme, only those flowers which are positioned in the middle portion of the inflorescence are selected. Male flowers which are situated above the middle portion are removed and are covered by a butter paper bag. Pollen is collected from the male parent and is crossed between 10-11 am for maximum seed set.

ANNUAL MORINGA

Moringa pterygosperma Family : Moringaceae. Floral biology Anthesis has been reported to commence as early as 4.30 AM and continue till 6.30 AM peak. Observed at 5.30 A.M In another report the anthesis was found to be from 5 to 9 hrs. In association with temperature range of 27.3 to 29.20C and RH 68 to 78%. At Horticultural College and Research Institute, Periyakulam the anthesis was reported to commence as early as 2.30 AM and continue till 7.00 AM peak being 5.40 AM. Anthesis was irregular. However no flower was found to open after 7.00AM. The anther dehiscence starts around 4.00 AM and continues upto 6.30 AM the peak at 5.30 to 5.45 AM. In anther of longest stamen dehisces first followed by the stamens in the descending order of filamental length. At full maturity the anthers are greenish yellow and after dehiscence they turn to pale colour. On an average each anther has 7400 pollen and the diameter of each pollen measures 5-4 microns. The stigma becomes receptive a day prior to opening of flowers and continues to be receptive on the day of opening. The receptivity is lost on the next day of anthesis too. The flowers are good source of nectar and hence the pollination was predominantly by honeybees. Cross-pollination yields good fruit set and seed set than self-pollination. The pollen viability is 72% at anther dehiscence. Pollens stored beyond 66 hours were unable to germinate. By hand pollination using fertile pollens there was even 100 percent set. But under natural condition the fruit setting ranges from 11-15% depending upon the seasons. Hybridization Techniques The flowers of same parent, which are going to open in next day, should be emasculated in the evening and bagged with butter paper cover next day morning pollen grains are collected and dusted on the emasculated flowers of female parent between 6.30-8.30 AM and immediately covered with butter paper cover. Flowers are again dusted in the next day morning for effective fruit setting. The paper covers are removed 45 days after pollination.