Lecture 4: Cross Pollination and Plant Breeding Tool requirements

Cross Pollination

Cross-pollination, also called **heterogamy**, type of pollination is the transfer of pollens from the anthers of a flower to the stigma of another flower of the same or a different plant of the same species. Cross-pollination always requires a pollinator and it facilitates cross-fertilization and outbreeding. This movement of pollen may occur by biotic (animals, birds, insects) and abiotic (wind) factors.

There are two types of cross-pollination as follow:

1. When pollen is transferred to a flower of the same plant, cross-pollination is equivalent to self-pollination. It tends to **decrease** the chances of genetic variation in the crop.
2. The other type of cross-pollination takes place when pollen from the flower of one plant is transferred to a flower of another plant of either the same or a different variety. This type of cross-pollination **increases** the chances of genetic variation.

Cross-pollination occurs if:

1. **flowers are unisexual** also called incomplete flowers are appear on either the same or different plants (for example, the pumpkin has male and female flowers on the same plant and kiwi fruit has male and female flowers on separate plant).

2. **Anthers and stigma are mature at different times**, for example, onion and tree fruits such as peaches and almonds.

3. **Anthers and stigma are physically excluded**, i.e., they are present at different heights, for example, sunflower.
4. **Plants are self-incompatible** (flowers are not fertilized by the pollen of the same variety); for example, many varieties of apples, almonds, and pears. Self-incompatibility pollen will not germinate on genetically similar individuals which promotes cross breeding.

The importance of cross-pollination

When compared to self-pollination, cross-pollination clearly has certain evolutionary advantages:

1- Cross-pollination is important for **fruit and seed production** in plants that produce unisexual flowers; for example, species belonging to the family Cucurbitaceous.
2- Cross-pollination increases or **enhances the yield and quality** of many self-pollinated crops. A dramatic demonstration of this effect is found with hybrid corn (maize), a superior product that results from cross-breeding of several especially bred lines.
3- In a changing environment, the genetic variability within a cross-pollinated population may enable some individuals to be adapted to their new situation, ensuring survival of the species, whereas the individuals resulting from self-pollination might all be unable to adjust.

The agents (Pollinators) of cross-pollination

Self-pollinated plants are pollinated automatically when receptive stigmas come into contact with freshly released pollens from the same flower. However, many plants are not pollinated automatically. Such crops need external agents (pollinators) to help them to transfer pollens. A pollinator is anything that helps carry pollen from the male part of the flower (stamen) to the female part of the same or another flower (stigma). Two types of pollinating agents occur in nature: **abiotic** and **biotic**.

1) **Abiotic pollinating agents**

Good examples of abiotic pollinating agents are wind, water, and gravity. This type of pollination is random and not reliable.

a) Wind. It is also called **anemophily.** Many crop plants are successfully pollinated by wind, especially those that produce **dry pollen**; for example, grain crops such as wheat, rice, maize, and nuts such as chestnut, pecan nut, and walnut. Wind-pollinated plants have specific characteristics include **reduced leaf-surface area**, **exposed flowers**, **reduced perianth (sepals and petals)**.

Meanwhile there is no need to attract biotic pollinating agents, long stamens and sometimes explosive anther dehiscence (pollen release), production of large amounts of pollen, smooth and dry pollen grains, winged pollen grains, balloon-shaped pollen grains, lack of nectar and nectarines, and flowers without colour or scent.

b)Water. Water pollination, also called **hydrophily**, is only found in some water plants, for example, Trapa. Inflorescences (flowering branches) float on the water or are submerged. Many fresh water plants produce flowering branches that are raised into the air (aerial inflorescence).

c)Gravity. It is also called **geophily**. It is found in self-pollinated crop plants. In this case, pollen falls because of gravity on to receptive stigma of other flowers. However, gravity is highly unreliable and a rare and insignificant pollinating agent.

2) **Biotic pollinating agents**

Biological pollination agents (biotic agents) include insects, birds, and various mammals.

Biological pollination is also called **zoophily**. Animals visit flowers for nectar and/or pollen, and they intentionally (searching for food like bees) or accidentally (visiting the flower for their attractive colors or other purposes like butterflies or other animals) transfer pollen grains from one flower to another flower of the same or another plant.

a. Birds. Pollination by birds, called **ornithophily**, some birds visit flowers of a particular plant species for nectar, and so pollinate them. These pollinating agents visit only those few crop plants that produce plenty of nectar, for example pineapple are visited by humming birds.

b. Mammals. Certain mammals - Queensland blossom bat, short-nosed fruit bat, honey possum, and Namaqua rock mouse - visit flowers of a particular plant species for nectar, and so pollinate them. Mammals are, however, the pollinating agents of only a few plants.

c. Insects. Insect pollination, also called **entomophily**, is found in many agricultural and horticultural crops.

Different kinds of insects such as bees, flies, beetles, butterflies, moths and wasps are important pollinators of many plants. Crops that require insect pollination to set fruit and seed are called **entomophilous**.

Characteristics of crop plants that are pollinated by biotic agents include:

1. The production of relatively small amounts of pollen.
2. Pollen grains that vary in size and external sculpture and are sticky in nature.
3. The production of flowers of attractive colours and odours, and Flowers that have nectaries that produce nectar.

Mechanism promoting self-pollination

1. Bisexuality. Presence of male and female organs in the same flower is known as bisexuality. The presence of bisexual flowers is a must for self pollination. All the self pollinated plants have **hermaphrodite** flowers.

2. Homogamy. Maturation of anthers and stigma of a flower at the same time is called homogamy. As a rule, homogamy is essential for self-pollination.

3. Cleistogamy. When pollination and fertilization occur in unopened flower bud, it is known as cleistogamy. It ensures self pollination and prevents cross pollination. Cleistogamy has been reported in some varieties of wheat, barley, oats and several other grass species.

4. Chasmogamy. Opening of flowers only after the completion of pollination is known as chasmogamy. This also promotes self pollination and is found in crops like wheat, barley, rice and oats.

5. Position of Anthers. In some species, stigmas are surrounded by anthers in such a way that self pollination is ensured. Such situation is found in tomato and brinjal. In some legumes, the stamens and stigma are enclosed by the petals in such a way that self pollination is ensured. Examples are greengram, blackgram, soybean, chickpea and pea.

Mechanism promoting cross-pollination

1. Dicliny. It refers to unisexual flowers. This is of two types: viz. i) monoecy and ii) dioecy. When male and female flowers are separate but present in the same plants, it is known as **monoecy**. In some crops, the male and female flowers are present in the same inflorescence such as in mango, castor and banana. In some cases, they are on separate inflorescence as in maize. Other examples are cucurbits, grapes, strawberry,

cassava and rubber. When staminate and pistillate flowers are present on different plants, it is called **dioecy**. It includes papaya, date palm, spinach, hemp and asparagus.

2. Dichogamy. (from the Greek *dikho*-apart and *gamous*-marriage) It refers to maturation of anthers and stigma of the same flowers at different times. Dichogamy promotes cross pollination even in the hermaphrodite species. Dichogamy is of two types: viz. i) protogyny and ii) protandry. When pistil matures before anthers, it is called **protogyny** such as in pearl millet. When anthers mature before pistil, it is known as **protandry**. It is found in maize, sugarbeet and several other species.

3. Heterostyly. When styles and filaments in a flower are of different lengths, it is called heterostyly. It promotes cross pollination, such as linseed.

4. Herkogamy. Hinderance to self-pollination due to some physical barriers such as presence of hyline membrane around the anther is known as herkogamy. Such membrane does not allow the dehiscence of pollen and prevents self-pollination such as in alfalfa.

5. Self incompatibility: The inability of fertile pollens to fertilize the same flower is referred to as self incompatibility. It prevents self-pollination and promotes cross pollination. Self incompatibility is found in several crop species like*Brassica*, *Radish*, *Nicotiana,* and many grass species. It is of two types **sporophytic** and **gametophytic**.

6. Male sterility: In some species, the pollen grains are non functional. Such condition is known as male sterility. It prevents self-pollination and promotes cross pollination. It is of three types: viz. **genetic, cytoplasmic** and **cytoplasmic genetic**. It is a useful tool in hybrid seed production.

Study of **floral biology** and aforesaid mechanisms is essential for determining the mode of pollination of various crop species. Moreover, if selfing has adverse effects on seed setting and general vigour, it indicates that the species is cross pollinated. If selfing does not have any adverse effect on these characters, it suggests that the species is self-pollinated.

The percentage of cross pollination can be determined by growing a seed mixture of two different varieties together. The two varieties should have marker characters say green and pigmented plants. The seeds are harvested from the recessive (green) variety and grown next year in separate field. The proportion of pigmented plants in green variety will indicate the percentage of **outcrossing** or cross pollination.

Classification of crop plants based on mode of pollination and mode of reproduction

Mode of pollination and reproduction	Examples of crop plants
A. Autogamous Species	
1. Seed Propagated	Rice, Wheat, Barley, Oats, Chickpea, Pea, Cowpea, Lentil, Green gram, Black gram, Soybean, Common bean, Moth bean, Linseed, Sesame, Khesari, Sunhemp, Chillies, Brinjal, Tomato, Okra, Peanut, etc.
2. Vegetatively Propagated	Potato
B. Allogamous Species	
1. Seed Propagated	Corn, Pearlmillet, Rye, Alfalfa, Radish, Cabbage, Sunflower, Sugarbeet, Castor, Red clover, White clover, Safflower, Spinach, Onion, Garlic, Turnip, Squash, Muskmelon, Watermelon, Cucumber, Pumpkin, Kenaf, Oilpalm, Carrot, Coconut, Papaya, etc.
2. Vegetatively propagated	Sugarcane, Coffee, Cocoa, Tea, Apple, Pears, Peaches, Cherries, grapes, Almond Strawberries, Pine apple, Banana, Cashew, Irish, Cassava, Taro, Rubber, etc.
C. Often Allogamous Species	Sorghum, Cotton, Triticale, Pigeonpea, Tobacco.

Breeding Tools for the Cross Pollination:

1) **Magnifying glass** (10 or 15 power) use to identify flower parts as quick as possible. The breeder uses this all the time when determining sex of the flower, identifying pests, looking at flower parts in detail, just being curious etc. Every plant grower should have a magnifying lens.
2) **Tweezers** use to manipulate small flower parts, or use to pollinate if you pluck the whole stamen.
3) **Small sharp-pointed scissors** use to manipulate small flower parts, such as to clip immature anthers on the seed parent.

4) **Small paint brush** use to apply pollen grains to the stigma. Note that the brush should be made from animal hair not plastic, for example Camel hair brush would be great.
5) **Small containers or vials** use to collect pollen. Petri dishes can be used, they are large so pollen is easily collected and get at when you are pollinating. They are also easy to label and store in the refrigerator to use over several days. If you sterilize the dishes after use, this may be enough for a lifetime.
6) **Alcohol** to sterilize equipment and remove foreign pollens before doing another cross.
7) **Rubber bands or soft wire** to tie shut flowers or tie paper bags onto branches.
8) **Paper bags** use for pollination and/or to prevent flowers from being pollinated by unwanted pollens before you choose to pollinate.

9) **Tags** use to label the plants by type or trait. You can buy tags or use tape or write right on the pots with a permanent marker (Scratch out last times information if you reuse your pots).
10) **Notebook** it is necessary to keep track of the parents and their traits so you should take notes, even if it is just a few symbols to help you remember things like DATE PLANTED or POTTED UP DATE or FIRST FLOWER DATE or size (height), branching pattern, time until maturity, or any traits you are trying to breed. The minimum you should record if you are serious about breeding is the **DATE of POLLINATION** and **the number of seeds harvested** and most important thing is **DATE of HARVESTING SEEDS**.

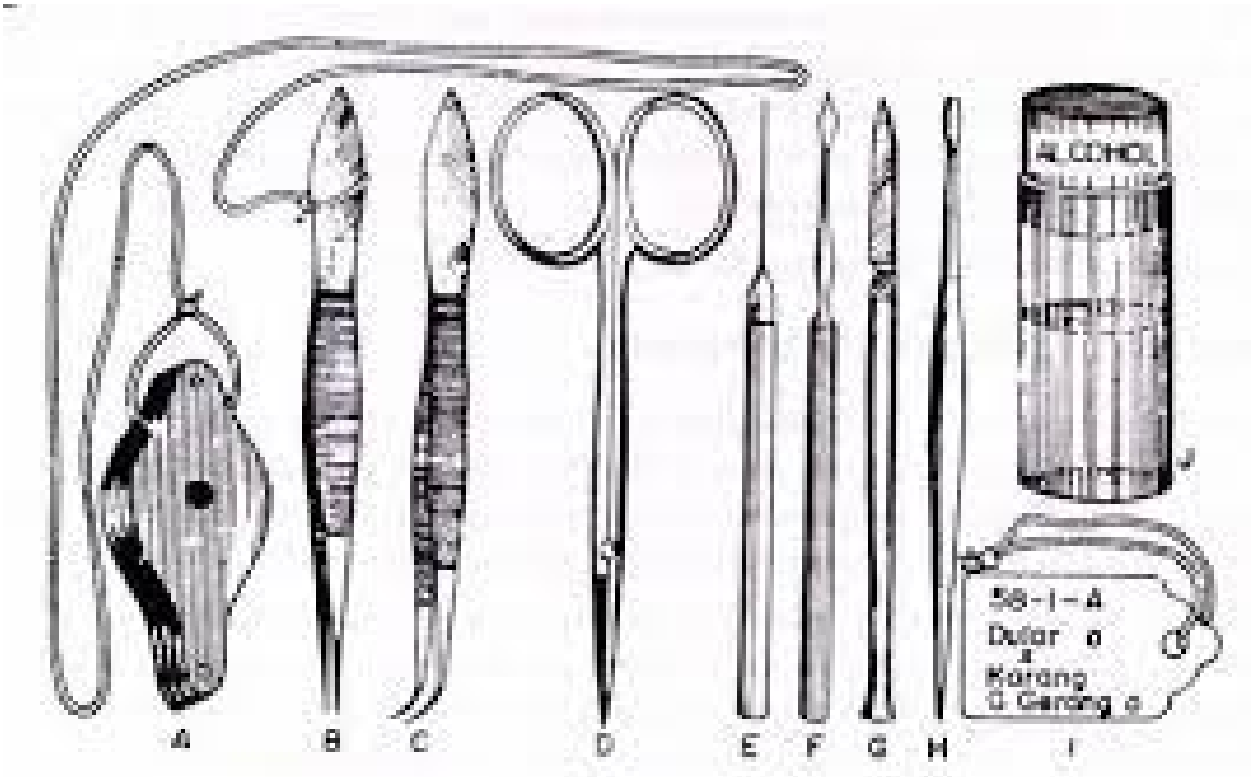

Fig. 4.1 : Plant breeding kit : (A) Magnifying glass, (B & C) Forceps, (D) Scissors, (E & F) Needles, (G) Scalpel, (H) Brush, (I) Level, (J) Alcohol tube