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|  |  | |  |  | | --- | --- | | **PBG-202** |  | |  | | |  | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | **C:\Users\SHEZI\Desktop\CONFERENCE ROUGH\New Picture.bmp** **INTRODUCTORY**  **PLANT**  **BREEDING**  **C:\Users\SHEZI\Desktop\CONFERENCE ROUGH\University-of-Sargodha-logo.jpg**  **Muhammad Shehzad Adil**  [Muhammad.shehzad@uos.edu.pk](mailto:Muhammad.shehzad@uos.edu.pk)  +92-312-746-0-746 |  |   **Reproduction** in crop plants may be by seeds, *sexual*, or by vegetative parts, *asexual*. In **sexual reproduction** specialized reproductive cells called *gametes* are formed, a process known as *gametogenesis*. Fusion of the male and female gametes leads to the development of an embryo and eventually the seed. Crop plants such as corn, wheat, rice, soybean, tomato, or common bean normally reproduce sexually and are multiplied from seeds  In **asexual reproduction** new plants arise from specialized vegetative organs such as tubers, rhizomes, runners, bulbs, corms, or by various artificial means of propagation such as rooting of plant cuttings, grafting, layering, or tissue culturing. Crops such as sugarcane, potato, bermudagrass, or cassava may reproduce sexually but are normally propagated asexually for commercial use.  ***KINDS OF FLOWERS*** |  |  |
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|  | ***Complete*** flowers contain all four floral organs (sepals, petals, stamens, pistil),  ***Incomplete***, flowers are lacking one or more of these floral organs.  Complete flowers are borne on cotton, tobacco, rape, potato, cowpea, soybean, common bean, tomato, clovers, alfalfa, cabbage, and many other field and vegetable crop plants (Fig. 2.2A, B, C, and D). Flowers of buckwheat and sugarbeet are incomplete lacking petals and sepals. Crops belonging to the grass family, including corn, sorghum, millet, wheat, triticale, barley, oat, sugarcane, rice, forage grasses, and turf grasses, have incomplete flowers in which petals and sepals are lacking. |  |
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|  | ***Perfect*** flowers are bisexual, bearing stamens and a pistil in the same flower structure, but one of these essential organs is absent in ***Imperfect*** or unisexual flowers. Most crop plants have perfect flowers, for example, wheat, oat, barley, rye, rice, sorghum, cotton, flax, potato, tobacco, sugar beet, sugarcane, soybean, common bean, tomato, common forage and turf grasses, and forage legumes. Imperfect flowers may be *staminate*, bearing stamens but no pistil, or *pistillate*, bearing a pistil but without stamens. The corn plant has staminate flowers in the tassel and pistillate flowers on the shoot. In castor and wild rice, pistillate flowers are commonly borne in the upper portion of the floral structure and staminate flowers in the lower portion. Crop plants in which staminate and pistillate flowers are borne on the same plant, as in corn, cassava, squash, or castor, are ***monoecious*** (Fig. 2.4); plants in which the staminate and pistillate flowers are borne on different plants are *dioecious* (Fig. 2.5A and B). Hemp, hops, buffalograss, papaya, and asparagus are species with dioecious flowers, although occasional hemp or papaya plants may produce monoecious flowers. Imperfect flowers are always incomplete. Some incomplete flowers, such as occur in the grasses or in buckwheat, are perfect because both the stamens and a pistil are present in the same flower although petals or sepals may be missing.  **FLORAL MODIFICATIONS**  **Bisexual flower**  Flowers which have both sexes  **Unisexual**  Flowers having only one sex e.g tessel of maize plant  Unisexual flowers are further divided into monoecious and dioecious  **Monoecious:** two different kinds of flowers pistilate and staminate flowers are present on the same plants at different locations  **Dioecious:** male and female flowers (pistilate and staminate flowers) are present on different plants. Hence these plants are named as male and female plants. E.g. date palm.  **Hermaphrodite flower**  Both male and female reproductive parts e.g stamen and pistil are present in the same flower of the plants.  Hermaphrodite plants are subdivided into following categories   |  |  |  | | --- | --- | --- | | **Dichogamous**  Stamens and pistil mature at different times | **Homogamous**  Stamen and pistil mature at the same time | **Heterogamous**  Self-pollination is impossible due to relative position of stamen and pistil | | 1. **Protandrous**   Stamen mature first than stigma | **a-Cleistogamous**  First pollination occurs then flower opens e.g cotton and barley | **a-Homostylus**  same length of stamen and pistil but direction may be opposite | | 1. **Protogynous**   Stigma matures first than the stamen | **b-Chasmogamous**  First flower opens then pollination occur | **b-Hetrostylus**  Stamen and pistil are of different length. Usually stamen is in reduced form |   Plants can be self-pollinated **(Autogamous)**  Transfer of pollen grain from the stamen of a flower to the stigma of same flower  Or they can be cross pollinated **(Allogamous)**  Transfer of pollen grain from the stamen of a flower to the stigma of some other flower of different genotype.  Pollination is completed in different ways so types of pollination is named accordingly  **ENTMOPHILOUS:** Pollination is carried out with the help of insects **ANIMOPHILOUS:** Pollination is carried out with the help of wind **HYDROPHILOUS:** Pollination is carried out with the help of water **ZOOPHILOUS:** Pollination is carried out with the help of animals |  |
| |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | **Chromosome number of some cultivated crop species** |  | |  | | | |  | | | | | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | **Crop name** |  | |  | | | |  | | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | **Species name** |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | **Diploid (2*n*)**  **chromosome number** |  | |  | | | |  | | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | **Cereal crops** |  | |  | | | |  | | | | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Barley |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Hordeurn vulgare* L. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 14 |  | |  | | | |  | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Corn (maize) |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Zea mays* L. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 20 |  | |  | | | |  | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Millet, finger (ragi) |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Eleusine coracana* (L.) Gaertn. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 36 |  | |  | | | |  | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Millet, pearl (bajra) |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Pennisetum glacum* (L.) R.Br. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 14 |  | |  | | | |  | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Oat |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Avena sativa* L. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 42 |  | |  | | | |  | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Rice |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Oryza sativa* L. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 24 |  | |  | | | |  | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Sorghum |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Sorghum bicolor* (L.) Moench |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 20 |  | |  | | | |  | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Wheat, bread |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Triticum aestivum* L. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 42 |  | |  | | | |  | | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | **Fiber crops** |  | |  | | | |  | | | | |  |  | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Cotton, American upland |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Gossypium hirsutum* L. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 52 |  | |  | | | |  | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Jute |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Corchorus capsularis* L., *C. olitorius* L. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 14 |  | |  | | | |  | | | | | | | | |
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Coss. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 36 |  | |  | | | |  | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Peanut (groundnut) |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Arachis hypogaea* L. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 40 |  | |  | | | |  | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Safflower |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Carthamus tinctorius* L. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 24 |  | |  | | | |  | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Soybean |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Glycine max* (L.) Merr. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 40 |  | |  | | | |  | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Sunflower |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Helianthus annus* L. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 34 |  | |  | | | |  | | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | **Pulse crops** |  | |  | | | |  | | | | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Chickpea (gram, garbanzo) |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Cicer arietinum* L. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 16 |  | |  | | | |  | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Cowpea |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Vigna unguiculata* (L.) Walp. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 22 |  | |  | | | |  | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Mungbean (green gram) |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Vigna radiata* (L.) Wilczek |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 22 |  | |  | | | |  | | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | **Root crops** |  | |  | | | |  | | | | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Potato |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Solanum tuberosum* L. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 48 |  | |  | | | |  | | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | **Stimulant crops** |  | |  | | | |  | | | | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Tobacco |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Nicotiana tabacum* L. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 48 |  | |  | | | |  | | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | **Sugar crops** |  | |  | | | |  | | | | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Sugar beet |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Beta vulgaris* L. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 18 |  | |  | | | |  | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Sugarcane |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Saccharum officinarum* L. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 80 |  | |  | | | |  | | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | **Vegetable crops** |  | |  | | | |  | | | | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Cabbage |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Brassica oleracea* L. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 18 |  | |  | | | |  | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Onion |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Allium cepa* L. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 16 |  | |  | | | |  | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Pepper |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Capsicum annuum* L. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 24 |  | |  | | | |  | | | | |  | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Tomato |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | *Lycopersicum esculentum* Mill. |  | |  | | | |  | | | | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | 24 |  | |  | | | |  | | | | | | | | |

**SYNCHRONIZATION IN FLOWERING**

Male and female flowers may not mature at the same time. If the flowering time of male and female flower is different there is a need to synchronize flowering. Various methods are used to make male and female plants flower at the same time and that the flowers are available for a comparatively longer time to make maximum crossing. They are listed as under:

* 1. Sowing of different lines is repeated after a period of week or more
  2. Pruning helps delay flowering
  3. High temperature helps hasten flowering and low temperature delays flowering
  4. Application of nitrogen fertilizer delays flowering
  5. Day length can be exploited to delay or hasten flowering

**METHODS OF MASS EMASCULATION**

1. High temperature treatment helps killing the male gametes
2. Growth hormones like GA3 (Gibberelic Acid) kill male gametes. commercial gametocides are also available with different brand names but have limited advantage
3. Protogynous condition could be exploited as in millets
4. Reproductive systems like male sterility, self-incompatibility, and apomixes are also used for mass emasculation.

**SELFING AND CROSSING TECHNIQUES**

**MAIZE**

*Zea mays L.*

**Equipment**

A pair of scissors, camel hair brush, craft paper bag, butter paper bag (7'x3’), Petri dish. methylated spirit, Tag and lead pencil.

**Procedure**

Maize is naturally cross pollinated crop. Staminate flowers are produced on the tassel and pistillate on the shoot. Pollen shedding starts one to three days before appearance of silks and generally continues for many days. Pollen may remain viable for 18-24 hours under favorable conditions.

**Selfing**

1. Select the desirable plant and cover the tassel (male flowers) of plant with Kraft paper bag (14” x 11”) before the opening of anthers.
2. Bag the ear shoot (female parts) of the same plant with butter paper bag (7"x3") before the emergence of silks.
3. Daily visit the plant and observe the appearance of silks.
4. When the silks appear collect the pollen grains from craft paper bag of by slightly shaking the tassel.
5. Place the pollen grains in the Petri dish.
6. Remove the Kraft paper bag from the ear shoot of the plant and dust the pollen grains with the camel hair brush on the silks of the ear shoot.
7. Again cover the ear shoot with its respective bag after pollination.
8. Pollinate each ear shoot for four or five times to ensure good seed setting.
9. If the silks grow longer during pollination days. Cut them down to a one-inch length with a pair of scissors to facilitate easy pollination.
10. Leave the bag on the ear shoot till seed setting to avoid contamination with unwanted pollen grains.
11. Sterilize your instruments and hands with methylated spirit before moving to the other pollinations.

**Labelling**

Tag the plant, indicating the name of the cross, date of pollination and your signature. Write the-female parent first and then the name of the pollen parent (male). Always use lead Pencil as it is water proof and will, not be damaged during rains or due to dew.

**Crossing**

To make a cross between the two varieties, A and B proceed as follows.

1. Treat “ the variety A as female parent and select a desirable plant.
2. Remove the tassel (detassel) with a pair of scissors and cover the ear shoot with a butter paper bag (7"x3"), before the silk have appeared.
3. Use the variety B as the male parent and select the desirable plant.
4. Cover the tassel with craft paper bag (14’x11") whose anthers have not yet opened.
5. Daily visit the plant and observe the emergence of silks.
6. When the silks of the variety A appear, collect the pollen grains from the variety B in Petri diSh by slightly shaking the bagged tassel.
7. Remove the butter paper bag from the ear shoot of the variety A and dust the pollen grains with a camel their brush.
8. Again place the respective bag on the ear shoot.
9. Pollinate 4-5 times to ensure good seed setting.
10. Cut the silks with a pair of scissors down to a one inch length if they have grown long during pollination days.
11. Sterilized your hands and instruments with methylated spirit after every pollination.

**Labelling**

Tag the plant, indicating the name of the cross, date of pollination and your signature. Write the-female parent first and then the name of the pollen parent (male). Always use lead Pencil as it is water proof and will, not be damaged during rains or due to dew.

**COTTON**

*Gossipium hirsutum*

**Equipment**

Forceps, pointed needle, razor, camel hair brush, soda straw tube, copper Wire #30, wax butter paper bag (3”x2"), needle and thread, methylated spirit. Tag and lead pencil, acetone or any adhesive material.

**Procedure**

Cotton is an often cross pollinated crop. The first flower to open is low on the plant and near the main axis, the succession being centrifugal and acropetal. Most of the flowers complete anthesis between 7-10 a.m. although there is a great variation in flowering time.

**Selfing**

You can self the flower in the following different ways.

1. Place a rubber band around the unopened large size floral bud of a desirable plant in the evening to prevent the corolla from opening
2. Tie the bud with copper wire number 30 below the flower tip taking care that the pistil is not damaged
3. Stitch the unopened floral bud below the top of the flower with a needle and thread.
4. Loop the thread twice around the unopened bud and complete the operation by passing the needle through the bud in the direction opposite to the first.
5. Place the butter paper bag on the unopened floral bud and tie the loose end by means of a soft thread
6. Apply acetone or any other adhesive materiel like nail polish at the apex of the unopened floral bud.

**Crossing**

**Emasculation**

1. In the evening select e desirable floral bud and cut the corolla by giving e circumcision around the floral bud and near the basal side
2. Remove the stamen (male part) gently with a forceps
3. Slide a wax based soda straw tube on pistil after emasculation
4. Plug the open end of the tube with surgical cotton or turn it back
5. You can cover the emasculated bud with a butter paper bag also

**Pollination**

1. ln the evening bag the unopened desirable flowers of the male parent before anthesis.
2. Next morning collect the pollen grains in the Petri dish.
3. Dust the pollen grains with the help of a fine camel hair brush on the stigma of the emasculated floral bud after removing the soda straw tube or butter paper bag as the case may be.
4. Pollinate between 8-10 a.m.
5. Put the respective bag or the soda straw tube after Pollination to protect it from, stray pollen contamination
6. Sterilize your hands and equipment with Methylated spirit after every pollination.

**Labelling**

Tag the plant, indicating the name of the cross, date of pollination and your signature. Write the-female parent first and then the name of the pollen parent (male). Always use lead Pencil as it is water proof and will, not be damaged during rains or due to dew.

**SORGHUM**

*Sorghum bicolor*

**Equipment**

A pair of scissors. forceps, fine pointed needle, thermometer, Hot water container, rubber bladder, camel hair brush, Petri dish, methylated spirit, lead pencil and tag

**Procedure**

Sorghum is an often cross pollinated crop. Blooming starts in the upper most panicle branch and progresses downward. All the flowers in a panicle bloom Within 6-9 days. Pollen of sorghum loses its viability very rapidly. The stigma is receptive ‘1-2 days before the opening of flower and continues to be receptive for 8-16 days after blooming.

**Selfing**

Cover the panicle with a Kraft paper bag before the opening of flowers. Mere bagging of the panicle will result in self-pollination, avoid foreign pollen contamination.

**Crossing**

**Emasculation**

You can use two methods for emasculation.

**i. Hand Emasculation**

1. In the evening, visit field and select a desirable plant
2. Retain 8-15 florets on a panicle and clip off the rest with the help of a pair of scissors.
3. Cut off 1/3 of the upper portion of the floret very carefully
4. Open the glumes of the floret very gently with a fine pointed needle and forceps by holding the floret with thumb and the fore-finger
5. Remove the anthers very gently with a forceps. taking care the pistil is not damaged
6. Cover me panicle with Kraft paper bag.

**ii-Hot Water Emasculation**

1. Select the panicle whose flowers are not yet opened-
2. Place a large rubber bladder on the panicle and tie it with the peduncle by a jute twine (seba).
3. Punch the bladder on one side near the mouth.
4. Insert the centigrade thermometer in the mouth of the bladder
5. Heat the water in the container on the stove.
6. Take the hot water from the container and pour it into the bladder through the punched hole
7. Let the panicle remain dipped in the hot water with a temperature ranging from 42-48 C for about ten minutes
8. Keep an eye on the thermometer
9. Maintain the prescribed temperature by adding the hot or cold water
10. Remove the bladder from panicle after exposing the panicle to a desirable temperature
11. Cover the panicle with a Kraft paper bag. The pollen is killed with the hot water treatment

**Pollination**

1. In the evening bag the panicle of the male parent before anthesis with a Kraft paper bag
2. Next morning collect the pollen grains from the bagged plant and place them in the petri dish
3. Dust the pollen on the emasculated floret with the camel hair brush after removing the Kraft paper bag or place the mature anther within the emasculated floret
4. Again cover the panicle with the respective bag
5. Sterilize your hands and equipment with Methylated spirit after every pollination.

**Labelling**

Tag the plant, indicating the name of the cross, date of pollination and your signature. Write the-female parent first and then the name of the pollen parent (male). Always use lead Pencil as it is water proof and will, not be damaged during rains or due to dew.

**WHEAT**

*Triticum aestivum*

**Equipment**

A pair of scissors, pointed forceps, needle, magnifying lens, camel hair brush, Petri dish, methylated spirit, butter paper bag (4” x 2”) tag and lead pencil.

**Procedure**

Wheat is a naturally self- pollinated crop. Anthesis first begins above the middle of the spikelet and move both upward and downward. The Upper Spikelet’s are last to bloom. Generally, a wheat spike completes anthesis 2-3 days after first anther appears.

**Selfing**

As wheat is a naturally self-pollinated crop. To avoid even the slightest chances of foreign pollen contamination, cover the spike With a butter paper bag.

**Crossing**

***Emasculation***

1. In the evening select the desirable plant and retain only 8-15 lateral spikelets on a Spike and remove the rest.
2. Remove 3-4 florets from the base and 4-5 florets from the apex of the spike and central floret from each spikelet.
3. Clip 1/3 of the upper portion of the floret with a pair of scissors and remove the anthers before dehiscence with a fine forceps.
4. Take care that carpel is not injured
5. Cover the spike so emasculated with a butter paper bag.

***Pollination***

1. In the evening. bag the spike of male parent before opening of the anthers.
2. Next morning collect the pollen grains from the bagged male parent in a petri dish
3. Apply pollen with a soft camel hair brush on the bifid hairy stigma of the emasculated floret or place the mature anthers as such within the floret.
4. Cover the spike again with respective butter paper bag at least until fertilization.

**Labelling**

Tag the plant, indicating the name of the cross, date of pollination and your signature. Write the-female parent first and then the name of the pollen parent (male). Always use lead Pencil as it is water proof and will, not be damaged during rains or due to dew.

**RICE**

***(Oryza sativa L.)***

**Equipment**

A pair of scissors, forceps, a pair of pointed needles, magnifying lens. Camel hair brush, butter paper bag (4'x2'), black paper, petri dish, methylated spirit, thermos bottle, centigrade thermometer, stove, hot water container, tag and lead pencil.

**Procedure**

Rice is naturally self-pollinated crop. Blooming sometimes occur the same day on which a spikelet emerges above the sheath. Ordinarily the whole panicle completes anthesis in 4-7 days. Flowers in the middle of inflorescence open first and blooming progress downward and then upward. The most active period of blooming is in September and between 11:00 am. To 12 noon in October.

**Selfing**

Bag the panicle to avoid whatever little chances there are for the cross pollination.

**Crossing**

***Emasculation***

**i. Hand Emasculation**

1. in the evening, select a desirable panicle.

2. Retain only 10-20 florets on the panicle and clip off the top 1/3 portion of the floret with a pair of scissors.

3. Remove the anthers with forceps very gently so that the female parts are not injured.

4. Bag the emasculated panicle with butter paper bag.

**ii. Hot water treatment**

1 Dip the panicle in hot water at 40-44 C in the thermos bottle for about 10 minutes.

2. After the dipping remove the panicle and cover it with a butter paper bag.

**iii. Black paper bag method**

1. Cover panicle with a black paper bag
2. Next day remove the bag from the panicle and remove the protruding stamens with a fine forceps. This protrusion of stamens is brought about by the heat produced Within the black paper bag.

**Pollination**

1. ln the evening, cover the panicle of the male parent before the dehiscence of anthers with the butter paper bag.
2. Next day collect the pollen grains from the bagged male parent in the Petri dish.
3. Remove the bag of the emasculated panicle and dust the pollen grains with a camel hair brush by opening the floret with a forceps and a needle, or place the mature anther as such within the floret
4. Again cover the panicle with the respective bag.
5. Sterilize your hands and equipment with methylated spirit.

**Labelling**

Tag the plant, indicating the name of the cross, date of pollination and your signature. Write the-female parent first and then the name of the pollen parent (male). Always use lead Pencil as it is water proof and will, not be damaged during rains or due to dew.

**BARLEY**

*(Hordeum vulgare)*

**Equipment**

A pair of scissors, pointed needle, forceps, a magnifying lens, camel hair brush. Petri dish, butter paper bag (4'x2‘), methylated spirit, tag and lead pencil.

**Procedure**

Barely is a naturally self-pollinated crop. Anthesis starts usually slightly above the middle of the spike and progresses upward and downward. All the spikes on a plant complete blooming within 7-9 days. In two rowed barley, the central spikelet develop into fertile flowers, the lateral being sterile.

**Selfing**

Self-pollination in barley occurs by nature. Cover the spike with a butter bag to avoid the stray pollen contamination.

**Crossing**

***Emasculation***

* 1. In the evening, out the lateral spikelets with a pair of scissors retaining 8-15 central spikelets on a spike.
  2. Cut off 3-4 spikelets from the basal side and 4-5 florets from the apical side of the spike.
  3. Cut 1/3 upper portion of the floret with the help of a pair of scissors and remove the anthers from the spikelets before the anthesis with a fine pointed forceps and a sharp needle.
  4. Carefully handle the flower and see that the pistil does not get injured.
  5. Cover the emasculated spike with a butter paper bag.

**Pollination**

1. In the evening bag the spike of the male parent before the dehiscence of anther.
2. Next day collect the pollen grains in the Petri dish from the already bagged male parent.
3. Take the pollen grains from the Petri dish and apply to the stigma with a soft camel hair brush or place mature anther as such within the floret.
4. Cover the spike within its respective bag after pollination.
5. Sterilize your hands and instruments with methylated spirit shifting to the other pollinations.

**Labelling**  Tag the plant, indicating the name of the cross, date of pollination and your signature. Write the-female parent first and then the name of the pollen parent (male). Always use lead Pencil as it is water proof and will, not be damaged during rains or due to dew.

**OATS**

*Avena Sativa*

**Equipment**

A pair of scissors, pointed needle, forceps, a magnifying lens, camel hair brush. Petri dish, butter paper bag (4'x2‘), methylated spirit, tag and lead pencil.

**Procedure**

Oat is a highly self-pollinated crop. Anthesis begins first in the upper spikelets and generally a panicle takes 5-7 day’s to bloom completely. Best pollen is available usually just before or at the time of natural anthesis.

**Selfing**

To avoid even a little chance of cross pollination, cover the panicle with butter paper bag

**Crossing**

**Emasculation**

1. In the evening, visit the field and select the desired plant.
2. Retain a few good spikelets on the spike and cut the rest by a pair of scissors.
3. Clip off 1/3 top floret and remove the anthers by opening the floret with a fine forceps and a pointed sharp needle.
4. Cover the spike so emasculated with butter paper bag.
5. Handle the flower very gently.

**Pollination**

1. In the evening. bag the spike of the male parent before the opening of anthers.
2. Next morning collect the pollen grains in the Petri dish from the male parent already begged for the purpose.
3. Remove the bag from the emasculated floret and apply pollen grains with a soft camel hair brush on the hairy stigma or place the mature anther as such inside the floret.
4. Cover the spike again with its respective bag after pollination.
5. Sterilize your hands and instruments with methylated Spirit

**Labelling**

Tag the plant, indicating the name of the cross, date of pollination and your signature. Write the-female parent first and then the name of the pollen parent (male). Always use lead Pencil as it is water proof and will, not be damaged during rains or due to dew.