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3. Role of Pollination in Crop Improvement

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Abstract:

Pollination plays a pivotal role in plant breeding by facilitating the transfer of pollen from the male reproductive organs to the female reproductive organs of flowers.

This process leads to fertilization and the production of seeds, ensuring genetic diversity and promoting the evolution of plant species.

Through pollination, plants exchange genetic material, enhancing traits such as yield, disease resistance, and adaptation to environmental conditions. Natural and artificial pollination methods are employed by breeders to manipulate genetic combinations and create desired plant varieties.

Understanding the mechanisms and importance of pollination is fundamental for sustainable agriculture and food security.

Keywords:

Pollination, Sustainable Agriculture, Food Safety, Genetic Diversity, Seed

3.1 Introduction:

Pollination:

It is the process in plants by which pollen from the male reproductive part of a flower is transferred to the female part stigma of the same or different flower, leading to fertilization which leads to seed and fruit formation.

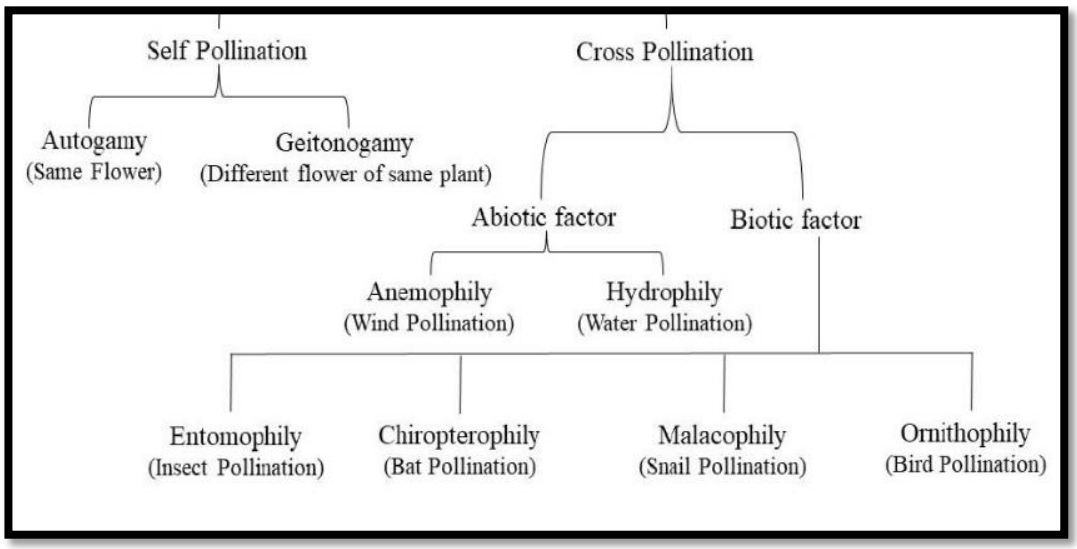

Figure 3.1: Types of Pollination

3.2 Pollination is of Two Types:

3.2.1 Self-Pollination:

It is the process in which transfer of pollen from the same flower, or from a different flower on the same plant, to the stigma of the same flower or different flower of same plant. As this process does not have transfer of genetic material between different plants, the new offspring produced have similarly or identically have same genetic make-up as to their parent plant.

A. Some Main Types of Self Pollination Are:

a. Autogamy: In this type of self-pollination the pollens are transferred from anther of same flower to the stigma of the same flower. This can take place with the help of different mechanisms:

- **Cleistogamy:** Some plants contain particular flowers that remain closed during another plant's pollination, which ultimately prevent foreign pollen from entering thus the flower self-pollinates before it opens. For example, flowers in peas and peanuts, etc.
- **Geitonogamy:** In this the pollen from one flower is fuses with the stigma of another flower in the same plant. This usually takes place with some abiotic and biotic pollinators such as wind, insects and rain etc. For example, in corn, maize etc.

b. Homogamy: It is the process in which male reproductive part and female reproductive part mature at the same time leading to self-pollination. For example, potato, tomato, wheat etc.

c. Chasmogamy: In this process flowers open, which exposes their stigma and lead to cross pollination with the help of pollinators like bees, wind and rain. Examples include, Sunflower, Hibiscus etc.

d. Cleistogamous and Chasmogamous Flowers in the Same Plant: In this type of flowers both self and cross pollination takes place, cleistogamous flowers ensures self-pollination when external pollinators are less beside chasmogamous flowers promotes cross pollination. For instance, Camelina.

e. Self-Fertile Varieties: They are also known as self-fruitful varieties, as they are capable of producing seeds without external pollinators like insects and wind. For example, cherry trees, blueberries, peppers etc.

3.2.2 Cross-Pollination:

This process involves the transfer of pollen from the male reproductive part to the female reproductive part of a different flower on a separate plant of same species. For example, Pumpkins, grapes etc.

A. Various Types of Cross-Pollination on The Basis of Pollinators:

a. Abiotic Pollination: When pollination takes place with the help of non-living pollinators such as wind and water.

Two Types of Abiotic Pollination:

- **Wind Pollination or Anemophily:** This type of pollination takes place with the help of wind in which wind carry light weight pollens and transfer them to stigma for fertilization. For example, grasses, oaks, pistachios etc.
- **Water Pollination or Hydrophily:** In this pollination the pollen grains are released into water and by floating these pollen reaches a female flower for fertilization. It usually takes place in aquatic plants. Example include, Vallisneria, hydrilla etc.

b. Biotic Pollination: Process in which pollination takes place with the help of living pollinators such as insects, bees, birds, bats etc.

Types of Biotic Pollination:

- **Insect Pollination or Entomophily:** This type of pollination takes place with the help of insects such as bees, butterflies, moths and beetles as they visit different flowers in search of food and nectar but they unknowingly carry pollen from the male reproductive part of a flower to female part of another flower which ultimately leads to fertilization. Examples include, Rose, Hibiscus etc.
- **Bird Pollination or Ornithophily:** This type of pollination usually takes place with the help of certain species of birds as they get attracted towards bright flowers in search of nectar and while eating nectar their beaks come in contact with the flowers reproductive

parts which leads to transfer of pollens to stigma facilitates pollination among varies plant species. Some pollinators are hummingbirds and sunbirds. For example, silk cotton, red coral tree etc.

- **Bat Pollination or Chiropterophily:** This pollination usually happens in tropical regions, as bats get attracted to night-blooming flowers that are pale or white in color and due to their contact with these flowers the pollen grains get attached to their body and when they fly to another flowers the pollen grains are transferred to female reproductive part of that flower and fertilization takes place. Examples include, mango, agave etc.
- **Mammal Pollination:** This pollination is carried out by small mammals like rodents and marsupials as they move around or on flowers for nectars and food, by which pollens get attached to their body and get transferred to female reproductive parts of flowers. For example, combretum, dragon fruit etc.

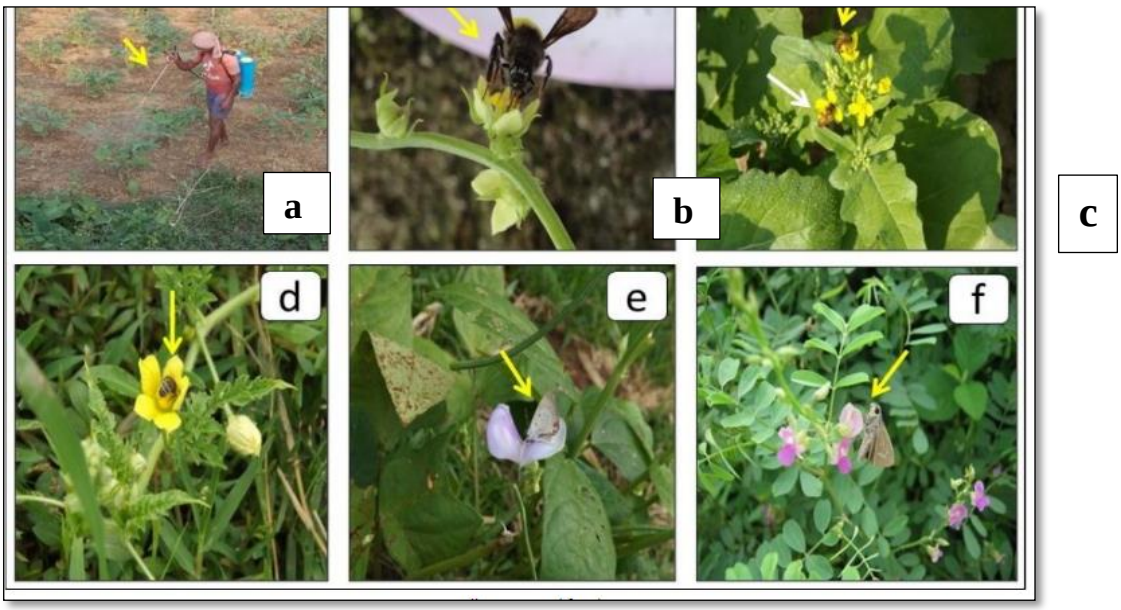

Figure 3.2: Insect Pollination and food security (a) Spraying of Pesticide on Crop Field, (b). Visiting of Xylocopa as Pollinator on Flower, (c). Visiting of Apls Spray as Pollinator on Flower (d). Visiting of Amigella as Pollinator on Flower, (e). Visiting of Borbo as Pollinator of Flower, (f). Visiting of Lycebean as Pollinator of Flower

3.3 Methods of Pollination Used in Crop Improvement:

Plant breeders utilize various kind of pollination methods to fulfil specific breeding objectives in crop improvement.

A. Controlled cross-pollination (Artificial Cross-Pollination): This type of method is used by plant breeder to precisely control the parent plant to produce the desired traits. It involves the deliberate movement of pollen from male reproductive part from one parent to female reproductive part stigma of another selected parent.

B. Hand Pollination: In this type of pollination breeders transfer pollen grains from one plant to female reproductive part of another with the help of hand. It helps to produce offspring with required traits.

C. Open-Pollination (Natural Cross-Pollination): Also known as uncontrolled pollination as in this type breeders do not hinder the transfer of pollen to female reproductive part and it happen naturally with the help of several biotic and abiotic pollinators.

D. Emasculation: It is the method of removal of male reproductive part of a flower to stop self-pollination.

E. Bagging or Caging: In this method flowers are covered by bags or cages before their opening to prevent it from pollinating from external pollinators such as wind, water, and insects.

F. Selfing: Many a time breeder deliberately allows a plant to self-pollinate to produce a uniform and stable line. It also helps in the fixation of desirable traits.

G. Clone Propagation: Few plants like fruit trees are propagated vegetatively instead of using seeds for fertilization which result in production of offspring with exactly the same traits as of their parent plant without any variations.

H. Biotechnological Pollination Techniques: When by using specific biotechnological methods such as gene modification and gene editing special traits are introduced to the offspring or parent plant.

I. In Vitro Pollination: In this method plants are produced in controlled conditions with desired use of pollens for desired traits.

3.4 Role of Pollination in Plant Breeding:

Pollination is a fundamental biological process that forms the cornerstone of flowering plant reproduction. Pollination plays key role in improvement of crops by giving several merits that help in production of better, productive and more resilient crops.

3.4.1 Some Roles of Pollination Are There:

A. Genetic Diversity: Cross pollination helps in production of plants with genetic variation from their parent plant. This diversity widens the range of traits for selection and utilization helping the breeders to produce crops with high yield, wider adaptability in different environments and diseases and insect resistant.

B. Desired traits combination: Pollination help breeders to produce plants with desirable features. For example, breeders might combine drought tolerance from one parent with pest resistance from another.

C. Heterosis or Hybrid Vigor: The use of cross pollination technique it helps to gain hybrid vigor or heterosis. Hybrid tend to be healthier, vigorous than their parent plants. This often leads to improved yield and better performance.

D. Reduction in Undesirable Traits: By controlled pollination a breeder can eliminate the undesirable characteristics in the offspring. For instance, a plant susceptible to a particular disease can be crossed with a resistant variety, ultimately producing offspring with disease resistant.

E. Accelerated Breeding Programs: With the help of cross-pollination, a breeder can produce a wide range of genetic combinations. Having a wide range of genetic material

help the breeder to create and evaluate numerous new varieties of plants with superior qualities. As the demand for new hybrid varieties is on peak nowadays farmers require high quality plants with high yield and disease and pest resistant.

F. Creating new varieties: By selecting desired parent material breeders can produce offspring with desired traits and features which ultimately enhances the number of good quality plants and seeds available for cultivation.

G. Resilience to Environmental Stress: With the help of cross pollination crops can be generated which can adapt to wide environment ranges and can bear natural calamities such as flood, drought, heat or cold stress etc.

H. Increased Yield and Quality: Using controlled pollination seeds and fruits can be produced with desired nutrient, starch content which enhances the quality and quantity of the seed and fruits.

I. Economic Impact: High quality and quantity of plants means high earnings which directly add to the GDP of the nation.

J. Biodiversity Conservation: Pollination supports biodiversity by facilitating the reproduction of various species of plants which help in providing habitat and food to a wide range of organisms such as insects, animals and birds.

K. Cultural and Aesthetic value: As pollination promote growth of a wide range of plants and flowers which are used for decoration, religions and to make medicines thus have a crucial value.

L. Climate Regulation: Pollination is important in producing several plants and plants similarly contribute to climate regulation by absorbing carbon dioxide which help in maintaining the temperature and precipitation.

Overall, pollination have a key role in ecosystem processes that contribute to a range of ecosystem service important for the maintenance of human well- being and natural ecosystems. Thus, protecting and supporting the pollinators is crucial for healthy ecosystem and for promoting the valuable services.

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