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Chapter 1

Introductory Chapter: Pollination

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1. Introduction

Pollination is the transfer of pollen grains from the anther, which is the male part of the flower, to the stigma, which is on the female part. This process normally precedes fertilization. It is an important process in the reproduction of plants without which sexual reproduction will not take place. It is a process that has been coordinated and perfected over the ages as plants coevolved with animals, where the animals act as pollinators or pollination agents. The plants and animals coexist in same habitats [1].

The coevolution between plants and animals in respect of pollination led to the development of pollination syndromes. In pollination syndromes, specific pollination agents pollinate specific plants or flowers. This is, however, not a water tight arrangement as there are polyphilic flowers which attract and are pollinated by different types of pollination agents and polytrophic pollinators which are attracted and pollinated by different types of flowers. Pollination syndromes are a symbiotic relationship between the plants and the agents or animals in which both benefit. The agents get nutrients from the flowers and the plants benefit from improved reproduction (**Figure 1**). The latter is very important in crop production.

There are two types of pollination, namely, cross- and self-pollination. In cross-pollination, pollen grains are transferred from the anther to the sigma of a different plant. Cross-pollination when followed by fertilization leads to the production offspring with heterosis or hybrid vigor. Self-pollination, on the other hand, is the transfer of pollen grains from an anther to a stigma of the same flower or plant. This often results in inbreeding depression where undesirable recessive traits are expressed in the offspring. Self-pollination occurs in species where pollination agents are scarce and in closed flowers where the pollination agents have limited access to the sexual structures of the flower.

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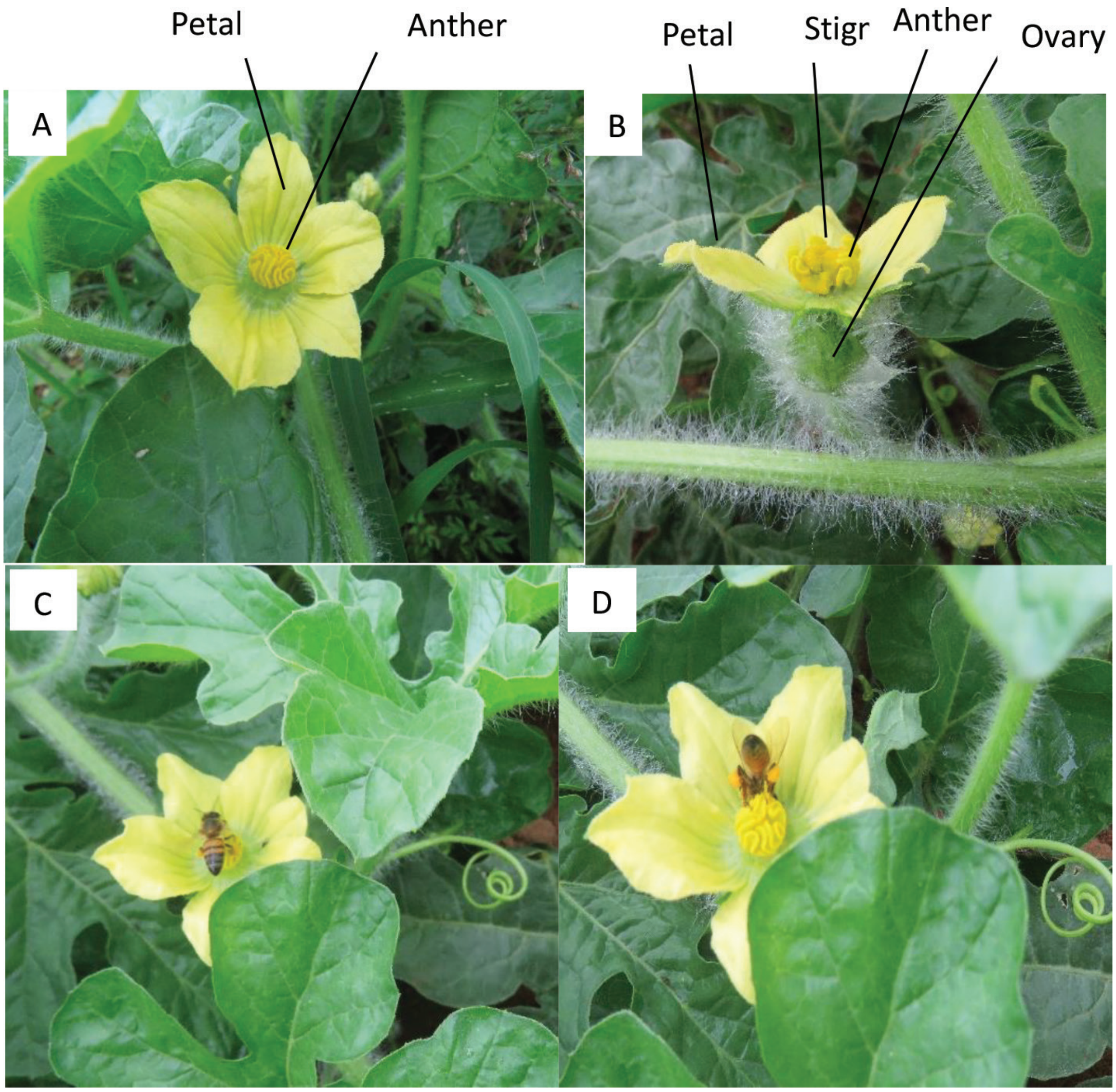

Figure 1. Flowers of the watermelon (*Citrullus lanatus* Thunb.); A is the male flower and B is the bisexual flower; the species is andromonoecious producing male and bisexual flowers on the same plant; in C, a honeybee is foraging for pollen grains on a male flower and in D, it is foraging for nectar with pollen grains visible on its legs.

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2. Pollination syndromes

Within pollination syndromes, plants and animals exploit each other for their own advantage. Animals exploit the relationship to guarantee their reproduction and survival. They forage on the flowers for carbohydrates (in nectar) and proteins (in pollen grains), which are the rewards. On the other hand, the plant guarantees its pollination and reproduction by providing the rewards and offering other attractive features like color and scent [2].

Scent plays a major role in cases where the pollination agents are deceived. The deception involves mainly reproduction hues like pheromones and reproduction substrates or sites [3]. Different plants produce flowers of different colors. The colors reflect light of different wave lengths. Because animals can perceive color of specific wavelength, each type of animal will be attracted by a flower of different color [4]. A combination of floral structure, reward, color and scent from the plant and color perception and nutrient preference on the side of the animal will result in a specific pollination syndrome. The following pollination syndromes are recognized: cantharophily (beetles), melittophily (bees), myophily (by flies), psychophily (butterflies and moths), chiropterophily (bats), and ornithophily (birds). In these pollination syndromes, the pollen grains are attached on some parts of the animals and become brushed onto the stigma. On the other hand, some pollen grains are transferred by abiotic factors (wind and water) from anther to stigma.

2.1. Cantharophily

The flowers in beetle pollinated plants are unspecialized. They are dull in color, scented, and produce lots of pollen grains. The beetles feed on the pollen grains and other flower parts. The scent is emitted from different parts of the flower [5].

2.2. Chiropterophily

Flowers pollinated by bats are large, bowl-shaped, dark to green in color, produce large amounts of nectar and pollen, and smell like rotten fruit. Bats pollinating the flowers are frugivores and nectarivores [6].

2.3. Melittophily

Bees are known to forage flowers for pollen and nectar for their hives. Such flowers are blue, yellow in color or reflect UV light and produce lots of nectar and pollen grains. Carneiro et al. [7] reported of oil gathering bees on flowers containing elaiophores or oil secreting bodies.

2.4. Myophily

Flies are attracted by the mimicry of carrion and feces, a phenomenon called sapromyiophily [8].

2.5. Ornithophily

Flowers pollinated by birds are red in color, tubular in shape, scented, and nectariferous (Medan). The birds are attracted by the red color and scent while they obtain nectar as reward. Bird pollinators are mainly hummingbirds and sunbirds [9]. These are hoverers which flip their winds while sucking. Others are perchers which sit on branches while sucking nectar.

2.6. Other pollination syndromes

In wind pollinated flowers (anemophily), the pollen grains are very fine released on dangling anthers. The stigmas are sticky and hang out of the flower like beard. This increases the chances of the pollen grains landing on the stigma. This type of pollen transfer occurs mainly in the grasses and some acacias. Water aided pollination occurs mainly in submerged water plants. Both water and wind pollinated flowers do not produce nectar and are not brightly colored. It is suggested that anemophily evolved from entomophily (pollination by insects) is a result of limitation of insect availability [10].

3. Processes that ensure cross-pollination

Nature devised a means of ensuring that cross-pollination succeeds and self-pollination is prevented. Some plants are dioecious. In dioecious plants, male plants produce female flowers and female ones produce female flowers. This is different from monoecious plants where plants produce both male (staminate) and female (pistillate) or bisexual flowers. Clearly, self-pollination cannot take place in dioecious plants since one plant produces either male or female flowers. Prevention of self-pollination in monoecious plants includes mechanisms like dichogamy, heterostyly, and self-incompatibility. Dichogamy is a condition in which either the anthers mature or release pollen grains before the stigmas are receptive (protandry) or the stigmas become receptive before the anthers mature (protogyny) [11]. In self-incompatible species, the pollen tube fails to reach the embryo sac. Either the pollen grain fails to germinate on the stigma or the pollen tube is hydrolyzed in the style after germination. In some cases, self-incompatibility is due to morphological characteristics. Some plant species produce long-styled flowers (pin morphs) and short-styled flowers (thrum morphs). Pin morphs can only fertilize thrum morphs and vice versa [12].

4. Systems in which self-pollination occurs

Self-pollination occurs in species with cleistogamous flowers and in plants in which pollinators are scarce. In cleistogamous flowers, the sexual structures (androecium and gynoecium) are enclosed by the petals which form a keel. Pollination agents cannot access the stamens and pistils within the keel. Self-pollination occurs also in monoecious plants.

5. Pollination in agricultural production systems

Pollinators play a major role in crop production. A balance between plants and pollination agents in ecosystems was maintained through the ages though disturbed now and then by natural disasters like wild fires and diseases. However, with the advent of monoculture and expanding agricultural land, the balance is constantly disturbed. Pollinators became supplemented with managed bee hives [13, 14]. On the other hand, an increase in managed honey bee hives has a negative impact on natural pollinators like bumble bees [14]. It is suggested that the introduction of honey bees needs to be managed in combination with pollinator habitat and pesticide use in a system called integrated crop pollination [15].

6. Pollination in changing climatic conditions

Global warming will have an effect on both plants and pollinators. Bumble bees were found to be less sensitive to temperature change than managed honey bees [9]. According to [16], expected climate change will negatively affect the geographical distribution of five native bees in Brazil which will potentially decrees tomato production by the year 2100.

7. Conclusion

Pollinators are necessary for ecosystem services and crop production productivity. Changes in ecosystems due to global warming as well as agricultural production systems will need to be studied and managed in order to keep ecosystem productivity and crop production sustainable and to feed an increasing world population.

Conflict of interest

The author has no conflict of interest in the publication of this article.

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