ROLE OF BEES POLLINATION IN CROP PRODUCTION

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INTRODUCTION

Pollination is essential for maintaining ecosystem balance and is the foundation of crop production, bridging the gap between agriculture and the natural cycle of life. Pollination is the process of pollen transferring from male anthers to female stigmata, either within the same flower (self-pollination) or between plants (cross-pollination). Cross pollinated plants solely rely on vectors to transport their pollens. These vectors (pollinators) are wind, water, birds, insects, bats, and other animals. Among them insect pollinators are major players in the crop production. For example, pollinators such as bees, birds, and bats affect 35% of world crop production (FAO,2021). Furthermore, insect pollination provided EUR 153 billion, representing 9.5% of the total economic value of agricultural production used directly for human food. Honey bees are the major insect pollinators of agricultural as well as other crops and plants. The frequency of visits and the cumulative effects of different bee species influence not only the quantity but also the quality of crops produced, which is relevant primarily from an economic viewpoint. Pollination of plants by multiple bee species, such as honey bees, carpenter bees, stingless bees, bumble bees, long-tongued bees, feral bees, social bees, and solitary bees, improves the pollination process.

HONEY BEES

Since the beginning of pollination services, European honey bee (*Apis mellifera*) have been widely utilized as pollinators and they are the most widely managed species for both honey production and crop pollination globally. It is the most effective pollinator and crop visitor worldwide. However, there are at least eight honey bee species in genus *Apis*, such as *A. florea* Fabr., *A. cerana* Fabr., *A. andreniformis*, and *A. dorsata* Fabr. The exchange of nectar and pollen between plants and honey bees creates a mutualistic relationship. Plants secrete a rich liquid sugar similar to nectar from their glands to attract pollinators to their flowers so that pollen can adhere to bee-collected pollen grains. Researchers have found that honey bees (*A. mellifera* L.) appear to prefer crops rich with nectar and pollen in order to store large quantities of food, thus sustaining the colony growth and improving foraging performance. Many countries have used honey bees as pollinators for improving the crops quality and quantity. In India, using honey bees as pollinators enhanced the quality of guava (*Psidium guajava* Linn) fruit, as well as the length and girth of coconut (*Cocos nucifera* Linn) and citrus (*Citrus spp.*) fruits, when compared to controls. Honey bees have clearly dominated pollination of oilseed rape (*Brassica napus* Linn), buckwheat (*Fagopyrum esculentum* Moench), and strawberry (*Fragaria ananassa* (Duchesne ex Weston) Duchesne ex Rozier), all of which have improved quality and production. Enhanced flower visitation rates by high-quality honey bee colonies increased fruit set by 15%, as well as fruit sugar content and seed set, when compared to visits by conventional colonies, resulting in a 70% increase in farmer earnings for the apple (*Malus domestica Borkh*). Pollination by high-quality colonies also resulted in a 20 % increase in fruit weight.

BUMBLE BEES

Bumble bees (Apidae: Bombini) are important pollinators for both agricultural and wild plants all over the world, and their pollination helps to ensure food security. *Bombus terrestris* Linn (Europe, North Africa, Asia, and Australia), *Bombus occidentalis* Greene (western North America), Bombus ignitus and *B. lucorum* Linn (East Asia), and *Bombus impatiens* Cresson (in North America) are the most commonly utilised bumble bee species for commercial crop pollination. Bumble bees pollinate a wide range of crops, including buzz pollinated crops like blueberries and tomatoes, as well as large-flower and small-flower crops, indicating that they have the potential to be sufficient pollinators in both open fields and greenhouses. Buzz pollination by Bombus haemorrhoidalis Smith in India has also been found to result in larger, longer, heavier, and healthier fruits, particularly in kiwi fruit. Bumble bees' great adaptation to many climates and habitats explains their ability to forage in both hot and cold conditions.

STINGLESS BEES

In tropical and subtropical places around the world, stingless bees (Apidae: Meliponini) are common flower visitors. They forage more diversely and intensely than honey bees, and hence are more likely to impact the future development of pollination solutions that are best suited to the needs of specific crops and environments. Stingless bees are a big and diversified eusocial bee species that make good pollinators. Their body size ranges from small to medium, and they feature vestigial stings. Stingless bees' physiology is well-suited to flower pollination since they have mechanisms for gathering pollen and nectar, as well as the lack of stinging behaviour that makes them easier to handle than honey bees. Some stingless bees, such as those in the *Melipona* genus, use vibration to harvest pollen, which is required in plants with poricidal anthers, such as tomato and pepper. Stingless bees are also important pollinators of greenhouse cucumber crops, helping to improve fruit weight and yield. Cucumber pollination by the stingless bee *Heterotrigona itama* and manual cross-pollination boosted crop quantity and quality, enabling for the production of heavier, longer, and wider fruit.

CARPENTER BEES

The genus *Xylocopa* belongs to the tribe Xylocopini, and large carpenter bees are a group of bees that live in tropical and subtropical regions (Apidae: Xylocopinae). Carpenter bees have significant advantages in crop pollination over other non-Apis bees, as they eat on a wide variety of plant species during their long activity seasons. They can also buzz-pollinate flowers, giving them even greater versatility as crop pollinators. However, there is an urgent need to develop a strong breeding programme that includes genotype selection, controlled mating, and nest foundation. Carpenter bees are well-known for their ability to build nests in tunnels in hard wood, logs, stumps, or dead twigs. Carpenter bees have been observed to visit flowers that generate odoriferous nectar thus it's plausible that they use this odour as a guide to visit the correct blooms. As shown in the Philippines, Brazil, the United States, and Malaysia, the usage of carpenter bees for pollination services is required to ensure adequate pollination for numerous crops, including passion fruit (*Passiflora edulis* f. *flavicarpa*), cucurbits, and other vegetables and fruits. Yellow passion fruit is pollinated successfully when only native bees, particularly carpenter bees, visit the blooms.

SOLITARY BEES

Solitary bees make up the vast majority of the world's bee species. Solitary bee species comprise 85 percent of the total number of bee species. The majority of solitary bees are polylactic (i.e., they collect pollen from a wide variety of plants), while a smaller number are oligolectic (i.e., they only collect pollen from a limited number of plants) and only a few are monolithic (i.e., they only collect pollen from a single plant species). Monolithic and oligolectic species have declined in the United Kingdom in recent decades. For some crops that rely on pollinators for reproduction, such as apples, solitary bees are more effective pollinators than honey bees.

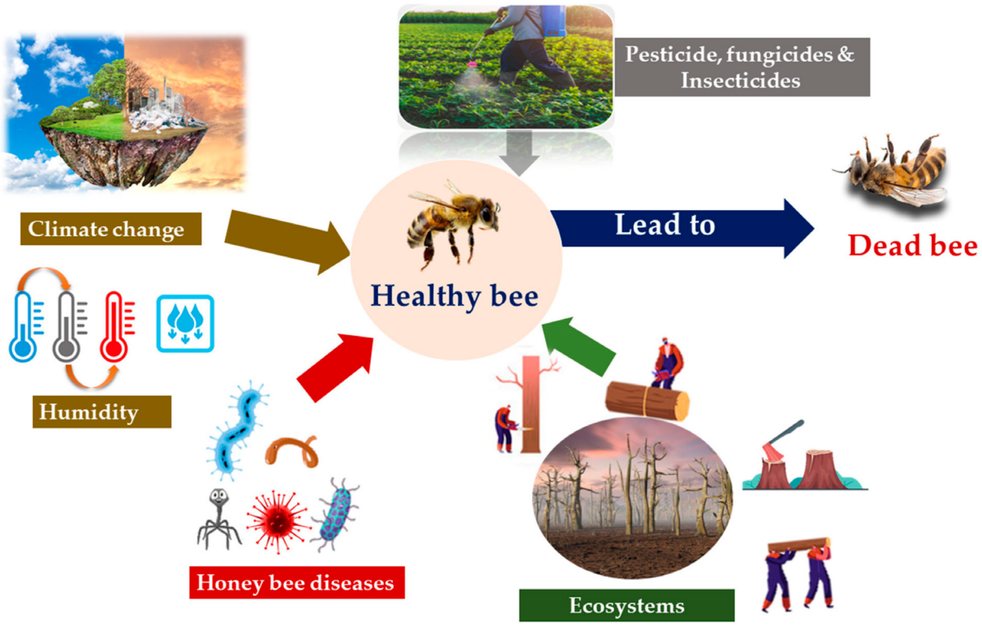
BEE VISITATION

For a variety of plants, pollination is carried out by bees and other insects. Plants have evolved to be more appealing to pollinators since pollination is so crucial to them. Floral colour, flower motion (as in bumble bees), visual and olfactory cues (as in honey bees) and nectar and pollen grain production (as in apple pollination) are all ways that plants attract bees. As a result, plants play an essential role in influencing pollinator visitation rates. The colour of the blooms is one of the most essential characteristics of plants that attract bees. Bees have a trichromatic visual system that allows them to see a wide range of colours since it is sensitive to green, ultraviolet, white, and blue wavelengths. Blue or purple flowers are frequently visited by bees, but they prefer blue blossoms.

Furthermore, floral volatile substances influence bee direction, pollen gathering, and behaviour in bumble bees. Bumble bees (*Bombus diversus*) enjoy large floral displays and flower size plays a role in attracting pollinators. Finally, bee visitation of flowers may be affected by the quantity and/or quality of pollen and nectar produced. Other pollinators and bees are driven to plants to give food for their brood, while nectar and pollen are sources of energy, protein, and lipids for bees. Honey bees look for blooms with a lot of nectar, whereas solitary bees look for pollen but rarely nectar. Only five of nine bee families search for flowers in low light, while the majority of bees visit flowers during the day. Light intensity and temperature are two parameters that affect the flowering visits of nocturnal bees.

CHALLENGES IN BEES' POLLINATION

Some factors like pathogens, nutritional deficiencies, climate change, and deforestation limit bees' ability to pollinate. Pathogens such as viruses and bacterial diseases have a severe impact on bee health and longevity, posing a threat to crop and wild plant pollination services. Viruses attack the immune systems of bees, causing sickness in entire colonies. Colony collapse disorder (CCD) is a phenomena in which managed bee colonies experience inexplicable fast losses of adult working bees, leaving only the queen and a few nurse bees. The parasites *Nosema ceranae* and *Nosema apis* are also very harmful in the United States, causing massive honey bee losses. Pesticides such as acetamiprid and ergosterol-inhibiting fungicides, in addition to natural factors affecting bee pollination, are a threat to pollination services. Pesticide and other synthetic product residues persist in bee nectar and pollen, causing neurotoxicity, immunological deficiencies, behavioural abnormalities, and chronic illnesses. One of the key co-factors linked to bee losses is the use of neonicotinoid pesticides, which are systemic insecticides that are transferred into the pollen and nectar of many pollinated crops. Spraying agrochemicals such as fungicides, insecticides, and pesticides causes contamination, toxicity, and nutrient decreases in pollen and nectar, resulting in poor colony health and as a result, bee survival. Bee populations can be harmed by deforestation. In the tropical agricultural highlands of Guatemala, for example, the abundance of bumble bees increased with the rise in forests and semi-natural vegetation in particular areas, but was unaffected by the season. Honey bees are affected by habitat loss and climate change all across the world, resulting in pollinator losses.



CONCLUSION

Pollination by bees serves humanity in a variety of ways, including food processing, raw materials, pharmaceuticals, textiles, social and cultural values, biodiversity preservation, and environmental protection. Pollination by bees has a direct impact on the profitability and productivity of a large number of crop kinds around the world, including most vegetables, seeds, and nuts, as well as some high-value agricultural crops like coffee, cocoa, and rapeseed. Without the pollination service rendered by bees, 5–8% of all global crop output would be lost, necessitating dietary modifications and the development of agricultural fields to address crop production deficiencies. Concerns about the reduction of domestic and wild bee populations have heightened the need to promote the use of natural pollinators on agricultural grounds. Because the establishment of high-diversity bee habitats in the surrounding landscape has boosted wild bee journeys, the restoration of high-diversity bee habitats is required to increase free pollination levels. Bee pollination must be improved not only for environmental reasons, but also to ensure global food security. Bees play a vital part in the production of global crops and certain medicinal plants, with considerable effects on quantity and quality. Researchers should concentrate their efforts on determining the effects of bees on crop quality, as this will provide more precise information on how bees might modify the chemistry of certain crops.