



Significance of Pollination and Honeybees in Cucurbits

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Cucurbits as well as gourds are members of the Cucurbitaceae family. Cucurbits are the most diverse group of vegetables, ranging from arid regions to the tropical tropics. Cucurbitaceae is a family with around 118 genera and 825 species. Since a long time, ten different species have been commercially cultivated. Cucurbitaceous crop pollens are sticky and thus cannot be blown by the wind. Cross-pollination is only possible if the number of insect pollinators working on the flowers is optimal. Male and female flowers are borne independently in cucurbits, so pollination and fruit setting are managed by insect pollinators. As a result, cucurbitaceous crops depend on insect pollinators such as honeybees to transfer pollen from staminate (male) blossoms to pistillate (female) flowers. According to the FAO, cucurbits are grown on approximately 4,290,000 hectares of land in India, with a productivity of 10.52 t ha⁻¹. Cucurbit crop cultivation thus accounts for around 5.6% of total vegetable production in India.

Economic importance

Three vegetable crop genera, Cucumis (cucumber, melons), Cucurbita (pumpkins, squash), and Citrullus (watermelons), are among the top ten in terms of economic importance. Bitter gourd, bottle gourd, ridge gourd, sponge gourd, pointed gourd, pumpkin, and ivy gourd are cooked vegetables, but cucumber and melon are salad vegetables. Pickles are made from cucumbers and pointed gourds. Water melon and musk melon are popular desserts and additions to many diets. Cucurbits are also high in carbohydrates, minerals, and vitamins. They are high in polyphenols and tannins. They have antioxidant, antimicrobial, antidiabetic, and anticancer properties. They could be utilized to treat stomach and intestinal disorders. They also help the human body's blood and sugar management.

Importance of pollination to cucurbits

Pollination is the initial step in plant sexual reproduction and is essentially the transfer of pollen from the anthers to the stigma of a flower. Many crops, including most cucurbit crops, require pollinator services to produce fruit. Pollination is a mutually beneficial relationship between pollinators and plants because pollinating insects benefit nutritionally for their visits and pollen distribution.

Biology of cucurbit flower

Cucurbits plants have several types of sex expression, and the majority of commercial cultivars are monoecious, andromonoecious, or gynoeceous. On the same plant, monoecious cucurbits produce both staminate (male) and pistillate (female) flowers. On the same plant, andromonoecious cucurbits produce both staminate and hermaphrodite (perfect) flowers, whereas Gynoeceous plant types produce only pistillate flowers. Specific environmental

factors are known to influence sex expression, and a Gynoecious plant will frequently produce anywhere from a few to numerous staminate flowers depending on the environment. Although commercial cucurbit varieties are self-compatible, pollen movement from staminate to pistillate the flowers require insect pollinators. This spatial separation in cucurbit flowers can occur by having male and female reproductive parts in the same flower without contact (hermaphrodite), or by having male and female reproductive parts in different flowers, with staminate and pistillate flowers spatially separated on the same plant. Furthermore, insect pollinators are required in hermaphrodite flowers because anthers frequently dehisce outward, permitting pollen grains to fall and be deposited on the petals (Free, 1993).

Morphology of cucurbit flower

Except for a few exceptions, most cucurbit plants have five yellow petals. The bottle gourd has white flowers, while pumpkins may produce flowers that range in colour from creamy white to yellow to dark orange, depending on the species or cultivars grown. The stigmas of most cucurbit flowers are receptive during anthesis (from 6:00 to 14:00 each day), although they are most receptive soon after the flower opens. Within a few hours of flower blooming, pollen viability is also with its highest. High temperatures and dry conditions during flowering can reduce the amount of time that stigmas are receptive and pollen grains become viable. Cucurbit flowers open for only one day. The anthesis period of cucurbit flowers varies among species and even cultivars within a species. Also, temperature, sunlight and humidity have great influence on the opening and closing of flowers. Once flowers close, they will never reopen and female flowers will not regain the ability to accept pollen after this time. The female flowers that are insufficiently pollinated and all male flowers will generally die and drop to the ground within a few days after opening (Free, 1993).

Table 1: Sex expression in different cucurbits

S. No.	Crop	Sex expression
1.	<i>Cucumis sativus</i> (Cucumber)	Monoecious Gynoecious Hermaphrodite Andromonoecious
2.	<i>Cucumis melo</i> (Musk melon), <i>Citrullus lanatus</i> (Water melon), <i>Momordica charantia</i> (Bitter gourd)	Andromonoecious Monoecious Gynoecious
3.	<i>Cucurbita pepo</i> (Squash), <i>Lagenaria siceraria</i> (Bottle gourd), <i>Luffa cylindrica</i> (Sponge gourd), <i>Cucurbita moschata</i> (Pumpkin)	Monoecious

Attractiveness of cucurbit flowers to pollinators

Cucurbit flowers are attractive to pollinators primarily as sources of pollen or nectar when they open. Both male and female flowers produce nectar, which provides pollinators with a plentiful source of sugar. Pollen grains stick to anthers after dehiscence because they are sticky; they are frequently scarce in flowers after midday. The intensity of flowers visitation and pollen removal by insect visitors is closely related to the speed at which pollen becomes scarce during the day. Floral visitors seek nectar or pollen in cucurbit flowers; but they are easily diverted by plants that provide more attractive flowers nearby, particularly wildflowers. This is a problem that frequently affects the effectiveness of cucurbit crop pollination. For this reason, growers are often interested in the use of bee attractants; however, none has shown the ability to improve pollination in cucurbit crop pollination (Delaplane and Mayer, 2000).

Table 2: Anthesis time observed in different cucurbitaceous crops

Crop	Timing of anthesis	References
Sponge gourd	Early morning (Before sunrise) until noon (during ≈ 8 h)	Silva (2012)
Cucumber	Early morning until afternoon (during ≈ 7 h in open fields and ≈ 10 h in greenhouse)	Delaplane and Mayer (2000), Nicoldemo <i>et al.</i> (2012)
Melon	Early morning until late afternoon (during ≈ 12 h)	Delaplane and Mayer (2000)
Pumpkin	Early morning until noon (during ≈ 6 h)	
Snake gourd	Late evening 8.30 PM	
Bottle gourd	Late evening 6.40 PM	
Bitter gourd	Early morning 5.40 AM	Bhardwaj <i>et al.</i> (2012)
Ridge gourd	Late evening 5.25 PM	
Watermelon	Early morning until early afternoon (during ≈ 8 h)	Free (1993), Delaplane and Mayer (2000)

Significance of pollination

Pollination is one of the most important mechanisms in the maintenance and conservation of biodiversity and life on earth. Pollination by insects and other arthropods is a requirement for about 90 per cent of flowering plants (Haq *et al.*, 2016). About 80 per cent of the world's fruits, vegetables and other crops depend on insect pollination. Among the insect pollinators, bees are of prime importance. Pollination is a vital environmental service provided by a variety of animals, mainly insects. Most pollination species are found in the orders of bees, flies, butterflies, moths, wasps, beetles, and other insects. Most insect pollinators are classified into three orders: Hymenoptera, Lepidoptera, and Diptera. Honeybees are the most widely used manageable pollinators in commercial cucurbit crops worldwide.

Outstanding abilities of honeybee as cucurbit pollinator

Bees are the most studied and utilized pollinators throughout the world for cucurbit crops and provide the greatest contribution to the pollination of cucurbits (Delaplane and Mayer, 2000). Their outstanding abilities as cucurbit pollinators are due to several adaptation which are as follows:

They also have well-developed foraging activities and behaviours, which increases the chance of pollen grains being deposited on the stigma (Winston, 1987).

They have branched hairs that spread over their body surface which increase adherence of pollen grains to their body and transference to the stigmatic surfaces of fruit producing flowers.

The hind legs are also called the metathoracic legs of the bees. The metathoracic legs are those that are present at the back of the thorax. These legs have an arrangement of the hair on the tibia. The tibia which is a jointed appendage and is used for walking has a pollen comb.

Cucurbit flowers encourage bee visitation for several reasons. All cucurbit flowers have the entire anthesis period during daylight hours, which favor visits by diurnal insects and only a few cucurbits have flowers that open during night time. The bottle gourd is a cucurbit that receives visits from nocturnal insects. Although its flower starts to open during evening hours, this cucurbit also receive visits from diurnal insect since the flower anthesis period lasts until the afternoon of the following day.

Foraging by honeybee in cucurbits

Foraging behaviour is defined as bees collecting pollen and nectar from flowering plants (Mattu and Nirala, 2016). The degree of cross-pollination is primarily determined by foraging speed, foraging rate, pollinator strength, and pollinator diversity. Foraging habit is a key factor in successful cross-pollination and varies between pollinator species and even within species (Shivashankara *et al.*, 2016). Pollinator foraging rates were measured in terms of the number of flowers visited each minute. The number of flowers visited every minute was recorded, as well as the time it takes to fly from one flower to another. Pollinator foraging speed was measured in terms of time (seconds) spent on each flower (Free, 1993). The time spent in each flower was determined as time spent per flower.

Conclusion

Honeybees are essential pollinators of cucurbitaceous crops such as bitter melon, muskmelon, squash, pumpkin, watermelon, and cucumber. To achieve a large supply of high-quality fruits, these crops require efficient pollination. Because of their foraging behaviour and capacity to transmit pollen between flowers, honeybees are the most successful pollinators. Honeybee pollination efficiency relates to floral biology and foraging behaviour, resulting in improved fruit set, fruit weight, fruit length, fruit diameter, number of seeds per fruit, test weight, germination percentage, yield per plant, and seed vigour. Crop management practices that are beneficial to honeybees (pollinators) should be implemented. In order to increase cucurbit production, combine the use of insecticides for protection and the usage of bees. Select pesticides which are less toxic to honeybee for pest management. There is inevitable need to create awareness about the value of honeybee in increasing crop yields through pollination.

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