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# Importance of Pollinators in Fruit Production: A Review

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**Abstract**

Pollinators play a pivotal role in the pollination of a variety of crop species. Pollination, especially by insects, is a critical component of ecosystem functioning and thus constitutes a globally important ecosystem service. Not only plant sexual reproduction is assured, but yields are also stabilized and seed genetic diversity is preserved, preventing inbreeding depression and enhancing system resilience. More than 1300 plant species are thought to be grown for fruit, drinks, medicines, condiments, spices, and even cloth around the world. Animals pollinate about 75% of these species. In reality, pollinators such as bees, birds, and bats affect 35% of global crop production, resulting in increased yields of 87 of the world's most important food crops. Honey bees are the prime pollinators of the world's angiosperms, pollinating about 66% of the 1500 crop species and contributing 15–30% of global food supply. For the pollinators who visit them, the form of flower, shape, colour, odour, nectar, and composition are all critical. To ensure pollination, many fruit crops need an insect pollinator. Pollinators boost the quantitative and qualitative characteristics of a wide variety of fruit crops. It is critical to comprehend the significance of pollinator species diversity in their natural environment.

***Keywords:*** Fruits, pollinator, production, pollens, yield

## 1. Introduction

A pollinator is a biotic agent that transfers pollens from anther to flower stigma, which by fertilization contributes to the production of fruits or seeds. The pollinators include bees, flies, bats, moths, or birds. Several fruits, vegetables, and field crops rely heavily on pollinators (Klein et al., 2007) and numerous studies have praised insect pollination as an eco-system service for agricultural food production on a global (Gallai et al., 2009) and national scale (Smith et al., 2011). Insect pollinators are becoming increasingly common among farming communities as a way to boost crop productivity and feed the world's rising population (Hajjar et al., 2008). Improved pollination can shorten the time between flowering and fruit set, minimizing the risk of pests, disease, bad weather, and agrochemical exposure while also conserving water. More than one of each three nibbles of food we eat or refreshments we drink are straight forwardly a result of pollinators.

For several factors, including feeding, pollen gathering and warmth, pollinators come across flowers. When pollinators visit flowers, pollen rubs or drops onto their bodies (scoopa on hind tibia and scoopa on ventral abdomen of a bee). The pollen is then transferred to another flower or a different part of the same flower as the pollinator moves from one location to the next. This activity is a crucial phase in the life cycle of all flowering plants and is mandatory to start seed and fruit production in flowers. Exclusively fertilized plants can make fruit and seeds, and without them, the plants cannot reproduce (Richardson et al., 2000; Dawkins and Krebs, 1979). Despite the fact that a variety of insects are known to play an important role in pollination, honey bees (*Apis mellifera*) are often thought to provide the bulk of agricultural pollination services (Breeze et al., 2011). Honey bee pollination is not only considered to improve the fruit production and the quality of fruits but also to be cost effective (Kozin, 1976). Bee pollination increases fruit yield by 50% as compared to wind pollination (Krishnan et al., 2012). By virtue of efficient pollen deposition on the stigma of an apple flower, a variety of widely grown plant species need pollination in order to bear marketable fruits. As a result, the higher the number of fertilized ovules, the more likely the fruit can successfully compete for tree nutrients and continue to grow until harvest. Having a large number of seeds would ensure that the fruit is perfectly formed and of higher quality (Chaudhry, 2008).

Numerous fruit crops depend upon insect pollinator to help insure pollination (i.e. apples, blueberries, blackberries, cherries, cranberries, raspberries, strawberries). In order to

yield a viable harvest, there must be adequate pollinators present during bloom. Appropriate pollination boosts fruit size at harvest, speeds up maturity and results in a more symmetrical fruit form. Although inappropriate pollination will result in deformed fruits with smaller seeds, lowering the market value of the product (Khan et al., 2012). Natural pollinators are used by developed regions such as the United States, Europe, China, and Japan to produce high-value crops, while natural pollinators are used by less developed regions such as India, South Asia, and Sub-Saharan Africa to produce crops that provide vital nutrients (Ken et al., 2012). The scale of agriculture's dependence on animal pollinators was assessed in 200 countries by Klein et al. (2007) and it was discovered that about 70% of crops used as human food are dependent on animal pollinators. However, due to changes in their food and breeding environments, shrinkage in natural ecosystems (forests and grassland ecosystems), pesticide contamination, foreign organisms, diseases and pests, over collecting, smuggling and trafficking in some uncommon and endangered species, human activity, climate change, and other factors, the population of wild, native, and controlled pollinators is declining at alarming rates (Abrol, 2012). So, reduced pollination service can lead to inappropriate seed set formation and lower fruit quality, causing food supply disruption in natural communities. Many of the foods we consume and the natural environments we enjoy will not work without pollinators. Protecting pollinators and reducing the use of harmful chemicals now is a good thing for our climate and economy.

## 2. Pollinators' Involvement in Fruit Production

A diverse pollinator population may benefit a number of commercially valuable fruit crops.

### *2.1. Strawberries*

Strawberries that have not been pollinated by a variety of insects such as flies, solitary bees, and honey bees, for example, may be smaller and irregular in shape, while those that have been pollinated by these insects are larger and have fewer deformations, allowing farmers to charge a higher price (Figure 1). Moreover, fruits pollinated by bees had a higher fruit weight and shelf life, resulting in a higher commercial value as well as better post-harvest quality due to more intense red colour and lower sugar–acid ratios than fruits pollinated by wind or self-pollination. Birds, bugs, thrips, butterflies, and various bees are among the insects that visit strawberry flowers; however, only bees, especially the honey bee (*Apis mellifera* L.), have been shown to be the most effective in avoiding injury to flower parts. Strawberry pollination was done using by *Bombus lucorum* and *A. mellifera* in greenhouses (Li et al., 2006).

### *2.2. Mango*

Insect pollinators play a critical role in mango production in many mango-producing countries around the world.

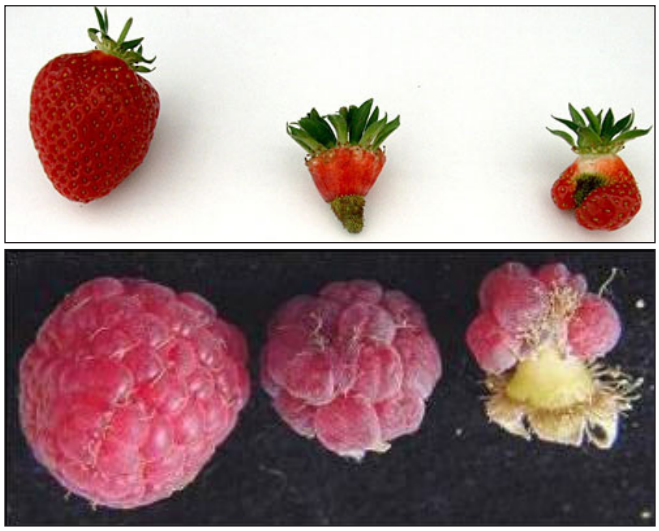

Figure 1: Role of pollinators in affecting fruit size and shape of berries. In both pictures pollinated fruit is on the left side

Fruit set in uncaged inflorescences (41%) was significantly higher than that in caged inflorescences (0.7%) after the introduction of bee colonies in mango orchards (Fajardo et al., 2008). Sharma et al. (1998) attempted to increase the abundance of pollinators in a mango orchard by rearing *Lucilia* sp. (Calliphoridae) and *Sarcophaga* sp. (Sarcophagidae) flies. Major pollination insects of mango were *Melipona* sp. and *Syrphus* sp. (Singh, 1988). *Rhynchaenus mangiferae* Marsh., although a pest, helped in pollination and increased fruit setting when its population was below the damaging level.

### *2.3. Passion fruit*

Pollinators are also essential for yellow passion fruit pollination because the plants cannot self-fertilize and must rely on cross-pollination. Passion fruit is Brazil's main export crop, but production often falls short of demand. Since the density of successful pollinators for this crop is poor in many passion fruit-growing areas, crops must often be hand-pollinated, which increases production costs. Encouragingly, introduction of occupied carpenter bee nests can escalate pollination. Carpenter bees are the most effective pollinators for the crop. The bee species richness influenced the fruit set of yellow passion fruit (Yamamoto et al., 2012) (Figure 2).

Figure 2: *A. cerena* pollinating flower of yellow passion fruit. *A. mellifera* pollinating flower of yellow passionfruit

### *2.4. Cape gooseberry*

Pollinator visitation should be a concern for *P. peruviana*

growers because findings showed that autonomous self fertilization reduces the amount of export quality fruits by decreasing fruit diameter (Chauta-Mellizo et al., 2012).

*2.5. Pomegranate*

Since pollen is heavy, it does not disperse well in the wind, so insects are primarily responsible for pollen transfer between flowers in pomegranate. Growers in California, according to McGregor (1976), arrange for honey bee colonies to be placed in or near their fields, hoping that their presence would help pomegranate fruit production. Moreover, bee pollination could improve the setting rate and weight of pomegranate fruit significantly compared with self pollination (Derin and Eti, 2001).

*2.6. Guava*

Guava is a fruit that grows in tropical climate. The best pollinators were honey bees, which resulted in increased fruit set and improved fruit quality (Rajagopal and Eswarappa, 2005). Honeybees are responsible for 20 to 40% of all pollination (Figure 3). The length and girth of the fruit were also substantially increased in bee pollination procedure compared to the control group (Anonymous, 2011; Sehgal, 1961).


Figure 3: *Apis dorsata* (A), *Apis cerana* (B), *Apis florae* (C), Bee colony kept in the plantation (D), Fruit setting in open pollinated plant (E)

*2.7. Litchi*

Honey bee pollination has been shown to increase the yield of litchi crop in numerous studies. When Badiyala and Garg (1990) introduced four honey bee colonies into a litchi orchard in India at the start of flowering, they found that fruit set was two to three times higher in inflorescences open to honey bees than in those bagged to keep them out. European honey bee (*A. mellifera*) is most effective pollinator of litchi as compared to others species (Kumar, 2014).

*2.8. Ber*

Cross-pollination by insects attracted by the fragrance and nectar is needed for fruit set. Indian jujube pollen is thick and high. It is not spread by wind, but rather by honeybees from flower to flower. *Apis* spp was observed foraging on both nectar and pollen, while dipteran and lepidopteran insects foraged for nectar on the flowers (Kumar, 1990).

*2.9. Aonla*

Aonla is a cross pollinated flowering plant. In order for pollination to be successful, wind, honeybees and gravity all play a role. The pollination studies revealed a wide range of results in terms of fruit set and retention. Increased fruit yield requires the use of pollinators (honeybees) and pollinizers in aonla orchards (Allemullah and Ram, 2009).

*2.10. Banana*

Among the insects visiting banana inflorescence, honeybees (*A. cerana*, *A. mellifera* and *A. dorsata*) were the dominant visitors (77.50%) followed by the wasps (*Polistes haebraceous* and *Vespa orientalis*) with 15.53% visitation. The remaining insect visitors comprised of other hymenoptran insects including the sting less bees (Kaushik et al., 2012).

*2.11. Apple*

The majority of apple varieties are incompatible with one another. Providing enough cross-pollination of two or more apple varieties is the best way to ensure a successful harvest. Commercial farmers are increasingly turning to flowering crabapples for pollination. Crabapple bloom dates must be chosen to coincide with the bloom of the key cultivars. For 2–3 mature trees, at least one pollinator is needed, or one row of pollinizer should be planted for two rows of main crop. Every sixth tree should be a pollinizer in case of HDP. Pollination services provided by bees have been shown to have a major benefit in increasing apple fruit production in many studies (Sharma et al., 2012) (Figure 4).

Figure 4: Honey bee, most significant pollen-transferring insect in apple orchard (©2021 DPIRD)

**3. Characteristics of Effective Pollinators and Degree of Dependence**

The degree to which different plants rely on animal pollinators varies greatly, ranging from critical to insignificant. Animal pollinators, specifically insects, are critical for fruit and vegetable production (Table 1). The most effective pollinator species are those that are abundant, actively moving from

Table 1: Pollinators of fruit crops

| Fruit Crops | Pollinators/visitors | References |
|---|---|---|
| Mango | Honeybees, allodapine bees, sweat bees | Sung et al. (2006), Fajardo et al. (2008) |
| Guava | Honeybees | Rajagopal and Eswarappa (2005) |
| Strawberry | Bombus lucorum and A.mellifera in greenhouses | Li Ji-Lian et al. (2006) |
| Pomegranate | Bees | Derin and Eti (2001) |
| Litchi | European honey bee | Kumar (2014) |
| Banana | Honeybees, wasps and sting less bees | Kaushik et al. (2012) |
| Passion fruit | Honeybees and carpenter bees | Kishore et al. (2010) |
| Apple | Bees | Sharma et al. (2012) |
| Cherries and plums | Honeybees | Somerville (2000) |

flower to flower (has a high visitation rate) and transferring many pollen grains on the stigmas (Rader et al., 2009). Pollinator efficiency is determined by a variety of factors, including their abundance, ability to reach individual plants of the same genus and ability to pick up pollen from, move and deposit it to the required plant organs.

*3.1. Dependence of leading crops on animal pollinators*

The crops fall under the following categories:

| | |
|---|---|
| Requisite | Atemoya, kiwi, passion fruit, pawpaw, sapodilla |
| Heavily reliant | Almond, apple, apricot, avocado, blueberry, cranberry, durian, feijoa, loquat, mango, peach, pear, plum, raspberry, sour cherry, starfruit, strawberry (cross-pollinated varieties), sweet cherry |
| Moderately reliant | Blackcurrant, fig, guava, jujube, pomegranate |
| Slightly reliant | Citrus (most varieties), hog plum, longan, litchi, papaya, persimmon, rambutan |

## 4. Threats to Pollinator Populations

Due to changes in their food and breeding environments, shrinkage in natural ecosystems, pesticide contamination, invasive species, diseases and pests, human activity, climate change, smuggling and trafficking of some rare and endangered species; the density of wild, native, and controlled pollinators is currently decreasing at an alarming pace. The number of honeybee hives in the world has grown at a slower pace than the number of agricultural crops that depend on pollinators (increases of 45% and >300%, respectively), implying pollinator shortage. To meet nutritional needs of bees, they need a variety of pollen and nectar and they can alter their foraging behaviour to meet those needs. Pollen and nectar do not always contain all of the necessary nutrients and pollen protein content varies greatly. Bees tend to operate within a half-mile of the hive, but they can travel up to 6 miles for food. The more time and energy bees spend flying long distances to fulfil nutritional needs, the fewer bees can visit the fruit trees.

## 5. Measures to Increase Pollinator Population

Growers can do themselves a favour by ascertaining their bees don't have to work too strenuously to find fresh water and a variety of flowers to provide diverse sources of carbohydrates (nectar) and protein (pollen) and other essential nutrients to fuel the hive. The planting of a variety of flowering plants in and around the orchard, such as borage, sunflower, poppy, clover, alfalfa and even dandelions will promote the growth of native pollinator species including wild bees. Growers should be advised to build *A. mellifera* bee hives to increase the likelihood of honey bee visits to compensate for the lack of native pollinators. According to Albano et al. (2009), honey bee colony success can necessitate the use of certain management practises aimed at maintaining and increasing the number of foragers during the blooming season (Ohishi, 1999).

Increased pollination source diversification, rather than relying on a single particular community, may be the best choice for growers. In order to maximise the long-term success of bee hives in fruit crops, certain guidelines must be followed when they are mounted. The use of trained apiculture technicians to track these bee hives should be considered. As a result, pollinator habitat restoration and introduction of agro-environmental practices to improve wild plant resources and bee nesting sites in horticulture are critical.

## 6. Conclusion

Hymenopteran and Dipteran insects are the most important pollinators of fruit orchards. Honeybee pollination can improve the qualitative and quantitative characteristics of various fruit crops, depending on the variety and conditions at the site. More studies and experiments are needed to determine the economic value of pollinator services to fruit crops. The value of pollinator species diversity in their natural environment must be understood and human activities must be subjected to their protection.

## 7. References

Abrol, D.P., 2012. Decline in pollinators. In. Pollination Biology, Springer, Dordrecht, 545–601.

Albano, S., Salvado, E., Borges, P.A.V., Mexia, A., 2009. Floral visitors, their frequency, activity rate and Index of Visitation Rate in the strawberry fields of Ribatejo,

Portugal: selection of potential pollinators. Advances in Horticultural Science 23(4), 238–245.

Allemullah, M., Ram, S., 2009. Causes of low fruit setand heavy fruitdrop in Indian gooseberry (*Emblica officinalis* Gaertn). Indian Journal of Horticulture 47(3), 270–277.

Anonymous, 2011. Annual report of AICRP on honey bees and pollinators. PC Unit, CCS HAU Hisar.

Badiyala, S.D., Garg, R., 1990. Studies on the pollination and fruit production by in seven cultivars of litchi. Indian Bee Journal 52(1–4), 28–30.

Breeze, T.D., Bailey, A.P., Baelcombe, K.G., Potts, G., 2011. Pollination services in the UK: How important are honeybees? Agriculture, Ecosystems and Environment. 142, 137–143.

Chaudhry, O. P., 2008. Influence of Different colony placement distances on yield and quality parameters of peach (*Prunus persica* L.). Korean Journal of Apiculture 23(2), 89–95.

Chauta-Mellizo, A., Campbell, S., Bonilla, M.A., Thaler, J.S., Poveda, K., 2012. Effects of natural and artificial pollination on fruit and offspring quality. Basic and Applied Ecology 13, 525–532.

Dawkins, R., Krebs, J.R., 1979. Arms races between and within species. In Proceeding: Soc, R., Lond, B. (Eds.), Proceedings of the Royal Society B: Biological Sciences 205(1161), 489–511.

Derin, K., Eti, S., 2001. Determination of pollen quality, quantity and effect of cross pollination on the fruit set and quality in the pomegranate. Turkish Journal of Agriculture 25, 169–173.

Fajardo, A.C., Medina, J.R., Oscar Opina, S., Cervancia, C.R., 2008. Insect pollinators and floral visitors of mango (*Mangifera indica* L. cv. *Carabao*). The Philippine Agricultural Scientist 91(4), 372–382.

Gallai, N., Salles, J.M., Settele, J., Vaissiere, B.E., 2009. Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. Ecological economics 68(3), 810–821.

Hajjar, R., Jarvis, D.I., Gemmill-Herren, B., 2008. The utility of crop genetic diversity in maintaining ecosystem services. Agriculture, Ecosystems and Environment, 123(4), 261–270.

Kaushik, H.D., Yadav, S., Nadaf, H.A., 2012. Role of insect pollinators in tropical/ sub-tropical/arid fruit crops. In: Advances in bio-ecology and management of insect pollinators of crops. Centre of advanced faculty training, Department of Entomology, CCS, Haryana Agricultural University, Hisar, 113.

Ken, T., Marma, A., Munawar, M.S., Partap, T., Partap, U., Phartiyal, P., 2012. Value of insect pollinators to Himalayan agricultural economies. International Centre for Integrated Mountain Development (ICIMOD).

Khan, K.A., Ahmad, K.J., Razzaq, A., Shafiqe, M., Abbasi, K.H., Saleem, M., Ullah, M.A., 2012. Pollination Effect of honey bees, *Apis mellifera* L. (Hymenoptera: Apidae) on Apple fruit development and its weight. Persian Gulf Crop Protection 1(2), 1–5.

Kishore, K., Pathak, K.A., Shukla, R., Bharali, A., 2010. Studies on floral biology of passion fruit (*Passiflora* spp.). Pakistan Journal of Botany 42(1), 21–29.

Klein, A.M., Vaissiere, B.E., Cane, J.H., Steffan-Dewenter, I., Cunningham, S.A., Kremen, C., Tscharntke, T., 2007. Importance of pollinators in changing landscapesfor world crops. Proceedings of the Royal Society Series B-Biological Sciences 274, 303–313.

Kozin, R.B., 1976. Insect pollination of crops. In: Freitas, B.M., Pereira, J.O.P. (Eds.), Solitary bees: Conservation, rearing and management for pollination: Management and policy. Amsterdam: Amsterdam Publishing Press, 125–134.

Krishnan, S., Kushalappa, C.G., Shaanker, R.U., Ghazoul, J., 2012. Status of pollinators and their efficiency in coffee fruit set in a fragmented landscape mosaic in South India. Basic and Applied Ecology 13(3), 277–285.

Kumar, R., 2014. Planned honey bee pollination in litchi (*Litchi chinensis* Sonn.)- a new production strategy for enhancing fruit yield and quality in India. Acta Horticulturae 1029, 281–286.

Kumar, S., 1990. Studies on insect pollination in 'ber', *Zizyphus mauritiana* Lamk. M.Sc. Thesis. Haryana Agricultural University, Hisar.

Li, J.L., Peng, W.J., Wu, J., An, J.D., Guo, Z.B., Tong, Y.M., Huang, J.X., 2006. Strawberry pollination by *Bombus lucorum* and *Apis mellifera* in greenhouses. Acta Entomologica Sinica 49(2), 342–348.

McGregor, S.E., 1976. Insect pollination of cultivated crop plants.USDA, Tucson, Arizona.

Ohishi, T., 1999. Appropriate management of honeybee colonies for strawberry pollination. Honeybee Science 20(1), 9–16.

Rader, R., Howlett, B.G., Cunningham, S.A., Westcott, D.A., Newstrom-Lloyd, L.E., Walker, M.K., Teulon, D.A.J., Edwards, W., 2009. Alternative pollinator taxa are equally efficient but not as effective as the honey bee in a mass flowering crop. Journal of Applied Entomology 46, 1080–1087.

Rajagopal, D., Eswarappa, G., 2005. Pollination potentiality of honeybees in increasing productivity of guava in Karnataka. Advances in Pollen Spore Research 22, 131–141.

Richardson, D.M., Allsopp, N., Dantonio, C.M., Milton, S.J., Rejmanek, M., 2000. Plant invasions–the role of mutualisms. Biological Reviews 75(1), 65–93.

Sehgal, O.P., 1961. Studies on morphology and blossom biology in guava (*Psidium guajava* L.) M.Sc. Thesis. IARI, New Delhi.

Sharma, H.K., Uma, P., Bisht, K., Tewari, P., Phartiyal, P., 2012. Impact of honeybee pollination in enhancing the apple

production in Nainttal district of Uttarakhand. Advances Pollen Spore Research 30, 99–102.

Sharma, S., Abbas, S.R., Shukia, R.P., Sharma, S., 1998. An easy and quick method of breeding flies for pollination of mango blossoms. Insect Environment 4, 76–77.

Singh, G., 1988. Insect pollination of mango and their role in fruit setting.Acta Horticulture 231, 629–632.

Smith, P., Ashmore, M., Black, H., Burgess, P., Evans, C., Hails, R., 2011. UK national ecosystem assessment – Chapter 14: Regulating Services. UNEP-WCMC, Cambridge,

Somerville, D., 2000. Honey bees in cherry and plum pollination. Agnote DAI/126, State of New South Wales NSW Agriculture.

Sung, H.I., Lin, M.Y., Chang, C.H., Cheng, A.S., Chen, W.S., 2006. Pollinators and their behaviors on mango flowers in Southern Taiwan. Formosan Entomology 26, 161–170.

Yamamoto, M., Silva, C.I., Augusto, S.C., Barbosa, A.A., Oliveira, P.E., 2012. The role of bee diversity in pollination and fruit set of yellow passion fruit (*Passiflora edulis* forma *flavicarpa*, Passifloraceae) crop in Central Brazil. Apidologie 43, 515–526.

 