हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद
Agrisearch with a human touch

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Bees: The Efficient Pollinators

ICAR KVK HAILAKANDI
ICAR (RC) FOR NEH REGION
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Preface

Plants require pollen to be transferred from one plant to another to aid reproduction. This transfer of pollen grains is called pollination. Insects including bees forage plants for food, they visit many flowers a day in search of pollen and nectar. Many flowering plants depend upon these insects for the pollen transfer (pollination) as they forage. Adequate insect pollination improves the quality of the crop.

Among the insects, bees are considered the most efficient pollinators because they have hairy bodies which easily pick up pollen grains as they move about in flowers. During a single day one bee may visit several hundred flowers. Furthermore, bees are consistent foragers and tend to work one kind of flower at a time.

It has been established through research that, installation of 3-5 bee colonies of *Apis cerana indica* / acre of crop increased the seed yield in sunflower by 79 %, mustard by 55 %, niger by 33 %, sesamum by 15 %, safflower by 64 %, cotton by 18 %, litchi by 20 %, coconut by 40 %, and gourd crops by 20%.

Keeping the above facts in mind an attempt was made to develop this bulletin to bring out the importance of pollinators in production and productivity of agriculture and horticulture as a whole.

We would like to acknowledge all the respected authors/workers/sources whose works/ findings have been incorporated in this bulletin.

We extend our deep appreciation and sincere thanks to all staff of ICAR KVK Hailakandi for providing help and support during the preparation of this bulletin and also ICAR Research Complex Region for NEH Rigion, Umiam for their financial support under TSP.

Authors

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Chapter I

Introduction

Pollinators provide an essential ecosystem service that contributes to the maintenance of biodiversity and ensures the survival of plant species including crop plants. It has been estimated that over three quarters of the world's crops and over 80 per cent of all flowering plants depend on animal pollinators, especially bees. Globally the annual contribution of pollinators to the agricultural crops has been estimated at about US$54 billion.

Over 16500 species of bees are found in the world. These include honeybees, bumble bees, sting less bees and solitary bees. Honey bees are best known for the valuable products they provide to mankind, however, their services are indispensable and they are most widely recognized and known pollinators of many crops of the world.

Plants require pollen to be transferred from one plant to another to aid reproduction. This transfer of pollen grains is called pollination.

Insects are the most commonly occurring pollinators of many agricultural and horticultural crops. Different kind of insect pollinators such as bees, flies, beetles, butterflies, moths and wasps are important pollinators of many crops. They forage plants for food, they visit many flowers a day in search of pollen and nectar. Many flowering plants depend upon these insects for the pollen transfer (pollination) as they forage. Adequate insect pollination improves the quality of the crop. Uneven, misshaped and small fruits are often indication that pollination has been insufficient.

Among the insects, bees are considered the most efficient pollinators because unlike other insects, they are social and collect nectar and pollen not only to satisfy their own needs but to feed their young; their body hairs help transfer pollen from one flower to another; they show flower constancy and move from one flower to another of the same species; and many species can be reared and managed for pollination. During a single day one bee may visit several hundred flowers. Furthermore, bees are consistent foragers and tend to work one kind of flower at a time.

Honeybees are main pollinating agent followed by solitary, alkali and carpenter bee and therefore, play a vital role in food production and overall agricultural productivity, as pollinators. So beekeeping provides pollination services.

In some countries the economic value of pollination is higher than the value of honey. Beekeepers move their hives to different bee forages in order to maximize honey flow and to improve crop pollination.

In America, India and China pollination by bees is hired and fetches additional money to the beekeeper. Growers are willing to rent hives from beekeepers. Hives are placed near to the blooming crops (especially fruit and oil seed crops) and removed after flowering. Many beekeepers earn money in this way and still have the honey from the hive.

Chapter II

Pollinators and its types

A pollinator is the biotic agent (vector) that moves pollen from the male anthers of a flower to the female stigma of a flower to accomplish fertilization or 'syngamy' of the female gamete in the ovule of the flower by the male gamete from the pollen grain. Though the terms are sometimes confused, a pollinator is different from a pollenizer, which is a plant that is a source of pollen for the pollination process.

Plants fall into pollination syndromes that reflect the type of pollinator being attracted. These are characteristics such as: overall flower size, the depth and width of the corolla, the color (including patterns called nectar guides that are visible only in ultraviolet light), the scent, amount of nectar, composition of nectar, etc. For example, birds visit red flowers with long, narrow tubes and lots of nectar, but are not as strongly attracted to wide flowers with little nectar and copious pollen, which are more attractive to beetles. When these characteristics are experimentally modified (altering colour, size, orientation), pollinator visitation may decline.

Types of pollinators

The most recognized pollinators are the various species of bees, which are plainly adapted to pollination. During visit to flowers, pollen grains adhere to their bodies, but they also have specialized pollen-carrying structures; in most bees, this takes the form of a structure known as the scopa, which is on the hind legs of most bees, and/or the lower abdomen (e.g., megachilid bees), made up of thick, plumose setae. Honey bees, bumblebees, and

their relatives do not have a scopa, but the hind leg is modified into a structure called the corbicula (also known as the “pollen basket”). Most bees gather nectar, a concentrated energy source, and pollen, which is high protein food, to nurture their young, and inadvertently transfer some among the flowers as they are working.

Pollination by Honey bees

Honey bees travel from flower to flower, collecting nectar (later converted to honey), and pollen grains. The bee collects the pollen by rubbing against the anthers. The pollen collects on the hind legs, in a structure referred to as a “pollen basket”. As the bee flies from flower to flower, some of the pollen grains are transferred onto the stigma of other flowers.

Pollination by other insects

Many insects other than bees accomplish pollination by visiting flowers for nectar or pollen, or commonly both.

- ✡ Males of many species of Hymenoptera, including many hunting wasps, rely on freely flowering plants as sources of energy (in the form of nectar) and also as territories for meeting fertile females that visit the flowers.
- ✡ Lepidoptera (butterflies and moths) also pollinate plants to various degrees. They are not major pollinators of food crops, but various moths are important pollinators of other commercial crops such as tobacco.
- ✡ Beetles of species that specialize in eating pollen, nectar, or flowers themselves, are important cross-pollinators of some plants such as members of the Araceae and Zamiaceae, that produce prodigious amounts of pollen.
- ✡ Various midges and thrips are comparatively minor opportunist pollinators. Ants also pollinate

some kinds of flowers, but for the most part they are parasites, robbing nectar without conveying useful amounts of pollen to a stigma.

- Hoverflies are important pollinators of flowering plants worldwide. Often hoverflies are considered to be the second most important pollinators after wild bees.
- Other insect orders are rarely pollinators, and then typically only incidentally (e.g., Hemiptera such as Anthocoridae and Miridae).

Bumble bee

Large carpenter bee

White-banded digger bee

Butter fly

Red cotton bug

European beewolf (wasp)

Fig: Various pollinators are at work

Chapter III

Some facts about bee pollination

Mohapatra *et al.* (2010) reported the following facts about bee pollination:

- More than 50% of the existing species of plants propagated by seeds are dependent upon insects for adequate pollination.
- Only 15% of the 100 or so crops that fed the world are pollinated by domestic honey bees while 80% are pollinated by wild bees and other wild life.
- Value of additional yield obtained due to bee pollination alone is 15-20 times more than the value of all the hive products put together.
- The total value of pollination services rendered by all insects globally comes in excess of 100 billion US dollars annually (2003 valuation).
- In India 50 million hectares of land is under bee dependent.
- It has been estimated that bees are gainfully tapping only about 1/4th of the available floral resources of the country.
- Of the 90% of flowers which are cross pollinated, 85% depend upon insects for pollination.
- Being a mega diversity country there are about 1000 species of bee forage plants offering rich food to all the four important species of honey bees.
- The estimated losses in India due to complete absence of bee pollination has been measured to be somewhere between Rs.10,000 to Rs.55,000 per hectare in some crops.

Advantages of bee pollination:

Honey bees are the most efficient pollinators of several agricultural, horticultural, silvicultural, fodder and wild plants because of their following characteristics:

- ✡ body parts are specially modified to pick up many pollen grains,
- ✡ flower fidelity and constancy,
- ✡ potential for long hours,
- ✡ maintainability of high populations as and when needed,
- ✡ adaptability to different climates and niches,
- ✡ through micromanipulation of flowers

Chapter IV

Qualitative and quantitative changes in crop plants due to bee pollination

As a result of cross pollination by bees, somatic, reproductive and adaptive heterosis or hybrid effect occurs in plant progeny. Such hybrid effect brings the following qualitative and quantitative changes in plants:

- Stimulate germination of pollen on stigma,
- Increase viability of seeds, embryos and plants,
- More nutritive and aromatic fruits,
- Stimulate faster growth of plants,
- Increases number and sizes of seeds and yield of crops,
- Increases nectar production in the nectaries,
- Increases fruit set and reduces fruit drop,
- Enhances resistance to diseases and other adverse climatic conditions,
- Increases the oil content in oil seed crop.

Increase in yield due to bee pollination:

It has been established through research that, installation of 3-5 bee colonies of *Apis cerana indica* / acre of crop increased the seed yield in sunflower by 79 %, mustard by 55 %, niger by 33 %, sesamum by 15 %, safflower by 64 %, cotton by 18 %, litchi by 20 %, coconut by 40 %, and gourd crops by 20% (Mohapatra *et al.*, 2010)

It is now apparent that most of the pulses and oilseeds, fruits and orchard crops including vegetables heavily depend on bees for their pollination. This is also true for seed production of vegetables like onion,

cabbage, cauliflower, tabacco, sunnhemp, alfa alfa and clovers. The number of colonies of honeybees required per hectare very much depends on the strength of foraging bees in the colony, the crops and prevailing weather conditions. The optimum number of colonies of average strength may range from 3 to 9 colonies per hectare, since the bees usually forage within a radius of about 1 to 2 km to harvest their nectar and pollen loads, and then return to their own hive.

Chapter V

Management of honey bee hives for pollination

Colonies used for pollination require a certain minimum management besides protecting them from diseases and natural enemies.

a) Strength of colony:

- Large and stronger colonies (6- 7 brood frame) are four to five times better pollinators than smaller and weaker ones as it has greater foraging bee population at all the times .
- There should be enough adult bees to fully cover 8 frames and a young prolific queen.
- A hive used for pollination should contain enough honey and pollen stores.

b) Number of colonies required:

- The number of colonies required for pollination of different cultivated crops depends upon the several factors like: density of plant stand, number of flowers per inflorescence, duration of flowering, strength of bee colonies and number of flowers per unit area. In general three colonies of *Apis cerana indica* and two colonies of *Apis mellifera* are required per hectare.

c) Time and placement of colonies :

- For better pollination, bee colonies should be placed in the field or orchard at night times when 10 to 20 per cent of the crop is in bloom.

d) Distribution of colonies in the field:

- Honeybees as a rule visit primarily those sources of nectar which are within 0.3 to 0.5 kms radius from the apiary.

- ✡ The pollination activity diminishes significantly at a distance more than 0.5 kms.
- ✡ The number of honey bees on the crop decreases with increased distance of the crop from the colonies and there is corresponding decrease in fruit set, production and productivity.
- ✡ For effective pollination *Apis cerana indica* hive should be placed singly instead of groups.

e) Attracting bee pollinators to a crop in bloom:

- ✡ Bees should be fed sugar syrup flavoured by the flowers required to bee pollinated in order to attract large number of bees for effective pollination.

Chapter VI

Protecting the bees from pesticide poisoning

Irrational and indiscriminate application of non specific broad spectrum pesticides give devastating set back to the non target useful fauna mainly pollinators and biocontrol agents. Various ways to reduce bee poisoning are:

- ✡ Persuade the farmers not to use pesticides or use selective pesticides that are less harmful to bees at recommended concentrations,
- ✡ Avoid the use of dust formulation as they are harmful to bees than spray formulation,
- ✡ Prior information about spraying would help in reducing poisoning of bees,
- ✡ Avoid spraying of pesticides during flowering of the crop and peak foraging time of the bees would help in reduction in the mortality of foraging bees,
- ✡ Spraying may be done in the evening hours when bees do not forage,
- ✡ Colonies may be temporarily shifted if heavy spraying schedule is fixed,
- ✡ If shifting of colonies is not possible, feed the colonies with 200ml of sugar syrup and close the entrance gate by using wire screen for the day of spraying.

Bee flora and pollination of crops

Bee visits plants for its food, nectar and pollen. This floral dependability of bees is due to their preference for nectars having sugar contents and pollens with higher nutritive values. Besides getting food for the bees as a result of their visit pollinate a number of crops.

Qualities of honeybees which make them good pollinators

- Body covered with hairs and has structural adaptation for carrying nectar and pollen.
- Bees do not injure the plants
- Adult and larva feed on nectar and pollen which is available in plenty
- Considered as superior pollinators, since store pollen and nectar for future use
- No diapauses is observed and needs pollen throughout the year
- Body size and proboscis length is very much suitable for many crops
- Pollinate wide variety of crops
- Forage in extreme weather conditions also

Effect of bee pollination on crop

It increases yield in terms of seed yield and fruit yield in many crops

- It improves quality of fruits and seeds
- Bee pollination increases oil content of seeds in sunflower
- Bee pollination is a must in some self incompatible crops for seed set

Crops benefited by bee pollination

Fruits and nuts: Almond, apple, apricot, peach, strawberry, citrus and litchi

Vegetable and Vegetable seed crops: Cabbage, cauliflower, carrot, coriander, cucumber, melon, onion, pumpkin, radish and turnip.

Oil seed crops: Sunflower, niger, rape seed, mustard, safflower, gingelly.

Forage seed crops: Lucerne, clover.

Yield increase due to bee pollination

Crop	Per cent yield increase
Mustard	43
Sunflower	32-48
Cotton	17-19
Lucerne	112
Onion	93
Apple	44

(Source: TNAU Agritech Portal, surfing date 20.09.2014)

Management of bees for pollination

- ✡ Place hives very near the field source to save bee's energy
- ✡ Migrate colonies near field at 10 per cent flowering
- ✡ Place colonies at 3/ha for Italian bee and 5/ha for Indian honey bee
- ✡ The colonies should have 5 to 6 frame strength of bees, with sealed brood and young mated queen
- ✡ Allow sufficient space for pollen and honey storage

Fig. Placing bee hives for mustard pollination

Fig. A worker honey bee is busy in collecting nectar

Fig. Placing beehives in onion field for pollination

Fig. Bee hives set out in a sunflower field for pollination

Fig. Bee hives set out in a cherry orchard to pollinate blossoms.

Pollination by bees - case studies with selected crops*

1. Sunflower: It is a cross-pollinated crop. The pollen of the plant cannot fertilize ovary of same plant. Pollen source should be from different plant. Hence, honey bees acts as important agents for pollination in sunflower. In sunflower, yield increases even up to 600 per cent due to bee pollination. It improves quality and quantity of seeds. Oil content also increases by 6.5 per cent in seeds. To achieve this it requires five strong *Apis cerena indica* colonies or three *A. mellifera* colonies. Mostly irrigated crop is preferred by bees.

2. Cucurbitaceous vegetables: Cucurbits are monoecious with staminate and pistillate flowers in same plant. Due to bee pollination fruit set increases up to 30 to 100 per cent.

3. Alfalfa or lucerne: These plants have tubular flowers with 5 petals joined at base. They posses one large standard petal, 2 smaller petals on sides and 2 keel petals holding staminal column. When bee sits on a keel petal, stamina column strikes against standard petal resulting in shattering of pollen. This is called *tripping.* Seed set occurs only if bee sits to trips the flowers.

4. Coriander: In coriander yield increases up to 187 per cent due to pollination.

5. Cardamom: It is an important commercial crop depending on bees for pollination. Here yield increases up to 21 to 37 per cent.

6. Gingelly: Another oilseed crop where bee pollination

causes 25 per cent increase in yield.

7. Apple: In apple seed set occurs only if it is pollinated by bees. Fruit is formed only around the seeds. If improper seed set occurs fruit shape is lopsided resulting in decreased market value.

Other fruit Trees

All kinds of citrus, litchi, peach, apple, guava, *jamun*, date palm, apricot, quince, pear, almond, plum, loquat, phalsa, and cashew.

Cultivated field crops

Pigeon pea, lentils, clovers, Lucerne, mustard, rape, linseed, sesame, gingelly, buck-wheat, Cambodia, safflower, millet and sunflower

Vegetables

All cucurbitaceous plants, okra, beans, turnip, radish, onion, brinjal, and sweet potato.

Timber trees

Neem, Cassia fistula, Acacia, Albizzia spp., Kachnar (Bauhinia purpurea), eucalyptus, sandle-wood, raintree, wild cherry.

Natural and ornamental flowers

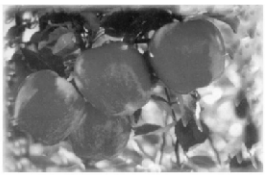
Cosmos, shoe flower, Golden rod, Cup & saucer, Tecoma stans, zinnia, coral creeper (*Antigonon leptopus*), rose, rangoon creeper, aster, wild rose (kuja), hydrangea, violet, portulaca, poinsettia, honey suckle, corn flower, coreopsis, dandelion etc.

It is now apparent that most of the pulses and oilseeds, fruits and orchard crops including vegetables heavily depend on bees for their pollination. This is also true for

seed production of vegetables like onion, cabbage, cauliflower, tabacco, sunnhemp, alfa alfa and clovers. The number of colonies of honeybees required per hectare very much depends on the strength of foraging bees in the colony, the crops and prevailing weather conditions. The optimum number of colonies of average strength may range from 3 to 9 colonies per hectare, since the bees usually forage within a radius of about 1 to 2 km to harvest their nectar and pollen loads, and then return to their own hive.

*(*case studies given in this chapter has been depicted from TNAU Agritech Portal website)*

Litchi



Apple

Sunflower

Mustard

Marigold

Wild rose / Rose

Calendula

Golden rod

Plum

Chapter IX

Pollinator population declines

Pollinators provide a key ecosystem service vital to the maintenance of both wild and agricultural plant communities.

Today pollinators are considered to be in a state of decline; some species, such as Franklin's bumble bee (*Bombus franklini*) have been red-listed and are in danger of extinction. Although managed bee hives are increasing worldwide, these cannot compensate for the loss of wild pollinators in many locations.

Declines in the health and population of pollinators pose what could be a significant threat to the integrity of biodiversity, to global food webs, and to human health.

At least 80 % of our world's crop species require pollination to set seed. An estimated one out of every three bites of food comes to us through the work of animal pollinators.

The quality of pollinator service has declined over time and this had led to concerns that pollination will be less resistant to extinction in the future.

Chapter X

Conserving pollinator populations

The crop plant species which need pollination service will be in flower only in certain months or seasons of the year. During other parts of the year, it is necessary to understand on what plants the pollinators forage. Hence, it is necessary to develop a floral calendar for the given region. If the target crops are closer to natural habitats like forests the plant species closer to the cropped area should be identified and the flowering phenology of each species should be recorded. In addition, the common weeds and other species of plants in the vicinity of the crop are also to be identified and their flowering times recorded. All these information can be used to analyze their importance in conserving populations of pollinators in the fields.

Nesting sites: Pollinators, whether they are social bees or solitary bees, require nesting places. In pollination studies it is also essential to locate the nesting sites of the common pollinator species and make efforts to conserve them. *Apis cerana* nests in existing cavities like tree hollows or burrows in soil. Non-*Apis* bees which are solitary, require entirely different kinds of nesting sites. Leaf cutter bees nest in existing holes in plants or in the soil, digger bees nest in soil and several other bees like the *Ceratina* spp. bore into the cut ends of dry twigs for nesting. Out of ignorance, these nesting sites are disturbed and the populations of pollinators decline. Instead, attempts can be made to increase their populations by providing artificial nesting sites.

Trap nests: Artificial nesting sites are also called trap

nests. These can be prepared by drilling holes of 2, 4, 5, 8 and 10 mm dia into wooden pieces. Ideally any soft wood 4" thick, 4" wide and 12 or 24" long can be used. In these pieces, as many holes as possible may be drilled. The trap nests can be placed before flowering of the crop so that the leaf cutter bees or other solitary bees start nesting.

Fig. Artificial nesting sites for the pollinators in the crop field

Chapter XI

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"If the bee disappears from the surface of the earth, man would have no more than four years to live"

-- *Albert Einstein*

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