# Significance of Honey Bee as a Pollinator in Improving Horticultural Crop Productivity in N.E. Region, India: A Review

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## ABSTRACT

*Sustainable food production system is the key to sustainable development especially for farming communities where horticulture is the mainstay of economy. The focus of agriculture in the North Eastern region of India is slowly shifting from traditional cultivation system to high-value horticultural crops farming such as fruits and vegetables. The change of subsistence systems to commercial cultivation of horticultural crops posses' new challenges for improving crop productivity and quality. Amongst several factors attributing to low productivity or crop failures inadequate pollination is the most important that include the lack of adequate number of pollinators as a result of decline in pollinator. Based on review studies in horticultural crop pollination issues and farmers' concerns in North Eastern region, this paper presents a general picture of pollination issues faced by the farmers in the region. The paper explains the importance of pollination in improving food security and livelihoods through enhancing productivity of horticultural crops such as fruits and vegetables.*

**Keywords:** Pollination, Insect Pollinator, Honey bee, Fruits, Vegetables and Production

## INTRODUCTION

Agriculture is the basis of the livelihood of over 80 percent of the rural population in India. However, more than 90 percent of the farmers in the hill and mountain areas are marginal or small land-holding families, cultivating less than one hectare of land each (Partap, 1999). The North Eastern Himalayan region covering an area of about 25.608 million hectare possesses a diverse topography, altitude and climatic conditions which offers a wide scope for the cultivation of numerous varieties of horticultural crops. The total area under horticultural crops is about 0.82 million hectare which constitutes 3.14% of the total geographical area of the region. It gives total production of 6.82 million tonnes. North East Councils data has shown that area under fruits is 0.27 million hectare with production of 6.82 million tonnes. In spite of suitable climatic and soil conditions the region could not make any headway in fruit production recording comparatively a low productivity 8.65 tones/hectare much below the national average.

Bee visits plants for its food, nectar and pollen. This floral fidelity of bees is due to their preference for nectars having sugar contents and pollens with higher nutritive values. Honeybees are best known for the honey they produce. But the principal economic role of honeybees in nature is to pollinate hundreds and thousands of flowering plants and ensure seed set in quantity and quality. Both flowering plants and honeybees are interdependent for their biology and life cycle. Flowering plants offer nectar and pollen to honeybees and

honeybees reciprocate their obligation by bringing about pollination, maintaining genetic diversity and continuation of the plant species. But honeybees are still of greater importance to farmers for the pollination service they offer and increase crop yields both qualitatively and quantitatively through pollination.

In the UK, 39 crops grown for fruit or seed are insect pollinated, whereas a further 32 need insect pollination for propagative seed production (Carreck and Williams, 1998). Over 25000 species of bees are found in the world. These include honeybees, bumble bees, stingless bees and solitary bees. Bees are the most effective pollinators of crops and natural flora and are reported to pollinate over 70 percent of the world's cultivated crops. It has also been reported that about 15 percent of the hundred principal crops are pollinated by domestic bees, while at least 80 percent are pollinated by the wild bees (Kenmore and Krell, 1998).

Therefore, it is necessary to explore all possible ways of increasing the sustainable productivity and carrying capacity of the farming systems in order to improve the livelihoods of marginal households (Partap, 1998, 1999). Amongst several factors attributing to increase productivity, the most important of which include the number of bee pollinators. Thus, keeping in view the importance of Bee as an agro-based industry and its role in increasing crop yields through bee pollination this article will review some literature regarding the importance of pollination in improving horticultural crop productivity.

## EFFECT OF POLLINATION IN IMPROVING HORTICULTURAL CROP PRODUCTIVITY

Many horticultural crops are actually self-sterile and require cross-pollination to produce seeds and fruit (McGregor, 1976; Free, 1993). But it is not only self-sterile varieties that benefit from cross-pollination, but self-fertile varieties also produce more and better quality seeds and fruits if they are cross-pollinated (Free, 1993). Logically, the increase in the cultivation of cross-pollinated horticultural crops will also increase the need for managed pollination. There are two well-known methods for improving crop productivity. The first method is making use of agricultural inputs such as the use of quality seeds or planting material and good cultural practices like timely irrigation, organic and inorganic fertilizers and chemical pesticides to increase yield. The second method includes the use of biotechnological techniques, such as manipulating rate of photosynthesis and biological nitrogen fixation, etc. These conventional techniques ensure healthy growth of crop plants, but work up to a limit. At some stage crop productivity becomes stagnant or declines with additional inputs for the known agronomic potentials of crop will have been harnessed (Partap and Partap, 1997).

Nearly 70 percent of the cultivated crops all over the world are cross-fertile and depend on insects like honeybees for pollination. Insects are the most commonly occurring pollinators of many agricultural and horticultural crops. Different kinds of insect pollinators such as bees, flies, beetles, butterflies, moths and wasps are important pollinators of many crops. Of all the pollinating insects, honeybees are considered as the most efficient and reliable crop pollinators. The beekeeping industry has rarely put itself forward as a Key Factor in agricultural production. For instance, the value provided by the pollination service with respect to US agriculture alone is estimated at between US$ 6 and 14 billion per year (Southwick and Southwick, 1992; Morse and Calderone, 2000). Levin (1984) estimated the US honey bee's value to agriculture to be almost 19 billion dollars, of which around US$ 10 billion related to the production of crops (fruits, vegetables, nuts) and the remaining US$ 9 billion mostly for the production of hay. In terms of methodology, Levin multiplied the value of the crop production with the amount of crop production depending on pollination (which



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ranges from 10% for soybean to 90% for apples). The value of honey bees and bumble bees as pollinators of major selected UK crops for which market statistics are available has been estimated to be £172 million for outdoor crops (rape, beans, tree and soft fruit) and £30 million for glasshouse crops like tomatoes and sweet peppers (Carreck and Williams, 1998). A range of studies have shown that pollination makes a very significant contribution to the agricultural production of a broad range of crops, in particular fruits, vegetables, fibre crops and nuts (e.g. Levin, 1984; Costanza et al., 1997). Dependency of some horticultural crops on insects for pollination is given in the Table1.

**Table 1. Dependence of some crops on insects for pollination is as under:**

| *Crops* | | | | | |
|---|---|---|---|---|---|
| *Oil Seeds* | *Percent Dependence* | *Fruits* | *Percent Dependence* | *Vegetables Seeds* | *Percent Dependence* |
| Sunflower | 100 | Grape Fruit | 80 | Pumpkin | 90 |
| Safflower | 100 | Lemon | 20 | Water Melon | 70 |
| Rape Seed | 100 | Lime | 30 | Vegetable Seed | 100 |
| Niger | 100 | Strawberry | 40 | | |

(Source: American Bee journal, 1989)

These results confirm the usefulness of bee pollination and its role in increasing crop productivity and improving the quality of fruits and seeds.

## INADEQUATE POLLINATION AND CROP PRODUCTION

Amongst several factors attributing to low productivity, the most important is the lack of adequate pollination for that the overall productivity of many upland crops is going down. The worst affected crops are the horticultural crops like fruit, particularly apples, and off-season vegetables that are the hope of the region in terms of providing farmers with cash income and underpinning development efforts. This reduction in productivity is taking place despite extensive efforts at extension and information to support improvements in a range of management practices, and strong support for the introduction of successful commercial varieties. The experiment has showed that among the several factors affecting hill crop productivity pollination plays an important role. Evidence of this emerging pollination problem has been documented in a series of field studies carried out by ICIMOD across the Himalayan region (Partap, 1998; Partap and Partap, 2000, 2001; Partap *et al.,* 2000).

## ROLE OF BEE POLLINATOR IN CROP PRODUCTIVITY

Honey bees, another important insect, that render very valuable ecological services like pollinating wild and cultivated plant species besides producing honey, and their advanced eusocial behaviour has always been a source of fascination for mankind. They are the most efficient pollinators of cultivated crops because their body parts are especially modified to pick up pollen grains, they have body hair, have potential for long working hours, show flower constancy, and adaptability to different climates (Free, 1993). The honey bee is undoubtedly the best known insect species that contributes most to the pollination of entomophilous crops in Canada (CAPA 1995). The native European honey bee (*Apis*

*mellifera*) is undoubtedly the insect species that contributes most to crop pollination (Williams 1994).

Honey bees are the most common pollinator in agriculture due to the relative ease in which humans can keep and move them around. It is estimated that honey bees are worth $14.6 billion to the agricultural industry (Morse and Calderone, 2000) and contribute to 1/3 of the food we eat (McGregor, 1976). Honey bees may be more effective pollinators due to their colony size (up to 60,000 honey bee workers in the summer), but native bees are also important pollinators and in some cases are more efficient than honey bees at the individual level. However, the quantity of native bees is declining across the US (Status of Pollinators in North America, 2007), increasing agriculture's reliance on beekeeper managed honey bees.

Equally interesting is the adoption of apiculture as a new enterprise by many people. The impact on fruit productivity due to honey bees is given in the Table 2. Pollination using honeybees is the most cost-effective method for pollinating apple and other fruit crops. Use of beekeeping is, therefore, the most promising method of horticultural crop pollination in the north eastern region. Research has shown that pollination by honey bees increases fruit set, enhances fruit quality and reduces fruit drop in apple (Dulta and Verma, 1987), peach, plum, citrus, kiwi (Gupta *et al.*, 2000) and strawberry (Partap, 2000; Partap *et al.,* 2000). Bee pollination did not only increase the fruit set but also reduced fruit drop in apple, peach, plum and citrus (Dulta and Verma, 1987; Partap, 2000; Partap *et al.,* 2000). Reports have also indicated an increase in fruit juice and sugar content in citrus fruits (Partap, 2000). In strawberry, bee pollination reportedly reduces the percentage of misshapen fruits (Partap, 2000). It has been estimated that the benefit of using honeybees for enhancing crop yields through cross-pollination is much higher than their role as producers of honey and beeswax. Various estimates have been made to prove the economic value of honeybees in agriculture in developed countries (Table 2). Experiments on effect of bee pollination on various crops were conducted by Central Bee Research and Training Institute and various Agricultural Universities under All India Coordinated Project on Honeybee Research and Training (ICAR). The impact on vegetable seed production due to honey bees is given in the Table 3. The experiment have showed that honeybee pollination enhanced seed production and quality of seed in various vegetable crops such as cabbage, cauliflower, radish, broad leaf mustard and lettuce (Partap and Verma, 1992; 1994; Verma and Partap,1993;1994).

**Table 2. Impact of honeybee (*Apis cerana*) pollination on fruit productivity**

| *Crop* | *Increase In Fruit Set (%)* | *Increase In Fruit Weight (%)* | *Increasein Fruit Size (Length, Diametre) (%)* | *References* |
|---|---|---|---|---|
| Apple | 10 | 33 | 15, 10 | Verma and Dulta, 1998 |
| Peach | 22 | 44 | 29, 23 | Partap et al., 2000 |
| Plum | 13 | 39 | 11, 14 | Partap et al., 2000 |
| Citrus | 24 | 35 | 9, 35 | Partap, 2000 |
| Strawberry | 112 | 48 | Misshapen fruits decreased by 50 percent | Partap, 2000 |

(Source: Verma and Dulta, 1998; Partap *et al*., 2000)

Recent estimates by Morse and Calderone (2000) show that the value of honeybee pollination to crop production in the US is US$ 14.6 billion and the value of honeybee pollination has been estimated at CAN $ 1.2 billion in Canadian agriculture (Winston and Scott, 1984), US $



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3 billion in EEC (Williams, 1992), and US$ 2.3 billion in New Zealand (Matheson and Schrader, 1987). Cadoret (1992) estimated that the direct contribution of honeybee pollination to increase farm production in 20 Mediterranean countries was US$ 5.2 billion per year, 3.2 billion in developing countries and two billion in other countries. Similarly, Chen (1993) estimated the value of honeybees to four major crops in China, including cotton, rapeseed, sunflower and tea, at US$ 0.7 billion. It has been estimated that over three quarters of the world's crops and over 80 percent of all flowering plants depend on animal pollinators, especially bees (Kenmore and Krell, 1998).

Four indigenous species of honey bees are recognized from India, these are *Apis cerana, A. dorsata*, *A. florae* and *A. andreniformes*. The Indian hive bee *Apis cerana* and rock bee *Apis dorsata* are the most abundant and predominant pollinators in the region for cross pollinated crops including vegetables which constitute 46 and 42%, respectively of the total pollinators population. Other insect visitors are little bee *Apis florae (*Bumble bee) *Bombus haemorrhoidalis* and *B. tunicatus* (Carpenter bee), *Xylocopa aestuans* (Alkali bee) *Nomia curuipes* (Leaf cutter bee), *Megachile umbripennis (*Sweet bee), *Halictus albescens (*Drone flies) Ishcodon (*Scutellaris* and *Episyrphus balteatus)*. Promoting use of beekeeping for pollination of horticultural crops will be of benefit to both the beekeeper who will receive money for the pollination services of his honeybees and harvest honey and to the farmer whose income will be increased through boosting crop productivity as a result of pollination services of bees.

**Table 3. Impact of honeybee (*Apis cerana*) pollination on vegetable seed production**

| *Crop* | *Increase in Pod Setting (%)* | *Increase in Seed Setting (%)* | *Increase in Seed Weight (%)* |
|---|---|---|---|
| Cabbage | 28 | 35 | 40 |
| Cauliflower | 24 | 34 | 37 |
| Radish | 23 | 24 | 34 |
| Broad Leaf Mustard | 11 | 14 | 17 |
| Lettuce | 12 | 21 | 9 |

Source: Partap and Verma, 1992; 1994, Verma and Partap, 1993; 1994.

This will help ensure food security and enhance the livelihoods of both the farmers and the beekeepers. This system of hiring and renting honeybee colonies for apple pollination is being practiced in Himachal Pradesh in northwest Indian Himalayas.

## CONCLUSION

The declining horticultural productivity can be attributed to a number of factors, but pollination plays a crucial role. One can go for use of improved agricultural technologies, such as the use of quality seed, high yielding verities, good agronomic practices like timely irrigation and fertilizers, but without pollination, neither fruit nor seed will be formed. Pollinator scarcity is the main factor responsible for inadequate pollination; this can be overcome by conserving manageable species of honey bees' populations. Promoting use of beekeeping for pollination of horticultural crops will be of benefit to both the beekeeper and to the farmer. Widespread adoption of these practices is unlikely unless there is a general

appreciation by the production agriculture sector of the ecological and economic benefits of pollinators. The dramatic decline in pollinator populations is a critical issue for production agriculture but it is not yet on the top priority list for many agricultural organizations. Many growers are not aware of how significant the contribution of native pollinators is to the production of their crops and farm profitability. Other challenges include active participation of researcher and extension specialist will help in expansion of use of honey bee rearing for crop pollination.



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