Pollinator management: An eco-friendly green revolution eludes India

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Production of cross-pollinated crops can be increased considerably in areas where there is a dearth of natural pollinators by bringing pollinators like domesticated bees to the crop when it is in bloom. This practice has yielded excellent results and the technique is widely used in advanced countries to enhance production, particularly of self-sterile crop varieties; and significant investment is made in research in evolving more efficient techniques as well as pollinators. In India this method is virtually non-existent. The National Commission on Agriculture was fully aware of the enormous potential of bee pollination and made a chain of very important recommendations aimed at increasing bee population and utilizing bee pollination as a powerful instrument for higher productivity. Unfortunately there was no follow up action and the unsatisfactory position of bee culture and crop productivity continue to afflict Indian agriculture.

The genesis of pollinator management

IN 1892, the US Department of Agriculture received a complaint that 22,000 Bartlett pear trees in the State of Virginia failed to bear fruit. It sent a specialist who found there was an absence of natural pollinators in the area and bees were necessary for pollen transfer[1]. The introduction of bee hives brought about a total transformation in fruit production, from a zero yield situation to one of optimum yield. This was perhaps the earliest demonstration of the enormous potential of bees to enhance crop yields and establishing the honey bee as a powerful agent of crop productivity. Since then, great strides have been taken leading to harnessing bees for pollination in cross-pollinated crops.

'Pollinator management', 'applied pollination', 'managed pollination' have now become common expressions associated with enhancing productivity by bringing the pollinator to the target crop. Use of honey bees has yielded unprecedented levels of crop production in advanced countries. A honey bee colony – comprising, at peak strength, about 20,000 bees in a colony of *Apis indica* and 80,000 in that of *Apis mellifera* – possessing a workaholic instinct, an uncanny ability to locate accurately and forage on fields 30 to 35 km^2 around the hive, versatility in working on a wide range of crops and each bee endowed with branched hairs that trap millions of pollen grains, constitutes a formidable pollinating force hardly matched by any other pollinator (Figure 1).

Progress made in the US

About 60 years ago, it became clear in the US that production could increase considerably by careful management of pollination in many fruit, seed and nut crops. Size and quality of the crop improved with better pollinator service. Besides, agricultural areas were coming under such intensive use that the natural habitats of pollinators were being destroyed, resulting in scarcity of potential pollinators. The logical consequence was resorting to the use of bee colonies reared in boxes that could be moved to wherever the pollinator service was required[2]. Today in the US, the criss-crossing of the country by trucks transporting thousands of bee hives over long distances is a common feature. Beekeepers rent their hives against handsome payments, to the agriculturists during flowering time. One estimate of bee

Figure 1. *Apis cerana* in a mustard field in Srinagar. (Courtesy: Central Bee Research and Training Institute, Pune).

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hives rented annually places it at one million, with several of them moved over to a second crop in the year[3]. The value of crops resulting directly from bee pollination is estimated to be about 8 billion dollars annually.

The phenomenal advances achieved in the US owe their success to the infrastructure by way of research, extension, legal provisions and other assistance provided by the Federal and State Governments and State Universities, who have several specialists in different branches of bee science on their faculty engaged in teaching, research and extension work in apiculture. The US Department of Agriculture recognized the need to increase the number of pollinators nearly 50 years ago and the Agricultural Research Service provided support to the beekeeping industry by establishing a number of bee research laboratories and other funded programmes. The Bee Biology and Systematics Laboratory, Logan, Utah was set up[3] in the late 1940s to determine the efficacy of non-honey bee species as pollinators of targeted crops, as a result of which several bee species have been developed into commercially-managed pollinators of various crops. These bee varieties, popularly known as solitary bees, do not live in colonies but individually in hollow twigs or other tubular cavities above or below ground[4]. They include varieties like *megachile*, *chalicodoma*, *xylocopa* (also known as the carpenter bee). These are mostly oligotropic, visiting only a few related species of plants, but excellent pollinators of those plants. Notable case of such a solitary bee pollinator is the *Megachile pugnata* also called the sunflower leaf cutter bee, the pollinating efficiency of which is so high that less than a thousand of their number is adequate to pollinate a hectare[5] of sunflower crop whereas 50 to 60 times the number of honey bees would be required for the same purpose.

Relevance of the technology to developing countries including India

In the developing countries, the much vaunted green revolution that encouraged the practice of 'food self sufficiency at any cost' has wrought considerable environmental depredation. Increasing dependence on intensive practices, pesticides and other chemicals as also deforestation have had an adverse impact on the nesting and mating sites of natural pollinators. Extensive use of farm machines creating noise disturbance has driven them out of their natural habitats. Under these circumstances, recourse to pollinator management has become imperative for obtaining optimum crop production. Some countries have increased productivity of certain crops through pollinator management practices by empolying pollinators other than honey bees. The experience of Malaysia presents a classic example. Despite the importance of oil palm, the means of its pollination was elucidated as recently as 1979. The pollinator for this crop which has received the most attention is the weevil *Elaeidobius kamerunicus*. This weevil was introduced[6], after careful quarantine and study of its potential to become a pest of non-target crops, from its native habitat in West Africa into Malaysia in 1981. There it immediately became established and spread rapidly throughout the plantations of the country, resulting in millions of dollars of profit to the industry. Today Malaysia is the global leader in both the production (58% of world output) and export (78% of total exports by exporting countries) of palm oil[7].

This tool for enhancing production of cross-pollinated crops by almost exponential proportions, a virtual eco-friendly green revolution, seems to have eluded India. In isolated cases like Kodagu (coffee), Mahabaleshwar (horticultural crops), Punjab and Haryana (oilseeds and vegetables), Kashmir and Himachal Pradesh (apples), this has been brought about, though adventitiously, by beekeepers in their attempt to maximize apiary yields, by migrating their hives to places around farms of cross-pollinated crops in bloom. The numbers, however, are far too small, even negligible, viewed from the national context.

The Indian scenario

In our country, recourse to pollinator management aimed at enhanced crop production is practically unknown. Not much attention has been devoted to beekeeping as such. Even countries like Mexico, Argentina and China are far ahead of India in having much larger number of bee colonies and raising greater output of apiary products, enabling them to be established exporters of such products for decades whereas our country does not feature on the export map[7].

Research activity in India on bees is in a state of neglect. The National Commission on Agriculture (1970–1976) recommended that every Agricultural University – at present there are 33 of them in the country, including the deemed Universities – should develop a section on Apiculture under their Entomology Division for research, education and training. The implementation of this recommendation would have sown seeds of accelerated apicultural development leading to agricultural prosperity, but that was not to be. Very few Universities are engaged in bee research. As against a large number of scientists at the command of the US Department of Agriculture, the solitary expert under the Union Government is the Project Director of the All India Co-ordinated Project on Honey-bee Research and Training of the Indian Council of Agricultural Research and his seems to be a voice lost in the wilderness. The woeful situation is best summed up in his words: *It is unbelievable but true the science of beekeeping starves of man-*

power. There are just about two dozen scientists in the whole of India who are engaged in bee research. This negligible number is supposed to look after all branches of bee research such as management, biology, breeding, biochemistry, nutrition, bee pathology, bee toxicity, pollination, etc. There is no provision to keep these scientists committed to beekeeping and they move out after a brief stay in the field.

Research in science provides a powerful engine for development. The turning around of the foodgrains situation from one of hopeless shortages and imports to that of self-sufficiency and surpluses is primarily the achievement of our scientists. The Government has made considerable investment in agricultural research. The Apex Institution, the Indian Council of Agricultural Research, has spread out to cover a large canvas of agricultural disciplines. Under this Council, there are 4 National Institutes and 41 Central Institutes of Research. Besides, the Central Government controls 4 National Bureaux, 10 Project Directorates and 30 National Research Centres, all dedicated to agricultural research. All these cover a vast array of subjects including various foodgrains, forestry, horticulture, fisheries, soils, dairying, sheep, goats, buffaloes, and even uncommon animals like camels, equines, yak, mithun, etc. *The one notable omission is, however, bee science*, despite its importance. Under the Council, there is, no doubt, an All India Coordinated Project on Honey-bee Research and Training which is one among 86 such projects. These projects are not full-fledged research entities like the Institutes.

The only Research Institute in bee science in the country is the Central Bee Research and Training Institute, Pune. Strangely this Institute is not under the Ministry of Agriculture but under the Khadi and Village Industries Commission which has no science or research background or orientation. (Contrast nearly a dozen Bee Research Institutes *directly* under the US Department of Agriculture.) Considering the vastness of the country, widely varying climatic conditions, and diverse bee pollinated crops grown over a third of the total area under crops in the country, there is need to establish at least 4 to 5 research institutes with competent scientists.

The master plan recommended by the National Commission on Agriculture

The eminent cytogeneticist and bee scientist, late G. B. Deodikar had made a statement in the sixties that beekeeping has the potential to raise resources equal to the revenues of the Indian Railways. He did not have in mind at the time, honey and other apiary products. The reference was to the benefits arising from bee activity on cross-pollinated crops. The National Commission, too, laid stress on the immense, hitherto untapped potential of bee pollination in the country. It set out a completely new direction to the pursuit of beekeeping which was being practised for securing higher apiary yields to beekeepers. 'The primary objective of modern apiculture should be to secure higher crop yields', the Commission observed, 'Honey and beeswax will come as a byproduct'[9]. It planned to use apiculture as an important instrument to enhance substantially the yields of cross-pollinated crops like oilseeds, pulses, fruits, vegetables, legumes and certain commercial crops. On the basis of experiments conducted in the country and information collected from abroad, the Commission found that additional yields attributable to bee pollination could be obtained in crops to the following extent: coffee – 83%; onion – 178%; mosambi – 750%; orange – 900%; alfalfa – 19,733%; berseem – 33,150%; vetches – 20,000%; kidney beans – 600%; runner beans – 1,100%; apple – 6,950%; pear – 6,014%; plum – 2,739%; litchi – 10,246%; grape – 6,700%; among oilseeds toria – 220%; sarson – 222%; sunflower – 3,400%. Similar experiments, separately conducted by the Central Bee Research Institute, Pune supported these findings[10].

The observations and conclusions of the Commission acquire special significance in the case of oilseeds and pulses which are in short supply. It held that for enhanc-

Box 1.

The role of bees as the sole providers of honey has been known for thousands of years. Nevertheless, the fact that in collecting nectar from flowers, bees bring about pollination which is essential for seed production was realized only in the 18th century. In modern times the Western countries have been exploiting this phenomenon for enhancing the productivity of crops and farmers rent bee hives for keeping in their fields during flowering of crops to ensure sufficient pollination. Raising bee hives for providing pollination services has become a profitable industry there. The direct benefit from bee pollination in the US is estimated at an enormous 8 billion dollars annually.

India with a wealth of bee-pollinated crops, including oilseeds and pulses grown over a third of the area under crops, can also reap comparable benefits but the practice of pollinator management, i.e. taking the pollinator (primarily bees) to crops in bloom for pollination is virtually unknown in this country. The National Commission on Agriculture (1970–76) was conscious of this and made a chain of radical recommendations for spreading apiculture to every nook and corner of the country for raising nationwide productivity besides creating rural employment. Sadly, the nation failed to take heed. As a result, the country is paying a heavy price. The benefit of thousands of crores of rupees worth of crops that could have been raised annually has been denied to our farmers and the country made to depend on import of oilseeds and pulses year after year.

ing productivity, especially of oilseeds, bee pollination was unavoidable. It observed: 'In the case of crops which have varying degrees of self-sterility, any amount of fertilizers, irrigation or cultural care may not give even a fraction of their potential yields unless bees are provided during the flowering period. Examples of such crops are mustard, gingely, niger, safflower....'

Among oilseed crops, the result of experiments single out the sunflower as one responding with abundant yield to bee pollination. The Indian Council of Agricultural Research too has made a special note of this phenomenon. This is attributable to the very large number of florets – even 2 to 3 thousand – on a single flowerhead and the high level of self-sterility of this crop, and therefore cross pollination by bees is essential for seed set. The conclusion that the high yield of this crop is ascribable to bee pollination not only in experimental plots but even in normal field conditions is corroborated by the experience of the State of Punjab which has the densest bee population among all the States and where the enterprising beekeepers, unlike elsewhere, migrate their colonies to sites around farms during the flowering period. The yield per hectare of this crop in Punjab is about 300% of the national average, a performance not equalled by any other crop, not even rice or wheat for the high productivity of which that State is reputed.

The Commission drew up a highly ambitious plan to extend apiculture over the length and breadth of the country, pervading every village – each village growing crops was to have on an average ten bee hives – thereby ensuring bee activity on a nationwide scale. The underlying principle evidently was that pollinators should be sited proximate to the target crops, practically dispensing with the need to move bee hives to the cropped areas as is the practice in the West where beekeepers and agriculturists constitute two distinct and different but mutually-dependent entities. This pollinator-at-site concept is now being tried out in the USA under the name of 'designer pollinators' by resorting to the use of solitary bees for pollination since such a system would reduce dependence on the massive movements of bee hives[2]. The Commission thus laid the foundation for a pollination revolution designed to enhance, in one big leap, the productivity of a very wide range of crops by significant margins. It aimed at a multifaceted rural development, creating of far-reaching rural employment and self employment, providing additional source of income to the rural poor – especially to the small and marginal farmers – apart from increasing farm output.

The salient features of the strategy spelt out by the Commission involved increasing the number of bee hives, of which there were only 0.5 million at that time, by 6 million in 24 years (1976–2000); enabling achievement of this target by establishing a network of 125 queen bee multiplication stations so that each station would serve 5,000 villages; ensuring that each such station would raise 2,000 queens in a year so as to meet the sub-target of 0.25 million hives every year; establishing 3,000 honey houses for testing, processing, packing and storing the resultant huge quantities of honey estimated at 60,000 tonnes per year; and marketing the product through 30,000 markets (by the year 2000) recommended, at an average of ten markets per taluk. In other words it was a comprehensive and complete master plan for substantially raising nationwide agricultural productivity.

Unfortunately, *not one of these vital recommendations has been implemented for the last 21 years*. The number of bee hives in the country is just about a million. Even assuming, on a conservative basis, that only one fourth of the percentage yield increases noted by the Commission were to be realized, and these too limited to the three crops, viz. mustard, safflower and sunflower, the annual edible oilseed production today would have been 37 million tonnes, about 66% over the current level and valued at nearly 14,000 crores of rupees a year, calculated at the support prices of these crops for the 1996–97 crop season. By now India could have emerged as the world's major, if not leading, exporter of edible oils.

The National Beekeeping Development Board

In 1993, the Government constituted a 14-member National Beekeeping Development Board with the Secretary Agriculture as Chairman. It drew up a six point programme 'Development of beekeeping for improving crop productivity' to be implemented in 3 years (1994–97), with an outlay of Rs 18.87 crores. The components of the scheme were: promotion of research and development; production of bee colonies (0.45 million to be raised by March 1997); development of infrastructure for handling and marketing honey kits products; training; promotion; and planning for long term development. In 1995 three working groups were set up for research and development; processing and marketing; and production of bee colonies. Plans drawn up seem to be still on the drawing board. The targeted 0.45 million colonies have defied attainment.

The Board however, deviated from the basic approach advocated by the National Commission. The securing of higher crop yields was not the primary objective but a byproduct of the pursuit of apiculture for obtaining higher returns from apiaries. Crop productivity did not feature as a specific component of the scheme nor was a working group set up on the subject. Clear targets were not defined for the extent of productivity to be achieved. Consequently it is difficult to conclude that the scheme has succeeded in its objective of improving crop productivity.

Impact on the agricultural economy

India which extends over the tropical and sub-tropical agro climatic regions and is bestowed with a rich and wide variety of cross pollinated crops grown over 50 million hectares can raise the production of these crops to yield additional benefits comparable to what is derived by the USA. The National Commission had given a detailed comprehensive blueprint designed to achieve this objective toward the turn of this century. It is appalling that the far-reaching recommendations of this high level Commission comprising the country's leading agricultural scientists, economists and administrators have been treated with disdain. Naturally the country had to pay a heavy price. The worst affected are the farmers who stand deprived of benefits worth thousands of crores of rupees annually – surpassing by far the total subsidies handed out to them over the years – which the timely implementation of the recommendations of the Commission would have brought them. The country could also have saved large amounts spent year after year on edible oil imports.

Multibillion dollar questions seek answers

In the twenties, Mahatma Gandhi in his advocacy of rural republics comprising self-governing self-contained villages pioneered the adoption of beekeeping as a village industry. Consequently the early beekeepers were his followers who systematically nurtured and kept alive this activity and spread it in the rural areas. Historically this is the reason why the subject was allotted to the Khadi and Village Industries Commission. However, that body could not cope with the pace with which the science was progressing elsewhere nor with the shift in the objective of apiculture from obtaining higher apiary yields to its utilization as an effective tool for enhanced crop production. With the subject coming under close scrutiny of the Agricultural Commission and its findings, it was expected that the profile of apiculture would undergo a radical change and the country's agriculture would receive a vigorous boost.

What are the causes of ignoring the Commission's vital recommendations? Bureaucracy overruling specialists on technical matters? Absence of the latter at decision-making levels? Or are we completely oblivious to the multibillion dollar benefits other countries are reaping through pollinator management? No agricultural strategy for increased productivity, much less an environment compatible one, can render such high yields in so short a time with as little investment as applied apiculture. Even now can the Commission's recommendations be retrieved and implemented for the sake of rural prosperity? Will apiculture, the Cinderella among agricultural sciences in India, forsaken and neglected so far, ever be rescued and given an opportunity to play her legitimate role in contributing to the nation's agricultural wealth? Can the country look forward to a future when the enormous untapped potential of bee pollination is exploited to raise crop production to unprecedented heights? Time alone has the answers.

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