



Declining Apple Production and Worried Himalayan Farmers: Promotion of Honeybees for Pollination

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Diversification of mountain farming to high-value cash crops is going through a major crisis due to pollination-related productivity failures. Citing the example of apple crops in the Hindu Kush-Himalayan (HKH) region, this paper brings to light a lesser-known ecological dimension that is severely affecting apple production and quality. The studies carried out by ICIMOD reveal that declining apple productivity is a result of inadequate crop pollination. Some apple farmers in India and China are aware of this and are trying to overcome this problem using different approaches, including the use of honeybees. But the majority of farmers and institutions in the HKH region have little knowledge about this crucial factor that is limiting the productivity and quality of cash crops like apples and other fruits and vegetables.

Introduction

Agriculture in the Hindu Kush-Himalayan (HKH) region is in a stage of transition from traditional cereal crop farming to high-value cash crops such as fruits and vegetables. However, this ongoing transformation from subsistence to cash crop farming poses new challenges for maintaining crop productivity and quality. Among these challenges are crop failures due to inadequate pollination (Partap and Partap 1997). Evidence of this emerging problem has been documented in a series of field studies (to be published soon) carried out by ICIMOD across the HKH region.

Pollination Problems of Cash Crops in the HKH: Apples as an Emerging Example

Apples are the lead cash crop in several areas of the HKH region where they account for 60 to 80 % of the total household income. Over 84 hilly and mountainous districts of India, Pakistan, Bhutan, China, and Nepal grow apples on cold, sloping, and marginal land covering about 320,000 hectares. It is estimated that the annual production of apples in the HKH region is over 2.5 million tonnes, bringing in an income of about US\$ 450 million per year to farmers and others involved in apple farming and marketing. However, over the past decade, farmers have been complaining about decline in apple production despite agronomic inputs and orchard management practices (e.g. irrigation, fertilisers, and pesticides). The majority of farmers claim that productivity has declined by about 50 %.

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Against this background, field surveys were carried out to examine pollination-related problems in the apple growing districts of the HKH. The surveys focused on investigating pollination-related productivity problems of apple crops and on farmers' management practices in Himachal Pradesh in India, Maoxian County in China, the Thimphu and Paro valleys in Bhutan, Balochistan and the northern areas in Pakistan, and in western Nepal. The findings were startling. Apple productivity is declining in many of these areas as a result of inadequate pollination. In two areas, Maoxian

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The general observation of farmers is that, in the past, there used to be a lot of insects such as wild bees, butterflies, and moths during the apple flowering season, but now they have disappeared.

County in China and Himachal Pradesh in India., farmers are managing pollination by adopting different methods.

Factors Responsible for Inadequate Pollination of Apple Crops in the HKH

The factors responsible for inadequate pollination of apple crops in the Hindu Kush-Himalayan region are believed to be the following.

Scarcity of Polliniser Varieties

Swayed by market demand, farmers have begun to ignore the appropriate ratios of polliniser varieties of apple trees in planting. Almost all of the commercially important varieties of apples are not in themselves compatible. In order to produce fruit these varieties require pollen from other compatible polliniser varieties. Some farmers do not have even a single polliniser tree in their orchards. Lack of appropriate proportions of polliniser varieties in the orchards is the key cause of inadequate pollination.

Inadequate Populations of Insect Pollinators in the Local Environment

Insecticides have contributed to the extermination of both the diversity and abundance of pollinating insects. Farmers observe that, in the past, there used to be a lot of insects such as wild bees, butterflies, and moths during the apple flowering season but now they have all disappeared.

Inadequate populations of pollinating insects in apple growing areas is another reason for pollination failure. The population of natural insect pollinators is declining as a result of the alteration in their food and nesting habitats caused by shrinking natural ecosystems, i.e. forests and grassland ecosystems. Another important reason for the declining diversity of natural insect pollinators is the excessive use of pesticides on the new generation of cash crops by farmers. Insecticides have contributed to the extermination of both the diversity and abundance of pollinating insects. Farmers observe that, in the past, there used to be a lot of insects such as wild bees, butterflies, and moths during the apple flowering season but now they have all disappeared. Yet another reason, which

is not so well understood, is that there may be fewer natural populations of pollinators than needed to pollinate the large, newly developed areas of apple crops in the HKH region.

Changes in Weather Conditions during Flowering

The third important cause of pollination failure is climate change. During the last few years, bad weather conditions such as frost, rain, and hailstorms and low temperatures during the apple flowering period have been experienced. For example, sudden falls in temperature and rainfall during the apple flowering period can adversely affect pollination.

Box 1: Market-led Scarcity of Polliniser: Example from Himachal Pradesh, India

When apple farming started in the 1960s, farmers in Himachal Pradesh planted many varieties such as Commercial, Golden, Jonathan, Red Gold, Kali Devi, Red, and Royal Delicious. These provided compatible pollen to other varieties and a balanced fruit set was ensured. However, due to the better market value of Delicious varieties, especially Royal and Red Delicious, since the early 1980s farmers started to uproot polliniser varieties and planted the Royal Delicious on a large scale. Royal Delicious is self-sterile and requires cross-pollination. It requires pollen from other compatible varieties for fruit setting. So, wherever the orchards have Royal Delicious only, there are serious pollination problems.

Experiences of Apple Pollination Management in the HKH

The following section describes briefly two different approaches used by farmers in Himachal Pradesh in India and Maoxian county, Sichuan, in China.

Polliniser Management

In Himachal Pradesh in India, polliniser trees have been planted to increase the proportion of polliniser varieties. Polliniser varieties are grafted on to commercially premium varieties for rapid results. Farmers have even devised short-term solutions to bridge the gap until the grafted

branches or newly-planted polliniser trees begin flowering. Bunches of small flowering branches of the pollinisers called 'bouquets' are put in plastic bags filled with water. These branches are hung on the trees of commercially premium varieties. This type of pollination method is locally referred to as 'Bouquet Pollination'. The large-scale use of plastic bags has increased the price of plastic bags in the local market from US\$ 0.75 per kg to US\$ 2.1 per kg. In Maoxian County of China, however, no efforts are made to plant pollinisers. It was observed that only a few farmers have grafted pollinisers on to other trees.

Pollinator Management

As reported, the scarcity of natural insect pollinators has become a crucial factor in inadequate pollination. The solution lies in supplementing pollinator populations. Known crop pollinators include different types of bees such as honeybees, bumble bees, stingless bees, solitary bees, and so on. In the HKH, however, this is a relatively new problem that has not received adequate research attention and therefore these options have not been explored. Farmers in Himachal Pradesh are using honeybee colonies - *Apis mellifera* and *Apis cerana* - for pollination (Partap 1998). A system of renting and hiring bee colonies is evolving rapidly in Himachal Pradesh. At present, it is mostly the Department of Horticulture and a few private beekeepers that rent out bee colonies to apple farmers. The current rate for renting an *Apis cerana* or *Apis mellifera* colony for apple pollination is US\$ 20 per colony (US\$ 12 as security and US\$ 7.5 as rent). Only a few farmers keep their own colonies for pollination. A heavy demand for honeybees for pollination has been created, and there are not enough bee colonies to meet this demand, hence, in the apple growing areas of Himachal Pradesh, there is a tremendous scope for entrepreneurial beekeeping for pollination.

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Hand Pollination

Hand pollination of apples is a common practice in Maoxian county of China. It ensures that each flower is properly pollinated. This is a massive exercise in a sixty-km long valley in which every family member - men, women, and children - is involved (Partap and Partap 2000). In Maoxian county, hand pollination is a community effort in most villages. Labourers are employed for this purpose; better termed as 'human bees'. These people are doing the work of honeybees (Beekeeping and Development 2000). Farmers either share days among themselves or hire labourers to pollinate their apple orchards. Since the orchards are small, families try to pollinate them themselves by training all the members of the family. Farmers report that hand pollination has increased their apple crop production by up to 50 per cent.

The use of honeybees by the farmers is surprisingly absent, even though migratory beekeepers are found in the area. A cost-benefit analysis of hand pollination shows that it is an expensive, laborious, and time-consuming method of pollination. Alternatively, if these farmers were to use bees for pollination of their apple trees it would be eight times cheaper. It is foreseeable that the fast improving economy in the area will make hand pollination an increasingly costly option for farmers.

Box 2. Human Bees doing Hand Pollination in Maoxian County, Sichuan, China

The hand pollination process adopted by the Maoxian farmers involves picking up anthers from the flowers of the polliniser trees in the balloon stage, i.e. from partially open flowers. These are then dried to release pollen grains. Farmers usually dry anthers by spreading them out in the sun for a day or two. Some farmers also use cardboard boxes fitted with a 25-Watt electric bulb and electric blankets to dry the anthers. The pollen grains are stored in a cool, dry place and remain viable for three to four days. These are mixed with white flour or skimmed milk powder. This mixture is then applied to the flowers of the main variety within two days after the flowers open. Pollen is applied with the help of either a hand-made brush or the filter end of a cigarette, or by using a pencil eraser. The farmers pollinate three out of five flowers in each inflorescence. The hand pollination process is repeated three times in a season to cover all flowering stages in a tree. The process is repeated in billions of flowers by thousands of farmers every year.

Why don't Maoxian farmers use honeybees for pollination? Investigations revealed that there was a lack of awareness about the use of honeybees. Research and development institutions were not promoting the use of bees in the first place, so farmers did not know about it. The migratory beekeepers, which moved their bee colonies to this valley, expressed reluctance to rent out their bee colonies unless farmers ceased over using pesticide sprays on their apple crops.

Box 3. The Role of Maoxian County Government in Promoting Hand Pollination and Ignoring Beekeeping

Using its extension system, the Maoxian County Government spread the technology of hand pollination throughout the County. Field experiments to standardise the technique were completed by 1990 and farmers were given training in 1991. At that time only some farmers accepted the technique. But, as the impact of pollination by hand became apparent, other farmers in the County were also convinced. In 1994, 1,300 hectares of apple plants were pollinated by hand, and, by 1999, about 2,000 hectares of apple plants were hand pollinated. On the other hand, the Maoxian Government did not take steps to bring awareness and/or promote the use of beekeeping for pollination.

Potential Solution: Promoting the Use of Honeybees for Pollination

Both traditional stationary beekeeping with *Apis cerana* and migratory commercial beekeeping with *Apis mellifera* are common in the HKH region. However, farmers in most areas where pollination is a problem were not aware of the value of honeybees for apple pollination. The practice of using bees for pollination is limited, e.g. Himachal Pradesh only. This is because, in the past, awareness about and promotion of beekeeping focused on promoting it for honey production only. Institutions rarely promoted the more valuable role of bees for pollination. Therefore, neither the policies nor the institutions supported the development of beekeeping from the point of view of facilitating crop pollination. Today, the few beekeepers who are willing to rent their bees for apple pollination do so only if the farmers control pesticide use and pay acceptable fees. Good rental fees are rarely paid. In some areas, for example, Maoxian County, China, and Swat Valley, Pakistan, farmers are prepared to offer only food and fuelwood to beekeepers in return for keeping bees in their orchards for pollination services.

Need for Strengthening Research and Extension Systems

Beekeeping for crop pollination is a relatively new initiative in the HKH region. There are few institutions in the region that have explicit mandates and capable manpower to undertake it. Most institutions (GOs and NGOs) have focused on the honey production aspect and they promote beekeeping as a cottage industry to increase family income through the sale of honey. There are only isolated examples like that of Himachal Pradesh where special efforts have been taken by government agencies to strengthen the research and extension systems to enable them to promote beekeeping for crop pollination. Governments in other countries of the HKH region need to introduce similar initiatives. Many farmers do not know whether the decline in productivity is due to lack of pollination. For example, there is a problem of crop pollination in the mountain areas of Pakistan. Commercial beekeeping with *Apis mellifera*, promoted by the government of Pakistan, is common, but there are no efforts to use bees for crop pollination. Similarly, in Bhutan farmers are yet to be made aware of the pollination problem in apple production.

ICIMOD's Initiatives in the HKH

ICIMOD has an ongoing programme to raise awareness about this problem in the HKH region. Awareness about the value of honeybees as crop pollinators has to be raised at all levels – among planners, policy-makers, beekeepers, or farmers. The thrust of the pollination programme is to raise awareness about the need for managing pollination through bees. ICIMOD's programme is also trying to generate knowledge and information to facilitate the development of strategies that will ensure wider use of beekeeping for pollination. To achieve this objective various steps are being taken.

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Conclusion

From the preceding discussion, it can be seen that in addition to soil, water, and nutrients, pollination can also be one of the factors limiting crop productivity. Problems related to pollination are relatively new in the HKH region and need attention in the early stages. Apples are only one example of any number of cash crops grown in the HKH that require pollination management for better production and quality. Vegetable seed production is yet another crucial sector in which pollination management is essential. The preferable solution to this problem is to promote honeybees for pollination. The more effective strategy would be to use area-based approaches, as explained earlier, in order to benefit from the existing diversity of honeybee species in the HKH region.

Box 4: Institutional Efforts to Promote Beekeeping for Apple Crop Pollination in Himachal Pradesh, India

The Role of the Himachal Horticulture and Forestry University

- There is strong scientific expertise available on honeybees, beekeeping, and pollination aspects at the Himachal Pradesh Horticulture University.
- University field stations in apple farming areas constantly monitor horticulture-related problems of farmers and focus on problem-solving research.
- On-farm research and demonstration are carried out on the positive effects of using beekeeping for apple pollination.
- Special awareness programmes are launched by the University in apple farming areas.
- Agricultural Science Centres or extension centres of the University are located in these areas and give on-demand beekeeping training to farmers and interested new entrepreneurs.
- The University provides bee colonies for pollination. The Beekeeping and Horticultural Research Stations of the University have maintained both *Apis cerana* and *Apis mellifera* for this purpose.
- The University also provides the training and demonstration on how to use bees for pollination.

The Role of the Department of Horticulture, Govt of Himachal Pradesh

- The Department of Horticulture set up a Beekeeping Development Office (BKDO) for Pollination which maintains bee colonies and rents to farmers. It is also selling *Apis mellifera* colonies at a subsidised rate of US\$ 7.5 per colony. The current market price of a healthy colony is over US\$ 50.
- The Department of Horticulture does an annual assessment of the possible demand for bee colonies by apple farmers and, as facilitator, makes arrangements for supplies with private beekeepers.
- It provides attractive financial support to start beekeeping enterprises for pollination.
- It provides honeybee colonies at subsidised prices to promote their use in pollination.

The Role of the Himachal Apple Growers Association

- It is an excellent platform for farmers to discuss emerging problems and to act as a strong pressure group to seek government intervention.
- It raised the apple pollination problem faced by farmers with the University and government - seeking rapid solutions.
- It raised awareness about the scale of the problem in the state and encouraged farmers to become beekeeping entrepreneurs for pollination. It coordinated bee demand-supply aspects.

The focus of beekeeping needs to change from conventional honey production to crop pollination. In this way honey becomes a by-product. Crop pollination will also require a large number of honeybee colonies to match the pollination needs of crops over a wide area. The number of honeybee colonies required in any area may even go beyond the carrying capacity of the respective areas. To manage bee colonies in such large numbers either bee forage plants need to be increased through new plantations or migratory beekeeping should be promoted as an enterprise. The latter option will also help strengthen upland-lowland linkages. One way to have a number of bee colonies would be to promote beekeeping for pollination entrepreneurs. Another option is to encourage farmers needing pollination services to keep a few bee colonies. In doing so, the farmer will not only earn more from the improved productivity of cash crops, but honey will also be a by-product. It is, however, hard to say which option is better. The determining factors will be the farmers, markets, and institutional capacities in an area.

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In the HKH region, lack of awareness among farmers is further compounded by weak institutional capacities (research, extension, development) in this field. Thus, there is a need for strengthening R & D institutions in terms of new approaches.

In western countries, farmers are already using honeybees and a number of other bee species such as bumblebees and solitary bees (species of *Osmia*, *Megachille*, *Nomia*, *Xylocopa*, and many others) for pollination of different crops. There are companies that rear these insects and sell them to farmers for the purpose of pollination. However, in the HKH region the insect-based enterprises supplying crop pollinators are not there yet. Therefore, this is yet another sector open for entrepreneurship development.

Acknowledgement

The financial assistance of the Federal Chancellery of Austria through the Austroprojekt to carry out this study is thankfully acknowledged. We greatly appreciate the cooperation extended by the farmers and local institutions in sharing their insights regarding the problems during the surveys.

These studies investigated the state of inadequate pollination, its causal factors, and its impact on crop productivity. This IMD flags the key findings of investigations about pollination problems in the HKH region. Full details of these studies are soon to be published by ICIMOD.

References

- BFD (2000) Beekeeping and Development, 54. A Quarterly Newsletter of Bees for Development. U.K.:BFD
- ICIMOD (1994) 'Promotion and Development of Beekeeping through Preservation of Indigenous *Apis cerana*' (Unpublished). First annual report submitted to the Federal Chancellery of Austria
- Partap, U. (1998) 'Successful Pollination of Apples'. In Beekeeping and Development, 48: 6-7
- Partap, U. and Partap, T. (2000) 'Pollination of Apples in China'. In Beekeeping and Development, 54: 6-7.
- Partap, U. and Partap, T. (1997) Managed Crop Pollination: The Missing Dimension of Mountain Agricultural Productivity. Mountain Farming Systems' Discussion Paper Series No. 97/1. Kathmandu: ICIMOD
- Partap, U. and Verma, L.R. (1994) 'Pollination of Radish by *Apis cerana*'. In Journal of Apicultural Research, 33: 237-241.
- Verma, L.R. and Partap, U. (1993) The Asian Hive Bee, *Apis cerana*, as a Pollinator in Vegetable Seed Production. Kathmandu: ICIMOD.

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July
2001