Chapter 4

Apple Farming and Pollination Issues in Himachal Pradesh, India

Himachal Pradesh: The Apple State of India

Himachal Pradesh is a mountainous state in the northwest Indian Himalayas. Its five million people live on marginal sloping lands in hills, mountains, and highlands covering an area of 55,673 km^2 where altitudes range from 350 to 6975 masl. The climate varies from hot to severely cold depending upon altitude. Agriculture is the main occupation of around three-quarters of the total rural population. The average size of landholdings is 1.62 ha, although a large number of holdings are less than 1 ha. The main agricultural crops are wheat, maize, and rice. At higher elevations, crops such as buckwheat, barley, and potatoes are grown in place of rice. Cash crops include fresh vegetables such as cabbages, cauliflower, and tomatoes, and fruit such as apples, almonds, peaches, plums, pears, and cherries in the middle hills and valleys; off-season vegetables, potatoes, pulses, beans, and fruit such as apples, cherries, and pine nuts at higher altitudes; and citrus fruits, mangoes, litchi, guavas, and loquat in the foothills and valleys near the plains.

Himachal Pradesh is sometimes called the 'Fruit State' or the 'Apple State' of India. Out of 614,000 ha of arable land, 32% is under horticultural crops. At present, about 196,000 ha are under fruit cultivation producing about 312,000 tonnes of fruit annually (Department of Horticulture, Himachal Pradesh 1998). Apples are the main cash crop, accounting for 42% of the total area under fruit cultivation and about 90% of total fruit production. About 78,000 ha are planted with apples, there are about 150,000 apple growers, and annual production is about 277,000 tonnes (Department of Horticulture, Himachal Pradesh 1998). Apple trees have been planted in Kinnaur, Kullu, Shimla, and parts of Chamba, Mandi, and Solan Districts.

Apple farming is playing a major role in the economy of Himachal. Its present contribution to the state economy is estimated at about US $1.7 billion per year, with about US $150-170 million contributed directly, and about US $1.5 billion contributed indirectly through providing jobs to thousands of people, not only in Himachal but also in Asia's biggest fruit market in Delhi during the six-month long apple-selling season (Toderia 2000).

Declining Apple Productivity

Apple productivity in the state has been declining continuously for the past few years. Farmers estimate that productivity has declined by 50%. Apple productivity reportedly dropped from 10.8 tonnes per ha in 1982 to about 4.3 tonnes per ha in 1990, which is more than 50%.

Survey Findings

The survey covered 209 households in 76 villages in Shimla, Kullu and Kinnaur Districts (Chapter 3, Table 3.1).

Agro-climatic conditions

In Shimla and Kullu Districts, information about temperatures was based on the farmers' perceptions. The farmers indicated that the winter temperature in the apple-growing areas lay between -10 and +10°C in the upper valley areas and between 3 and 15°C in the lower valley areas; and the spring temperatures between 10 and 15°C in the upper areas and 18 and 22°C in the lower areas. Farmers felt that the chilling requirement of the apples was not always met in the lower valley areas where the temperature was higher and the number of cold days less. In the upper valley areas, the lower temperatures and the greater number of cold days were sufficient to meet the chilling requirement. In some parts, frost at the time of apple flowering affected pollination and fruit set.

In Kinnaur, meteorological data was available from a meteorological station at Sharbo. The maximum winter temperature lay between 0 and 20°C and the minimum between 5 and 9°C. In spring, the maximum temperature lay between 8 and 28°C and the minimum between 0 and 11°C. Only a few districts had low enough temperatures and a high enough number of cold days to meet the chilling requirement of apples.

Humidity in all areas lay between 21 and 100% and varied with the season. Overall, the farmers felt that the climate had become warmer. During the past decade, snowfall has decreased and it now occurs later in the season. A decade ago it used to snow in December, nowadays it doesn't snow until late February or sometimes even March.

Landholdings

Figure 4.1 and Table 4.1 show details of the landholdings of the farmers surveyed in the three areas. In Shimla District the average landholding size was 2.9 ha; slightly more than half the households were small farmers cultivating between 1 and 2 ha of land. In Kullu Valley the average landholding size was 1.3 ha; nearly two-thirds of households were marginal farmers cultivating less than 1 ha of land, and 30% were small farmers. In Kinnaur, the average landholding size was 3.5 ha; overall the landholding size was more varied, with similar numbers in each of the classes of marginal, small, medium, and larger landowners. The population density in Kinnaur is lower and there is plenty of dry sloping marginal land, better known as marginal support land, which is now being used for apple plantations.

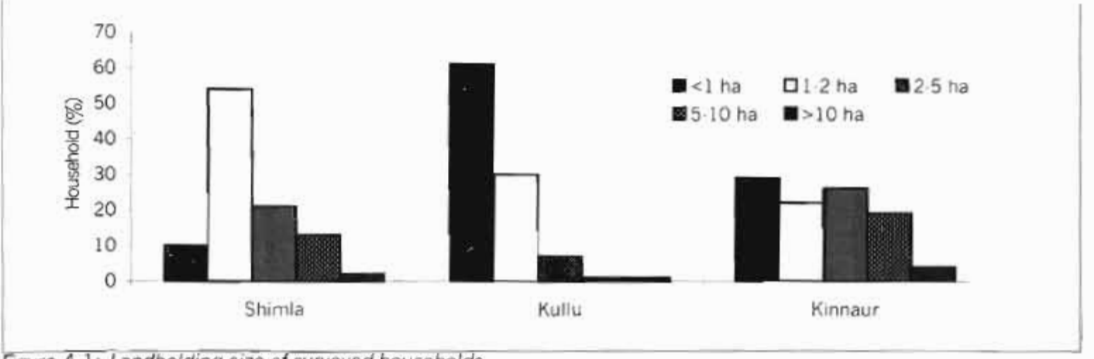

Figure 4.1: *Landholding size of surveyed households*

Table 4.1: Landholdings of the surveyed households

Landholding area per household	Shimla	Kullu	Kinnaur
Total land			
Average (ha)	2.9	1.3	3.5
Range (ha)	0.8-12	0.16-14.1	0.3-33.0
Irrigated land			
Average (ha)	0.3	0.2	1.8
Range (ha)	0.3-2.0	0.1-2.0	0.5-14.6
Percentage of total	10	15	51
Percentage of farmers	20	18	67

Overall the number of large landowners with more than 10 ha was very low, 1 farmer in Shimla with 12 ha, 1 in Kullu Valley with 14 ha, and 1 in Kinnaur with 33 ha. Most of the large landholdings comprised sloping marginal land.

Most of the land, in particular the orchard land, was not irrigated. Only 10 to 15% of the total land in the Shimla Hills and Kullu Valley was irrigated, although this rose to half in Kinnaur Valley, and less than a quarter of all farmers in Shimla and Kullu owned any irrigated land.

Land use

Figure 4.2 summarises the main use of agricultural land in the three areas. Crops were divided into 'agricultural crops' covering staple commodities like grain, potatoes, and pulses, and 'horticultural crops' like apples and vegetables grown primarily for sale. In Kullu and Shimla only 15 and 31% of the total landholdings was agricultural cropland compared with 51% in Kinnaur. The agro-climatic conditions in Kinnaur offer considerable advantages for the cultivation of off-season vegetables and pulses like kidney beans, which were cultivated as cash crops by

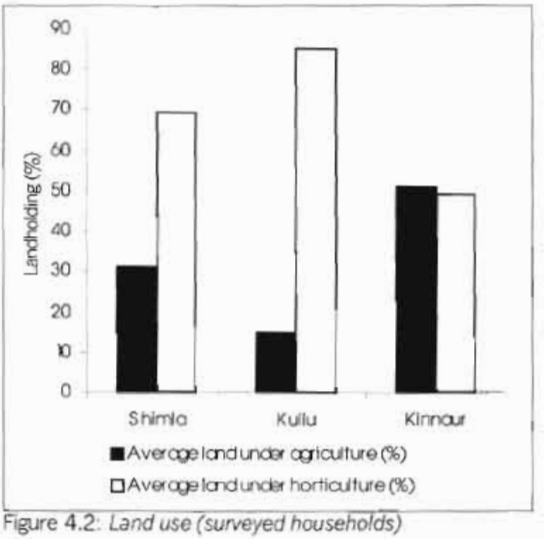

Figure 4.2: *Land use (surveyed households)*

over 95% of the farmers surveyed. Apple farming is relatively new in Kinnaur, but slowly more people are planting apple trees.

Farmers grew agricultural crops such as wheat, maize, and rice in areas at lower altitude and barley, potatoes, and pulses (beans) in areas at higher altitude. Apples were the main cash crop of all the farmers surveyed in all the districts except in Kinnaur where off-season vegetables and pulses were equally important. A few farmers were growing other fruit crops like plums (8% in the Shimla Hills, 5% in Kullu Valley), pears (5% in Kullu Valley), almonds, cherries, peaches, and other fruits (8, 2, 2, and 6% respectively in the Shimla Hills) as potential cash crops. Cultivation of off-season vegetables has emerged as an important source of cash income after apples. In Kinnaur, kidney beans *(Phaseolus vulgaris)*, off-season vegetables, pine nuts (*Pinus girardiana)*, and black grams were grown by 93, 96, 7, and 7% of farmers respectively.

Apple farming

Apples were the main cash crop for 76% of households in the Shimla Hills, 75% in Kullu Valley, and 63% in Kinnaur Valley and an important subsidiary crop for many more (Figure 4.3).

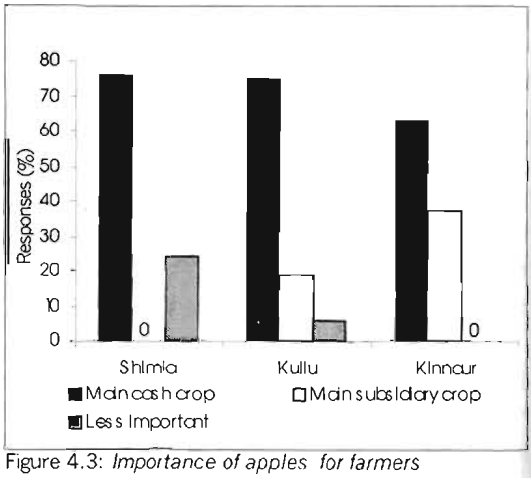

Figure 4.3: *Importance of apples for farmers*

The number and type of apple trees planted by the farmers surveyed is shown in Table 4.2. The average number of apple trees per household ranged from 317 in the Kinnaur Valley to 441 in the Shimla Hills. The proportion of bearing trees of the main variety was 46% in Shimla, 63% in Kinnaur, and 83% in Kullu, indicating that Shimla had the most newly planted orchards followed by Kinnaur, and that apple farming is expanding faster in Shimla and Kinnaur than in Kullu.

Table 4.2: Apple cultivation by surveyed households

	Shimla	Kullu	Kinnaur
Average number of trees per household			
Total number of trees	441	329	317
Number of bearing trees	205	271	202
Percentage of bearing trees	46	83	63
Main variety planted *(responses in per cent)*			
Royal Delicious	95	87	67
Red Delicious	2	8	26
Other varieties (included Golden Spur, Vance Delicious, Red Spur, Richard, Star Crimson, Crimson Gold, and Red Chief)	3	5	7
Main pollinizer variety *(responses in per cent)*			
Golden Delicious	35	70	93
Red Gold	31	14	–
Other varieties (included Tydeman's Early Worcester, Commercial, Jonathan, and Crab)	34	16	7

Royal Delicious was by far the most common main variety, followed by Red Delicious. Golden Delicious was the preferred pollinizer variety, particularly in Kullu and Kinnaur, followed by Red Gold in Shimla and Kullu. Other varieties included Tydeman's Early Worcester, Commercial, Jonathan, Crabapple, Winter Green, Snowdrift, Golden Hornet, Manchurian, and McIntosh (Table 4.2). The actual proportion of pollinizer trees is discussed below.

Changes in apple productivity

The response of the farmers to questions on problems in apple productivity is summarised in Table 4.3. The experiences in the three areas were somewhat different. Whereas in Shimla and Kinnaur most farmers felt that productivity was decreasing, three quarters of farmers in Kullu thought it was increasing or at least stable. There was a certain correspondence between the proportion of new plantations in the three areas (Table 4.2) and reports of decreasing productivity. The great majority of farmers in all three areas reported an increase in the cost of production.

Most farmers felt that lack of proper floral pollination was an important factor affecting apple productivity, changes in climate were also thought to be important, particularly in Shimla, as were disease and pests, especially in Kullu (Table 4.3).

Table 4.3: **Problems in apple productivity (percentage of responses)**

	Shimla	Kullu	Kinnaur
Apple productivity			
Increasing	16	56	44
Decreasing	76	26	56
No change	8	18	
Cost of production			
Increasing	88	97	78
No change	12	3	22
Factors affecting apple productivity*			
Change in climate	74	47	24
Diseases and pest attacks	20	89	33
Lack of pollination	86	75	78

*Individual farmers mentioned more than one factor

The farmers' perceptions of climate (weather) change and its impact on apple productivity are summarised in Table 4.4 and Figure 4.4. When asked about the overall change in climate, all the farmers surveyed responded that there was a change in the climate, and that this change was evident in a changing weather pattern, including general warming up, less snowfall, fewer days serving as a chilling period, and changes in rainfall period and pattern. Although they had different perceptions of the detailed changes, all showed a common concern that this climate change was affecting their productivity in one way or another, and most felt that the climate change was affecting pollination, and a number that it was affecting fruit set and fruit quality, causing an increase in the incidence of various diseases like scab and canker, and pests such as mites, and causing various problems such as accelerated leaf fall, delay in fruit ripening, accelerated fruit drop, and a decrease in overall productivity.

Table 4.4: **Farmers' perception of climate change (percentage of responses)**			
	Shimla	Kullu	Kinnaur
Change in temperature			
Increasing	43	53	67
Decreasing	18	4	7
Fluctuating	10	3	0
Don't know	29	40	26
Change in rainfall			
Increasing	25	31	30
Decreasing	6	4	27
Fluctuating	12	26	17
Don't know	57	39	26
Humidity			
Excess	29	5	30
Decreasing	0	1	4
Don't know	71	94	66
Snowfall			
Less	36	33	26
Don't know	64	67	74

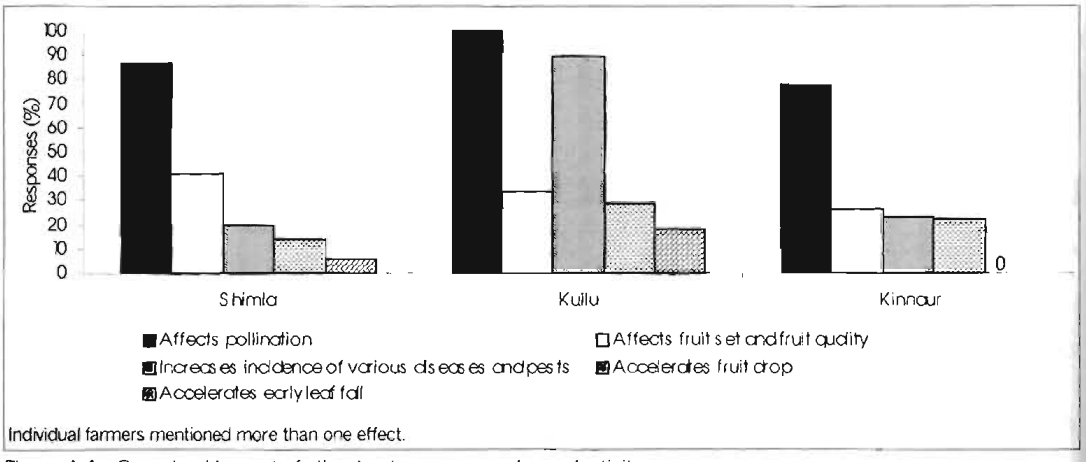

Figure 4.4: *Perceived impact of climate change on apple productivity*

Apple pollination problems

The majority of farmers felt that lack of proper floral pollination was one of the important factors in declining apple productivity (Table 4.3). The possible reasons for pollination failure include a lack of the appropriate ratio of pollinizer, scarcity of natural insect pollinators, and unfavourable climatic factors or bad weather conditions (see Chapter 2).

Farmers had different perceptions of the factors responsible for inadequate pollination (Figure 4.5). The great majority of farmers thought that weather factors were responsible at least in part.

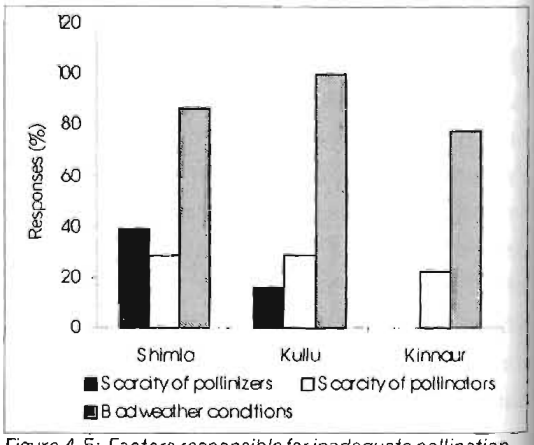

Figure 4.5: *Factors responsible for inadequate pollination in apples*

Less than half the farmers in Shimla, only 16% in Kullu, and none in Kinnaur thought that a lack of appropriate proportions of pollinizer varieties could be responsible for inadequate pollination in their orchards, and rather less than a third in all areas pointed to a lack of natural pollinating insects as another key factor. Other problems related to pollinizers included less flowering in pollinizer varieties (10% of farmers in Shimla and 3% in Kullu), their habit of flowering in alternate years (11% of farmers in Shimla and Kullu), and lack of synchronisation of flowering between the pollinizer and the main varieties (8% of farmers in Shimla and 2% in Kullu).

Scarcity of pollinizer varieties in the fields

The surveys showed that one of the key factors in inadequate pollination was the lack of sufficient pollinizer trees within the orchards. The Royal Delicious and Red Delicious varieties preferred by most farmers (Table 4.2) are completely self-sterile and require pollen from other compatible varieties (pollinizer trees) in order to set fruit. The standard pollinizer proportion recommended for adequate pollination of self-incompatible varieties of apple is 20%. But the values in the study areas were much lower. Figure 4.6 summarises the responses to the question on the proportion of pollinizer trees. The majority of farmers in Kullu and nearly half in Kinnaur had between 5 and 10% of pollinizer trees in their orchards. Some 11% of farmers in Kinnaur and about 2% in Kullu did not have a single pollinizer tree. The situation was slightly better in Shimla, nearly two-thirds of the farmers had between 10 and 20% of pollinizer trees. But only three farmers in the whole survey had the optimum 30% or more of pollinizers. Most farmers were not aware, however, that this lack of pollinizers was probably contributing to the inadequate pollination (Figure 4.5). A combination of lack of awareness and a wish to have the maximum number of trees of a single (or two) commercial varieties, has meant that farmers have not planted the appropriate ratios of pollinizer varieties of apples.

Inadequate populations of insect pollinators in the local environment

The lack of pollinating insects in apple-growing areas was almost certainly another major reason for crop pollination failure. The general observation made by farmers was that in the past there used to be lot of insects like wild bees, butterflies, and moths during the apple-flowering season, but that now they have all disappeared. Less than a third of farmers, however, realised that this

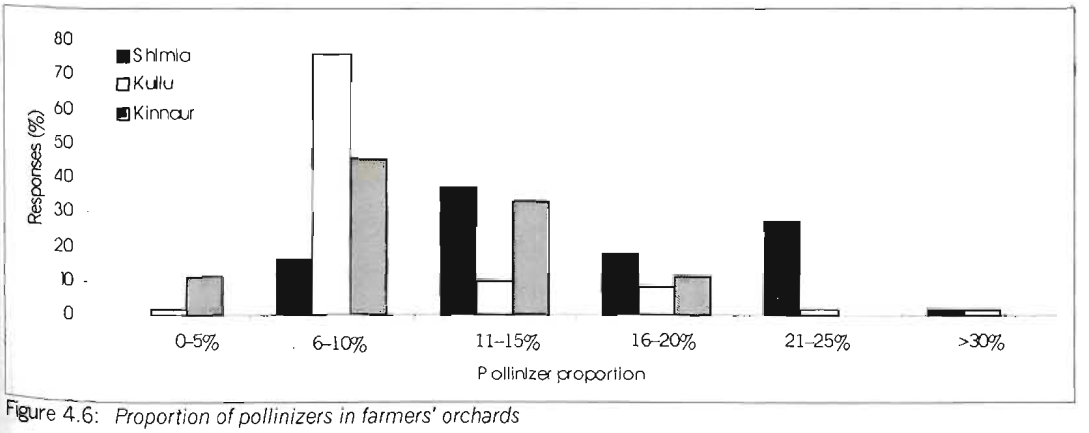

Figure 4.6: *Proportion of pollinizers in farmers' orchards*

could be affecting pollination. Insect populations are declining for a variety of reasons including loss of natural habitat (forests and grasslands) as agriculture expands, and resultant changes in their food and nesting habitats, and the excessive use of pesticides on the new generation of cash crops. Insecticides have affected both the diversity and the abundance of pollinating insects. It is also possible that even if the natural insect populations had remained stable, they would still have been too small to pollinate the new large areas of apple crops.

Use of pesticides

The surveyed farmers used a lot of pesticides, mostly fungicides but also one or two types of insecticides, to control various pests on their crop (Table 4.5). The most commonly used insecticides were metacid, metasystox, diathane M-45, durmet, thiodan, monocrotophos, fenitrothion, and melathion. Of these, fenitrothion, monocrotophos, melathion, and thiodan are highly toxic to honeybees and other pollinating insects. Apples were sprayed from 3-4 times a season in Kinnaur to as much as ten times per season in Shimla (Table 4.5). Farmers sprayed pesticides both to control existing pests and diseases and to prevent the outbreak of diseases such as apple scab and red apple mite. Some farmers believed that spraying with some of the chemicals, particularly fungicides, improved the size, colour, and overall quality of the fruit.

Around two-thirds of the farmers were aware that insecticides can kill honeybees and other useful insect pollinators. However nearly one-third were not, and nearly 30% of farmers in Shimla and Kullu and 15% in Kinnaur still used pesticides during the apple-flowering period (Table 4.5).

Changes in weather conditions during flowering

The great majority of farmers thought that bad weather conditions during the flowering period were contributing to pollination failure in the apple crops (Figure 4.5). In the years prior to the survey, farmers had experienced frost, rain, hailstorms, and low temperatures at the time of apple flowering. Low temperature and frost affect apple pollination by stopping honeybees and other natural insect pollinators flying and damaging flowers and early fruit. Mild rains also affect apple pollination by affecting insect foraging and pollination activities, whereas heavy rains wash away the pollen grains from flowers. Hailstorms can damage the apple flowers themselves.

Sources of knowledge about pollination

Table 4.5: **Pesticide use and its impact on apple pollination (percentage of responses)**

	Shimla	Kullu	Kinnaur
Number of pesticide sprays per season			
3-4	0	0	78
4-5	0	35	18
6-7	0	63	4
9-10	100	2	0
Pesticides sprayed during flowering	29	29	15
Types of pesticide			
Insecticides	100	100	100
Fungicides	100	100	100
Do pesticides kill insect pollinators and bees?			
Yes	76	67	63
No	4	4	15
Don't know	20	29	22

The great majority of farmers were aware of pollination failure and its effects on apple productivity (Table 4.3), even though they were less informed about the causes. The Government Department of Horticulture and the Dr Y.S. Parmar University of Horticulture and Forestry had played a key role in raising awareness among the apple farmers about pollination failure and the need for its management (Figure 4.7). In the relatively new apple growing area of Kinnaur, almost all information was from these sources; they were the most frequently cited source of information in Shimla too, but there other farmers were nearly as important; in Kullu where the orchards were older, farmers relied more heavily on their own experience and that of other farmers. The farmers' own experience was based on observations that there was higher productivity and better fruit quality near pollinizer varieties and when there were pollinating insects like honeybees in the orchards. Some farmers had also observed that the crop was reduced or had failed completely in the absence of pollinating insects.

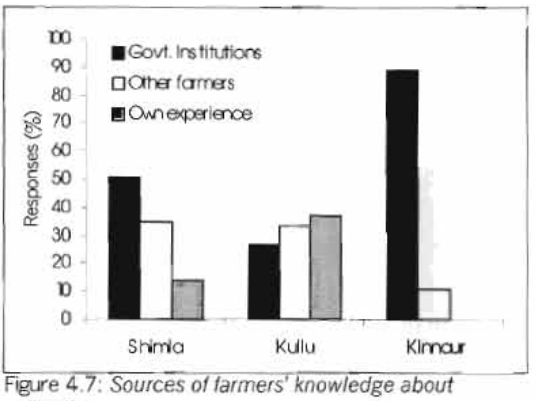

Figure 4.7: *Sources of farmers' knowledge about pollination*

Farmers' strategies for pollination management

Many farmers in Himachal Pradesh are now aware of the problem of failed pollination in apple crops and the need to consciously create optimum conditions for pollination – that is for 'pollination management'. Farmers are managing both pollinizers and pollinators, and are also using different strategies to avoid the effects of low temperatures and frost on pollination and fruit set. Some 43% of the farmers interviewed in Shimla, 33% in Kullu, and 41% in Kinnaur had introduced some form of managed pollination (Table 4.6).

Increasing the pollinizer proportion in apple orchards

When commercial apple farming started in the 1960s, farmers in Himachal Pradesh had many varieties of apples such as Commercial, Golden, Jonathan, Red Gold, Red Delicious, and Royal Delicious. These provided compatible pollen for each other and there was good fruit set. Since the early 1980s, however, farmers have focused on planting Royal Delicious on a large scale because of its better market value, and have slowly uprooted the other varieties – many of which could have been excellent pollinizers for Royal Delicious. All new orchards have been planted with pure stands of Royal Delicious without any pollinizers. Earlier, as the orchards were being changed over, there

Table 4.6: **Use of managed pollination (percentage of responses[1])**

	Shimla	Kullu	Kinnaur
Grafting pollinizers	25	21	0
Using pollinizer bouquets	30	58	4
Using honeybees for pollination	65	48	40
Own bee colonies	*38*	*37*	*75*
Rented bee colonies	*62*	*63*	*25*
Want to use bees for pollination, but not available	25	30	30
Hand pollination	8	3	0

[1]Some farmers use more than one method

were still sufficient pollinizer trees for reasonable pollination to occur, but over the last seven to eight years, the pollination problem has become serious.

Now farmers have started planting pollinizers in place of some of the trees of the main variety. But newly planted pollinizer trees take a minimum of five years to produce flowers. To accelerate the process, around a quarter of the farmers in Shimla and Kullu were grafting pollinizers onto the main trees, because grafts flower after three years.

The main pollinizer varieties planted in Kullu District were Commercial and Golden, and in Shimla, Golden, Red Gold, and Tydeman's Early Worcester. Some varieties of crab apple (wild apple) are also gaining popularity as pollinizers in Himachal Pradesh, both as trees and as grafts. This is because the plants are small, take less space in the orchards, produce many flowers, and have long flowering periods of more than a month, therefore providing pollen to any variety, whether early or late blooming.

The spread of bouquet pollination in Parvati Valley, Kullu

In 1994 Mr Gulab Singh tried out bouquet pollination in his orchard in Jalugran Village, the first person in Parvati Valley. Over the past few years, his fruit set had gone down to 10% using the bouquets the fruit yield increased by about 50%. Other farmers came from all the nearby villages to see for themselves how Mr Singh had been so successful; they were still suffering from poor fruit set. The next year most farmers in the nearby area had started bouquet pollination, and by 1998, all the farmers in Parvati Valley knew about the practice and, as they all had problems with fruit set, had started using it.

Bouquet pollination has also brought some unwanted problems. Many farmers do not have enough pollinizer trees left to be able to cut and spread the branches, the temptation is to steal from other orchards. There are many such cases of theft. Now, whenever a farmer sees somebody with scissors in his orchard, he chases the intruder away. During the survey, we met a farmer near a village in Kullu Valley carrying a load of blooming pollinizer branches. When we asked him to stop for a photo, he rapidly explained that he was not stealing but had brought the branches from a relative's orchard.

Newly-planted trees and grafts take three to five years to produce flowers (and supply pollen). As an interim solution to the immediate requirement for pollinizers, many farmers are hanging flowering pollinizer branches on the trees of the main variety, the base is kept in water in a plastic bag so that the branch stays fresh for a few days. Scientists call this 'bouquet pollination'; the pollinizer branches are 'bouquets'. More than half the farmers in Kullu Valley and a third of those in Shimla were using this method (see Box). Only one of the farmers interviewed in Kinnaur was trying this approach. Overall, the practice has become so widespread in the area that the price of plastic bags has risen from IRs 25 (US $0.75) per kg to IRs 90 (US $2.1) per kg.

Increasing the number of pollinators in apple orchards (hiring honeybees)

Until the early 1990s, pollination of apple crops in all the sample villages had depended largely upon naturally occurring pollinating insects. At the time of the survey, the majority of farmers in all three areas felt that natural pollination was not sufficient (Figure 4.8) although as can be seen from Figure 4.5 they hadn't necessarily understood the reasons for this.

About half of the surveyed farmers had started using honeybees (*Apis cerana* and *Apis mellifera*) for apple pollination (Table 4.7). The Dr Y.S. Parmar University of Horticulture and Forestry and

its Beekeeping and Horticulture Research Stations provide some honeybee colonies free of charge to apple farmers for pollination (*Apis cerana* and *Apis mellifera*). Both the University and the Government Department of Horticulture also provide training on how to use bees for pollination. The State Government is encouraging farmers to keep their own bees for pollination through the specially created Beekeeping Development Office (BKDO), under the Department of Horticulture (Chapter 2). The large-scale use of rented honeybee colonies, originally introduced as a government measure, has also helped to promote a number of commercial beekeeping entrepreneurs in the province who keep *Apis mellifera* in movable, frame hives specifically to rent out for apple pollination. There are also some small beekeepers with five to ten colonies of *Apis cerana* kept in traditional wall or log hives who rent bees for apple pollination.

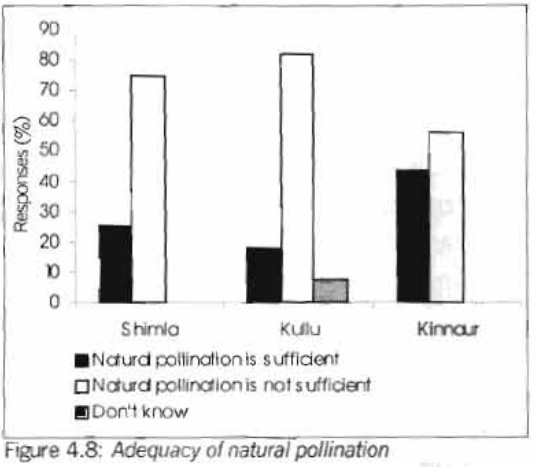

Figure 4.8: *Adequacy of natural pollination*

In Shimla and Kullu around two-thirds of the colonies that farmers used were rented, the majority from commercial sources, in Kinnaur it was one-quarter. The remainder were owned by the farmers themselves (Table 4.7).

The number of colonies available for pollination is still much lower than the demand. Between a quarter and a third of all farmers wished to rent bee colonies but were unable to obtain them (Table 4.6). Some commercial beekeepers were unwilling to provide colonies for apple pollination. These beekeepers keep *Apis mellifera* bees in movable frame hives for honey production. At the time of apple flowering these bees were kept on the Indian plains where they produced large quantities of honey from oil seed crops, clover, and eucalyptus. These beekeepers felt that renting honeybees for apple pollination might bring in less money than selling the honey produced in the plains. Moreover, it might also reduce the strength of the honeybee colonies because apples bloom only for one or two weeks.

Despite the overall success in promoting honeybees as pollinators, the survey indicated that about a quarter of farmers had still not understood the potential role of honeybee pollination in enhancing apple yield.

Table 4.7: **Rented honeybees**

	Shimla	Kullu	Kinnaur
Source of rented honeybee colonies (% of responses)			
Government institution (Dept. of Horticulture)	39	17	73
Private beekeepers	61	83	27
Rental fees (approximate in US $)			
Rental fees per colony for two weeks	6	6	6
Refundable security deposit	11	11	11

Hand pollination

Few farmers were aware of the possibility of using hand pollination. Only a small number of farmers (four in Shimla and one in Kinnaur) reported hand pollinating their apple crops using hired labour to ensure that the flowers were properly pollinated. These farmers considered that hand pollination was important in ensuring the quality and yield of apples. The method of collection and preparation of pollen was the same as in Maoxian county in China (see Chapter 2) except that in Himachal Pradesh only selected flowers on a tree (about 20-50 flowers per branch) were pollinated and honeybees were then used to transfer this pollen to other flowers on the same branch.

Safe use of pesticides

Some farmers had reduced the number of pesticide applications from 10 sprays to only 4 or 5 sprays in a year, and were mainly using the less toxic chemicals. They also sprayed when there were fewer insect pollinators present, that is a week before and/or a week after apple flowering. A few of the large farmers had started to control the apple pests using biological pest control. They reared various predator insects and used them to kill the apple pests.

Orchard management to counter the impact of low temperatures and frost

When there is low temperature and the possibility of frost occurring at the time of flowering and early fruiting, some farmers collect grass and burn it in the orchards to create smoke, this raises the temperature by 2-3°C. Some farmers in the Shimla Hills also sprayed their orchards with water in the middle of the night to avoid frost the following morning. A few farmers also sprayed chemicals such as borax or TSO (tree spray oil), or some alternative insecticides, on a limited scale to delay flowering when the temperature was very low. Such chemicals delay flowering by about a week (Chauhan and Mankotia 1998). Some farmers in hailstorm-prone areas covered their crops with hailstorm-proof nets to prevent damage.

Government support to apple farmers

More than 80% of the farmers acknowledged the State Government efforts to support apple farmers through providing training on orchard management, including managing pollination; making honeybees available for pollination; and providing subsidies for planting materials, pesticides, and orchard management equipment. They expected that the government would continue such support in the future. Needs were expressed for more training in orchard management and the use of honeybees for pollination management; financial support and subsidies to buy better planting materials, farm equipment, pesticides, and honeybee colonies, and to attend apple workshops and meetings in India and abroad to receive advanced training; and support in obtaining honeybee colonies for pollination (Table 4.8).

Table 4.8: **Expressed training and support needs (percentage of responses)[1]**

	Shimla	Kullu	Kinnaur
Training in orchard management	76	98	100
Training in use of bees for pollination	8	6	11
Financial support/subsidies	34	90	74
Support in obtaining bees	8	6	52

[1]more than one answer possible

Summary of Issues

Farmers in all three survey sites in Himachal Pradesh were aware of the pollination problem in their apple crop. As a result of support provided by the Department of Horticulture and Dr Y.S. Parmar University of Horticulture and Forestry, many farmers knew about the factors causing inadequate pollination in the orchards and between a third and a half were trying out different methods of pollination management. Himachal Pradesh is the only state in the whole of the HKH region where honeybee colonies are being used specifically for apple pollination and the only state in the region where there is an organised system of hiring and renting honeybee colonies for pollination. The government is promoting private entrepreneurship for bee pollination and arranges training and demonstrations to apple farmers on the use of honeybees. At the same time, new pollinizer varieties are being introduced, tested, and provided for farmers.

Even so, there is considerably more that needs to be done to raise productivity. Not only must various strategies be used to increase the number of pollinizer trees, but the number of honeybee colonies available is also still much lower than needed. A total of 156,000 colonies would be needed to pollinate the 78,000 ha of apple orchards in the state at the recommended rate of two colonies of honeybees to one ha of apple orchards. The 10,000-12,000 colonies available, represent less than 10% of total demand. Farmers are becoming increasingly aware of the problems and the demand for honeybee colonies is rising (Nadda and Tiwari 1998). Expansion of apple farming in Himachal Pradesh has not been accompanied by the necessary increase in pollination resources and technology, and this deficit must now be made up in order to enhance apple productivity in the state (Nadda and Tiwari 1998). Various strategies should be followed to increase the number of pollinators including reduced spraying, providing better conditions for the survival and growth of natural insect pollinators, and in particular finding ways of increasing the number of honeybee colonies available for pollination.