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QUANTITATIVE AND QUALITATIVE EFFECTS OF HONEYBEE POLLINATION ON APPLE CROP IN SHIMLA HILLS OF WESTERN HIMALAYA, INDIA

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ABSTRACT
Quantitative and qualitative effects of honeybee pollination on apple crop were investigated on Indian hive bee *Apis cerana* F. and European bee *Apis mellifera* L., by placing two colonies of each species in experimental apple orchards located at Shilaroo (2409 m), Matiana (2514 m) and Narkanda (2648 m) areas in Shimla hills of Western Himalaya. In self-compatible varieties of apple (Golden Delicious and Red Gold), there was no significant difference (P>0.01) in the fruit set in different experimental designs (honeybees pollinated flowers, open pollinated flowers and in control), but the differences in these experimental designs were significant (P>0.01) in self-incompatible varieties like Royal Delicious and Red Delicious. There was some difference in the fruit drops of self-incompatible varieties between open and honeybees pollinated flowers but it was not significant (P>0.01). Qualitative pollination data showed that weight, length, breadth, volume and number of seeds per fruit in Golden Delicious and Red Gold were significantly maximum (P<0.01) which developed from honeybee pollinated flowers and minimum in fruits under control experimental conditions in all the three orchards whereas, in Royal Delicious and Red Delicious varieties, the weight, length, breadth, volume and number of seeds per fruit were significantly more (P<0.01) in fruits developed from honeybees pollinated flowers than in fruits from open pollinated flowers.

KEY WORDS: - Quantitative and Qualitative Effects, Bee Pollination, Apple Crop, Shimla Hills, Western Himalaya

INTRODUCTION

Honeybees and flowering plants are dependent upon each other for their existence. Most of the plants are dependent on insects for their pollination requirements, whereas, insects in turn depend upon plants for energy to maintain their activities (Seeley, 1985). This energy relationship between plants and nectar gathering insects is the necessary basis for studying the crop pollination, honey production and their foraging strategies (Morse, 1976; Akaratanakul, 1987). Bees and certain flowering plants have, therefore, evolved a well adjusted system of interdependence, which is very important in the process of their organic evolution (Deodikar, 1962; Martin, 1992). For a farmer, the most desired goal in agriculture is to get the maximum possible crop yields and better quality fruit and seeds under given inputs and ecological settings. It is particularly important to get a premium price for the produce when farmers are engaged in cash crop farming. There are two well known methods for improving crop productivity. The first method is making use of agronomic inputs, including plant husbandry techniques such as the use of good quality seeds and planting material, and practices to improve yields, for example, providing good irrigation, organic manure and inorganic fertilizers and pesticides. 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 which have been harnessed (Verma, 1992; Partap and Partap, 1997).

Honeybees are considered as the most efficient pollinators of cultivated crops because of their floral fidelity, potential for long working hours, presence of pollen baskets, maintainability of high population, micromanipulation of flowers and adaptability to different climatic conditions (Verma, 1990). Further, honeybees can be domesticated, marketed and transported from place to place (Ribbands, 1953; Crane, 1990). The vital role which honeybees play in the pollination of large number of cultivated crops is often under estimated in developing countries. As a matter of fact, the main significance of honeybees and beekeeping is pollination. Therefore, income from agriculture by the use of honeybees in crop pollination is many times higher than their value as honey and beeswax producers (Verma, 2003). In the absence of honeybee pollination, the important factors that lacked in the complex of agronomical practices in apple cultivation were the total cross-pollination and fertilization of flowers and this led to the flower as well as fruit drop and a higher fruit drop in Golden Delicious and Red Gold cultivars (Kolesnikov 1972; Dulta and Verma 1987) but pollination by *Apis cerana* enhanced increase in fruit setting and quality of fruit set in apple crop (Sharma *et al.* 2010)

METHODOLOGY

Quantitative and qualitative effects of honeybee pollination on apple crop were investigated on Indian hive

bee *Apis cerana* F. and European bee *Apis mellifera* L., by placing two colonies of each species in experimental apple orchards located at Shilaroo (2409 m), Matiana (2514 m) and Narkanda (2648 m) areas in Shimla hills of Western Himalaya.

Effect of Honeybees Pollination on Fruit Set

To study the effect of honeybee pollination on fruit set, the following experimental designs at the time of bloom were set in the apple orchards located at different altitudes.

Experiment No. 1 (Honeybee pollinated flowers)

In honeybee pollinated flowers, four trees, one each of Golden Delicious, Red Gold, Royal Delicious and Red Delicious were enclosed in an insect proof net in which two colonies of honeybees (one of *A. mellifera* and one of *A. cerana*) were placed as pollinators of apple bloom. In this experiment, five branches of each variety, containing approximately one thousand pink buds were chosen at random. These branches of experimental trees were chosen in such a way that they were of same dimensions with respect to their spread, phase of flowering and height above the ground. The bees were kept inside the net till the last flower on experimental trees. Fruit set was observed after ten days of petal fall and the percentage was measured as below:

$$\text{Percentage of Fruit Set} = \frac{\text{Number of Fruits}}{\text{Number of Pink Buds}} \times 100$$

Experiment No. 2 (Open, where honeybees and other natural insect pollinators were present)

In open pollinated flowers, honeybees and other natural insect pollinators could visit the apple flowers freely. In this experiment also, equal number of branches of ten experimental trees, two trees each of Golden Delicious and Red Gold and three trees each of Royal Delicious and Red Delicious were chosen in the same way as in case of honeybees pollinated experiment, and each branch contained approximately one thousand pink buds. The results were expressed in terms of percentages of fruit set and calculated as honeybee pollinated flowers.

Experiment No. 3 (Control, where no insect pollinator was present)

In control experiment ten trees, two each of self-compatible varieties (Golden Delicious, Red Gold) and three each of self-incompatible varieties (Royal Delicious and Red Delicious) were selected and in each tree five branches, each containing approximately four hundred flowers at pink bud stage were chosen at random and covered with muslin bags so that no insect pollinator could enter the bag for pollination. These branches of experimental trees were chosen in the same way as in case of honeybee pollinated experiment. Before covering with muslin bags, the numbers of pink buds were counted in each experimental branch. The fruit set was observed after ten days of the petal fall, calculated as honeybee pollinated flowers.

In all the three orchards, similar experimental designs were set up and the percentage of fruit set was observed.

Effect of Honeybee Pollination on Fruit Drop

After observing the fruit set in different experimental designs, the number of fruits dropped in the month of June, was also noted in different experimental designs i.e. open, honeybee pollinated and control. The fruit drop was calculated from the ratio of fruits dropped to the total number of fruits set. This fruit drop was also calculated in terms of percentage (Dulta, 1986).

Improvement in the Quality of Fruit due to Honeybee Pollination

The improvement in the quality of fruit due to pollination was assessed in terms of increase in weight, length, breadth, volume and number of seeds per fruit. Weight of fruit in grams was measured with the help of a top pan electric balance; length and breadth in centimetre with the help of Vernier callipers; volume in ml on the line of the principle that the volume of an object is equal to the amount of water displaced by it. Finally, the number of seeds in a fruit was counted by cutting it. For each parameter, ten fruits were taken to get the mean values of weight, length, breadth, volume and number of seeds (Dulta, 1986; Kumar, 1997).

RESULTS & DISCUSSION

Effect of insect pollinators on fruit set of apple

At Shilaroo (2409 m) in self-compatible varieties like Golden Delicious and Red Gold, the fruit sets in control experiment were 15.03 and 13.24 percent respectively, whereas, in open pollinated flowers the percentages in Golden Delicious and Red Gold were 18.27 and 15.41 respectively. In honeybees pollinated flowers, the percentages of fruit set in Golden Delicious and Red Gold were 28.83 and 21.19 respectively. However, in case of self-incompatible varieties of apple, such as Royal Delicious and Red Delicious, the role of honeybees in pollination was very significant. For example, the percentages of fruit set in Royal Delicious were 0, 13.21 and 20.02 percent in control, open and honeybee pollinated flowers respectively. Similarly, at the same orchard, the percentages of fruit set in Red Delicious were 0, 11.00 and 18.52 percent in control, open and honeybee pollinated flowers respectively (Table 1).

At Matiana, (2514 m) in Golden Delicious, Red Gold, Royal Delicious and Red Delicious the percentages of fruit set in control experiment were 14.39, 13.43, 0 and 0 respectively. These percentages in open pollinated flowers were 16.01, 14.83, 13.07 and 9.45 per cent in Golden Delicious, Red Gold, Royal Delicious, Red Delicious respectively, whereas, in honeybees pollinated flowers the percentages of fruit set in Golden Delicious, Red Gold, Royal Delicious and Red Delicious were 27.24, 20.32, 19.11 and 18.01 respectively.

The percentages of fruit set in Golden Delicious, Red Gold, royal Delicious and Red Delicious were 15.42, 14.87, 0 and 0 percent respectively in control experiment, whereas, these percentages were 17.32, 17.54, 6.24 and 6.13 percent respectively in open pollinated flowers at

Narkanda (2648 m). Moreover, at the same height, the percentages of fruit set in honeybees pollinated flowers of Golden Delicious, Red Gold, Royal Delicious and Red Delicious were 20.08, 19.21, 14.89 and 14.42 respectively (Table 1). In self-compatible varieties of apple (Golden Delicious and Red Gold) there was no significant difference (P>0.01) in the fruit set in different experimental designs (honeybees pollinated flowers, open pollinated flowers and in control) but the differences in these experimental designs were significant (P>0.01) in self-incompatible varieties like Royal Delicious and Red Delicious.

Effect of insect pollinators in fruit drop

In the present investigations it has been found that fruit drop was significantly higher (P>0.01) in self-compatible varieties of apple under controlled experiment as compared to the fruits from open and honeybees pollinated flowers. At Shilaroo, Matiana and Narkanda in Golden Delicious, the fruit drops were maximum (36.23, 37.80 and 38.67 percent respectively) under control experiment and minimum (24.24, 25.61 and 27.42 percent respectively) in honeybees pollinated flowers. In open pollinated flowers of Golden Delicious, the fruit drops were 27.81, 27.23 and 29.49 percent at Shilaroo, Matiana and Narkanda respectively (Table 2). Similarly, in Red Gold, the fruit drops were maximum (35.93, 37.40 and 36.02 percent) under control experiment and minimum (23.19, 24.78 and 26.87 percent at Shilaroo, Matiana and Narkanda respectively) in honeybees pollinated flowers. In open pollinated flowers of Red Gold, the fruit drops were 29.38, 31.39 and 30.49 percent respectively. No significant difference (P>0.01) was observed in fruits drops of self-compatible varieties between open and honeybees pollinated flowers. In self-incompatible variety like Royal Delicious, the fruit drops in open pollinated flowers were 28.69, 29.43 and 29.73 percent at Shilaroo; Matiana and Narkanda respectively, whereas, in honeybees pollinated flowers the percentages of fruit drops were 24.70, 24.97 and 26.08 respectively. In other self-incompatible variety of Red Delicious, the fruit drops in open pollinated flowers at Shilaroo, Matiana and Narkanda were 28.86, 28.49 and 29.97 percent respectively, whereas, in honeybees pollinated flowers of Red Delicious, the fruit drops were 25.93, 25.31 and 26.79 per cent respectively. The difference observed in the fruit drops of self-incompatible varieties between open and honeybees pollinated flowers was without any significant difference (P>0.01).

Improvement in the quality of fruits due to insect pollination

Improvement in the quality of apple fruit was observed in terms of increase in weight (gm), length and breadth (cm), volume (ml) and number of seeds per fruit. In apple orchard at Shilaroo, the mean weights of apple fruit in honeybee pollinated Golden Delicious, Red Gold, Royal Delicious and Red Delicious were 188.05 ± 1.91 gm, 94.00 ± 2.51 gm, 186.66 ± 4.98 gm and 171.67 ± 9.53 gm respectively. Whereas, at Matiana the mean weights in honeybees pollinated Golden Delicious, Red Gold, Royal Delicious and Red Delicious were 245.66 ± 0.54 gm, 205.00 ± 2.90 gm, 346.33 ± 3.28 gm and 266.33 ± 9.22 gm respectively. At Narkanda, the mean weights of Golden Delicious, Red Gold, Royal Delicious and Red Delicious in honeybee pollinated fruits were 193.33 ± 2.72 gm, 179.00 ± 1.70 gm, 266.66 ± 1.36 gm and 215.00 ± 4.08 gm respectively (Table 3).

Under this set of experiment, the mean lengths of Golden Delicious, Red Gold, Royal Delicious and Red Delicious at Shilaroo were 7.03 ± 0.09 cm, 6.14 ± 0.02 cm, 6.57 ± 0.52 cm and 6.50 ± 0.17 cm respectively, while at Matiana the mean lengths of Golden Delicious, Red Gold, Royal Delicious and Red Delicious were 7.66 ± 0.10 cm, 6.45 ± 0.04 cm, 9.07 ± 0.22 cm and 7.63 ± .026 cm respectively. The mean lengths of fruit in honeybees pollinated flowers of Golden Delicious, Red Gold, Royal Delicious and Red Delicious were 7.32 ± 0.04 cm, 6.38 ± 0.11 cm, 8.00 ± 0.09 cm and 7.53 ± 0.13 cm respectively at Narkanda (Table 3).

An apple orchard at Shilaroo, the mean breadths of Golden Delicious, Red Gold, Royal Delicious and Red Delicious in honeybees pollinated flowers were 7.38 ± 0.13 cm, 6.83 ± 0.04 cm, 7.52 ± 0.47 cm and 7.43 ± 0.24 cm respectively. The mean breadths of Golden Delicious, Red Gold, Royal Delicious and Red Delicious in Honeybees pollinated flowers were 7.97 ± 0.09 cm, 7.75 ± 0.08 cm, 8.78 ± 0.35 cm and 8.13 ± 0.17 cm respectively at Matiana, whereas, the mean breadths were 7.87 ± 0.05 cm, 7.39 ± 0.13 cm, 8.10 ± 0.02 cm, and 7.51 ± 0.05 cm, in Golden delicious, Red Gold, Royal Delicious and Red Delicious respectively at Narkanda. The mean volumes of Golden delicious, Red Gold, Royal delicious and Red Delicious were 159.33 ± 3.14 ml, 73.17 ± 4.83 ml, 152.50 ± 3.78 ml and 138.33 ± 7.20 ml respectively at Shilaroo, whereas, 249.00 ± 3.27 ml, 198.33 ± 1.36 ml, 415.00 ± 3.51 ml and 240.00 ± 12.25 ml respectively at Matiana and 171.66 ± 1.36 ml, 152.33 ± 1.45 ml, 227.66 ± 1.18 ml and 175.00 ± 2.36 ml respectively at Narkanda (Table 3).

The mean number of seeds per fruit at Shilaroo in honeybee pollinated flowers of Golden Delicious, Red Gold, Royal Delicious and Red Delicious were 8.75 ± 0.22, 8.67 ± 0.54, 7.00 ± 0.81 and 6.33 ± 0.98 respectively whereas, the mean number of seeds per fruit were 9.00 ± 0.47, 10.00 ± 1.70, 7.60 ± 0.55 and 7.00 ± 1.42, respectively at Matiana and these were 9.00 ± 0.47, 9.60 ± 0.74, 7.33 ± 0.72 and 7.00 ± 0.81 respectively at Narkanda (Table 3).

TABLE 1: Percentage of fruit set in three different experimental designs

Sr. No.	Variety	Shilaroo (2409 m)			Matiana (2514 m)			Narkanda (2648 m)		
		Honeybees pollinated flowers (H)	Open pollinated flowers (O)	No insect pollinator (Control) (C)	Honeybees pollinated flowers (H)	Open pollinated flowers (O)	No insect pollinator (Control) (C)	Honeybees pollinated flowers (H)	Open pollinated flowers (O)	No insect pollinator (Control) (C)
1.	Golden Delicious	28.83	18.27	15.03	27.24	16.01	14.39	20.08	17.32	15.42
2.	Red Gold	21.19	15.41	13.24	20.32	14.83	13.43	19.21	17.54	14.87
3.	Royal Delicious	20.02	13.21	0	19.11	13.07	0	14.89	6.24	0
4.	Red Delicious	18.52	11.00	0	18.01	9.45	0	14.12	6.13	0

For Honey bee pollination two colonies (one *Apis cerana* and one *Apis mellifera*) with 7 frames each were placed inside the net
Each percentage is an average of ten observations.
For S.E. Standard error about the mean
For fruit set: $H > O > C$ ($P < 0.01$).

TABLE 2: Percentage of fruit drop in three different experimental designs

Sr. No.	Variety	Shilaroo (2409 m)			Matiana (2514 m)			Narkanda (2648 m)		
		Honeybees pollinated flowers (H)	Open pollinated flowers (O)	No insect pollinator (Control) (C)	Honeybees pollinated flowers (H)	Open pollinated flowers (O)	No insect pollinator (Control) (C)	Honeybees pollinated flowers (H)	Open pollinated flowers (O)	No insect pollinator (Control) (C)
1.	Golden Delicious	24.24	27.81	36.23	25.61	27.23	37.80	27.42	29.49	38.67
2.	Red Gold	23.19	29.38	35.93	24.78	31.39	37.40	26.87	30.49	36.02
3.	Royal Delicious	24.70	28.69	0	24.97	29.43	0	26.08	29.73	0
4.	Red Delicious	23.93	28.86	0	25.31	28.49	0	26.79	29.97	0

For Honey bee pollination two colonies (one *Apis cerana* and one *Apis mellifera*) with 7 frames each were placed inside the net
Each percentage is an average of ten observations.
For S.E. Standard error about the mean
For fruit set: $H < O < C$ ($P < 0.01$).

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TABLE 3: Effect of insect pollinators on the quality of apple fruit in terms of weight (gm) length (cm, breadth (cm, volume (ml) and number of seeds per fruit

Variety		Honeybees pollinated flowers (H)					Open pollinated flowers (O)					No. insect pollinator (C) control				
		Weight WH	Length LH	Breadth BH	Volume VH	No. of Seeds SH	Weight WO	Length LO	Breadth BO	Volume VO	No. of Seeds SO	Weight WC	Length LC	Breadth BC	Volume VC	No. of Seeds SC
		Shilaroo (2409 m)														
1.	Golden Delicious	188.05 ±1.91	7.03 ±0.09	7.38 ±0.13	159.33 ±3.14	8.75 ±0.22	143.00 ±2.16	6.29 ±0.06	7.20 ±0.01	136.66 ±1.36	7.33 ±0.27	84.00 ±2.49	5.08 ±0.02	5.73 ±0.03	67.66 ±7.09	3.67 ±0.27
2.	Red Gold	94.00 ±2.51	6.14 ±0.02	6.83 ±0.04	73.17 ±4.83	8.67 ±0.54	77.33 ±1.91	4.98 ±0.04	5.64 ±0.03	63.00 ±0.81	6.00 ±0.47	46.47 ±1.36	4.30 ±0.05	5.27 ±0.02	30.33 ±1.91	4.33 ±0.27
3.	Royal Delicious	186.66 ±4.98	6.57 ±0.52	7.52 ±0.47	162.50 ±3.78	7.00 ±0.81	168.33 ±3.86	6.18 ±0.29	7.09 ±0.38	143.33 ±3.40	4.70 ±0.27	No fruit set				
4.	Red Delicious	171.67 ±9.53	6.50 ±0.17	7.43 ±0.24	138.33 ±7.20	6.33 ±0.98	128.75 ±6.90	5.22 ±0.11	5.98 ±0.26	111.25 ±11.37	5.00 ±0.70	No fruit set				
		Matiana (2514 m)														
1.	Golden Delicious	245.65 ±0.54	7.66 ±0.10	7.97 ±0.09	249.00 ±3.27	9.00 ±0.47	219.33 ±1.09	7.21 ±0.01	7.38 ±0.14	201.66 ±0.54	8.00 ±0.81	103.66 ±0.54	6.17 ±0.06	6.87 ±0.07	98.00 ±3.74	5.40 ±0.27
2.	Red Gold	205.00 ±2.90	6.45 ±0.04	7.75 ±0.08	198.33 ±1.36	10.00 ±1.70	180.00 ±0.94	6.40 ±0.01	7.43 ±0.04	188.33 ±6.80	8.33 ±0.27	110.66 ±0.54	5.46 ±0.09	6.32 ±0.06	82.33 ±1.18	5.70 ±0.27
3.	Royal Delicious	346.33 ±2.28	9.07 ±0.22	8.78 ±0.35	415.00 ±3.51	7.60 ±0.55	243.40 ±5.73	7.37 ±0.40	7.67 ±0.26	230.40 ±3.97	5.00 ±0.47	No fruit set				
4.	Red Delicious	256.38 ±6.22	7.63 ±0.26	8.13 ±0.17	240.00 ±12.25	7.00 ±1.42	230.33 ±14.16	7.50 ±0.17	7.09 ±0.20	213.33 ±2.64	5.70 ±0.27	No fruit set				
		Narkanda (2648 m)														
1.	Golden Delicious	193.33 ±2.72	7.32 ±0.04	7.87 ±0.05	171.66 ±1.36	9.00 ±0.47	151.66 ±1.36	6.77 ±0.02	7.21 ±0.01	159.00 ±5.44	7.50 ±0.25	125.66 ±3.84	8.51 ±0.12	5.97 ±0.03	82.33 ±3.03	5.00 ±0.81
2.	Red Gold	179.00 ±1.70	6.38 ±0.11	7.39 ±0.13	152.33 ±1.45	9.60 ±0.74	148.66 ±1.51	6.00 ±0.09	7.03 ±0.07	137.33 ±5.30	6.66 ±0.27	90.66 ±4.63	5.05 ±0.06	571 ±0.09	78.32 ±2.72	6.00 ±0.81
3.	Royal Delicious	266.66 ±1.36	8.00 ±0.09	8.10 ±0.02	227.66 ±1.18	7.33 ±0.72	191.75 ±5.46	7.06 ±0.14	7.47 ±0.08	157.25 ±2.38	5.00 ±0.42	No fruit set				
4.	Red Delicious	215.00 ±4.08	7.53 ±0.13	7.51 ±0.05	175.00 ±2.36	7.00 ±0.81	192.33 ±3.54	6.97 ±0.13	7.31 ±0.09	152.66 ±6.43	5.00 ±0.81	No fruit set				

For Honey bee pollination two colonies (one *Apis cerana* and one *Apis mellifera*) with 7 frames each were placed inside the net.
Each percentage is an average of ten observations.
S.E. = Standard error about the mean.
In all the orchards:
1WH > 1WO > 1WC : 1LH > 1LO > 1LC : 1BH > 1BO > 1BC : 1VH > 1VO > 1VC : 1SH > 1SO > 1SC (P<0.01)
2WH > 2WO > 2WC : 2LH > 2LO > 2LC : 2BH > 2BO > 2BC : 2VH > 2VO > 2VC : 2SH > 2SO > 2SC (P<0.01)
3WH > 3WO : 3LH > 3LO : 3BH > 3BO : 3VH > 3VO : 3SH > 3SC(P<0.01)
4WH > 4WO : 4LH > 4LO : 4BH > 4BO : 4VH > 4VO : 4SH > 4SC (P<0.01)

There was not any fruit set in self-incompatible varieties like Royal Delicious and Red Delicious in control experiment but the quality of apple fruit in self-compatible varieties like Golden Delicious and Red Gold in control experiment was observed. It was observed that weight, length, breadth, volume and number of seeds per fruit in Golden Delicious and Red Gold at all the three orchards were significantly maximum ($P<0.01$) in fruits which developed from honeybees pollinated flowers and minimum in fruits under control experimental conditions, whereas, in Royal Delicious and Red Delicious the weight, length, breadth, volume and number of seeds per fruit were significantly more ($P<0.01$) in fruits from honeybees pollinated flowers than in fruits from open pollinated flowers.

Fruits from honeybee pollinated flowers were larger in size than fruits from open pollinated flowers which were in turn larger than the fruits from control experiment. Observations on fruit quality were made by some earlier workers like Singh (1962) and Morse (1976) who reported that honeybee pollination increased quality and quantity of apple fruits. The better pollinating efficiency of honeybees help in the fertilization of maximum number of ovules and thereby more number of seeds are formed in this way maximum amount of auxin (a growth hormone) is produced which results in better size of fruits. Murneek and Scohwengerdt (1935), Kozin (1972) and Childers (1976) found that fruits obtained by self pollination had a lower average weight, size and poor colour and contained a small number of seeds as compared to the fruits obtained from cross pollination. Bornus *et al.* (1977) reported that greater number of seeds depended upon greater number of bees involved in cross pollination. Dulta (1986) observed a positive relation between honeybee pollination and quality of apple crop. Recently, Sihag (1997), Belavadi *et al.* (2005) and Rana *et al.* (2010) reported similar results on fruit quality and yield in different crops.

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