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Impact of Bees's pollination and pollinizer proportion on apple profitability

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Abstract

Honeybees are acknowledged to be the most essential pollinating insects in apple orchards, accounting for the vast majority of pollinating insects. The ideal percentage of pollinating trees in apple orchards is 33.33 percent. However, the majority of the state's orchards have a low pollinizer proportion. Therefore, the purpose of the current investigations was to determine how pollinator proportion and bee pollination affect apple yield. The orchards at each location were separated into orchards with sufficient pollinator proportion and orchards with insufficient pollinator proportion. The recommended number of *A. mellifera* colonies was introduced at each location. A survey from major apple-growing area (Kullu, Shimla, Kinnaur, and Mandi) indicated fruit set percent ranged between 31.33 to 51.67 in orchards with bee colonies having a sufficient pollinizer proportion as compared to the location without bee colonies having insufficient pollinizer proportion. Bee colony placement in orchards with sufficient pollinizer proportion (SPP) and insufficient pollinizer proportion (IPP) has a great impact on fruit set. The apple yield increased in orchards with the recommended number of *A. mellifera* colonies and an adequate pollinizer ratio.

Keywords: Bee pollination, apple, orchardist, pollinizer proportion, fruit set

1. Introduction

In India, apple is primarily grown in Jammu and Kashmir, Himachal Pradesh and a small portion of Uttrakhand. The annual production of apple in Himachal was 643.85 metric ton during 2022. (Anonymous, 2022) ^[1, 2]. Apple production accounts for up to 60–80% of total household income in the districts of Kullu, Shimla, Kinnaur, and Mandi as well as other temperate fruit growing areas of the Hindu Kush Himalayas. It contributes around 48 percent of the total area used for production. The annual production averages approximately 2.5 crore boxes, but it might fluctuate from year to year depending on the weather. The apple fruit industry generates approximately Rs 4000 crores in revenue. Currently, Himachal Pradesh produces more than 4 tonnes of apples annually (Anonymous, 2022) ^[1, 2].

Apple productivity is influenced by various factors such as changing meteorological conditions, insufficient pollination, indiscriminate pesticide usage, and habitat degradation etc. out of which the primary causes are insufficient pollination and the planting of insufficient pollinizer trees in orchards, leading to a significant drop in the quality apple production and productivity. Cross pollination is the only way to sustain the ecological diversity (Katumo *et al.*, 2022) ^[8]. Good pollination increases fruit yield and size (Tantray and Kumari, 2020) ^[11]. About 80% of the world's flowering plant species depend on insect pollination (Burkle *et al.*, 2013) ^[3]. The worldwide economic value of the pollination services provided by insect pollinators in 2005 was estimated about €153 billion (Gallai *et al.* 2009) ^[6]. Amongst insects, honey bees alone accounts for more than 80 % for the pollination services. Honey bees are excellent pollinators for apple orchards, accounting for the vast majority of pollinating insects and found to increase yield and fruit quality in apple; (Burns and Stanley, 2022) ^[4]. They are also the only managed insects that are available for pollinating orchards. Pollination effectiveness was positively impacted by the pollinizer density in the main cv. tree surroundings (Carisio *et al.*, 2020) ^[5]. The recommended percentage of pollinating trees in an apple orchard is 33.33 percent. However, the majority of the state's orchards have a low pollinator share. Therefore, the goal of the current experiments was to ascertain how bee pollination, the quantity of pollinizer proportion and proper technical knowledge affect apple output.

2. Materials and Methods

The information was collected from four (Kullu, Kinnaur, Shimla, and Mandi) major apple-growing regions of Himachal Pradesh between 2019 and 2020 to find out the pollination (managed pollination, pollinizer proportion) and fruit set status of their orchards. Twenty farmers from each location were surveyed for the data on the pollinizer proportion, varietal status, age of tree, total number of tree in a orchard, use of any technology like pollen dispenser, colony number employed for pollination, percent fruit set, and yield. On the basis of data generated the farmers were grouped into orchard with insufficient pollinizer proportion (<15%) and other with sufficient pollinizer proportion (>15%). Observations on the fruit set was recorded on 10 randomly selected trees in the orchard with or without bee colonies along with orchards with sufficient and insufficient pollinizer proportions. Four branches from each of these randomly chosen trees that had pink buds were selected. These branches were chosen so that their spread, flowering stage, and height above the ground were all of the same dimensions. The percentage of fruits set was calculated by dividing the number of fruits on each experimental branch by the total number of pink buds after 10 days of petal fall.

$$\text{Percentage of Fruit set} = \frac{\text{Number of fruit}}{\text{Number of pink buds (flower)}} \times 100$$

3. Results and Discussion

Fruit set and yield were used to evaluate the impact of bee

pollination and the pollinizer proportion. The data on fruit set in apple orchards with and without bee colonies clearly showed the impact in terms of an increase in fruit set in the orchards with bee colonies. Fruit set percentages were 48.67, 46.67, 51.67, and 31.33 percent in Kullu, Mandi, Shimla, and Kinnaur, respectively, with bee colonies in the orchards having a sufficient pollinizer proportion. (Figure 1) Bee colony placement had a greater effect on fruit set in orchards with a low pollinator proportion. Fruit set increased in the orchards where bee colonies were maintained for pollination. Thakur and Mattu, 2013 [12]; also discovered that the placement of honeybee colonies increased fruit set. However, increase in fruit set was higher in the orchards with sufficient pollinizers (Table 1) than in orchards having insufficient pollinizer proportion. The percent fruit set ranged between 17.33 to 27.67 in different locations without bee colonies having insufficient pollinizer proportion, respectively. Khalifa *et al.*, 2021 [9]; Viana *et al.*, 2014 [13], who similarly demonstrated a consistently strong yield of apples in pollinator-scarce orchards by maintaining bee colonies. The fruit set varied from location to location regardless of the positioning of bee colonies and pollinizer proportion. This might occur as a result of the area's favourable microclimate, which has aided in pollination (Mushtaq *et al.*, 2018) [10]. The results also showed that orchards with suitable bee colonies and pollinators produced more fruit. Carisio *et al.*, 2020 [5] also observed a proportional increase in apple cultivar yields after bee introduction.

Table 1: Percent fruit set in apple orchards with and without bee colonies having sufficient (>15%) and insufficient (<15) pollinizer proportion at different locations of Himachal Pradesh

Location	Pollinizer proportion	Percent fruit set in apple orchards	
		Orchards With bee colony	Orchard Without bee colonies
Kullu	SPP	45.00 (42.10)*	23.33 (28.87)
	IPP	48.67 (44.22)	31.67 (34.21)
Mandi	SPP	45.00 (42.11)	27.67(31.62)
	ISP	46.67 (43.07)	27.67(31.65)
Shimla	SPP	51.67 (45.94)	24.33(29.53)
	ISP	34.00 (35.64)	17.67(24.48)
Kinnaur	SPP	31.33(34.01)	23.00(28.63)
	ISP	31.00 (33.81)	17.33(24.45)

C.D (0.05) Location : 2.46; Location x pollinizer proportion= 3.47; Colony: 1.74
 *The figures in the parenthesis are actual yield, whereas another are arc sine transformed values.
 SPP: Sufficient Pollinizer Proportion
 IPP: Insufficient Pollinizer Proportion

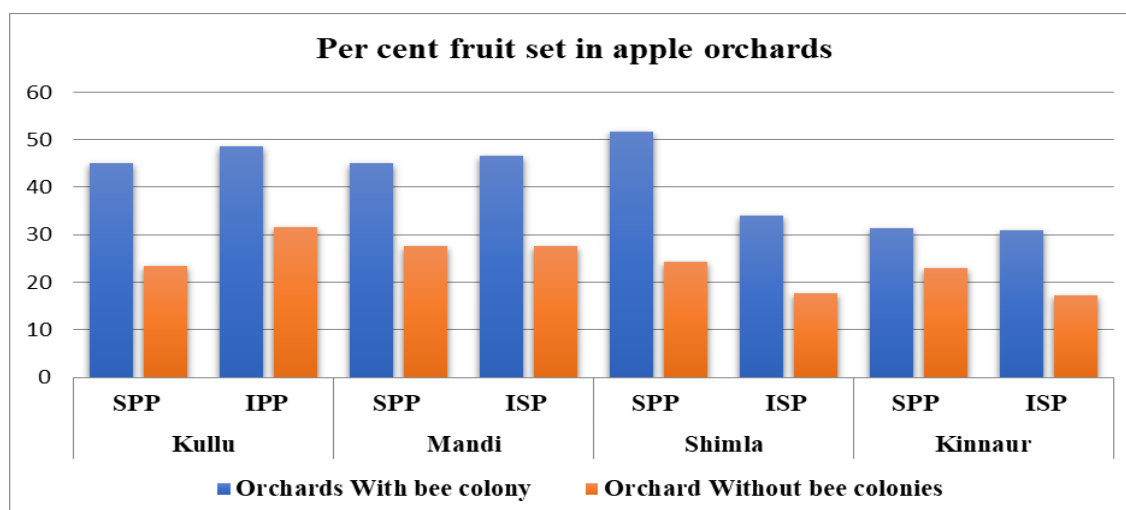


Fig 1: Percent fruit set in apple orchards with and without bee colonies having sufficient (>15%) and insufficient (<15) pollinizer proportion at different locations

4. Conclusions

Our investigation suggested that for enhanced pollination and fruit set, pollinizer percentage and managed pollination (by introducing bee colonies) should be taken into account. Our findings demonstrate that managing pollination is a practical solution to the problem of rising pollination service demand. Compatibility of cultivars and placement of honey bee colonies for pollination in orchards should also be taken into account.

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