Indian Journal of Entomology 85(Special Issue) May 2023: 21-24 eRef. No. NWRABNRG05 DoI. No.: 10.55446/IJE.2023.1154

# IMPACT OF BUMBLEBEE POLLINATION ON STRAWBERRY PRODUCTION UNDER PROTECTED CONDITIONS

**Kiran Rana*, Babita Kaushal, Harish K Sharma, Pramod Kumar and Meena Thakur**

Dr. Y S Parmar University of Horticulture and Forestry, Solan, Nauni 173230, Himachal Pradesh, India
*Email: kiranuhf@gmail.com (corresponding author): https://orcid.org/0000-0002-2732-9020

**ABSTRACT**

**Bumblebees are splendid pollinators of various crop plants; they are known to improve fruit productivity by enhancing its biophysical and biochemical properties. In the present investigation, the impact of bumblebee (*Bombus haemorrhoidalis* Smith) pollination was recorded in comparison to honey bee pollination, open pollination and control (crop devoid of pollinators) in strawberry grown under caged conditions in Nauni, Himachal Pradesh. Bumblebee pollination resulted in higher fruit set (87.16%), longer fruits (39.88 mm/ fruits), higher fruit breadth (30.94 mm/fruit), heavier berries (14.26 g/ fruit) and higher fruit yield per plant (402.26 g/ plant) in strawberry cv. Sweet Charlie which accounted for an increase of 10.38 and 7.87, 25.64 and 17.74, 16.22 and 13.41, 35.29 and 31.18 and 33.11 and 20.74%, respectively over control and open pollination. Bumblebee pollination was observed superior to control, open/ natural pollination and was equally good (at par) to honey bee pollination, in terms of all production parameters. These results signified the role of bumblebee pollination in enhancement of the quality and quantity of strawberries grown under caged conditions.**

**Key words:** Strawberry, *Bombus haemorrhoidalis*, pollination, bumblebees, bee pollination, Himachal Pradesh, production, fruit productivity, pollination efficiency, fruit quality

Strawberry (Fragaria × ananasa Duch) belongs to the family Rosaceae widely grown for sweet fleshy fruits. It is consumed in large quantities either fresh or in prepared foods as preserves. Besides its value for flavour, strawberry also possesses some health benefits. Though strawberry flowers are hermaphrodite, they need insect pollination for better quality fruit production and to yield maximum size strawberries (Chagnon et al., 1993). Earlier reports from different countries showed that yield, size and shape of strawberry fruit depends upon adequate pollination of its flowers by different insects (Crane, 1990) and in the absence of insects, the pollination rate of strawberry flowers rarely exceeds 60% and thus fruit production is reduced up to 48.6% of the berries produced by strawberry (Connor, 1970) and the fruits could also become malformed when insect pollinators are absent (Free, 1968).

Adequate pollination is one of the factors influencing the yield and quality of strawberries. Under open conditions, some pollination occurs naturally but under greenhouse growing there is far less possibility of pollination by natural means. Bumblebees are found to be the most efficient and reliable pollinators for protected crops as they work well under adverse conditions of weather, have low populations and short flight range. They are also valuable in buzz pollination of crops (Buchmann, 1983). Bumblebees are said to be valuable pollinators when it comes to their pollination services in agriculture, which is worth billions of dollars annually (Goulson, 2003; Winter et al., 2006). Many vegetable, fruit and seed growers who use bumblebees for pollination, are benefited from lower production costs, increased yields and improved quality of the products (Velthius and Doorn, 2006). Bumblebees are larger, furrier and sturdier than honey bees. They have a distinctive quality of foraging at low temperatures and very low light intensities which makes them important pollinators of various temperate crops. The use of bumblebees in pollinating strawberry cultivars under protected conditions enhances their production and quality (Paydas et al., 1998; Zaitoun, 2006). Keeping in view all, the present investigations were undertaken to evaluate the role of bumblebee (*B. haemorrhoidalis* Smith) pollination in strawberry.

## MATERIALS AND METHODS

The experiment was conducted in the experimental farm of the Department of Entomology located in Nauni, Solan (Himachal Pradesh) during 2019-2020. Three cages measuring 3.05×2.44×2.44 m made of insect proof nylon net were erected over five beds of strawberry each measuring 3×1 m. The seedlings of

strawberry (Fragaria × ananasa Duch var. Sweet Charlie) were transplanted in raised beds having two rows with alternate plants at a spacing of 60 x 30 cm during the first week of October 2019. All the recommended standard agricultural practices for strawberry cultivation were followed. The experiment was laid out in a randomized block design with four treatments with five replications. At the time of 5-10% of the new flush of strawberry flowers in April, a laboratory reared bumblebee colony inhabited by 8-9 workers and a queen was placed in the first net cage. Simultaneously, a nucleus hive of *A. mellifera* (4-framed) was introduced in the second cage. The third one was treated as a control without pollinators). The crop was also transplanted in the open field having access to natural pollinators for comparison. The data was recorded on ten randomly selected plants for each replication of all treatments on all productivity parameters of strawberry. After ripening, the berries from control, honey bee pollinated, bumblebee pollinated and open pollinated plants were picked up. Berries from each treatment were counted and weighed. The dimensions of the fruits were recorded. Number of healthy (well-formed) as well as misshapen berries from each treatment were also counted. The effectiveness of bumblebee pollination was assessed by calculating the % increase or decrease in quantitative and qualitative parameters of strawberries with bumblebee pollination over honey bee pollination, open pollination and control. Data was analysed statistically using analysis of variance (ANOVA) after appropriate transformations through online OP-STAT software (Sheoran et al., 1998).

## RESULTS AND DISCUSSION

The effect of bumblebee pollination on all the biophysical parameters of strawberry evaluated in this study was statistically at par to honey bee pollination and superior over control and open pollination. Maximum fruit set (89.81%) was recorded in cage with *A. mellifera* colony followed by cage with bumblebee colony (87.16%) and open pollination (80.80%) (Table 1). The minimum fruit set was recorded in control *i.e.* cage without pollinators (78.96%) which was at par with open/natural pollination (80.80%). It was observed that the fruit set recorded in strawberry with *B. haemorrhoidalis* pollination was at par with open/ natural pollination. Similarly, honey bee pollination resulted in significantly highest number (25.36) of fruits per plant followed by open pollination (23.47) which was at par with number of fruits in strawberry plants pollinated by bumblebee (22.98) and minimum was recorded in control i.e. cage devoid of pollinators (20.58). These findings are in agreement with those of Zaitoun et al. (2006), who carried out comparative study on the pollination of strawberry by bumblebees and honey bees under plastic house condition in Jordan valley, Canada and reported that higher number of fruits were obtained by honey bee pollination (9.47 fruits/ achen) as compared to bumblebee pollination (7.5 fruits/ achen) and control plants (4.5 fruits/ achen).

The bumblebee pollinated strawberry crop yielded bigger sized fruits as compared to other pollination methods and control. Bumblebee pollinated strawberry plants produced significantly longer berries (39.88 mm/fruit), higher berry breadth (30.94 mm/ fruit) and heavier berries (14.26 g/ fruit) (Table 1) and resulted in 25.64, 17.74 and 10.73; 16.22, 13.41 and 4.20 and 35.29, 31.18 and 1.68% increase over control, open pollination and honey bee pollination, respectively (Fig. 1). These results are in line with the findings

Table 1. Effect of *B. haemorrhoidalis* pollination on the fruit set and other bio-physical fruit parameters of strawberry

| Treatments | % Fruit set (Mean) | Fruit length (mm) | Fruit breadth (mm) | Fruit weight (g) | Fruit yield/ plant (g) | % Misshapen berries | % Healthy berries |
|---|---|---|---|---|---|---|---|
| $T_1$ Cage with *B. haemorrhoidalis* colony | 87.16 (69.16) | 39.88 | 30.94 | 14.26 | 402.26 | 6.04 (14.19) | 93.96 (75.78) |
| $T_2$ Cage with *A. mellifera* colony | 89.81 (71.78) | 35.60 | 29.64 | 14.02 | 406.63 | 6.21 (14.41) | 93.45 (75.16) |
| $T_3$ Control (cage without pollinators) | 78.96 (62.92) | 31.74 | 26.62 | 10.54 | 302.20 | 33.30 (35.21) | 67.01 (54.95) |
| $T_4$ Open pollination | 80.80 (64.17) | 33.87 | 27.28 | 10.87 | 333.16 | 7.86 (16.26) | 92.14 (73.70) |
| $C.D._{(0.05)}$ | 5.41 | 4.33 | 3.10 | 2.41 | 25.88 | 1.82 | 1.95 |

*Values in parentheses are expressed in angular transformation

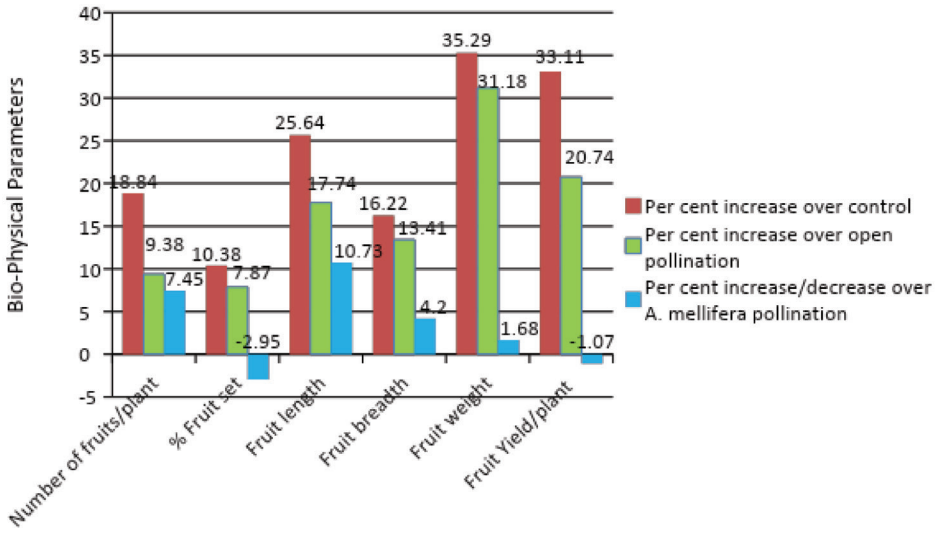


Fig. 1. Increase/ decrease in bio-physical parameters (%) of strawberry with *B. haemorrhoidalis* pollination over control, open pollination and *A. mellifera* pollination

of Paydas et al. (2000) who observed maximum fruit weight (16.02 g) in bumblebee pollinated strawberry plants as compared to control (7.81 g). Zaitoun et al. (2006) showed an increase in fruit length, diameter and fruit weight with bumblebee pollination (4.2 cm, 4.1 cm, 24.7 g/achen, respectively) as compared to control (3.6 cm, 3.1 cm, 17.4 g/ achen, respectively) in strawberry grown under plastic house condition.

Bumblebee pollination also resulted in better quality fruits as lower misshapen or crooked fruits (6.04%) were obtained from bumblebee pollinated strawberry plants which were at par with honey bee pollination (6.21%) and superior than open pollination (7.86%) (Table 1). Whereas highest misshapen fruits (33.30%) were observed in control cage. Similarly, the higher number of healthy fruits (93.96%) were recorded in bumblebee pollinated strawberry plants which were at par with honey bee pollinated (93.45%) and open pollinated (92.14%) whereas lowest healthy fruits were recorded in control (67.01%). *B. haemorrhoidalis* pollinated strawberry plants accounted for 40.22% increase in healthy fruits over control plants. Reduction in misshapen berries was found through bumblebee pollination as compared to control in the present studies. Bumblebee pollination has been proved as an excellent factor for improving the quality of strawberry fruits and reducing the number of malformed fruits. These results are in agreement with Paydas et al. (2000) who reported that bumblebee pollination reduced the asymmetrical fruits (%) as compared to control and honey bee pollination. Similarly, Zaitoun et al. (2006) showed that bumblebee pollination resulted in production of 13.3% misshapen fruits over control plants (26.7% misshapen fruits).

In the present investigation the fruit yield/plant was recorded highest in honey bee pollination (406.63 g) which was at par with bumblebee pollinated strawberry plants (402.26 g). Minimum yield was recorded in the control (302.20 g) cage which was at par with open pollination (333.16 g). A noteworthy difference in yield was recorded for bumblebee pollination, open pollination and control treatments. Bee pollination recorded significantly higher (402.26 g/ plant) fruit yield than control (302.20 g/ plant) and open pollination (333.16 g/plant) (Table 1) and accounted an increase of 33.11 and 20.74% over control and open pollination, respectively (Fig. 1). 30% higher yield per plant was reported in the bumblebee pollinated plants than in the control plants by Paydas et al. (1998).

Based on the results of present findings, it is inferred that bumblebee (*B. haemorrhoidalis*) pollination enhanced the quality and quantity of berries and proved superior to control (crop without pollinators) and open/natural pollination with respect to biophysical parameters (number of fruits/ plant, fruit length, fruit breadth, fruit weight, fruit yield/ plant and number of misshapen fruits) of strawberry grown under caged conditions. In this investigation, it was also observed that bumblebee pollination is as effective as the honey bee pollination as the data recorded on bumblebee pollination was found to be equally good or statistically at par to honey bee pollination for production parameters of berries. This signifies the

role of bumblebee pollination in terms of increased quality and quantity of strawberry grown under cage or net conditions.

**ACKNOWLEDGEMENT**

The authors are grateful to the Indian Council of Agricultural Research, New Delhi, India for providing financial assistance through the All India Coordinated Research Project on Honey bees and Pollinators.

**REFERENCES**

Buchmann S L.1983. Buzz pollination in angiosperms. In: handbook of experimental pollination biology (C E Jones and R J Little, eds). Van Nostrand-Rhein-hold, New York, USA. pp.73-113.

Chagnon M, Gingras J, DeOliveira D. 1993. Complementary aspects of strawberry pollination by honey and indigenous bees (Hymenoptera). Journal of Economic Entomology 86: 416-20.

Connor L J. 1970. Studies of strawberry pollination in Michigan. In Report of the Ninth Pollination Conference, Hot Springs, Arkansas, USA. pp. 157-62.

Crane E. 1990. Bees and Beekeeping. Heinmann, Oxford, UK. pp. 260-69.

Free J B. 1968. Pollination of strawberry by honey bees. Journal of horticulture science 48: 107-111.

Goulson D. 2003. Bumblebees, their behavior and ecology, Oxford University Press, Oxford.

Paydas S, Eti S, Kaftanoglu O, Yasa E, Derin K. 1998. Effects of pollination of strawberries grown in plastic greenhouses by honey bees and bumblebees on the yield and quality of the fruits. In: XXV International Horticultural Congress, Part 3: Culture Techniques with Special Emphasis on Environmental Implications. pp. 443-452.

Paydas S, Eti S, Kaftanoglu O, Yasa E, Derin K. 2000. Effect of pollination of strawberries grown in plastic greenhouse by bumblebees on the yield and quality of the fruits. Acta Horticulture 443-451.

Sheoran O P, Tonk D S,Kaushik L S, Hasija R C, Pannu R S. 1998. Statistical software package for agricultural research workers. In: Recent advances in information theory, statistics and computer applications (Hooda D S and Hasija R C eds). Department of Mathematics Statistics, CCS HAU, Hisar 1998, 139-143.

Velthuis H H W, Doorn V A. 2006. A century of advances in bumblebee domestication and the economic and environmental aspects of its commercialization for pollination. Apidologie 4: 421-51.

Winter K, Adams L, Thorp R W, Inouye D W, Day L, Ascher J, Buchmann S. 2006. Importation of non-native bumblebees into North American potential consequences of using *Bombus terrestris* and other non-native bumblebees for greenhouse crop pollination in Canada, Mexico, and the United States. p. 33.

Zaitoun S T, Al-Ghzawi A A, Shannag H K, Al-Tawaha A R M. 2006. Comparative study on the pollination of strawberry by bumblebees and honey bees under plastic house conditions in Jordan valley. Journal of Food Agriculture and Environment 4: 234-237.

(Paper presented: February, 2021;
Peer reviewed, revised and accepted: April, 2022; Online Published: May, 2023)
Online published (Preview) in www.entosocindia.org and indianentomology.org (eRef. No. NWRABNRG05)