DOI : 10.5958/0974-0112.2021.00012.8

Indian J. Hortic. 78(1), March 2021: 84-87

Bumble bee (*Bombus haemorrhoidalis* Smith) - a potential pollinator in bell pepper under protected cultivation

Shabnam Thakur*, Harish Kumar Sharma, Kiran Rana[1], Meena Thakur, Manish Kumar Sharma[1] and Rohit Kumar Nayak[1]

Department of Entomology, College of Horticulture, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan -173230, Himachal Pradesh, India.

ABSTRACT

The laboratory-reared bumble bee (B. haemorrhoidalis Smith) queens used for pollination resulted in an increase in the number of fruits per plant (3.77%), fruit weight (24.60%), fruit length (13.51%), fruit breadth (21.52%), healthy fruits (23.84%), seed number (113.64%), 1000 seed weight (g) (5.44%) and fruit yield per (89.42%) in bell pepper over control suggesting that bumble bee pollination is effective in improving bell pepper fruit yield and quality.

Keywords: *B. haemorrhoidalis,* Bell pepper, Pollination, Protected cultivation.

INTRODUCTION

Bumble bees are important pollinators belonging to insect order *Hymenoptera*. High speed of pollination, vibration to burst the pollen sacs and efficiency to forage at low temperature and light makes them the most reliable and efficient pollinators (Abrol, 1). Crops like tomato, pepper, cucumber, strawberries etc. grown under plastic tunnels, polyhouses or cages need such pollinators (Kwon and Saeed, 6). Bumble bee pollination helps in improving production with respect to fruit weight, size and other chemical characters to get cost effective production (Aizen *et al.,* 2). Rearing of bumble bees and utilization for pollination in crops grown in polyhouses has taken the shape of industry in western world. *Bombus haemorrhoidalis* Smith is the only bumble bee species reared successfully on smaller scale and experimented for its usefulness in pollination of crops at Solan in India (Thakur *et al.,* 13). Bell pepper (*Capsicum annuum* L.), an important often cross pollinated vegetable crop belonging to family *Solanaceae* has excellent prospects both for domestic and export market. Bell pepper is used in many ways for home consumptions, catering and food industries. The flowers of bell pepper are generally hermaphrodite, although some are monoecious, andromonoecious or dioecious and the anthers of bell pepper are poricidal, meaning that the flower's pollen is produced within the anthers and released through small pores, so bell pepper's anthers require agitation to release pollen. Therefore, pollination through bumble bees in greenhouses constitutes an attractive and cost-effective alternative to manual pollination (Velthuis and van Doorn, 14). To obtain pollen from blueberry, eggplant, seed potato, hot/sweet pepper and tomatoes, the insect pollinators must grip and vibrate the wing muscles. By doing this, the pollen grains are removed and dropped on to the insects, an activity called as 'buzz' pollination. The pollinators like bumble bees and certain solitary bees are capable of doing buzz pollination and offer valuable pollination services (Plowright and Laverty, 9).

Honey bees and bumble bees are frequently used for maximizing fruit set in different vegetable crops (Paydas *et al.,* 8). Insect pollination in capsicum has been considered to improve fruit quality and thus increase the income of farmers (Roldan Serrano and Guerra-Sanz, 10; Burt, 3). Bees visit the capsicum flowers for both nectar and pollen and pollination through bees result in high fruit set (Nagarathnam and Rajamani, 7). The increase in fruit weight and percentage of extra-large and large fruits have been found through pollination with different pollinators, such as solitary bees, bumble bees or honey bees in greenhouse capsicum when compared with self-pollinated fruits (Roldan Serrano and Guerra-Sanz, 10).

Dag and Kammer (5) reported high mean weight of sweet pepper fruits (213 g) from bumble bee pollinated plot than control plot (199 g). They also found that the average yield of bell pepper in honey bee pollinated plot (total of 22.6 kg per rows) was similar to the yield in bumble bee pollinated plot (23.4 kg). These two treatments showed significantly higher yield by 30 and 36 per cent, respectively, than

*Corresponding author: shabnamthakur2715@gmail.com

[1]Department of Seed Science and Technology, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan - 173230, Himachal Pradesh, India.

the control plot (without pollinators, 17.5 kg). Kwon and Saeed (6) reported that fruit mass of hot pepper was 11.0 g for bee pollinated pepper, which was statistically higher than without bee (8.0 g per fruit). They also showed that pepper pollinated with bumble bees have 156.3 seeds/fruit, which was significantly higher than without bee-pollinated pepper (81.6 seeds/fruit).

Roldán Serrano and Guerra-Sanz (10) and Shipp *et al.* (11) suggested the use of pollinators to obtain improved quality characteristics of bell pepper fruits. They also reported that the flowers which were visited by bumble bees form larger and heavier fruits as compared to those flowers which were not visited by bumble bees.

MATERIALS AND METHODS

The experimental field for carrying out pollination studies in bell pepper was selected at Khaltu, Department of Seed Science and Technology, Dr YSP University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh (1250 m AMSL, 35.5°N, 77.8°E) in the year 2017-18. The area falls in the mid- hill zone of Himachal Pradesh. Raising of bell pepper cv, Solan Bharpur was done as per package and practices for protected cultivation in polyhouse. The total area of the polyhouse (200 m^2) was divided into two parts by using insect proof net in the middle. In one portion (100 m^2), the bumble bee colony was placed for pollination at the time of 5-10% flowering and in the second portion of polyhouse *Apis mellifera* colony was introduced. Another polyhouse (100 m^2) was kept without bumble bees (control plot). Open pollination studies were conducted under normal conditions in the field. The spacing was 60×45 cm from row to row and plant to plant. The crop was transplanted in the third week of April and came in to the flowering in second week of June. Artificially reared bumble bee (*B. haemorrhoidalis*) colony was utilized for pollinating bell pepper crop in polyhouse. The bumble bee colony reared under laboratory conditions and further established in the field was introduced in polyhouse by placing it inside a Langstroth bee hive. The entrance of the hive was widened with the help of a drill to fix a plastic tube which served as a passage for incoming and outgoing bumble bee foragers. Bumble bee colony was fed with 50% sucrose solution and fresh/stored pollen from *A. mellifera* colonies for first two days to make it acclimatize to the polyhouse environment.

Impact of bumble bee pollination was recorded in flowers visited by bumble bees and those not visited by bumble bees (control). For this flowers were observed visually for bumble bee visits. The flowers visited by bumble bees were tagged and such fruits were considered as bumble bee pollinated. The data were recorded for number of fruits per plant, per cent healthy and misshapen fruits, average fruit weight (g), average fruit length (cm) and fruit breadth (cm), fruit yield (kg/m^2), number of seeds per fruit and weight of 1000 seeds (g).

RESULTS AND DISCUSSION

After fruit setting bumble bee colony was removed from the polyhouse and the impact of pollination on different productivity and quality parameters of bell pepper was recorded as under:

Data recorded on effect of bumble bee pollination on number of fruits showed that mean number of fruits per plant were more in open pollinated (49.8 ± 2.06) followed by bumble bee pollinated plants (44 ± 1.38) and control (42.4 ± 1.48) which do not differ significantly.

Data on fruit weight and fruit size (fruit length and fruit breadth) is presented in Table 1. The data revealed that significantly heavier fruits (60.94 g/ fruit) were recorded in bumble bee pollinated plants as compared to open pollinated (50.91 g) and control (48.91 g). Similarly, longer fruits (5.78 cm/fruit) were recorded from plants pollinated by bumble bees than the fruits (5.10 cm) obtained without pollinator. Significantly higher fruit breadth (4.40 cm/fruit) was observed from bumble bee pollinated plants than the control (3.62 cm).

Data recorded on percentage of healthy and misshapen fruits are presented in Table 2. Significantly higher percentage of healthy fruits (76.33 per cent) were produced from bumble bees pollinated plants as compared to open pollinated (63.26 per cent) and control (61.63 per cent). Significantly less percentage of misshapen fruits (23.67 per cent) was obtained from bumble bees pollinated plants as compared to open pollinated (36.74 per cent) and control (38.37 per cent).

Table 1. Effect of *B. haemorrhoidalis* pollination on fruit weight, fruit length and fruit breadth in bell pepper grown under protected cultivation

Treatment	Mean fruit weight (g)	Mean fruit length (cm)	Mean fruit breadth (cm)
B. haemorrhoidalis pollinated flowers	60.94	5.78	4.40
Open pollinated flowers	50.91	5.66	4.36
Control (flowers without *B. haemorrhoidalis*)	48.91	5.10	3.62
$CD_{p=0.05}$	4.22	-	0.35

Table 2. Effect of *B. haemorrhoidalis* pollination on physical fruit quality in bell pepper grown under protected cultivation

Treatment	Mean healthy fruits (%)	Mean misshapen fruits (%)
B. haemorrhoidalis pollinated flowers	76.33 (61.13)*	23.67 (28.84)
Open pollinated flowers	63.26 (52.69)	36.74 (37.27)
Control (flowers without *B. haemorrhoidalis*)	61.63 (51.79)	38.37 (38.18)
$CD_{p=0.05}$	4.58	4.58

*Figures in parenthesis are angular transformation

Data recorded on number of seeds per fruit, 1000 seed weight and fruit yield/m^2 is presented in Table 3. Bumble bees pollinated plants yielded fruits with maximum number of seeds (380.27 seeds/fruit), which differed significantly from number of seeds produced by open pollinated plants (203.27 seeds) and control (178.00). Similarly, significantly higher (6.32 g) 1000 seed weight was found in bumble bee pollinated plants as compared to open pollinated (6.12 g) and control (5.99 g).

The data revealed that significantly higher fruit yield/m^2 (3.19 kg) was recorded in bumble bee pollinated plants than open pollinated plants (1.94 kg). Significantly low fruit yield/m^2 (1.68 kg) was recorded from control plot.

The effect of *B. haemorrhoidalis* pollination on fruit yield has also been found superior in cucumber (Chauhan, 4) and tomato (Yankit, 15). Chauhan (4) found higher fruit yield (76.97%) in bumble bee pollinated cucumber plants than control (55.10%). Yankit (2016) reported that bumble bee pollinated fruits of tomato had higher fruit yield (12.7 kg) than control (6.86 kg).

Table 3. Effect of *B. haemorrhoidalis* pollination on number of seeds per fruit, 1000 seed weight and fruit yield in bell pepper grown under protected cultivation

Treatment	Mean number of seeds/fruit	Mean 1000 seed weight (g)	Fruit yield/ m^2 (kg)
B. haemorrhoidalis pollinated flowers	380.27	6.32	3.19
Open pollinated flowers	203.27	6.12	1.94
Control (flowers without *B. haemorrhoidalis*)	178.00	5.99	1.68
$CD_{p=0.05}$	41.84	0.09	0.07

Similarly *B. terrestris* have also proved to be superior in sweet pepper (Dag and Kammer, 5) and in chili pepper, sweet pepper and eggplant (Soud Yousef, 12). Dag and Kammer (5) reported that higher fruit yield was obtained from bumble bee plot (23.4 kg) than control plot (17.5 kg). Soud Yousef (12) has also reported that fruits pollinated by bumble bees had higher yield in chili pepper, sweet pepper and eggplant than control.

The bumble bee pollination showed positive effect on different fruit quality parameters in terms of increase in number of fruits per plant (3.77%), fruit weight (g) (24.60%), fruit length (cm) (13.51%), fruit breadth (cm) (21.52%), healthy fruits (23.84%), seed number (113.64%), 1000 seed weight (g) (5.44%) and fruit yield per m^2 (kg) (89.42%) suggesting that bumble bee pollination is effective in improving bell pepper fruit yield and quality.

AUTHORS' CONTRIBUTION

Conceptualization of research (Harish K Sharma); Designing of the experiments (Shabnam Thakur, Harish K Sharma, Manish K Sharma); Contribution of experimental materials (Shabnam Thakur, Harish K Sharma, Kiran Rana, Meena Thakur, Manish K Sharma); Execution of field/lab experiments and data collection (Shabnam Thakur, Harish K Sharma, Rohit K Nayak); Analysis of data and interpretation (Shabnam Thakur, Rohit K Nayak); Preparation of the manuscript (Shabnam Thakur, Harish K Sharma).

DECLARATION

The authors declare no conflict of interest.

REFERENCES

1. Abrol, D.P. 2012. Pollination Biology: Biodiversity Conservation and Agricultural Production. Springer, New York, 792 p.

2. Aizen, M., Garibaldi, L., Cunninghamm, S. and Klein, A. 2008. Long-term global trends in crop yield and production reveal no current pollination shortage but increasing pollinator dependency. *Curr. Biol.* **18**: 1572-75.

3. Burt J. 2005. Growing capsicums and chillies. *Farmnote*. Department of Agriculture and Food. No. 64/99. http://ausveg.com.au/infovegdatabase (Accessed on 18 December, 2017).

4. Chauhan, A. 2011. Refinement of bumble bee rearing technology and its use in cucumber pollination. M.Sc. Thesis. Department of Entomology, Dr YSP University of Horticulture and Forestry, Nauni, Solan.

5. Dag Arnon and Kammer Yossef. 2001. Comparison between the effectiveness of honey bee (*Apis mellifera*) and bumble bee (*Bombus terrestris*) as pollinators of greenhouse sweet pepper (*Capsicum annuum*). *American Bee J.* **141**: 447-48.

6. Kwon, Y.J. and Saeed, S. 2003. Effect of temperature on the foraging activity of *Bombus terrestris* L. (Hymenoptera: Apidae) on greenhouse hot pepper (*Capsicum annuum* L.). *Appl. Ent. Zool.* **38**: 275-280.

7. Nagarathnam AK and Rajamani TS. 1963. Studies on fruit setting in chillies (*Capsicum annuum* Linn.). *Madras Agric. J.* **50**: 138-39.

8. Paydas, S., Eti, S., Sevinc, S., Yasa, E., Derin, K., Kaska, N. and Kaftanoglu, O. 2000. Effects of different pollinators to the yield and quality of strawberries. *Acta Hortic.* **522**: 209-15.

9. Plowright, R.C. and Laverty TM. 1984. Bumble bees and crop pollination in Ontario. *Proceedings of the Entomol. Soc. Ontario*, **118**: 155-160.

10. Roldán Serrano, A. and Guerra-Sanz, J.M. 2006. Quality fruit improvement in sweet pepper culture by bumblebee pollination. *Scientia Hortic.* **110**: 160-66.

11. Shipp, J.L., Whitfield, G.H. and Papadopoulos, A.P. 1994. Effectiveness of the bumble bee, *Bombus impatiens* Cr. (Hymenoptera: Apidae), as a pollinator of greenhouse sweet pepper. *Scientia Hortic.* **57**: 29-39.

12. Soud Yousef Ahmad Al-abbadi. 2009. Efficiency of different pollination treatments on Solanaceae yields grown in plastic house. *J. Biol. Sci.* **9**: 464-69.

13. Thakur, R.K., Gupta, J.K. and Gupta, P.R. 2005. Investigation on rearing of bumble bees (*Bombus* spp.) in captivity. In: *International Beekeeping Congress*, November 13th to 18th organized by century foundation in association with Mountain Research Development Associates (MRDA), FAO, Banglore, India, 18 p.

14. Velthuis, H.H.W. and Van Doorn, A. 2006. A century of advances in bumble bee domestication and the economic and environmental aspects of its commercialization for pollination. *Apidologie* **37**: 421-51.

15. Yankit, P. 2016. *Studies on bumble bee pollination in tomato* (*Solanum lycopercicum* Mill.) *under protected condition*. M.Sc. thesis. Department of Entomology, Dr YSP university of Horticulture and Forestry, Nauni, Solan.

(Received : March, 2019; Revised : December, 2020; Accepted : Janaury, 2021)