International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Effect of Bee Pollination on Quantitative and Qualitative Parameters of Coriander (*Coriandrum Sativum* L.)

M P Damor[1], L V Ghetiya[2], M A Karkar[3]

Ph.D. Scholar [1, 3], Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari.
Associate Professor[2], Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari.

ABSTRACT:

The present study was carried out with the object of "Effect of bee pollination on quantitative and qualitative parameters of coriander (Coriandrum sativum L.)" during Rabi 2020 and 2021 at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat). In the present experiment, the highest (50.31 seeds/umbel) was recorded in Open pollination, which was remained at par with Pollination by A. mellifera (49.19 seeds/umbel). The minimum (25.58 seeds/umbel) seeds per umbel were observed in Absolute control. The maximum (4.20 mm) seed size was recorded in Open pollination, which was remained at par with Pollination by A. mellifera (4.13 mm) followed by Pollination by the stingless bee (3.48 mm) and which was remained at par with Pollination by A. cerana (3.37 mm). The minimum seed size was observed in Absolute control (2.74 mm). The highest (11.99 g) test weight was recorded in Open pollination, which was remained at par with Pollination by A. mellifera (11.77 g). The next best test weight was observed in Pollination by the stingless bee (10.52g) and which was remained at par with Pollination by A. cerana (10.48 g). The minimum test weight was observed in T5 - Absolute control (7.79 g). The highest (90.73%) seed germination in Open pollination, which was found at par with Pollination by A. mellifera (88.42). The next best treatment was Pollination by the stingless bee (85.28%) found to be at par with Pollination by A. cerana (84.22%). The lowest (42.49%) seed germination was recorded in Absolute control in coriander seed.

Keywords: Pollination, *Apis mellifera*, *Apis cerana*, Stingless bees, Honey bees, Coriander

I. INTRODUCTION

Coriander is grown over an area of 528.97 thousand hectares with an average production of 70.81 thousand tones in India. The productivity of Coriander is low, around 1325 kg/ha in India. The Coriander growing states in India are Madhya Pradesh, Rajasthan, Gujarat, Odisha, Assam, West Bengal, Maharashtra, Karnataka, Andhra Pradesh, Jharkhand, West Bengal and Arunachal Pradesh (Anon., 2021). In Gujarat, Coriander is cultivated on 86.18 thousand hectares of area with a production of 129.15 thousand tonnes with a productivity of 1499 kg/ha (Anon., 2021). The coriander are pollinated by many insects, including bees. Exploration of insect pollinators on coriander flowers provided food (nectar and pollen) to them. The anthesis and dehiscence are the important characters to understand the plant-pollinator interaction. Honey bees play an important role in the production of greater fruit quality, fruit set, seed set, fruit weight and fruit circumference of coriander. The information on the foraging behaviour and the effect of bee pollination on quantitative and qualitative parameters of coriander is scanty in South Gujarat situations. Therefore, it is necessary to evaluate the effect of bee pollination on coriander.

II. MATERIALS AND METHODS

The studies on "Effect of bee pollination on quantitative and qualitative parameters of coriander (*Coriandrum sativum L.*)" during Rabi 2020 and 2021 at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat. The effect of bee pollination on quantitative and qualitative parameters of coriander crop was investigated using pollination by three different domesticated bee species *viz*., *Apis cerana indica*, *Apis mellifera* and stingless bees and compared with open pollination (OP) and crop without insect pollination (WIP). The data was subject to analyzed of variance by a completely randomized design (CRD).

The experimental plots of treatment T_1, T_2, T_3 and T_5 were covered by ultra-violet resistance insect-proof double-sewed nylon net measuring 9.00 x 6.00 x 3.25 m having a fastener at one side, before initiation of flowering in coriander crop. The 0.25 m lower end of the nylon net was enclosed by soils; hence in/outside movement of foragers can be avoided. Healthy colonies with a young queen and large brood area of test species *viz*., *A. cerana indica*, *Apis mellifera* and stingless bees having around three thousand bee workers were kept at the initiation of flowering in the caged crop. The honey syrup was provided to bees at the initiation of flower and nearly to the cessation of flowering in crop as a feed supplement as well as when food need of the colony was raised. The number of fruits per umbel, fruit size (Length and width) and test weight (200 fruit weight) was recorded from 25 randomly selected umbel at harvest. The observations were made by weighing randomly drawn 200 dried fruits from each treatment using an electronic balance. Germination percentage: The per cent germination was recorded in a laboratory by putting 100 splitted seeds in germination papers. The germination paper was kept wet as per moisture requirements for seed germination.

III. RESULTS AND DISCUSSION

1. Effect of Bee Pollination on Quantitative Parameters

1.1 Number of Fruits per Umbel

In the year 2020-21 highest fruits/umbel (50.25 fruits/umbel) was recorded in T_4 - Open pollination, which was remained at par with T_2 - Pollination by *A. mellifera* (49.14 fruits/umbel). The next best treatment was T_3 - Pollination by the stingless bee (43.63 fruits/umbel) at par with T_1 - Pollination by *A. cerana* (43.48 fruits/umbel) in the coriander crop. In treatment T_5 - Absolute control, only 25.98 fruits/umbel) was observed. The descending order of the effect of different pollinators on the fruit set was recorded as $T_4 \geq T_2 > T_3 \geq T_1 > T_5$ (Table 1). However, in 2021-22, maximum fruits/umbel (50.37 fruits/umbel) are recorded in T_4 - Open pollination, at par with T_2 - Pollination by *A. mellifera* (49.23 fruits/umbel). In treatment T_1 - Pollination by *A. cerana* recorded (43.75 fruits/umbel), stastastically at par with T_3 - Pollination by the stingless bee (43.73 fruits/umbel). The lowest (25.19 fruits/umbel) was recorded in T_5 - Absolute control. The descending order of the effect of different treatments was recorded as $T_4 \geq T_2 > T_1 \geq T_3 > T_5$ (Table 1). The pooled data of both years indicated that the highest (50.31 fruits/umbel) was recorded in T_4 - Open pollination which remained at par with T_2 - Pollination by *A. mellifera* (49.19 fruits/umbel). The next best treatment was T_3 - Pollination by the stingless bee (43.68 fruits/umbel) and that has remained at par with T_1 - Pollination by *A. cerana* (43.61 fruits/umbel). The minimum fruits per umbel were observed in T_5 - Absolute control (25.58). The descending order of the effect of different pollinators on fruits per umbel in coriander was recorded as $T_4 \geq T_2 > T_3 \geq T_1 > T_5$ (Table 1).

Present work is more or less in confirmation with Roopashree (2011) who also observed the maximum number of fruits/umbel in the open-pollinated plot followed by *A. cerana* and stingless bees at Bengaluru. Similalrly, Kumar and Singh (2017) in Bihar reported the highest seed set in open pollination followed by crop caged with *A. mellifera* in fennel. Sandipan *et al*. (2017) also observed more or less the same trend at Surat (Gujarat) with a higher number of seeds/capitulum in an open-pollinated plot followed by a covered plot with a beehive of *A. mellifera* species.

The results of the present investigation different from the documentation of Patil and Pastagia (2016) at Navsari, Gujarat who reported significantly higher (54.03 fruits/umbel) fruits of coriander in bee pollination (BP) followed by open pollination (OP) (49.62 fruits/umbel) and lowest in pollination without insects (PWI) (27.40 fruits/umbel). Similalrly, Pradeep (2018) also reported slightly different results at Ranchi, Jharkhand as the maximum number of seeds/siliqua in the pollination caged with *A. mellifera* in mustard and coriander as well. Rasool (2018) reported a higher number of seeds per plant in *A. cerana* pollinated plot followed by open plot, *A. mellifera* plot and pollinator exclusion control at Wadura (Jammu and Kashmir). This might be due to pollinators' deficiency in the open pollination crop plot at the time of the investigation.

Table 1: Effect of different pollination treatments on the number of fruits per umbel during *Rabi* 2020-21 and 2021-22

Treatment		No of fruit/umbel		
		2020-21	**2021-22**	**Pooled**
T_1	Pollination by *A. cerana*	6.59 (43.48)	6.61 (43.75)	6.60 (43.61)
T_2	Pollination by *A. mellifera*	7.01 (49.14)	7.02 (49.23)	7.01 (49.19)
T_3	Pollination by stingless bees	6.60 (43.63)	6.61 (43.73)	6.61 (43.68)
T_4	Open pollination	7.09 (50.25)	7.10 (50.37)	7.09 (50.31)
T_5	Absolute control	5.10 (25.98)	5.02 (25.19)	5.06 (25.58)
SEm±T		0.13	0.13	0.09
CD at 5%T		0.37	0.40	0.26

Note: Figures in parentheses is retransformed value, those outside are arc sin (N+0.5) transformed values, N = Mean of 10 tagged flowers

1.2 Fruit Size (mm)

In *Rabi* - 2020-21, the maximum fruit size (4.16 mm) was noted in T_4 - Open pollination, it was found at par with T_2 - Pollination by *A. mellifera* (4.09 mm) followed by T_3 - Pollination by the stingless bee (3.50 mm) and that was found at par with T_1 - Pollination by *A. cerana* (3.40 mm), the minimum fruit size (2.69 mm) was recorded in T_5 - Absolute control. The descending order of the effect of different pollinators on fruit size was recorded as $T_4 \geq T_2 > T_3 \geq T_1 > T_5$ (Table 2). The results presented in Table 2 showed that the largest fruit size (4.25 mm) was observed in T_4 – open pollination in *Rabi* – 2021-22, through at par with T_2 - Pollination by *A. mellifera* (4.17 mm). The next in order was T_1 - Pollination by the stingless bee (3.47 mm), at par with T_1 - Pollination by *A. cerana* (3.34 mm), in coriander fruit size. In T_5 (Absolute control), minimum fruit size (2.74 mm) was noted. The descending order of the effect of different pollinators on the size of fruit was recorded as $T_4 \geq T_2 > T_3 \geq T_1 > T_5$. The pooled data of both years indicated that the highest (4.20 mm) fruit size was recorded in T_4 - Open pollination, which was remained at par with T_2 - Pollination by *A. mellifera* (4.13 mm). The next best fruit size was observed in T_3 - Pollination by the stingless bee (3.48 mm) and at par with T_1 - Pollination by *A. cerana* (3.37 mm). The minimum fruit size was observed in T_5 - Absolute control (2.74 mm). The descending order of the effect of different pollinators on coriander fruit size was recorded as $T_4 \geq T_2 > T_3 \geq T_1 > T_5$.

Present work is more or less in confirmation with Roopashree (2011) who also observed largest fruit size in open-pollinated plot followed by *A. cerana* and stingless bees at Bengaluru. Similalrly, Bhowmik *et al*. (2017) at West Bengal revealed that the diameter of the coriander fruit was increased in open pollination. Likewise, the results of the present investigation is corroborating with Paikara and Paikara (2021) at Ambikapur (Chhattisgarh) who also reported maximum fruit size in total open and minimum fruit size in total closed treatment. The results of the present investigation are a statistically different observation of of Rasool (2018) who reported a maximum fruit size in *A. cerana* pollinated plot followed by open plot, *A. mellifera* plot and pollinator exclusion control at Wadura (Jammu and Kashmir). This might be due to pollinators' deficiency in the open pollination crop plot at the time of investigation

Table 2: Effect of different pollination treatments on fruit size

Treatment		**Fruit size (mm)**		
		2020-21	**2021-22**	**Pooled**
T_1	Pollination by *A. cerana*	1.84 (3.40)	1.83 (3.34)	1.84 (3.37)
T_2	Pollination by *A. mellifera*	2.02 (4.09)	2.04 (4.17)	2.03 (4.13)
T_3	Pollination by stingless bees	1.87 (3.50)	1.86 (3.47)	1.87 (3.48)
T_4	Open pollination	2.04 (4.16)	2.06 (4.25)	2.05 (4.20)
T_5	Absolute control	1.64 (2.69)	1.67 (2.78)	1.66 (2.74)
SEm±T		0.06	0.05	0.04
CD at 5%T		0.17	0.15	0.11
Note: The figure in parentheses is retransform value, those outside are arc sin (N+0.5) transformed values				

1.3 Test Weight

In *Rabi* 2020-21, results indicated that the significantly highest test weight of fruit (11.97 g) was recorded in T_4 - Open pollination, which was remained at par with T_2 - Pollination by *A. mellifera* (11.77 g). The next in order T_3 - Pollination by the stingless bee (10.54 g) was found at par with T_3 - Pollination by *A. cerana* (10.50 g). The lowest fruit weight was observed in T_5 - Absolute control (7.87g). The descending order of the effect of different treatments was recorded as $T_4 \geq T_2 > T_1 \geq T_3 > T_5$ (Table 3). However, results of *Rabi* 2021-22 presented in Table 4.18 showed that the maximum fruit weight (12.01 g) was recorded in T_4 - Open pollination, which was remained at par with T_2 - Pollination by *A. mellifera* (11.77g). In the case of T_3 - Pollination by stingless bee recorded 10.49 g test weight, which was remained at par T_1 - Pollination by *A. cerana* (10.45 g). The lowest test weight (7.72 g) was detected in 5_6 - Absolute control. The descending order of the effect of different treatments was recorded as $T_4 \geq T_2 > T_3 \geq T_1 > T_5$. The pooled data of both years indicated that the highest (11.99 g) test weight was recorded in T_4 - Open pollination, which was remained at par with T_2 - Pollination by *A. mellifera* (11.77 g). The next best test weight was observed in T_3 - Pollination by the stingless bee (10.52g) and which was remained at par with T_1 - Pollination by *A. cerana* (10.48 g). The minimum test weight was observed in T_5 - Absolute control (7.79 g). The descending order of the effect of different pollinators on coriander test weight was recorded as $T_4 \geq T_2 > T_3 \geq T_1 > T_5$ (Table 3).

Present work close confirmation with work done by Bhowmik *et al*. (2017) who also reported the higher seed weight in open pollination conditions. Results of the present work are more or less in agreement with Roopashree, (2011) who revealed the higher fruit weight was recorded in open plot followed by pollination by *A. cerana* as well as, *T. iridipennis* and pollinators exclusion control plot in coriander at Bengaluru. Similalrly, Kumar and Singh (2017) also recorded a higher seed weight in open to all insect pollinators than crop caged with *A. mellifera* in fennel at Bihar. Sandipan *et al*. (2017) also observed more or less the same trend at Surat (Gujarat) with higher seed weight in an open-pollinated plot followed by a covered plot with a beehive of *A. mellifera* species. Tesfaye *et al*. (2020) also recorded the highest fruit weight and fruit yield of coriander in honey bee pollination in Ethiopia. Likewise, the results of the present investigation are in confirmation by Paikara and Paikara (2021) at Ambikapur (Chhattisgarh) who also reported the maximum fruit weight in total open and the minimum fruit weight in total closed treatment.

Table 3: Effect of different pollination treatments on test weight of coriander fruit

Treatment		**Test weight (1000 fruits)**		
		2020-21	**2021-22**	**Pooled**
T_1	Pollination by *A. cerana*	3.24 (10.50)	3.23 (10.45)	3.24 (10.48)
T_2	Pollination by *A. mellifera*	3.43 (11.77)	3.43 (11.77)	3.43 (11.77)
T_3	Pollination by stingless bees	3.25 (10.54)	3.24 (10.49)	3.24 (10.52)
T_4	Open pollination	3.46 (11.97)	3.47 (12.01)	3.46 (11.99)

T_5	Absolute control	2.81 (7.87)	2.78 (7.72)	2.79 (7.79)
SEm±T		0.06	0.06	0.04
CD at 5%T		0.17	0.18	0.12
Note: The figure in parentheses is retransformed values, those outside are arc sin (n+0.5) transformed values				

2 Effect of Bee Pollination on Qualitative Parameters

2.1 Fruit Shape

The results presented in the Table 4 revealed that the highest number of perfect fruit shapes 91.20 per cent was observed in T_4 Open pollination and T_2 Pollination by *A. mellifera* (87.60%) due to universal pollination in coriander in 2020-21. Whereas, in the case of T_1 Pollination by *A. cerana* (83.80%) and T_3 Pollination by stingless bees (79.00%). However, the higher deshaped fruit was recorded in treatment T_5 absolute control plot (62.00%) due to imperfect pollination of coriander. In the year 2021-22, the trend remained the same with little change in the percentage of deshaped fruits in the different treatments. Thakur and Rana (2008) also reported higher number of misshapen fruits of cucumber in open pollination at Solan, which is found in close agreement with the present study.

Table 4: Effect of different pollination treatments on the shape of coriander fruit

Treatment		**Fruit shape (%)**			
		2020-21		**2021-22**	
		Perfect	**Deshaped**	**Perfect**	**Deshaped**
T_1	Pollination by *A. cerana*	83.80	16.20	85.00	15.00
T_2	Pollination by *A. mellifera*	87.60	12.40	87.00	13.00
T_3	Pollination by stingless bees	79.00	21.00	83.40	16.60
T_4	Open pollination	91.20	8.80	89.40	10.60
T_5	Absolute control	62.00	38.00	64.50	35.50

2.2 Seed Germination

The data on seed germination for *Rabi* 2020-21 are presented in Table 5. Significantly highest (90.68%) seed germination was recorded in T_4 - Open pollination, which was remained at par with T_2 - Pollination by *A. mellifera* (88.17%), followed by T_3 - Pollination by the stingless bee (85.46%) and that was found at par with T_1 - Pollination by *A. cerana* (84.00%). Whereas, the lowest (42.09%) seed germination was recorded in T_5 - Absolute control (Pollination exclusion treatment). The descending order of the effect of different pollinators on seed germination was recorded as $T_4 \geq T_2 > T_3 \geq T_1 > T_5$.

Similarly, the data presented in Table 5 during second year also revealed the maximum (90.78%) seed germination in T_4 - Open pollination, which was remained at par with T_2 - pollination by *A. mellifera*. (88.66%). The next best treatment was T_3 - Pollination by the stingless bee (85.10%), which was remained at par with T_1 - Pollination by *A. cerana* (84.45%). The lowest seed germination was recorded in T_5 - Absolute control (42.89%) The descending order of the effect of different pollinators on seed germination was recorded as $T_4 \geq T_2 > T_3 \geq T_1 > T_5$. Likewise, pooled data of both years showed the highest (90.73%) seed germination in T_4 - Open pollination, which was found at par with T_2 - Pollination by *A. mellifera* (88.42 The next best treatment was T_3 - Pollination by the stingless bee (85.28%) found to be at par with T_1 - Pollination by *A. cerana* (84.22%). The lowest (42.49%) seed germination was recorded in T_5 - Absolute control in coriander seed. The descending order of the effect of different pollinators on seed germination was recorded as $T_4 \geq T_2 > T_3 \geq T_1 > T_5$ (Table 5).

Present work is in close confirmation with work done by Bhowmik *et al*. (2017) who reported that the seed germination was increased in open pollination conditions over bagged flowers. Results of the present work are more or less in agreement with Roopashree, (2011) who revealed that higher seed germination was recorded in open plots followed by pollination by *A. cerana* as well as, *T. iridipennis* and pollinators exclusion control plot in coriander at Bengaluru. Similarly, the results of the present study are in confirmation by Paikara and Paikara (2021) at Ambikapur (Chhattisgarh) who also reported higher seed germination in total open and minimum seed germination in total closed treatment.

Table 5: Effect of different pollination treatments on germination of coriander seed

Treatment		**Seed germination (%)**		
		2020-21	**2021-22**	**Pooled**
T_1	Pollination by *A. cerana*	66.42 (84.00)	66.78 (84.45)	66.60 (84.22)
T_2	Pollination by *A. mellifera*	69.89 (88.17)	70.32 (88.66)	70.10 (88.42)
T_3	Pollination by stingless bees	67.59 (85.46)	67.30 (85.10)	67.44 (85.28)
T_4	Open pollination	72.22 (90.68)	72.33 (90.78)	72.28 (90.73)

T_5	Absolute control	40.45 (42.09)	40.91 (42.89)	40.68 (42.49)
SEm±T		1.28	1.37	0.94
CD at 5%T		3.76	4.04	2.68
Note: The figure in parentheses is retransformed values, those outside are arc sin (n+0.5) transformed values				

IV. CONCLUSION

The honey bees are the most common visitors to the coriander crop as compared to other insect pollinators. The main insect pollinator's viz., Rock bee (*A. dorsata*), Indian bee (*A. cerana indica*) and little bees (*A. florea*) were abundantly available in the coriander crop under South Gujarat. The decreasing order of the effectiveness of different modes of pollination was recorded as Open pollination (OP) > Pollination by *A. mellifera* > Pollination by A. cerana > Pollination by stingless bees during the experiment. Plenty of pollinator's availability in research sites leads to the super effect on qualitative and quantitative parameters of coriander. Coriander crop requires bee pollination as an extra input in enhancing the yield in the pollinator's deficit area. The coriander growers should keep the bee colonies near the field during the flowering period appears to obtain a higher yield.

References

Anonymous (2021). Ministry of Agriculture and Farmers Welfare, Government of India. (http://www.indiastat.com retrieved on 30 March 2022).

Bhowmik, B.; Sarkar, S.; Sen, A. and Bhadra, K. (2017). Role of insect pollinators in fruit yield of coriander (*Coriandrum sativum* L.) and their electroantennogram response to crop volatiles. *Agric. Res. J.*, **54**(2): 227-235. (DOI: 10.5958/2395-146X.2017.00042.4).

Kumar, M. and Singh, R. (2017). Role of honeybees in the pollination of fennel (*Foeniculum vulgare* L.). *J. Pharmacogn. Phytochem.*, **6**(1): 214-218. (ISSN: 2349-8234).

Paikara, S. P. and Painkra, G. P. (2021). Influence of bee visitation on quantitative and qualitative parameters of coriander in Chhattisgarh. *J. Plant. Dev.*, **13**(5): 285-291.

Patil, P. N. and Pastagia, J. J. (2016). Effect of bee pollination on yield of coriander, *Coriandrum sativum* Linnaeus. *Int. J. Plant. Prot.*, **9**(1): 79-83.

Pradeep, A. (2018). Foraging behavior of honeybee pollination in coriander and mustard. M.Sc. (Agri.) Thesis submitted to Birsa Agricultural University, Ranchi. 112 p.

Rasool, J. (2018). Diversity of pollinators and role of honey bees in pollination of coriander (*Coriandrum sativum* L.). M.Sc. Thesis Submitted to University of Agricultural Sciences and Technology of Kashmir, Wadura. 87 p.

Roopashree, N. (2011). Role of honey bees in pollination of coriander (*Coriandrum sativum* L.). M.Sc. Thesis Submitted to University of Agricultural Sciences, GKVK, Bengaluru. 107 p.

Sandipan, P. B.; Jagtap, P. K.; Patel, M. C.; Solanki, B. P.; Sharma, A. P. and Rathod, N. (2017). Seed yield increase in Niger crop in to relation to honeybee and other pollinators. *Cercetari Agronomice in Moldova*, **2**(170): 73-81. (DOI: 10.1515/cerce-2017-0016).

Tesfaye, B.; Gelgelu, T. and Lelisa, W. (2020). Role of honey bee (*Apis mellifera*) pollination in enhancing seed yield and yield related parameters of *Coriandrum sativum* L. *J. Energy Nat. Resour. Low*, **9**(4): 120-124. (DOI: 10.11648/j.jenr.20200904.13).

Thakur, M. and Rana, R. S. (2008). Studies on the role of insect pollination on cucumber yield. *Pest Technology*, **2**(2): 130-133.