RESEARCH ARTICLE

INFLUENCE OF BEE VISITATION ON QUANTITATIVE AND QUALITATIVE PARAMETERS OF CORIANDER IN CHHATTISGARH

Surya Prakash Paikara and G. P. Painkra*

**All India Coordinated Research Project on Honey Bees and Pollinators*
IGKV, Department of Entomology, Raj Mohini Devi College of Agriculture and Research station Ambikapur- 497001(Chhattisgarh), India

Received-28.04.2021, Revised-14.05.2021, Accepted-25.05.2021

Abstract: The quantitative parameters such as number of seed per umbel (34.93), number of umbel per plant (30.45), seed yield per plant (4.35 g),seed weight per umbel (0.45 g), seed size (3.30 mm), 1000 seed weight (10.13 g) were recorded maximum in control treatment (total open) and minimum recorded number of seed per umbel (14.95), number of umbel per plant (13.30), seed yield per plant (1.98 g), seed weight per umbel (0.20 g), seed size (1.63 mm), 1000 seed weight (6.80 g) in total closed treatment. The qualitative parameter such as germination percentage (79.50 %), seedling vigour index (1233.84), shoot length (9.00 cm) and root length (6.50 cm) were significantly higher in total open (control) treatment compared to other treatment and the minimum germination percentage (58.75 %), seedling vigour index (587), shoot length (6.75 cm), root length (3.25 cm), were recorded in total closed treatment.

Keywords: Coriander crop, Indian honey bee, *Apis cerana indica*, Pollination, Yield parameter

INTRODUCTION

Coriander (*Coriandrum sativum Linn.*) belongs to the family *Apiaceae* (*Umbelliferae*) as an annual herbaceous crop. In the Sanskrit literature, it is referred to as' dhanayaka' or' kusthumbari.' The Coriandrum genus includes plant grown *C. sativum* and Wild species *C. tordylium.* It is cultivated as an annual summer or winter plant. The plant can attain heights of between 0.20 and 1.40 m at the flowering stage. In India, coriander cultivation area was estimated to be 4.7 lakh hectares with 37 lakh tons of output and an average 789 kg/ha of productivity. The export of coriander powder from India was 2246 metric tons (2003-04) and 8318 metric tons (2003-04) as curry powder including coriander in the mixture (Anonymous, 2006)

Coriander (*Coriandrum sativum* L.) is an annual herb belonging to the family Umbelliferae. It is originated from East Mediterranean and South Europe. It is mainly cultivated for its leaves and seeds as a summer or winter crop. At flowering, the plant can reach an height between 60 cm. The germination is epigaeal and the plant has a tap root. The stem is more or less erect and sympodial, monochasial-branched, sometime with several side branches at the basal node. Each branch finishes with an inflorescence. The stem of the plant is hollow and the leaves are alternate and the first ones are often gathered in a rosette form. The basal leaves are usually either undivided with three lobes or tripinnatifid. The higher leaves are inserted and more pinnate. The leaves are green or light green and underside of the leaves are often shiny and waxy. During flowering period, the leaves sometimes turn to red or violet. They wither before the first fruits are ripe, starting from the basal leave.

The inflorescence is a compound umbel with one or two linear bracts is a compound. The umbel has two to eight primary rays grouped in such a way that the umbellets are at the same point, having different sizes. Flowering starts with the primary umbel, and peripheral umbellets are found in every umbel, and peripheral flowers are the first to bloom in each umbellet. Protandro are the flowers. The flowers have five petals and pale pink or white is the shade of the petals . It takes about 5-7 days to complete the single umbel flowering cycle.

In the world, India has traditionally been known as the "home of spices." India is the world's largest seed spice manufacturer, consumer and exporter. Seed spices are an important agricultural product community and play a very important role in our national economy. Seed spices are essential commodities oriented towards exports and about 10% of our production is exported as raw and also as value-added products, realizing 206,25 rupees per annum in foreign exchange. The estimated global seed spice demand is 90,000 tons, of which our country is currently capable of exporting around 46,000 tons annually, which is around 51 percent of total demand. In India, fourteen seed spices are cultivated commercially. Among them, coriander is one of the most popular seed spices and accounted for 25% of total seed spices export with 13% earnings during 2000-01.It is the only seed spice included in the National Crop Projection System (Sivaraman *et al*., 2001).

Bee pollination not only increases yield rates, but also increases hybrid vigor, generates variability and preserves the gene flow in the eco system, while maintaining the diversity of plant varieties. The above claim that efficient use of pollinators can significantly increase the yield rate has been verified by experiments (Melinichenko, 1977).

*Corresponding Author

The cultivation of coriander has increased slightly over a period of time in India (from 1980 to 1990 between 2,80 and 3,34 lakh hectares). At present, however, it is cultivated in an area of 5. 46 lakh hectares with a total output of 2.90 tons and an average output of 531 kg per hectare. Rajasthan, Andhra Pradesh, Tamil Nadu, Gujarat, Madhya Pradesh and Karnataka. In Karnataka, coriander is grown in an area of 17,300 hectares with a total output of 2,900 tons and an average output of 168 kg / ha compared to the national average of 531 kg / ha (Sivaraman *et al.*, 2001). Karnataka's low coriander productivity is primarily due to poor production technologies, lack of improved varieties, management of nutrients, and adequate pollination.are the big rising coriander states.

In India it is being cultivated in an area of 583 thousand hectares with an annual production of 784 thousand tonnes (Anonymous 2019). In India, Madhya Pradesh, Rajasthan, Gujarat, Tamil Nadu, U.P. are the major producing states. In India the domestic marketing centers of coriander are Jodhpur. Coriander is the important vegetable, spice crop of the Chhattisgarh state with area of 20069 hectare an annual production 94730 metric tones.

Coriander's flowering phenology allows better cross-pollination. The inflorescence consists of a compound umbel, where the primary umbel is to bloom first, followed by the umbels of lower order. Therefore, pollination depends largely on various pollinating agents, including insects, especially honeybees, which are the cheapest and most environmentally friendly inputs to maximize yield in most cross-pollinated crops. Various insects such as honeybees *(Apis florea Apis cerana* Trigona iridipennis Smith.), solitary bees, butterflies and flies carry out cross pollination in coriander. Honey bees are among them the main coriander pollinators (80.30 percent) (Ricciardelli *et al.*, 1979). The bee pollination raised the yield in coriander by 49.86% (Anonymous, 2000).

MATERIALS AND METHODS

The experiment was undertaken at Raj Mohini Devi College Agriculture and Research Station, Ajirma Fa rm, Ambikapur, District, Surguja (C.G.), during 201 8-19. The experiment was conducted to study the pollination by Indian honey bee on coriander crop. Six treatments were taken i.e. T_1 - Open the cage between 0700 to 1000hrs and 1500 to 1700hrs, close between 1000 to 1500hrs, T_2 - Close the cage between 0700 to 1000hrs and 1500 to 1700hrs, open between 1000 to 1500hrs, T_3 - Close the cage between 0700 to 1200hrs Noon, and open between 1200 Noon to 1700hrs, T_4 - Open the cage between 0700 to 1200hrs Noon and close between 1200 Noon to 1700hrs, T_5 - Total closed and T_6 - Control (Total open).In this cage only Indian bee was allowed to visit and were sweep away from coriander bloom. The coriander crop was sown and the variety was Chhattisgarh dhaniya-1, taking plot size 2x2 m^2, six treatments replicated four times and then statically analysis was done with randomized block design (RBD).

RESULTS AND DISCUSSION

Quantitative parameters

Quantitative parameters such as number of seed per umbel, number of umbel per plant, seed yield per plant, seed weight per umbel, seed weight per plant size of seed, and weight of 1000 seeds (g) differed significantly between different pollination modes in coriander. (Table 1& 2).

1. Number of seeds/umbel

The highest number of seeds/umbels (34.93 seed/umbel) was recorded in the total open treatment and the least number of seeds/umbel (14.95 seed/umbel) was recorded in the total closed treatment. All the treatments were reported with a significantly lower number of seeds/umbel, close the cage between 0700 to 1200hrs Noon and open between 1200 to 1700hrs (22,50 seed/umbel), Close the cage between 0700 to 1000hrs and 1500 to 1700hrs, open between 1000 to 1500hrs (26.28 seed/umbel) Open the cage between 0700 to 1200hrs Noon and close between 1200 Noon to 1700hrs, (28.75 seed/umbel), were found statistically at par among each other open the cage between 0700 to 1000hrs and 1500 to 1700hrs, close between 1000 to 1500hrs (30.43 seed/umbel), and treatment with control (total open), (34.93 seed/umbel).

2. Number of umbel/plant

The maximum number of umbels/plants (30.45 umbel/plant) was recorded in the total open treatment followed by the lowest number of umbel/plant in total closed treatment (13.30 umbel/plant) was recorded. All treatments were recorded significantly lowest number of umbel/plant, like the open the cage between 0700 to 1200hrs, Noon, and the open between 1200 to 1700hrs (24.10 umbel/plant)), Close the cage between 0700 to 1000hrs, and between 1500 to 1700hrs, open between 1000 to 1500hrs, (22.03 umbel/plant), close the cage between 0700 to 1200hrs, Noon and open between 1200 Noon to 1700hrs, (19.16 umbel/plant), found statistically at par between opening the cage between 0700 to 1000hrs and between 1500 to 1700hrs, close between 1000 to 1500hrs (26.18 umbel/plant), and treatment superior significant control (total open), (30.45 umbel/plant).

3. Seed yield/plant (gm)

The maximum yield of seed/plant was measured total open treatment (4.35 g seed yield/plant) followed by the open of the cage between 0700 to 1200 hrs Noon. and close between 1200 to 1700hrs (3.88.00 g seed yield/plant), Open the cage between 0700 to 1000hrs and 1500 to 1700hrs (3.78 g seed yield/plant), Close the cage between 0700 to 1200hrs

Noon and open between 1200 Noon to 1700hrs (2.93 g seed yield/plant). Close the cage between 0700 to 1000hrs and 1500 to 1700hrs, open between 1000 to 1500hrs (2.46 g seed yield/plant) There was however, a significant difference between the various treatments. The lowest yield of seed/plant was recorded in total closed treatment (1.98 g yield seed/plant).

4. Seed weight/umbel (gm)

The maximum seed weight/umbel was noticed during the total open treatment (0.45 g) followed the open of the cage between 0700 to 1200 hours. Noon and close between 1200 Noon and 1700hrs (0.43 g), Close the cage between 0700 to 1000hrs and 1500 to 1700hrs, open between 1000 to 1500hrs (0.39 g), Close the cage between 0700 to 1200hrs Noon and open between 1200 Noon to 1700hrs (0.32 g), Open the cage between 0700 to 1000hrs and between 1500 to 1700hrs, close the cage between 1000 to 1500hrs (0.31 g). Compared with other treatment, the crop, which was complete closed condition, had a lower seed weight/umbel (0.20 g) Treatments including Open the cage between 0700 to 1000hrs and 1500 to 1700hrs, close the cage between 1000 to 1500hrs (0.31 g). The total closing (0.20 g) seed weight/umbel was found to be significantly low.

5. Seed size

The maximum number of seed sizes (3.30 mm seed size) was recorded in the total open treatment. The minimum number of seed sizes (1.63 seed size mm) was recorded in the total closed treatment. All treatment was recorded a significantly lower number of seed sizes, such as open the cage between 0700 to 1000hrs and 1500 to 1700hrs, close between 1000 to 1500hrs (2.69 mm seed size), Open the cage between 0700 to 1200 hrs Noon and close between 1200 hrs to 1700 hrs (2.45 seed size mm), close the cage between 0700 to 1200 hrs Noon and open between 1200 to 1700 hrs (2.00 seed size mm), close the cage between 0700 to 1000 hrs, and 1500 to 1700 hrs, open the cage between 1000 to 1500 hrs (1.88 seed size mm).

6. 1000 seed (test) weight

Total open treatment reported a maximum seed weight (1000 seeds) (10.13 g) followed by the treatment Open the cage between 0700 to 1000hrs and 1500 to 1700hrs, close the cage between 1000 to 1500hrs (8.93 g), and Open cage between 0700 to 1200hrs Noon and close between 1200 to 1700 hrs (8.88 g), Close the cage between 0700 to 1000hrs and 1500 to 1700 hrs, open between 1000 to 1500 hrs (7.98 g)) and close the cage between 0700 to 1200hrs Noon and open between 1200 and 1700hrs (7.40 g). The minimum seed weight (1000 seed) was recorded in total closed treatment (6.80 g). The treatments were found statistically significant.

Results on quantitative parameters in coriander crop are confirmation with the findings of Roopashree (2011) where the number of seeds, seed weight and seed size was significantly increased, when *A. florea* visits increased from two to eight and ten bee visits per umbel (18.20 to 25.00 seeds/umbel), 0.17 to 0.30g/umbel and 3.04 to 5.04 mm3, respectively). The number of seeds/umbel, seed weight/umbel and seed size was maximum, when *A. cerana* visits/umbel were eight to ten bees (22.40 seeds/umbel, 0.21g/umbel and 4.23 mm3, respectively). Similarly, number of seeds/umbel, seed weight/umbel and seed size was maximum, when *T. iridipennis* visits/umbel were eight to ten bees (19.40 seeds/umbel, 0.19g/umbel and 3.99 mm3, respectively). However, the number of seeds, seed weight and seed size was minimum in zero bee visit/umbel in all the species of honey bees. The present findings are in conformity with the findings made in some of the cucurbitaceous crops by Ramesh (2007), Manjula (2007) and Khaja Rubina (2010).

Qualitative parameters

The qualitative parameters such as germination percentage of seeds, shoot length, root length and seedling vigor index showed significant variation among different modes of pollination in coriander. (Table 2).

1. Germination percentage

It was indicated that the germination per cent of coriander seed was significantly higher in the total open treatment (79.50 %). Where other treatments had been found to significantly lower germination per cent, such as Open cage between 0700 to 1000hrs and 1500 to 1700hrs, close from 1000 to 1500hrs (68.75 %), Close cage between 0700 to 1000hrs and 1500 to 1700hrs, open from 1000 to1500hrs (62.50 %), close cage between 0700 to 1200hrs Noon and open between 1200. Noon to 1700hrs (61.00 %) Open cage between 0700 to 1200hrs. Noon and Close between 1200 Noon to 1700hrs (71.25 %). The lowest germination per centage was obtained in total closed treatment (58.75 %).

The finding was reported by Dhurve (2008) who recorded the highest germination percentage in niger seed in treatment, such as open pollination with cacambe 10 % (81.00%) and the lowest seed germination in crop cages without bees (64.00 per cent). Mupade *et al.* (2009) announced that the *Apis florea* colony with one frame having the highest germination rate (90.00%) followed by four frames *A. carena* (89.00%) and two frames *A. mellifera* Colony (88.00%).

2. Shoot length

The significantly maximum shoot length was recorded total open treatment (9.00 cm). Other treatments such as Open cage between 0700 to 1000hrs and 1500 to 1700hrs, close from 1000 to 1500hrs (8.25 cm), Close cage between 0700 to 1000hrs and 1500 to 1700hrs, open from 1000 to 1500hrs (7.25 cm), Close cage between 0700 to 1200hrs Noon and open from 1200hrs to 1700hrs (8.00 cm), open the cage between 0700 to 1200hrs

Noon and Close from 1200 Noon to 1700hrs (7.50 cm). The lowest shoot length was observed in total closed treatment (6.75 cm).

The present results on the qualitative improvement of coriander are verified by the findings of Chaudhary and Jage Singh (2006) and Khalid (2008) in coriander. The *A. florea* pollinated plants were substantially superior over other treatments as the maximum shoot length was found 10.66 cm, followed by open pollinated plants (9.96 cm), *A. cerena* (9.63 cm)

3. Root length

The significantly highest root length observed was total open treatment (6.50 cm). Other treatments such as Open cage between 0700 to 1000hrs and 1500 to 1700hrs, close from 1000 to 1500hrs (4.50 cm), Close cage between 0700 to 1000hrs and 1500 to 1700hrs, open from 1000 to 1500hrs (5.25 cm), Close cage between 0700 to 1200hrs Noon and open from 1200 to 1700hrs (5.00 cm), Open cage between 0700 to 1200hrs. Noon and Close from 1200 Noon to 1700hrs (4.75 cm) and Total closed (3.25 cm). The lowest root length was obtained in total closed treatment (3.25 cm).

The present findings on the qualitative improvement of coriander are confirmed by the findings of Khalid (2008) and Chaudhary and Jage Singh (2006) in coriander. the *A. florea* pollinated plants were found to be significantly higher, with a maximum root length of 7.76 cm, followed by open (7.26 cm), *A. cerena* (7.00 cm)

4. Seedling vigour index

The significantly maximum seedling vigour index was recorded total open treatment (1233.84) compared to other treatments such as Open cage between 0700 to 1000hrs and 1500 to 1700hrs, close from 1000 to 1500hrs (876.56), Close cage between 0700 to 1000hrs and 1500 to 1700hrs, open from 1000 to 1500hrs (765.62), Close cage between 0700 to 1200hrs Noon and open between 1200 to 1700hrs (897.50) Open cage between 0700 to 1200hrs. Noon and Close between 1200 Noon to 1700hrs (872.80) and Total closed (587.50) were found to be low in seedling vigour index. The lowest seedling vigour index was found in total closed treatment (587.50).

The results of Anonymous (2000), Chaudhary and Jage Singh (2006) and Khalid (2008) in coriander are confirmed by the present findings on qualitative improvement in coriander. The seedling vigour was maximum in *A. florea* Pollinated plants (1468) compared to open plants (1360), *A. cerena* (1247). The present findings on quantitative and qualitative improvement in coriander are in confirmity with the findings of Basawana (1982), Shelar and Suryanarayana (1989), Marvin (1992), Goyal *et al.*, (1989) in carrot and also with Mohana Rao and Suryanarayana (1989) and Mohammad Siddiqueet al (2020) in onion. Painkra *et al.* (2015) in niger, Painkra and Shrivastava (2015) and Painkra (2014) in niger crop. However, the variation in some of the yield and other parameters may be due to type of crop, soil condition and weather condition of the study locality.

Table 1. Influence of bee visitation on quantitative parameters of coriander.

Treatments	Quantitative parameter					
	Number of seeds per umbel	**Number of umbel per plant**	**Seed yield per plant (gm)**	**Seed weight per umbel (gm)**	**Seed size (mm^3)**	**Test weight 1000 Seed (gm)**
T_1 - Open the cage between 0700 to 1000hrs and 1500 to 1700hrs, close between 1000 to 1500hrs	30.43 (5.60)*	26.18 (5.21)	3.78 (2.16)	0.31 (1.13)	2.69 (1.91)	8.93 (3.14)
T_2 - Close the cage between 0700 to 1000hrs and 1500 to 1700hrs, open between 1000 to 1500hrs	26.28 (5.22)	22.03 (4.79)	2.46 (1.85)	0.39 (1.18)	1.88 (1.68)	7.98 (2.99)
T_3 - Close the cage between 0700 to 1200hrs Noon, and open between 1200 Noon to 1700hrs	22.50 (4.84)	19.16 (4.49)	2.93 (1.97)	0.32 (1.14)	2.00 (1.71)	7.40 (2.89)
T_4 - Open the cage between 0700 to 1200hrs Noon and close between 1200 Noon to 1700hrs	28.75 (5.45)	24.10 (5.09)	3.88 (2.20)	0.43 (1.18)	2.45 (1.81)	8.88 (3.13)
T_5 - Total closed	14.95 (3.99)	13.30 (3.78)	1.98 (1.72)	0.20 (1.09)	1.63 (1.61)	6.80 (2.79)
T_6 - Control (Total open)	34.93 (5.99)	30.45 (5.60)	4.35 (2.31)	0.45 (1.20)	3.30 (2.06)	10.13 (3.33)

SEm±	0.017	0.034	0.079	0.012	0.075	0.042
CD (P=0.05)	0.051	0.103	0.24	0.035	0.227	0.127

* Figures in parenthesis are $\sqrt{X + 0.5}$ transformed values

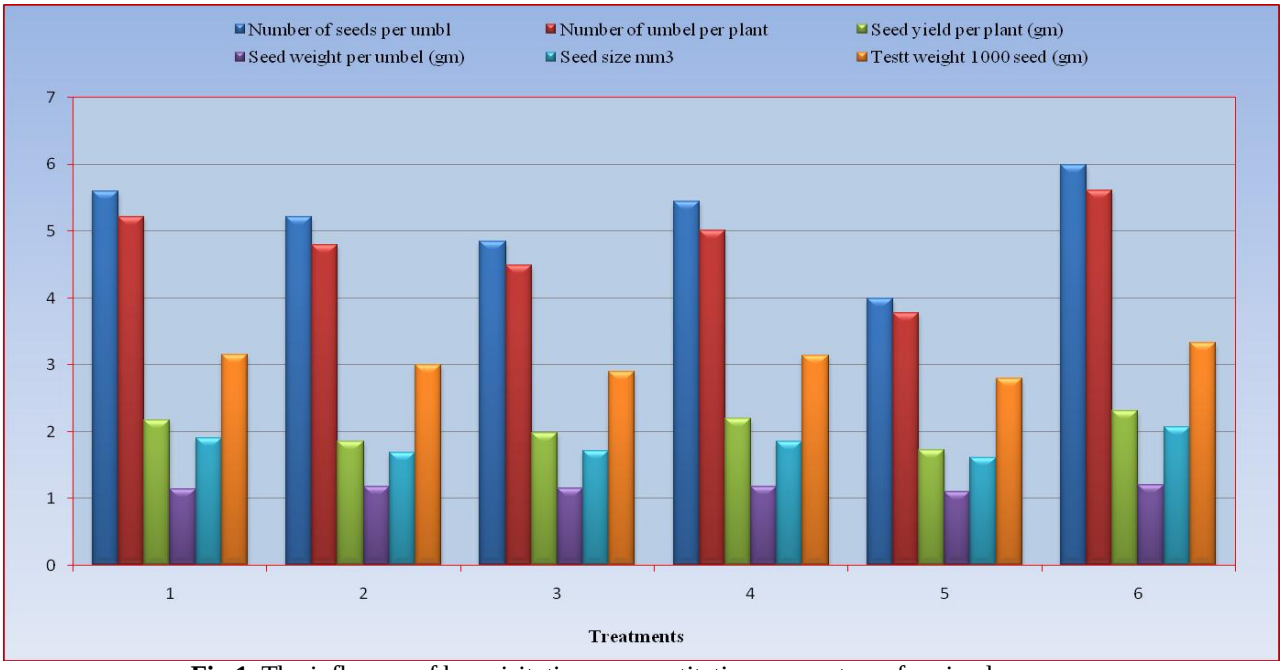

Fig 1. The influence of bee visitation on quantitative parameters of coriander

Table 2. Influence of bee visitation on qualitative parameters of coriander.

Treatments	Qualitative parameters			
	Germination percentage	Shoot length (cm)	Root length (cm)	Seedling vigour index
T_1 - Open the cage between 0700 to 1000hrs and 1500 to 1700hrs, close between 1000 to 1500hrs	68.75 (8.35)	8.25 (3.03)	4.50 (2.33)	876.56 (29.61)
T_2 - Close the cage between 0700 to 1000hrs and 1500 to 1700hrs, open between 1000 to 1500hrs	62.50 (7.96)	7.00 (2.82)	5.25 (2.48)	765.62 (27.64)
T_3 - Close the cage between 0700 to 1200hrs Noon, and open between 1200 Noon to 1700hrs	61.00 (7.87)	8.00 (2.98)	5.00 (2.44)	793.00 (28.13)
T_4 - Open the cage between 0700 to 1200hrs Noon and close between 1200 Noon to 1700hrs	71.25 (8.5)	7.50 (2.90)	4.75 (2.37)	872.80 (29.80)
T_5 - Total closed	58.75 (7.72)	6.75 (2.77)	3.25 (2.05)	587.50 (24.21)
T_6 - Control (Total open)	79.50 (8.97)	9.00 (3.16)	6.50 (2.73)	1233.84 (35.08)
SEm±	0.037	0.076	0.111	0.726
CD (P=0.05)	0.113	0.231	0.336	2.21

* Figures in parenthesis are $\sqrt{X + 0.5}$ transformed values

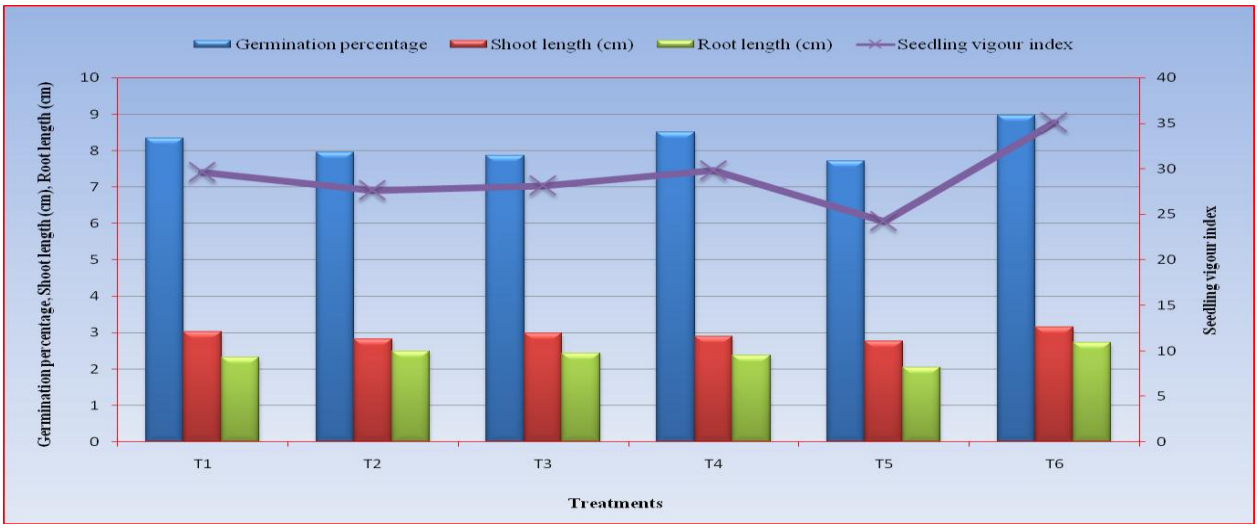

Fig 2. The influence of bee visitation on qualitative parameters of coriander

CONCLUSION

It is concluded that the quantitative parameters such as number of seed per umbel (34.93), number of umbel per plant (30.45), seed yield per plant (4.35 g),seed weight per umbel (0.45 g), seed size (3.30 mm), 1000 seed weight (10.13 g) were recorded maximum in control treatment (total open) and minimum recorded number of seed per umbel (14.95), number of umbel per plant (13.30), seed yield per plant (1.98 g), seed weight per umbel (0.20 g), seed size (1.63 mm), 1000 seed weight (6.80 g) in total closed treatment. The qualitative parameter such as germination percentage (79.50 %), seedling vigour index (1233.84), shoot length (9.00 cm) and root length (6.50 cm) were significantly higher in total open (control) treatment compared to other treatment and the minimum germination percentage (58.75 %), seedling vigour index (587), shoot length (6.75 cm), root length (3.25 cm), were recorded in total closed treatment.

ACKNOWLEDGEMENT

The authors are highly thankful to Project coordinating Unit All India Coordinated Research Project on Honey Bees and Pollinators, Division of Entomology, ICAR-IARI, New Delhi for providing the financial support to IGKV, Raipur centre and help for post graduate students.

REFERENCES

Anonymous (2000). Annual report, All India Co-ordinated Project on Honey bee Research and Training, Bhubaneshwar.; pp.2-10.

Basawana, K.S. (1982). Role of insect pollinators on seed production in Coriander and fennel. *South Indian Horticulture*. 56: 117-118.

Chaudhary, O.P. and Singh, J. (2006). Diversity, temporal abundance, foraging behaviour of floral visitors and effect of different modes of pollination on coriander (*Coriandrum sativum* L.) *Journal of Spices and Aromatic Crops* 16 (1): 8–14.

Dhurve, S.S. (2008). Impact of honey bee pollination on seed production of niger. M.Sc. (Ag.) thesis, university of agricultural sciences, Dharwad (Karnataka) India.

Goyal, N.P., Singh, Manjit and Kandoria, J.L. (1989). Role of insect Pollination in seed production of carrot. *Indian Bee Journal*, 51:89-93.

Khalid, A., Al-Tamimi, Mohammed and Khanbash, S. (2008). Study the role of honeybee in the pollination of *Coriandrum sativum*. Honeybee Center Hadhramout University..

Khaja Rubina, S. (2010). Pollinators diversity with special reference to role of honey bees in quantitative and qualitative improvement of cucumber, (*Cucumis sativus* L). *M.Sc. Thesis*, University of Agri. Sciences, Bangalore.

Manjula, S.C. (2007). Pollination potentiality of honeybee species in summer squash (*Cucurbita pepo* L.). M.Sc. Thesis, University of Agri. Sciences, Bangalore.

Marvin, D., Butler, Terry, Griswold, L. and Vincent, J. Tepedinoosu (1992). Extension Crop Scientist, USDA Bee Biology Systematical Lab, Madras, *Or and Logan*, UT.; pp-73-74.

Mohana Rao, G. and Suryanarayana, M.C. (1989). Effect of honeybee pollination on seed yield in onion (*Allium cepa* L.). *Indian Bee Journal*, 51: 9-11.

Mohammad, Siddique, Munawar, Shazia, Raja, Shahid, Niaz and Ghulam, Sarwar (2002). Comparative performance of honeybees (*Apis mellifera* L.) and blow flies (*Phormia terronovae*) in onion (*Allium cepa* L.) seed setting. *J. Agric. Res.*, 49(1).

Mupade, R.V., Kulkarni, S.N. and Kamte G.S. (2009). Effective of honey bee pollination on qualitative characters of onion *Indian Journal of Plant Protection*; 37 (1-2):186-187.

Painkra, G.P., Shrvastava Shiv, K., Shaw, S.S. and Gupta, Rajeev (2015). Effect of pollination by Indian honey bee, *Apis cerana indica* fabr. on yield, yield attributing characters and oil content of niger, *guizotia abyssinica* cass. *Journal of Plant Development Sciences*, 7 (4) : 321-326.

Painkra, G.P. and Shrivastava Shiv, K. (2015). Effect of pollination by Indian honey bee, *Apis cerana indica* on yield attributing characters and oil content of Niger,*Guizotia abyssinica* Cass. In Surguja of Chhattisgarh, *Journal of Entomology and Zoology Studies.* 3(4): 218-222.

Painkra, G.P. (2014). Studies on foraging behaviour of Indian honey bee, *Apis cerana indica* fabr. on quantitative and qualitative parameters of niger, *guizotia abyssinica* cass. with bio-efficacy against insecticides, Ph.D.(Entomology) Thesis, submitted to Indira Gandhi Krishi Vishwavidyalaya,Raipur (Chhattisgarh) India.

Ramesh, R.G. (2007). Pollination of honeybee species in ridge gourd (*Luffa acuntangula* L.). *M.Sc. Thesis,* University of Agri. Sciences, Bangalore,

Roopashree, N. (2011). Role of honey bee in pollination of coriander (*Coriandrum sativum* L.) *M.Sc. Thesis*, University Of Agri. Sciences, Bangalore,.

Shelar, G.D. (1981). Suryanarayana, CM. Preliminary studies on pollination of coriander. *Indian Bee Journal*, **4**: 110-111.