RESEARCH ARTICLE

FORAGING BEHAVIOR OF EUROPEAN HONEY BEE, *APIS MELLIFERA* (HYMENOPTERA-APIDAE) ON BROCCOLI (*BRASSICA OLERACEA* VAR. ITALICA) FLOWERS IN SURGUJA DISTRICT OF CHHATTISGARH, INDIA

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Abstract: A study was undertaken at Raj Mohini Devi College of Agriculture and Research station, Ambikapur (Chhattisgarh) substation of Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh) India. The foraging behavior of European honey bee, *Apis mellifera* was observed in Broccoli flowers during 11 January 2021- 15 February 2021. The maximum foraging activity of honey bee was observed third week of March 2021 (32.76 bees/5min/plant) followed by second week of March 2021 (25.38 bees/5min/plant) and fourth week of March 2021 (122.45 bees/5min/plant) however the lowest population was recorded during first week of April 2021 (6.61 bees/5min/plant). Similarly during the different hours of the day, the maximum population of honey bees were recorded at 10.00-11.00 AM (20.63 bees/5min/plant) followed by at 11.00AM-12.00PM (19.72 bees/5min/plant) and at 9.00-10.00AM (19.27 bees/5min/plant). However, the lowest population was recorded at 3.00-4.00PM (12.08 bees/5min/plant).

Keywords: Broccoli flowers, European honey bee, Foraging behavior

INTRODUCTION

Broccoli (*Brassica oleracea* var. italica) is a biennial plant belonging to the Brassicaceae family that is eaten as a vegetable throughout the world. It is a cool season crop and it can be grown in spring season. The edible plant parts are the stalk and large flowering head. Broccoli is a rich source of vitamin C and vitamin K. It also contains considerable amounts of vitamins B1, B3, B5, B6, and E. Folate, chromium, magnesium, phosphorus, zinc, calcium, iron, selenium, proteins, and omega-3 fatty acids are also found in broccoli. Broccoli also contains numerous phytochemicals, such as polyphenols, namely kaempferol, quercetin glucosides, isorhamnetin, glucosinolates, and their derivatives. These are responsible for its antioxidant and anticancer properties and other health benefits. Broccoli became one of the favorite foods due to its high nutrient and fiber content. Numerous epidemiological studies have confirmed the dietary and therapeutic benefits of broccoli, such as immunity modulation, detoxification, eye health, bone health, and antimicrobial and antioxidant properties (Nagraj *et al*., 2020). It is mainly used for salad purpose and can be eaten by lightly steaming. Broccoli crop requires moist soil well drained and contains good fertilizers and requires soil pH 5.0-6.5. For the seed production or good management of flower head the flowers are sprouting from the head and pods are found heathy. The flowers contain very good nectar and pollen or both for honey bees. Honey bees visited huge population in broccoli flowers from morning to evening during the blooming period (Painkra, 2019). In this article the foraging activity of Itlian bee, *Apis mellifera* is being described.

MATERIALS AND METHODS

Experimental Location The experiment was conducted in Broccoli orchard of Raj Mohini Devi College of Agriculture and Research station at Ambikapur, Surguja district of Chhattisgarh during 2021. This station is situated at an attitude 230 8’33.7596” N and a longitude 830 10’44.0184” E. The foraging behavior of European honey bee, *Apis mellifera* was observed in Broccoli flowers during 11 January 2021- 15 February 2021. The population of above honey bee sp. was recorded at seven days intervals per 5min/plant. 10 plants were randomly selected and count the number of honey bees visiting by visually observation starting from 8.00AM to 5.00PM, its total population was recorded and at the end it was averaged.

RESULTS AND DISCUSSION

The result depicted in Table 1. and Figure 1. that the population of Italian honey bee, *Apis mellifera* was recorded initiation of foraging activity during second week of January 2021 (7.13 bees/5min/plant) during this period the population was recorded highest at 09.00- 10.00 AM (9.90 bees/5min/plant) and peak population recorded during fourth week of January (24.60 bees/5min/plant) during this period the population was recorded highest at 09.00- 10.00 AM (41.90 bees/5min/plant) and its lowest population

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was recorded at 4.00- 5.00 PM (9.60 bees/5min/plant). Similarly, during the different hours of the day, the maximum population of honey bees were recorded at 09.00-10.00 AM (41.90 bees/5min/plant) followed by at 8.00AM-9.00AM (37.60 bees/5min/plant) and at 11.00-12.00PM (29.90 bees/5min/plant). However, the lowest population was recorded at 3.00-4.00PM (9.60 bees/5min/plant).

The results are more or less similar to the earlier workers Dalio (2013 and 2015) recorded the foraging behaviour of honey bee, Apis mellifera on Parthenium and Trianthema. Fazal Said *et al*. (2015) who recorded the foraging activity of Himalayan bee, Apis ceana on sunflower, Painkra (2016) who observed the foraging activity of rock bee, Apis dorsata on lajwanti grass, Painkra and Shaw (2016) recorded the foraging activity of honey bees on niger flowers. Kumar and Singh (2016) noticed the foraging activity of bees on coriander flowers and Manhare *et al*. (2017) observed the foraging activity of Indian honeybee on buckwheat. Painkra *et al*. (2014) recorded the foraging behavior of honey bees on niger flowers. Painkra (2018, 2019) observed the foraging activity of giant bee, Apis dorsata on Ageratum conyzoides an coriander flower. Painkra and Kumaranag and Painkra (2019) who recorded the foraging activity of stingless bee in sunflower and in broccoli flowers.

These findings are in agreement with the earlier workers, Painkra, (2019) observed that the maximum foraging activity of Italian bee at 10.00AM (43.30 bee/5min/m2) followed by at 12.00Noon (21.57 bee/5min/m2) and at 08.00AM (13.42bee/5min/m2) however the minimum activity was recorded at 2.00 PM (12.55 bee/5min/m2). The study supports the present findings. However, Singh et al., (2006) recorded the maximum number of bee foragers/minute/panicle at 10.30-11.30 hr., followed by 11.30- 12.30 hr., while the least number was recorded at 15.30-16.30 hr. in Broccoli and the peak foraging activity was recorded between 09.00-10.00 hr. Similarly, Bhatnagar and Karnatak (2010) revealed that in Broccoli total time spent per bee per flower was highest (5.83 sec.) in the morning at 09.00-11.00 hr. Khan (1929), Das and Chaudhury (1958) and Shukla (1968), while working on the floral biology of Broccoli, demonstrated that dehiscence in a maximum number of flowers occurred between 07.00 and 12.00 hr. Singh et al., (2012) reported that anthesis of Broccoli flowers occurred both during day and night, with peak opening in the early morning (6.00 hr.) and dehiscence began about one day after floral anthesis and continued upto three days, with not all the anthers in a flower dehiscing simultaneously. This took place continuously, occurring more frequently between 08.00 and 10.00 hr., with no apparent environmental, cultural or genetic effect. Further, nectar secreted only in the morning and the pollinators forage primarily between 06.00 and 12.00 hr. although foraging continues later in the day at much lower levels. This indicates synchronization with foraging rate and time of honey bees.

Table 1. Mean population of *Apis mellifera* visit/5 min/m^2 in Broccoli flowers during 11 January 2021- 15 February 2021

Date of observations	SMW (Standard Meteorological Week)	*Apis mellifera* visit/5 min/m^2 at different hours of the day										
		8:00-9:00 AM	9:00-10:00 AM	10:00-11:00 AM	11:00-12:00 AM	12:00-1:00 PM	1:00-2:00 PM	2:00-3:00 PM	3:00-4:00 PM	4:00-5:00 PM	Total	Mean
11/01/2021	2	4.10	9.90	6.70	17.90	6.30	9.80	6.40	2.90	0.20	**64.20**	**7.13**
18/01/2021	3	15.60	11.80	19.80	8.40	4.30	4.20	3.00	4.30	2.00	**73.40**	**8.16**
25/01/2021	4	34.30	37.70	23.10	35.50	22.00	18.40	13.90	8.00	3.80	**196.70**	**21.86**
01/02/2021	5	37.60	41.90	29.90	24.80	30.70	15.80	11.80	19.30	9.60	**221.40**	**24.60**
08/02/2021	6	26.70	32.00	35.40	33.80	16.90	14.80	9.00	4.10	5.30	**178.00**	**19.78**
15/02/2021	7	18.90	19.80	23.70	27.80	14.40	12.30	7.30	6.00	3.00	**133.20**	**14.80**
Total		**137.20**	**153.10**	**138.60**	**148.20**	**94.60**	**75.30**	**51.40**	**44.60**	**23.90**	**866.90**	**96.32**
Mean		**22.87**	**25.52**	**23.10**	**24.70**	**15.77**	**12.55**	**8.57**	**7.43**	**3.98**	**144.48**	**16.05**

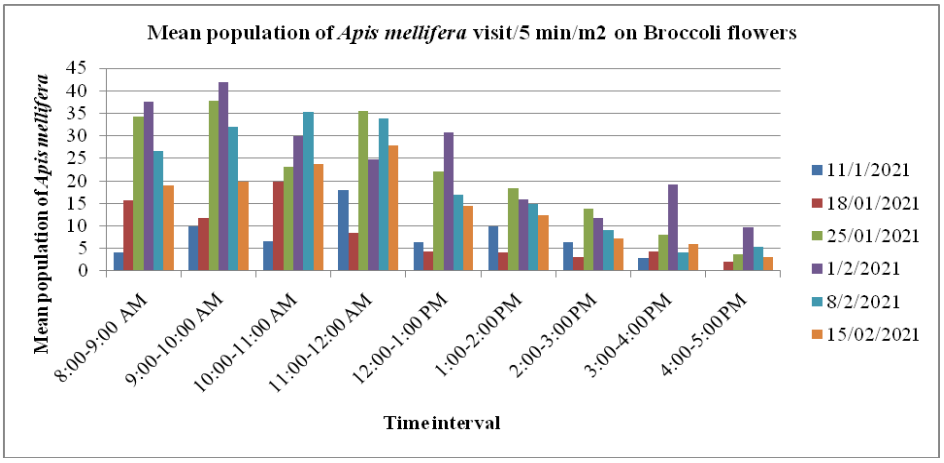

Fig. 1: Mean population of *Apis mellifera* visit/5 min/m^2 in Broccoli flowers during 11 January 2021- 15 February 2021

Fig. 1: Experimental field of Broccoli

Fig. 2: *Apis mellifera* recorded on Broccoli inflorescence

CONCLUSION

In conclusion, the present study revealed that the maximum foraging activity of honey bee was observed during fourth week of January (24.60 bees/5min/plant) during this period the population was recorded highest at 09.00- 10.00 AM (41.90 bees/5min/plant) and its lowest population was recorded at 4.00- 5.00 PM (9.60 bees/5min/plant). It is concluded that the maximum foraging activity of *Apis mellifera* was observed during the full bloom period at 9.00-10.00AM and gradually decreased its population at 12.00 Noon and 5.00PM when the flower was less amount. Hence, being an entomophilous plant, Broccoli requires adequate visit of insect pollinators which will help in better pollination resulted into better fruit set. Thus, to allow the frequent visit of different pollinators decision should be taken regarding any chemical measure during the flowering period.

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