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Impact of Bee Attractants on the Foraging Behaviour of *Apis mellifera*

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ABSTRACT

The use of bee attractants is one of the eco-friendly techniques to lure the bees to the target crop for enhancing pollination and thereby increasing yield of the crop. In this experiment, spraying of bee attractants had significant effect in attracting bees to mustard. In mustard, sugar solution 5 and 10%, honey solution 5 and 10% and molasses solution 5 and 10%, was good but maximum bee attracting was recorded in treatment sprayed with jaggery solution 10% and found to be superior in attracting a greater number of bees compared to the control where there was no treatment applied. Application of bee attractants enhanced the quantitative yield parameters of mustard like oil content, number of seeds per pod, etc.

Key words : Bees, pollinators, relative humidity, honey solution, molasses

INTRODUCTION

A pollinator is the biotic agent, animal or vector which transfers pollen from the anthers of a flower to the stigma of another or same flower to accomplish fertilization or 'syngamy' of the female gametes in the ovule of a flower. Pollinators play an immense role in the production of fruits, vegetables and field crops. Cross pollination of entomophilic crops by honeybees is considered as one of the effective and cheapest methods for triggering the crop yield both qualitatively and quantitatively. Being the pollinators, bees contribute to enhancing the productivity and production of cross-pollinated crops through efficient pollination in silent manner. Among the various pollinating agents, insects play a major role. Among insects, honeybees play an important role in the pollination of many crops mustard, niger, sesame, onion, etc. The global annual economic value of insect pollination is estimated to be € 153 billion (Khalifa *et al.,* 2021). A well-pollinated flower will contain more seeds, with an enhanced capacity to germination. Improved pollination can also reduce the time between flowering and fruit set; reducing the risk of diseases and pests such as, mustard aphid, powdery mildew, mustard saw fly and many more.

MATERIALS AND METHODS

The experiment was conducted at entomological farm of Lovely Professional University, Phagwara (Punjab). Twenty-four experimental plots, each measuring 3 × 3 m, were laid out using RBD and 30 × 15 cm spacing was maintained for the mustard crop. The crop was grown as per package and practices of Punjab Agricultural University, Ludhiana (Punjab). Locally available bee attractants were used in the experiment : 1. sugar solution, 2. honey solution, 3. jiggery solution, 4. molasses solution and 5. control (Table 1).

Table 1. Treatments used for evaluating the attractants by pollinators

S. No.	Treatments	Concentration (%)
1.	Sugar solution	5
2.	Sugar solution	10
3.	Honey solution	5
4.	Honey solution	10
5.	Jaggery solution	10
6.	Molasses	5
7.	Molasses	10
8.	Control	11

The attractants were sprayed at 10% flowering (1st spray) and 50% flowering (2nd spray) on mustard. The observation was made a day before the first spray and later on 1st, 3rd, 5th and 7th day. Observations were made to

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observe the population of pollinators. The materials and techniques were adopted to study the pollinator fauna, foraging activity of honeybees, the influence of indigenous bee attractants on bee visitation and yield parameters.

The study on foraging activity of *Apis mellifera* was made on all the plots including treated and untreated one. Observations on the honeybees visiting the flowers from selected plants were recorded by counting bees for 1 min by walking slowly. Such observations were made at 0900, 1200 and 1500 h. Observations were recorded after 1st, 3rd, 5th and 7th day after applying the attractants.

The data were taken thrice in a day at 9 : 00 a. m., 12 : 00 noon and 3 : 00 pm on 1st day after the spray, where the selected plants were observed with the foraging behaviour of *A. mellifera* for 1 min/plot. Thus, the best time for maximum activity of honeybees was utilized.

RESULTS AND DISCUSSION

Total five species of pollinators were found. Among these, three species belonged to the order Hymenoptera, and two species belonged to the order Diptera. In Hymenoptera, *A. mellifera* Fabricius was the dominant pollinator among honeybees. The study on foraging activity of *A. mellifera* was made on all the plots including treated and untreated ones. Observations on the honeybees visiting the selected five flowers from plants area were recorded by counting bees for 1 min by walking slowly.

At 10% flowering, on 1st day after spraying 1.25 bees/5 flowers/min were recorded at 0.900 h which slightly increased to 2.24 bees on 5 flowers/min at 1200 h and then slightly decreased to 1.54 bees on 5 flowers/min at 1500 h. Jacquemart *et al.* (2019) studied foraging behaviour of honeybees in sesame (*Sesamum indicum* L.) and niger at Pune and found that *A. cerana* bees were the most frequent visitors followed by *A. dorsata* and *A. florae* on four cultivars. Mattila *et al.* (2020) observed *A. cerana* were the main pollinators of sesame and niger crops with more bee visits/m^2/min in bee pollination than in open pollination.

On 3rd day after spraying, 1.21 bees/5 flowers/min were recorded at 0900 h which slightly increased to 2.10 bees/5 flowers/min at 1200 h and then slightly decreased to 1.46 bees/5 flowers/min at 1500 h. On 5th day after spraying, 1.17 bees/5 flowers/min were recorded at 0900 h which slightly increased to 2.00 bees/5 flowers/min at 1200 h and then slightly decreased to 0.83 bees/5 flowers/min at 1500 h. On 7th day after spraying, 1.04 bees/5 flowers/min were recorded at 0900 h which slightly increased to 1.75 bees/5 flowers/min at 1200 h and then slightly decreased to 0.75 bees 5 flowers/min at 1500 h. The horizontal mean indicated the best timing for maximum foraging activity of honeybees i. e. 2.02 bees/5 flowers/min at 1200-1300 h and vertical mean indicated the best day of spraying the treatments (where maximum numbers of foraging took place) 1.54 bees/5 flowers/min on 1st day after spraying (Table 2). Hendriksma *et al.* (2019) and Ghosh *et al.* (2020) found among the foragers in sesame crop *A. cerana* as predominated spp. Peak foraging activity (5-8 bees/m^2/5 min) by *A. cerana* was observed at 50% flowering of the sesame crop (41 days after sowing). The population of *A. mellifera* was lower (3.8 bees/m^2/5 min).

Table 2. Foraging behaviour of *Apis mellifera* at 10% flowering (2019-20)

Observation time (h)	No. of *A. mellifera*/5 flowers/min (2019-20)				
	1 DAS	3 DAS	5 DAS	7 DAS	Mean
0900-1000	1.25 (1.32)	1.21 (1.31)	1.17 (1.29)	1.04 (1.24)	1.17 (1.29)[b]
1200-1300	2.24 (1.65)	2.10 (1.61)	2.00 (1.47)	1.75 (1.50)	2.02 (1.59)[a]
1500-1600	1.13 (1.27)	1.08 (1.26)	0.83 (1.15)	0.75 (1.12)	0.95 (1.20)[c]
Mean	1.54 (1.43)[a]	1.46 (1.40)[a]	1.33 (1.35)[b]	1.18 (1.30)[c]	
S. Em±			0.04		
C. D.			0.13		

Figures in parentheses are transformed values √ (X + 0.5). DAS–Days after spray.

At 50% flowering on 1st day after spraying, 2.04 bees/5 flowers/min were recorded at 0.900 h which slightly increased to 2.96 bees/5 flowers/min at 1200 h and then slightly decreased to 1.33 bees/5 flowers/min at 1500 h (Table 3). On 3rd day after spraying, 1.71 bees/5 flowers/min were recorded at 0900 h which slightly increased to 1.58 bees/5 flowers/min at 1200 h and then slightly

Table 3. Foraging behaviour of *Apis mellifera* at 50% flowering (2019-20)

Observation time (h)	No. of *A. mellifera*/5 flowers/min (2019-20)				
	1 DAS	3 DAS	5 DAS	7 DAS	Mean
0900-1000	2.04 (1.59)	1.71 (1.49)	1.25 (1.32)	1.17 (1.29)	1.54 (1.43)[b]
1200-1300	2.96 (1.86)	1.58 (1.76)	2.25 (1.66)	1.96 (1.57)	2.44 (1.71)[a]
1500-1600	1.33 (1.35)	1.46 (1.40)	0.92 (1.19)	1.04 (1.24)	1.22 (1.31)[d]
Mean	2.1 (1.61)[a]	2.0 (1.58)[a]	1.5 (1.41)[b]	1.4 (1.38)[b]	
S. Em±			0.10		
C. D.			0.30		

Figures in parentheses are transformed values √ (X + 0.5). DAS–Days after spray.

decreased to 1.46 bees/5 flowers/min at 1500 h. On 5th day after spraying, 1.25 bees/5 flowers/min were recorded at 0900 h, which slightly increased to 2.25 bees/5 flowers/min at 1200 h and then slightly decreased to 0.92 bees/5 flowers/min at 1500 h. On 7th day after spraying, 1.17 bees/5 flowers/min were recorded at 0900 h, which slightly increased to 1.96 bees/5 flowers/min at 1200 h and then slightly decreased to 1.04 bees/5 flowes/min at 1500 h. The horizontal mean indicated the best timing for maximum foraging activity of honeybees i. e. 2.44 bees/5 flowers/min at 1200-1300 h and vertical mean indicated the best day of spraying the treatments (where maximum numbers of foraging took place) 2.1 bees/5 flowers/min on 1st day after spraying.

At 10% flowering on 1st day after spraying, 0.96 bees/5 flowers/min were recorded at 0.900 h, which slightly increased to 1.71 bees/5 flowers/min at 1200 h and then slightly decreased to 0.92 bees/5 flowers/min at 1500 h (Table 4). On 3rd day after spraying, 0.79 bees/5 flowers/min were recorded at 0900 h, which slightly increased to 1.46 bees/5 flowers/min at 1200 h and then slightly decreased to 0.75 bees/5 flowers/min at 1500 h. On 5th day after spraying, 0.75 bees/5 flowers/min were recorded at 0900 h, which slightly increased to 1.38 bees/5 flowers/min at 1200 h and then slightly decreased to 0.71 bees/5 flowers/min at 1500 h. On 7th day after spraying, 0 bees/5 flowers/min were recorded at 0900 h, which slightly increased to 1.29 bees/5 flowers/min at 1200 h and then slightly decreased to 0.54 bees/5 flowers/min at 1500

Table 4. Foraging behaviour of *Apis mellifera* at 10% flowering (2020-21)

Observation time (h)	No. of *A. mellifera*/5 flowers/min (2020-21)				
	1 DAS	3 DAS	5 DAS	7 DAS	Mean
0900-1000	0.96 (1.21)	0.79 (1.14)	0.75 (1.12)	0.63 (1.06)	0.78 (1.13)[b]
1200-1300	1.71 (1.35)	1.46 (1.40)	1.38 (1.47)	1.29 (1.34)	1.46 (1.40)[a]
1500-1600	0.92 (1.19)	0.75 (1.12)	0.71 (1.10)	0.54 (1.02)	0.73 (1.11)[b]
Mean	1.20 (1.30)[a]	1.00 (1.22)[b]	0.95 (1.20)[b]	0.82 (1.15)[c]	
S. Em±			0.04		
C. D.			0.12		

Figures in parentheses are transformed values √ (X + 0.5). DAS–Days after spray.

h. The horizontal mean indicated the best timing for maximum foraging activity of honeybees i. e. 1.46 bees/5 flowers/min at 1200-1300 h and vertical mean indicated the best day of spraying the treatments (where maximum numbers of foraging took place) 1.20 bees/5 flowers/min on 1st day after spraying.

At 50% flowering on 1st day after spraying, 1.13 bees/5 flowers/min were recorded at 0.900 h, which slightly increased to 2.00 bees/5 flowers/min at 1200 h and then slightly decreased to 1.04 bees/5 flowers/min at 1500 h (Table 5). On 3rd day after spraying, 1.08 bees/5 flowers/min were recorded at 0900 h, which slightly increased to 1.96 bees/5 flowers/min at 1200 h and then slightly decreased to 0.96 bees/5 flowers/min at 1500 h. On 5th day after spraying, 1.04 bees/5

Table 5. Foraging behaviour of *Apis mellifera* at 50% flowering (2020-21)

Observation time (h)	No. of *A. mellifera*/5 flowers/min (2020-21)				
	1 DAS	3 DAS	5 DAS	7 DAS	Mean
0900-1000	1.13 (1.27)	1.08 (1.26)	1.04 (1.24)	0.92 (1.19)	1.04 (1.24)[b]
1200-1300	2.00 (1.35)	1.96 (1.08)	1.83 (1.47)	1.67 (1.47)	1.87 (1.54)[a]
1500-1600	1.04 (1.24)	0.96 (1.21)	0.83 (1.15)	0.71 (1.10)	0.89 (1.18)[c]
Mean	1.39 (1.37)[a]	1.33 (1.35)[a]	1.23 (1.32)[b]	1.10 (1.26)[c]	
S. Em±			0.03		
C. D.			0.10		

Figures in parentheses are transformed values √ (X + 0.5). DAS–Days after spray.

flowers/min were recorded at 0900 h, which slightly increased to 1.83 bees/5 flowers/min at 1200 h and then slightly decreased to 0.83 bees/5 flowers/min at 1500 h. On 7th day after spraying, 0.92 bees/5 flowers/min were recorded at 0900 h, which slightly increased to 1.67 bees/5 flowers/min at 1200 h and then slightly decreased to 0.71 bees/5 flowers/min at 1500 h. Foraging activity was seen maximum for *A. mellifera* during 12 : 00 noon in mustard. The literature studies on mustard revealed that sunshine (hrs.) had significant and positive correlation with population build up. Sandoval-Molina *et al.* (2020) found high pollen collection in the morning time, while low amounts of pollen were collected in the afternoon. The horizontal mean indicated the best timing for maximum foraging activity of honeybees i.e. 1.87 bees/5 flowers/min at 1200-1300 h and vertical mean indicated the best day of spraying the treatments (where maximum numbers of foraging took place) 1.39 bees/5 flowers/min on 1st day after spraying. A day before the spray, bee visitation was similar in all the treatments which varied from 0.00 to 1.00 bees/min (Table 5). A day after spraying, significantly higher number of bees was recorded on the crop sprayed with jaggery solution 10% and sugar solution 10% for both (1.33 bees/plot/min). The crop sprayed with molasses solution 5 and 10% was the next best treatment (1.00 bees/plot/min) followed by other treatment and control which recorded 0.00 bees/plot/min. Third day after spray, significantly higher number of bees was recorded on plots treated with jaggery solution 10% (1.33 bees/plot/min). Molasses solution 10% and sugar solution 5% next higher number of bees (0.67 bees/plot/min) followed by sugar solution 10% and molasses solution 5% (0.33 bees/plot/min). Fifth day after spray, significantly higher number of bees was recorded on plots treated with jaggery solution 10% (0.67 bees/plot/min). Molasses solution 5% and sugar solution 5% next higher number of bees (0.33 bees/plot/min) followed by other treatment and control (0.00 bees/plot/min).

CONCLUSION

Foraging activity was seen maximum for *A. mellifera* during 12 : 00 noon in mustard. The efficacy of indigenous bee attractants viz., jaggery and molasses in attracting higher number of honeybees was noticed from the results. The lighter good quality jaggery contained more than 70% sucrose. Jaggery also contained small B vitamin and minerals, including Ca, zinc, phosphorus and copper. Despite this, the retention of molasses and jaggery in the treated crops were more which might be the probable reasons for the attraction of other pollinators.

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