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RR Manchare

Department of Agricultural
Entomology, Post Graduate
Institute, Mahatma Phule Krishi
Vidyapeeth, Rahuri,
Ahmednagar, Maharashtra,
India

SR Kulkarni

Department of Agricultural
Entomology, Post Graduate
Institute, Mahatma Phule Krishi
Vidyapeeth, Rahuri,
Ahmednagar, Maharashtra,
India

TS Chormale

Department of Agricultural
Entomology, Post Graduate
Institute, Mahatma Phule Krishi
Vidyapeeth, Rahuri,
Ahmednagar, Maharashtra,
India

Effect of bee attractants on foraging activities of Indian bees *Apis cerena indica* in bitter gourd (*Momordica charantia* L.)

RR Manchare, SR Kulkarni and TS Chormale

Abstract

Studies on role of honey bees as a pollinator in seed production of bitter gourd (*Momordica charantia* L.) was conducted at Mahatma Phule Krishi Vidyapeeth, Rahuri, during Rabi 2016. The experiment was laid out in randomized block design with nine treatments and three replications with view to find out the effect of bee attractants on foraging activities of Indian bees in bitter gourd. The bee attractants were sprayed two times, first at 10 percent flowering and second at 50 percent flowering. The results from the foraging activity of bees noted that the intensity of *Apis cerena indica* was increased on 1st day after spraying and it reduced as gone towards 7th days after spray. Spraying of bee attractants i.e. honey solution 10 percent, jaggery solution 10 percent and molasses 10 percent attracted the maximum number of *Apis cerena indica* up to 5th day after first spray and 7th day after second spray.

Keywords: Bitter gourd, bee attractants, honey solution, jaggery solution, molasses, *Apis cerena indica*

Introduction

Flowering anatomy and phenology of Cucurbitaceae family crops requires the cross pollination for better fruit set and seed yield. Their flowers are usually having male and female flowers are at different position on same plant i.e. the female to male flower ratio is about 1:25. Long duration of day cause male flowers to open to two weeks earlier than female flowers^[1]. In bitter gourd crop cross pollination that means allogamy percentage ranges from 80-100 percent. Anthesis of female flower takes place between 03:30 and 07:30 and stigma remains receptive from one day before to one day after anthesis and most receptive during morning section of the day^[2].

Apidae family has significant role in pollination in cross pollinated crops. Among Apidae family Indian bee and European bees are particularly important pollinators. They can carry pollen grains and nectar as their food. In the process of collecting of pollens the plants visited by them are pollinated by pollens collected from previous plant^[3].

In bitter gourd flower position is open type which makes them easy for the pollinators to access and exploit floral rewards. The high ratio of male to female flowers facilitate to sufficient pollens to pollinate all female flowers. Thus, results in effective pollination. A successfully pollinated flower after two to five days of opening of flower starts to develop fruits, un-pollinated flowers dry up and on fifth day the ovary become yellow^[4]. Hence, pollination in bitter gourd is largely dependent on various pollinating agents, Insect pollinators like honey bees play a great role in effecting optimum pollination including. Large size of pollens in bitter gourd can't goes from one flower to other so insects are required for pollen transfer. The stickiness and the way they are released from the anthers helps to attract bees towards flower and thus contributing to both increased production in quantity and quality^[5].

The material to increase the honey bee visit to specific crops would be of great practical value to harvest the benefits of cross pollination local bee attractants Sugar solution, Sugarcane juice, Jaggery solution, Molasses, etc. are being used to boost the foraging activities in some crops like pea, peach, blue berries, watermelon and apple in the United States, Spain and Canada. Though some studies have been made on pollination of bitter gourd, but no any work has done for exploring the possible use of bee attractants to increase foraging activities of Indian bees in bitter gourd in India. However, the related studies on use of bee attractants to pollinate flowers in India are very less. The conservation and management of insect pollinators is increasing importance day by day.

Correspondence

RR Manchare

Department of Agricultural
Entomology, Post Graduate
Institute, Mahatma Phule Krishi
Vidyapeeth, Rahuri,
Ahmednagar, Maharashtra,
India

In this regard, studies on effect of different bee attractants were studied with effect on foraging activities of Indian bees *Apis cerana indica* in bitter gourd.

Materials and Methods

Investigations were conducted at the seed production plot of All India Coordinated Research Project on Vegetable Crops, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, during *Rabi* 2016. The bee attractants viz., Coconut water 10%, Sugar solution 10%, Sugarcane juice 10%, Jaggery solution 10%, Molasses 10%, Honey solution 10% and Pomegranate juice 5% were sprayed two times, first at 10 percent flowering and second at 50 percent flowering. The experiment was laid out in randomized block design with nine treatments which having seven natural bee attractants and one with open pollination as check and one without insect pollination i.e. with caged plants and three replications for each treatment with view to find out the effect of bee attractants on activities of Indian bees in bitter gourd. The following methodologies were adopted to know the role of bee attractants in foraging activities in bitter gourd.

To study the effect of bee attractants on activities of Indian bees in bitter gourd

The attractants were sprayed two times, first at 10 percent and second at 50 percent flowering stages. The crop was protected from various pests and diseases, but no insecticides were used during the flowering period. Recommended agronomical package of practices were followed for raising good seed production plot.

Number of bees visiting per one-meter square area

In each plot one-meter square area was randomly selected and number of Indian bees visited the flowers per minute was recorded during its peak period. Such observations were recorded a day before the first and second spray and later 1st, 3rd, 5th and 7th days after first and second spray. Means of all observations were pooled for *Apis cerana indica*. The data from individual observation were made average and put it into Tables. Comparisons in this data made in Table 1 which shows the data was analyzed by RBD design with 9 treatments and 3 replications with view to 5% critical difference.

Results

The results of the present investigation revealed that, all the bee attractants sprayed were significantly affect on foraging activities of Indian bees in bitter gourd. They proved superior in recorded parameters over control i.e., unsprayed and without pollinators.

Influence of bee attractant on activity of *Apis cerana indica* on bitter gourd

The observations were recorded on *A. cerana* visitation on Bitter gourd treated with different bee attractants at 10 and 50 percent of flowering are presented in Table 1.

First spray

A day prior to the application of attractants, bee activity was ranged from 1.21 to 1.88 bees/m²/min

Table 1: Influence of bee attractants on activity of *Apis cerana indica* on bitter gourd

Sr. No.	Treatment	Number of bees per square meter per minute													
		1 st spray at 10 percent flowering							2 nd spray at 50 percent flowering						
		1 DBS	1 DAS	3 DAS	5 DAS	7 DAS	Total	Average	1 DBS	1 DAS	3 DAS	5 DAS	7 DAS	Total	Average
1.	Open Pollination	1.55 (1.43)*	1.44 (1.39)	0.88 (1.17)	0.77 (1.12)	0.66 (1.07)	3.75	0.93	0.66 (1.07)	1.65 (1.46)	1.66 (1.46)	0.99 (1.22)	0.99 (1.22)	5.29	1.322
2.	Coconut Water 10%	1.44 (1.39)	2.44 (1.71)	1.1 (1.26)	0.99 (1.22)	0.77 (1.12)	5.3	1.32	0.77 (1.12)	1.77 (1.50)	1.77 (1.50)	0.99 (1.22)	0.99 (1.22)	5.52	1.38
3.	Sugar Solution 10%	1.88 (1.54)	2.88 (1.83)	1.33 (1.35)	1.33 (1.35)	0.66 (1.07)	6.2	1.55	0.55 (1.02)	1.77 (1.50)	2.21 (1.64)	1.11 (1.26)	1 (1.22)	6.09	1.52
4.	Sugarcane Juice 10%	1.55 (1.43)	3.33 (1.95)	1.66 (1.46)	0.99 (1.22)	0.88 (1.17)	6.86	1.71	0.88 (1.17)	1.88 (1.54)	2.1 (1.61)	1.1 (1.26)	0.99 (1.22)	6.07	1.51
5.	Jaggery Solution 10%	1.66 (1.46)	4.44 (2.22)	2.1 (1.61)	1.33 (1.35)	0.77 (1.12)	8.64	2.16	0.77 (1.12)	1.88 (1.54)	2.33 (1.68)	1.22 (1.31)	1.1 (1.26)	6.53	1.63
6.	Molasses 10%	1.21 (1.30)	3.1 (1.89)	1.99 (1.57)	1.21 (1.30)	0.66 (1.07)	8.17	2.04	0.66 (1.07)	2.33 (1.68)	2.88 (1.83)	1.33 (1.35)	0.99 (1.22)	7.53	1.88
7.	Honey Solutions 10%	1.33 (1.35)	3.55 (2.01)	2.99 (1.86)	1.99 (1.57)	0.77 (1.12)	9.3	2.32	0.77 (1.12)	2.44 (1.71)	2.77 (1.80)	1.66 (1.46)	1.1 (1.26)	7.97	1.99
8.	Pomegranate Juice 5%	1.77 (1.50)	2.66 (1.77)	1.1 (1.26)	0.88 (1.17)	0.66 (1.07)	5.3	1.32	0.66 (1.07)	1.77 (1.50)	1.77 (1.50)	0.99 (1.22)	0.99 (1.22)	5.52	1.38
9.	SE +-	0.0269	0.0135	0.022	0.0362	0.0116			0.0121	0.033	0.0409	0.0171	0.015		
10.	CD 5%	0.0817	0.0408	0.0668	0.1099	0.0353			0.0366	0.0999	0.1241	0.0517	NS		

*=Figures in the parentheses are transformed $\sqrt{(x+0.5)}$ values

DBS = Days before spraying,

DAS = Days after spraying

A day after the first spray, jaggery solution 10 percent attracted higher number of bees (4.44 bees/m²/min) and was significantly superior compared to other treatments. Further this treatment was at par with honey solution 10 percent (3.55 bees/m²/min), sugarcane juice 10 percent (3.33 bees/m²/min), molasses 10 percent was next better treatment with 3.1 bees/m²/min. Least number of bees was recorded in open pollination without spray (1.44 bees/m²/min).

On 3rd day after first spray, honey solution 10 percent recorded maximum number of bees (2.99 bees/m²/min) and found superior over all the treatment. Jaggery solution 10 percent which was next better treatment which recorded 2.10 bees/m²/min. Further molasses 10 percent, sugarcane juice 10 percent and sugar solution 10 per attracted 1.99, 1.66 and 1.33 bees/m²/min respectively. Open pollination without spray was inferior over all the treatments as it recorded a smaller number

of bees (0.88 bees/m²/min).

On 5th day after first spray, treatment honey solution 10 percent was significantly superior to attract the maximum number of bees (1.99 bees/m²/min) followed by jaggery solution 10 percent, sugar solution 10 percent and molasses 10 percent with 1.33, 1.33 and 1.21 bees/m²/min, respectively. The next best treatments were sugarcane solution 10 percent recorded 0.99 bees/m²/min. Open pollination without spray recorded lowest number of bees (0.77 bees/m²/min).

On 7th day after first spray no significant difference was observed between different bee attractant treatments. Observations were recorded between 0.66 bees/m²/min to 0.88 bees/m²/min.

Overall performance of bee attractants spray at 10 percent flowering showed that honey solution has highest (2.32 bees/m²/min) average ability to attract *Apis cerana indica* towards it followed by jaggery solution 10 percent (2.16 bees/m²/min) and molasses 10 percent (2.04 bees/m²/min).

Second spray

One day before second spray, the visitation of *A. cerana indica* was in the range of 0.66 to 0.88 bees/m²/min.

A day after second spray treatment with honey solution 10 percent (2.44 bees/m²/min) was significantly superior over all the treatment thereafter molasses 10 percent (2.33 bees/m²/min). Jaggery solution 10 percent and sugarcane juice 10 percent (1.88 bees/m²/min) was the next best treatment and found at par with sugar solution 10 percent which recorded 1.77 bees/m²/min. Open pollination without spray found to be least efficient in attracting a greater number of bees (1.65 bees/m²/min).

On 3rd day after second spray, plot treated with molasses 10 percent attracted maximum number of bees (2.88 bees/m²/min). The next best treatment was honey solution 10 percent (2.77 bees/m²/min) followed by jaggery solution 10 percent (2.33 bees/m²/min). Rest of the treatments also found superior over open pollination without spray which recorded the least number of bees (1.66 bees/m²/min).

Similar trend was found in 5th day after second spray, the treatment honey solution 10 percent (1.66 bees/m²/min) which was proved to be the best treatment. Molasses 10 percent, jaggery solution 10 percent and sugarcane juice 10 percent was the next better treatment which recorded 1.33, 1.22 and 1.1 bees/m²/min, respectively.

On 7th day after second spray, the treatment honey solution 10 percent and jaggery solution 10 percent (1.10 bees/m²/min) was successful in attracting highest number of bees. Similarly, the rest of the treatments found to be superior over open pollination without spray which recorded least number of bees (0.99 bees/m²/min).

Overall recorded observations showed that honey solution 10 percent had highest average ability to attract *Apis cerana indica* (1.99 bees/m²/min) followed by molasses 10 percent (1.88 bees/m²/min) and jaggery solution 10 percent (1.63 bees/m²/min).

Discussion

The foraging activities of insect pollinators visiting the vegetables i.e. Bitter gourd (*Momordica charantia* L.), Ridge gourd (*Luffa acutangula*) and Brinjal (*Solanum melongena*). Two orders Diptera and Hymenoptera were identified as the major pollinators of these vegetables. The order Hymenoptera includes six species which are *Apis Sp.*, *Bombus sp.*, *Xylocopa sp.*, *Halictus sp.* and two unidentified species one from

Halictidae family and one from Megachilidae family [6].

Fourteen insect species including six hymenopterans, three dipterans and five lepidopterans were visiting the bitter gourd flowers. Among them, *T. iridipennis*, *A. florea* and *Halictus gutturosus* were the most frequent and abundant visitors of bitter gourd flower. Foraging activity of *T. iridipennis*, *A. florea* and *H. gutturosus* commenced at 06:00, 06:30 and 07:30 hrs, respectively with peak at 09:00-10:00 hrs and ceased by 14:00, 12:30 and 13:00 hrs, respectively [7].

Nine bee species of Apidae, Halictidae and Megachilidae families are visitors to bitter gourd flowers. Amongst these, *Megachile sp.*, *Halictus sp.* and *Apis dorsata* Fabricius were found to be the most frequent visitors. The abundance of *Halictus sp.* was highest, followed by *Megachile sp.* and *A. dorsata*. *A. dorsata* has greater efficiency in pollination of bitter gourd, followed by *Halictus sp.* and *Megachile sp.* [8].

The study of spraying of Bee here and Bee-Q on sesamum shows that increase in foraging activities of bees and yield parameters significantly increased on sprayed crop up to fifth day in Dharwad [9].

Study on attraction of *A. mellifera* to volatile compounds proved that anetholes and commercial trace Japanese beetle lure (10:22:11, 2-phenyl ethyl propionate : eugenol : geraniol) exposed in trace traps which attracted *A. mellifera*, but other floral lures and fatty acids did not attract the bees [10].

The studies on Bee-Q @ 10, 12.5 and 15 gms/lit, Fruit boost @ 0.50, 0.75 and 1 ml/lit, Cinnamon leaf extract @ 5%, Tuberoso floral scented water, 10% sugar solution on ridge gourd, which is open pollinated observed that spraying of Fruit boost @ 0.50 ml/lit and Bee-Q @ 12.5 gm/lit enhanced foraging activities of Indian bees and yield by increasing yield parameters like number of fruits per plant to 19.00 and 17.00 fruits, when compared to 10.66 fruits per plant in open pollinated plot. Number of fruits was 21.83 and 20.83 fruits per plot, when compared to 15.68 fruits per plot in open pollinated plots [11].

The research on bee attractants on *Cucumis sativa* proved that two applications of Bee-Q (12.5 gm/lit), Bee-here (4 ml/lit) and sugar solution (10%) on staminate or female flowers of *Cucumis sativa* attracted a greater number of bees (4.01 to 4.97 bees/flower in 5 min.) up to five days after first and second sprays compared to unsprayed crop (3.25 to 3.59 bees). Similarly, higher visits were recorded on pistillate or male flowers on the sprayed crop [12].

Comparison between various bee attractants and open pollination observed that spraying of cacambe 10 percent, Bee-Q 1.25 percent and jaggery solution 10 percent have significant influence in attracting a large number of pollinators over open pollination [13].

Studies on use of bee attractants like Bee-Q and Fruit Boost in the pollination of Niger. Bee visits to Niger flowers were observed for two weeks and seed yield was determined. Results indicate that applications of Bee-Q at 12.5 gm/lit and Fruit boost at 0.75 ml/lit on Niger significantly increased in the bee foraging activities over control plots. In addition, plots sprayed with these bee attractants significantly enhanced the seed set, seed weight and germination of Niger [14].

Bee attractant plays a significant and beneficial role in enhancing pollination and yield of crops especially when target crop is not so attractive to the bees naturally or when the weather conditions are not conducive for foraging by the bees on target crop and evaluated that Citral E, Citral Z, *F. budrunga*, *S. densifolia* attracted significantly a greater number of bees with 2.13 to 2.96 bees /10 m²/5 min. Which

were on par with each other and were as good as Fruit boost showed 2.00 to 2.17 bees /10 m²/5 min^[15]. The usage of bee attractants, Bee-Q and Fruit Boost in the pollination of watermelon at different concentrations and showed that, Bee-Q at 12.5 gm/lit and Fruit boost at 0.5 ml/lit of watermelon plots attracted several bee foragers than the control plots^[16]. The abundance and foraging activities of different bee visitors to pigeon pea (*Cajanus cajan* L.) cultivar ICPL-151 and Bahar. The four species of bees were observed that visiting the flowers viz. *Megachile* sp., *Apis florea*, *A. cerana indica* and *A. mellifera* and five species of bees namely *A. florea*, *A. dorsata*, *A. cerana indica*, *A. mellifera* and *Megachile* spp. of both cultivars respectively^[17]. The mean number of *Apis mellifera* collecting both nectar and pollens were found to be 14.71 + 2.47 and 3.71 + 0.65 per hour, respectively. The pollen collecting activity reached its peak at 13:00 hrs after that it began to decline^[18]. *A. cerana indica*, *A. florea*, *Apis dorsata*, *Xylocopa fenestrata*, *Andrena* sp., *Eristalinus arvorum*, *Nomia* sp., *E. taeniops*, *E. punctulatus*, *Erisyrphus balteatus* and *Pieris napi* as pollinators in rapeseed. Out of these, six species of pollinators viz., *X. fenestrata*, *Andrena* sp., *Nomia* sp., *E. taeniops*, *E. punctulatus* and *P. napi* were abundant^[19].

The fruit set of cucumber in bee and open pollinated plants were 75 and 58 per cent, respectively and these were significantly higher than the non-pollinated plants which has 33 percent. Bee and open pollination also yielded with high weight and uniform fruits^[20]. Greater fruit weight was obtained in cucumber (2.69 kg/plant) in honey bee pollinated plants compared to self-pollinated plants (2.03 kg/plant)^[20]. The best results were recorded from with European bees (*A. mellifera*) in sealed polyethylene tunnels which yielded 0.97 kg export grade fruits per plants compared to sealed polyethylene tunnels open at one end which gave 0.56 kg/plant^[21]. Honey bees *A. mellifera* under covered condition yielded good fruit size and good number of seeds and commercial grade fruit than control plots^[22]. Three major pollinators are recorded in bitter gourd and proved that *A. florea* spent less time on flowers. The maximum time spent by *A. florea* was 14.26 second with average foraging time of 9.28 second per flower. This was recorded during the peak foraging hour of all three-bee species. These findings are near with the earlier reports^[23]. The pollinators were composed of 15 insect species in 3 orders and 10 families in bitter gourd. Bees were the most dominant (435 individuals) floral visitors. *Parnara guttata*, *A. florea* and *A. dorsata* were the most abundant pollinators. *A. florea* and *A. dorsata* also exhibited the highest visitation rates and frequencies. Five major pollinators were tested for their single-visit efficacy, showing that *A. dorsata* was the most effective pollinator, along with *A. florea* and *Eristalinus laetus*. Conserving and enhancing these pollinators may enhance *M. charantia* production in Pakistan^[24].

Conclusion

Based on results obtained during present investigation, it could be concluded that:

- Among the bee attractants honey solution 10 percent found to be the superior treatment in attracting higher number of *Apis cerana indica* followed by 10% molasses solution and 10 percent jaggery solution.
- Irrespective of treatments, the peak pollinator activity was found on 1st day after spraying of bee attractants and reduces towards 7th day after spraying.

- In contrary lowest yield and yield related attributes recorded in pollination without insects and open pollination.

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