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Original research article

Effect of Bee Attractants on Foraging Activities of Honeybees *Apis mellifera*, *A. dorsata* and *A. cerana* on *Cucumis sativus* L. and *Memordica charantia* L. Flowers

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Abstract The results of the present investigations on various attractants used for attracring bews revealed that a day before spraying in case of *Apis mellifera* visiting cucumber flowers, the number of bees raised from 4.60–5.80 bees/5 plant/5 min which did not differ significantly among the treatments. However, 1DAFS there was considerable increase in the population of bees in all the treatments except control. The data revealed that the combination of Bee Q and Jaggery attracted higher number of bees and the number increased from 5.42–9.00/5 plant/5 min whereas sugar solution attracted less number of bees from 4.60–4.80 only. The other treatments were in between the two. Similarly, in 3DAFS and 5DAFS Bee Q+Jaggery attracted large number of bees as compared to other attractants but all these treatments was superior to control. A similar trend was observed during second spray and third spray. An overall examination revealed that the efficacy of different attractants was in the order Bee Q+Jaggery @100 g/Lit > Bee Q+Molasses @100 g/Lit > Bee Q+Sugar solution @100 g/Lit > Jaggery @100 g/Lit > Bee Q @100 g/Lit > Molasses @100 g/Lit > Sugar solution @100 g/Lit > control (without spray) for different bee species both in cucumber and bittergourd.

Keywords Cucumber, Bittergourd, Bee attractants, *A. mellifera*, *A. dorsata*, *A. cerana*, Flower visits

INTRODUCTION

One of the most important groups of the insects that provide pollination service to plant are pollinators which includes bees. Of the total pollination activities, over 80% is performed by insects and bees contribute nearly 80% of the total insect pollination and therefore, considered as the best pollinators (Robinson and Morse, 1989). About one-third of the total human diet comes from bee pollinated crops and pollination value worth about 143 times than honey production (Mishra, 1998). Honeybees are the center of attraction to mankind from the beginning for their pollination services and beehive products. The wide diversities of honeybee and flowering plant species occurring in the country help to maintain diversity of flora and bee fauna greatly influence crop pollination and reward hive production in the service of nature and human beings as well. A recent review on the worldwide dependence of crops on pollinators showed that 87 out of the 124 leading food crops are dependent on animal pollination (Klein *et al.*, 2007). In the tropics, insect pollination increases fruit and seed production in 70% of the crops (Roubik, 1995). Lack of pollination therefore, can be a major limiting factor to high fruit seed yields and its quality. Honeybees not only produce honey and wax, but also pollinate many crops and trees. It is due to bee pollination that the crop yield increases and improves in quality and quantity of seed and fruit yield. Therefore, bee keeping can play a vital role in improving crop yields besides resulting in to an additional source of income through honey and bee-wax. Utilization of pollinators especially honeybees is considered as one of

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the cheapest and ecofriendly approach in maximizing the yield of cross pollinated crops (Free, 1970). Many investigations have consistently confirmed that yield levels can be increased to an extent of 50 to 60 per cent in fruits and plantation crops, 45 to 50 per cent in sunflower, sesamum and niger and 100 to 150 per cent in cucurbitaceous crops, through good management of pollinators (Melnichenko and Khalifman, 1960).

Achievement of desired pollination lies in the planned and efficient use of honey bees to increase the yield as well as improving qualitative and quantitative parameters of the crop. Cucurbits form an important and vast group of vegetable crops cultivated extensively in India. The flowers of cucurbits are usually monoceious as they produce male and female flowers separately on the same plant at different internodes. The pistillate and staminate flowers open on the same day. But, the male flowers are borne first, a fortnight earlier than the female flowers. Both type flowers arise singly from different internodes. Insects are required for pollen transfer because of the large sized pollen grain, their stickiness and the way they are released from the anthers (Lauria and Fred, 1995). The female flower borne on ovary *i.e.*, inferior ovary and the stigma is receptive throughout the day. In male flowers, an anther dehisces when the corolla expands but the pollens remains on the anther as a sticky mass. The maximum pollination occurs in the forenoon. As the female flower closes in the afternoon and never reopens whether or not pollination has taken place further. The highest per cent of fruit set resulted from deposition of pollen on the stigma between 0900 to 1200 h of the day (Bailey, 1949). Of the several vegetables, cucumber and bitter gourd are important crops. Cucumber (*Cucumis sativa* L.) a native to Northern India, constitutes an important green vegetables among the cucurbitaceous crops and is fourth most important vegetable after tomato, brinjal and onion. It is an ideal summer vegetable crop, cheaply grown for edible tender fruits preferred as a salad ingredient. Similarly, bitter gourd *Memordica charantia* is an other important vegetable belonging to family Cucurbitaceae, widely grown for edible fruit, which is among the most bitter of all fruits. Cucumber (*Cucumis sativas* L.) and Bittergourd (*Memordica charantia* L.) belonging to cucurbitaceae are highly cross pollinated as pollen grains being sticky and large in size, need an agent to be transfer to the pistillate flowers for fruit set. Furthermore, reproductive organs of male and female flowers occur separately on staminate and pistillate flowers. Cucumber (*Cucumis sativus*) is normally monoecious which means that there are both male and female flowers on the same plant. Male flowers open about 10 days before female flowers and outnumber female flowers at least ten to one in ordinary monoecious varieties. Most cucumbers, whether monoecious or gynoecious, require insects to transfer pollen between flowers of the same or different plant. Fruit abortion can reach 100% in flowers bagged to exclude insect visitors (Stanghellini *et al*., 1997), but self-pollination rates of 30–36% have been documented in the absence of insects (Jenkins, 1942; Gingras *et al*., 1999), and a small rate of parthenocarpy is known to exist (Gustafson, 1939; Gingras *et al*., 1999). Nevertheless, insect pollination is the norm. All of the major varieties are interfertile. Each stigma should receive several hundred grains of pollen for best fruit-set and quality (Seaton *et al*., 1936). Among the agents, the insects especially honey bees are known to be the most efficient pollinating agents of cucumber and bittergourd (Grewal and Sidhu, 1979). Any material to increase visit of honeybee to specific crop could be of great practical value to harness the benefits of cross pollination. Commercial bee attractants *viz*., beeline, beehere, beescent, beescent plus, fruit boost and bee-Q are being used to boost the yield of pear, peach, blue berries, watermelon and apple in United States, Spain and Canada. However, in India studies on the use of bee attractants are meagre, though some studies have been made on pollination of cucumber and bittergourd, but no attempts have been made for exploring the possible use of bee attractants to boost the productivity in India. Attracting honeybees in sufficient numbers for efficient pollination requires evaluation of bee attractants and their impact on the pollinating effectiveness of bees on cucumber and bitter gourd.

MATERIALS AND METHODS

The present investigation was carried out in the experimental farm of Division of Entomology, Sher-e-Kashmir university of Agricultural Sciences & Technology main campus Chatha, Jammu located 10 kms from Jammu city. The study was made on crop raised in the month of February. The crop was raised in a plot size of 5×5 m following package of practices. The details of various materials used and methods employed for achieving the objectives of the present investigation are given under the following heads.

1. Impact of attractants on the pollinating effectiveness of bees

Different attractants were used to evaluate their relative efficiency to increase the honey bee visit to *Cucumis sativus* L. and *Memordica charantia* L. flowers for increased cross pollination. The different attractants used in this study are given in Table 1.

For evaluation of attractants, the study was made in *rabi* season of 2011–2012 and the attractants were sprayed three times at weekly intervals starting from 10 per cent flowering. Later, all the treatments were imposed at 10 per cent flowering of the crop. Spraying was done three times at ten days intervals starting from 10 per cent flowering of the crops. In each plot, five plants was randomly selected and number of honeybee species visiting the flowers per five plant per five minutes were recorded at 0900–1000, 1300–1400 and 1600–1700 hrs. The observations were made a day before the spray and 1, 3 and 5 days after 1^{st}, 2^{nd}, and 3^{rd} spray. Mean of all observation were made for three most dominant bee pollinators separately.

2. Statistical analysis

Experiments were set up as complete randomized design. Data were analyzed using one-way analysis of variance (ANOVA), and Fisher least significant difference (LSD) test was performed to make pairwise comparisons among treatment means (at a significance level of $\alpha=0.05$ and 0.01). The means and standard deviations of each variable were calculated. All calculations were performed using the MS Exel and Statistical software. Correlation coefficient analysis was performed using the methods described by Sokal and Rholf (1981).

Table 1. Different pollination treatments used in the study

T1	Jaggery @100 g/Lit
T2	Molasses @100 g/Lit
T3	Sugar solution @100 g/Lit
T4	Bee Q @100 g/Lit
T5	Bee Q+Molasses @100 g/Lit
T6	Bee Q+Jaggery @100 g/Lit
T7	Bee Q+Sugar @100 g/Lit
T8	Control (without spray)

The experiment was laid out in RBD with seven attractants replicated thrice. The attractants details are as under.

RESULTS

The results of the present investigations carried out on pollinator fauna, role of insect pollination, and impact of attractants on the pollinating effectiveness of insects on cucumber and Bittergourd yield conducted at experimental field, Division of Entomology, Main University campus Chatha, Jammu.

1. Impact of attractants on population dynamics of flower visiting insects

The data prsented in Table 2a, Fig. 1 on cucumber flowers showed that a day before spraying in case of *Apis mellifera* visiting cucumber flowers, the number of bees raised from 4.60–5.80 bees/5 plant/5 min which did not differ significantly among the treatments. However, 1DAFS there was considerable increase in the population of bees in all the treatments except control. The data revealed that the combination of Bee Q and Jaggery attracted higher number of bees and the number increased from 5.42–9.00/5 plant/5 min whereas sugar solution attracted less number of bees from 4.60–4.80 only. The other treatments were in between the two. Similarly, in 3DAFS and 5DAFS Bee Q+Jaggery attracted large number of bees as compared to other attractants but all these treatments was superior to control. A similar trend was observed during second spray and third spray. An overall examination revealed that the efficacy of different attractants was in the order Bee Q+Jaggery @100 g/Lit > Bee Q+Molasses @100 g/Lit > Bee Q+Sugar solution @100 g/Lit > Jaggery @100 g/Lit > Bee Q @100 g/Lit > Molasses @100 g/Lit > Sugar solution @100 g/Lit > control (without spray). In case of *Apis dorsata* (Table 2b, Fig. 2), the initial population 1DBFS raised between 1.80–2.80 which was non-significant. The population of *Apis dorsata* bees visiting cucumber

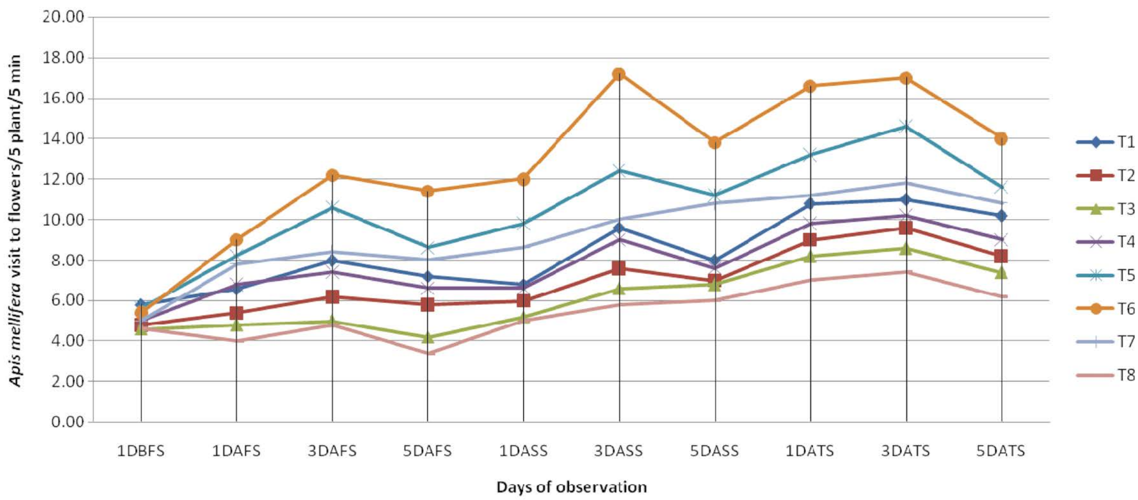

Fig. 1. Impact of attractants on visitation of *Apis mellifera* on Cucumber (*Cucumis sativus* L.) flowers.

Table 2a. Impact of attractants on visitation of *Apis mellifera* on Cucumber (*Cucumis sativus* L.) flowers

S. No.	Treatments	*Apis mellifera* visit flowers/5 plant/5 min									
		1st spray				2nd spray			3rd spray		
		1DBFS	1DAFS	3DAFS	5DAFS	1DASS	3DASS	5DASS	1DATS	3DATS	5DATS
T1	Jaggery @100 g/Lit	5.80	6.60	8.00	7.20	6.80	9.60	8.00	10.80	11.00	10.20
T2	Molasses @100 g/Lit	4.80	5.40	6.20	5.80	6.00	7.60	7.00	9.00	9.60	8.20
T3	Sugar solution @100 g/Lit	4.60	4.80	5.00	4.20	5.20	6.60	6.80	8.20	8.60	7.40
T4	Bee Q @100 g/Lit	5.00	6.80	7.40	6.60	6.60	9.00	7.60	9.80	10.20	9.00
T5	Bee Q+Molasses @100 g/Lit	5.60	8.20	10.60	8.60	9.80	12.40	11.20	13.20	14.60	11.60
T6	Bee Q+Jaggery @100 g/Lit	5.40	9.00	12.20	11.40	12.00	17.20	13.80	16.60	17.00	14.00
T7	Bee Q+Sugar @100 g/Lit	5.00	7.80	8.40	8.00	8.60	10.00	10.80	11.20	11.80	10.80
T8	Control (without spray)	4.60	4.00	4.80	3.40	5.00	5.80	6.00	7.00	7.40	6.20
	Mean	**5.10**	**6.58**	**7.83**	**6.90**	**7.50**	**9.78**	**8.90**	**10.73**	**11.28**	**9.68**
	Sem±	**0.07**	**0.11**	**0.13**	**0.11**	**0.09**	**0.13**	**0.09**	**0.21**	**0.20**	**0.14**
	CD	**0.21**	**0.35**	**0.40**	**0.32**	**0.27**	**0.39**	**0.28**	**0.63**	**0.59**	**0.42**
	CV	**2.37**	**3.00**	**2.94**	**2.68**	**2.03**	**2.28**	**1.77**	**3.38**	**3.01**	**2.46**

DBFS - day before first spray, DASS - day after second spray, Significant at 5% level, DATS - day after third spray, DAFS - day after first spray

flower increased 1DAFS. Of all the treatments, Bee Q with combination of Jaggery attracted more number of bees as compared to other treatments but all these treatments were superior over control. Similarly, population increased on 3DAFS and 5DAFS. Similar trend was observed during 2nd and 3rd spray. In general, the overall attractiveness of treatments to *Apis dorsata* was in the order Bee Q+Jaggery @100 g/Lit>Bee Q+Molasses @100 g/Lit>Bee Q+Sugar solution @100 g/Lit>Jaggery @100 g/Lit>Bee Q @100 g/Lit>Molasses @100 g/Lit>Sugar solution @100 g/Lit>control (without spray). In case of *Apis cerana*, the number of bees visiting cucumber flowers raised from 1.60–2.60. The observation revealed that in case of *Apis cerana* (Table 2c, Fig. 3)also Bee Q+Jaggery attracted highest number of bees as compared to other treatments. The data revealed that in all the treatments number of bees attracted to cucumber flowers was more as compare to 1DBS. All the treatments were superior as compare to control and similar pattern was observed in 2nd and 3rd spray. In case

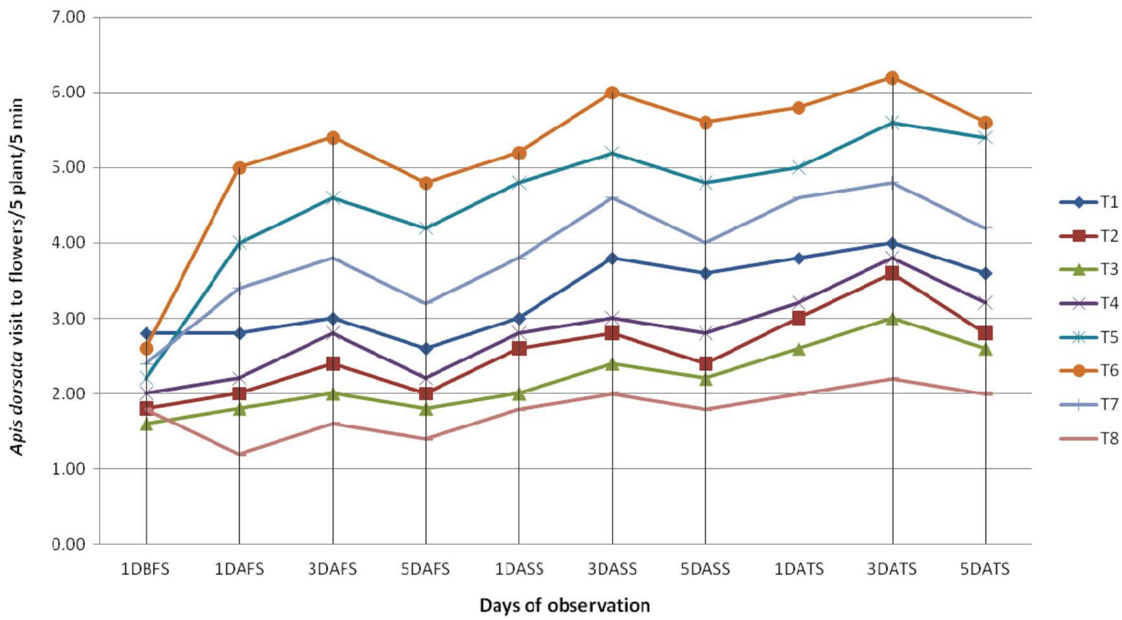

Fig. 2. Impact of attractants on visitation of *Apis dorsata* on Cucumber (*Cucumis sativus* L.) flowers.

Table 2b. Impact of attractants on visitation of *Apis dorsata* on Cucumber (*Cucumis sativus* L.) flowers

S. No.	Treatments	*Apis dorsata* visit flowers/5 plant/5 min									
		1st spray				2nd spray			3rd spray		
		1DBFS	1DAFS	3DAFS	5DAFS	1DASS	3DASS	5DASS	1DATS	3DATS	5DATS
T1	Jaggery @100 g/Lit	2.80	2.80	3.00	2.60	3.00	3.80	3.60	3.80	4.00	3.60
T2	Molasses @100 g/Lit	1.80	2.00	2.40	2.00	2.60	2.80	2.40	3.00	3.60	2.80
T3	Sugar solution @100 g/Lit	1.60	1.80	2.00	1.80	2.00	2.40	2.20	2.60	3.00	2.60
T4	Bee Q @100 g/Lit	2.00	2.20	2.80	2.20	2.80	3.00	2.80	3.20	3.80	3.20
T5	Bee Q + Molasses @100 g/Lit	2.20	4.00	4.60	4.20	4.80	5.20	4.80	5.00	5.60	5.40
T6	Bee Q + Jaggery @100 g/Lit	2.60	5.00	5.40	4.80	5.20	6.00	5.60	5.80	6.20	5.60
T7	Bee Q + Sugar @100 g/Lit	2.40	3.40	3.80	3.20	3.80	4.60	4.00	4.60	4.80	4.20
T8	Control (without spray)	1.80	1.20	1.60	1.40	1.80	2.00	1.80	2.00	2.20	2.00
	Mean	**2.15**	**2.80**	**3.20**	**2.78**	**3.25**	**3.73**	**3.40**	**3.75**	**4.15**	**3.68**
	Sem±	**0.04**	**0.03**	**0.05**	**0.05**	**0.06**	**0.06**	**0.05**	**0.08**	**0.09**	**0.06**
	CD	**0.12**	**0.10**	**0.15**	**0.15**	**0.18**	**0.19**	**0.14**	**0.23**	**0.27**	**0.17**
	CV	**3.08**	**2.10**	**2.63**	**3.00**	**3.12**	**2.92**	**2.35**	**3.48**	**3.68**	**2.63**

DBFS - day before first spray, DASS - day after second spray, Significant at 5% level, DATS - day after third spray, DAFS - day after first spray

of *Apis cerana*, the efficacy of the attractants was in the order Bee Q + Jaggery @100 g/Lit > Bee Q + Molasses @100 g/Lit > Bee Q + Sugar solution @100 g/Lit > Jaggery @100 g/Lit > Bee Q @100 g/Lit > Sugar solution @100 g/Lit > Molasses @100 g/Lit > control (without spray).

In Bittergourd (Table 3a, Fig. 4), the number of *Apis mellifera* on 1DBS raised between 3.00–4.20 bees/5 plant/5 min in different treatments which were non-significant. The number of bees visiting bittergourd flowers increases 1DAFS in all the treatments which were superior over control. The data reveal that Bee Q + Jaggery were most attractive and sugar solution was least one. The other treatments were in between the two and a

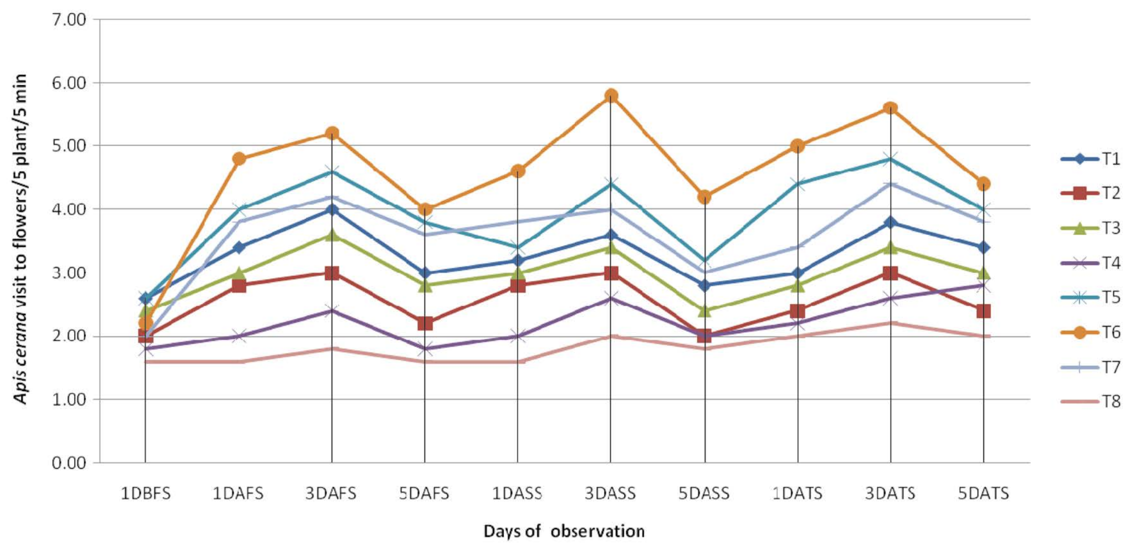

Fig. 3. Impact of attractants on visitation of *Apis cerana* on Cucumber (*Cucumis sativus* L.) flowers.

Table 2c. Impact of attractants on visitation of *Apis cerana* on Cucumber (*Cucumis sativus* L.) flowers

S. No.	Treatments	*Apis cerana* visit flowers/5 plant/5 min									
		1st spray				2nd spray			3rd spray		
		1DBFS	1DAFS	3DAFS	5DAFS	1DASS	3DASS	5DASS	1DATS	3DATS	5DATS
T1	Jaggery @100 g/Lit	2.60	3.40	4.00	3.00	3.20	3.60	2.80	3.00	3.80	3.40
T2	Molasses @100 g/Lit	2.00	2.80	3.00	2.20	2.80	3.00	2.00	2.40	3.00	2.40
T3	Bee Q @100 g/Lit	2.40	3.00	3.60	2.80	3.00	3.40	2.40	2.80	3.40	3.00
T4	Sugar solution @100 g/Lit	1.80	2.00	2.40	1.80	2.00	2.60	2.00	2.20	2.60	2.80
T5	Bee Q Molasses @100 g/Lit	2.60	4.00	4.60	3.80	3.40	4.40	3.20	4.40	4.80	4.00
T6	Bee Q + Jaggery @100 g/Lit	2.20	4.80	5.20	4.00	4.60	5.80	4.20	5.00	5.60	4.40
T7	Bee Q + Sugar @100 g/Lit	2.00	3.80	4.20	3.60	3.80	4.00	3.00	3.40	4.40	3.80
T8	Control (without spray)	1.60	1.60	1.80	1.60	1.60	2.00	1.80	2.00	2.20	2.00
	Mean	**2.15**	**3.18**	**3.60**	**2.85**	**3.05**	**3.60**	**2.68**	**3.15**	**3.73**	**3.23**
	Sem ±	**0.03**	**0.05**	**0.04**	**0.06**	**0.04**	**0.06**	**0.05**	**0.06**	**0.06**	**0.05**
	CD	**0.10**	**0.15**	**0.13**	**0.18**	**0.13**	**0.19**	**0.14**	**0.19**	**0.17**	**0.14**
	CV	**2.60**	**2.76**	**2.08**	**3.55**	**2.48**	**2.99**	**3.06**	**3.45**	**2.57**	**2.48**

DBFS - day before first spray, DASS - day after second spray, Significant at 5% level, DATS - day after third spray, DAFS - day after first spray

similar trend was observed during 2nd and 3rd spray on all the days of observations. In general, the efficiency of different treatments was in the order Bee Q + Jaggery @100 g/Lit > Bee Q + Molasses @100 g/Lit > Bee Q + Sugar @100 g/Lit > Jaggery @100 g/Lit > Bee Q @100 g/Lit > Molasses @100 g/Lit > sugar solution @100 g/Lit > control (without spray). In case of *Apis dorsata* (Table 3b, Fig. 5) visiting bittergourd flowers, the population raised between 1.00–2.20 bees/5 plant/5 min. The population increased following 1st, 2nd, and 3rd spray. All the treatments were effective in enhancing population visits as compared to control. Of all the different treatments, Bee Q + Jaggery was most effective whereas sugar solution @100 g/Lit was the least attractive (1.00–2.40 bees/5 plant/5 min) and the other treatments were in between the two. In general, the efficacy was in the order Bee Q + Jaggery @100 g/Lit > Bee Q + Molasses @100 g/Lit > Bee Q + Sugar @100 g/Lit > Bee Q @100

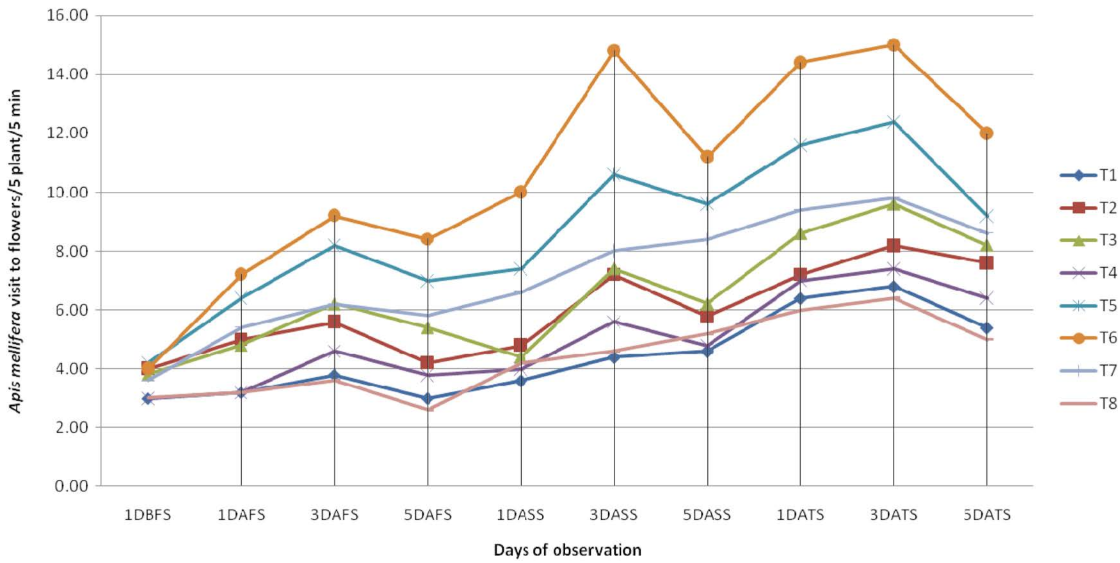

Fig. 4. Impact of attractants on visitation of *Apis mellifera* on Cucumber (*Memordica charantia* L.) flowers.

Table 3a. Impact of attractants on visitation of *Apis mellifera* on Cucumber (*Memordica charantia* L.) flowers

S. No.	Treatments	*Apis mellifera* visit flowers/5 plant/5 min									
		1st spray				2nd spray			3rd spray		
		1DBFS	1DAFS	3DAFS	5DAFS	1DASS	3DASS	5DASS	1DATS	3DATS	5DATS
T1	Sugar solution @100 g/Lit	3.00	3.20	3.80	3.00	3.60	4.40	4.60	6.40	6.80	5.40
T2	Bee Q @100 g/Lit	4.00	5.00	5.60	4.20	4.80	7.20	5.80	7.20	8.20	7.60
T3	Jaggery @100 g/Lit	3.80	4.80	6.20	5.40	4.40	7.40	6.20	8.60	9.60	8.20
T4	Molasses @100 g/Lit	3.00	3.20	4.60	3.80	4.00	5.60	4.80	7.00	7.40	6.40
T5	Bee Q + Molasses @100 g/Lit	4.20	6.40	8.20	7.00	7.40	10.60	9.60	11.60	12.40	9.20
T6	Bee Q + Jaggery @100 g/Lit	4.00	7.20	9.20	8.40	10.00	14.80	11.20	14.40	15.00	12.00
T7	Bee Q + Sugar @100 g/Lit	3.60	5.40	6.20	5.80	6.60	8.00	8.40	9.40	9.80	8.60
T8	Control (without spray)	3.00	3.20	3.60	2.60	4.20	4.60	5.20	6.00	6.40	5.00
	Mean	**3.58**	**4.80**	**5.93**	**5.03**	**5.63**	**7.83**	**6.98**	**8.83**	**9.45**	**7.80**
	Sem ±	**0.05**	**0.07**	**0.07**	**0.11**	**0.10**	**0.15**	**0.09**	**0.15**	**0.18**	**0.10**
	CD	**0.15**	**0.20**	**0.21**	**0.32**	**0.31**	**0.45**	**0.28**	**0.46**	**0.55**	**0.30**
	CV	**2.43**	**2.40**	**2.00**	**3.67**	**3.18**	**3.25**	**2.28**	**2.98**	**3.31**	**2.16**

DBFS - day before first spray, DASS - day after second spray, Significant at 5% level, DATS - day after third spray, DAFS - day after first spray

g/Lit > Jaggery @100 g/Lit > Molasses @100 g/Lit > Sugar solution @100 g/Lit > control (without spray). In case of *Apis cerana* (Table 3c, Fig. 6) also, the population raised from 1.60–2.60 bees/5 plant/5 min between different treatments which were non-significant. In case of *Apis cerana* also, all the treatments were very effective in increasing the population visits as compare to control. The efficiency of various attractants has given in the order Bee Q + Jaggery @100 g/Lit > Bee Q + Sugar solution @100 g/Lit > Bee Q + Molasses @100 g/Lit > Jaggery @100 g/Lit > Bee Q @100 g/Lit > Molasses @100 g/Lit > sugar solution @100 g/Lit > control (without spray). It is evident from the above that different attractants had a profound influence on population of bees enhancing pollination efficiency.

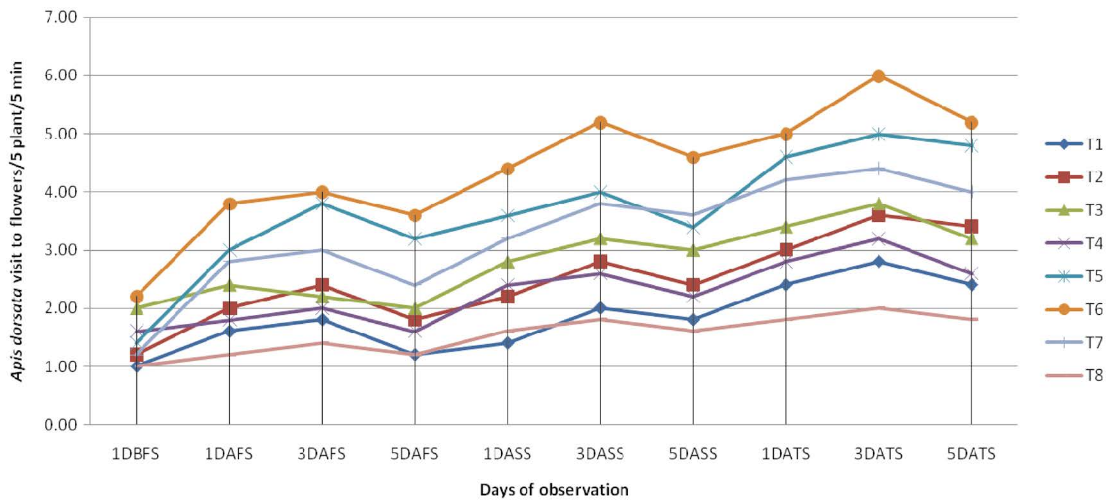

Fig. 5. Impact of attractants on visitation of *Apis dorsata* on Cucumber (*Memordica charantia* L.) flowers.

Table 3b. Impact of attractants on visitation of *Apis dorsata* on Cucumber (*Memordica charantia* L.) flowers

S. No.	Treatments	*Apis dorsata* visit flowers/5 plant/5 min									
		1st spray				2nd spray			3rd spray		
		1DBFS	1DAFS	3DAFS	5DAFS	1DASS	3DASS	5DASS	1DATS	3DATS	5DATS
T1	Sugar solution @100 g/Lit	1.00	1.60	1.80	1.20	1.40	2.00	1.80	2.40	2.80	2.40
T2	Bee Q @100 g/Lit	1.20	2.00	2.40	1.80	2.20	2.80	2.40	3.00	3.60	3.40
T3	Jaggery @100 g/Lit	2.00	2.40	2.20	2.00	2.80	3.20	3.00	3.40	3.80	3.20
T4	Molasses @100 g/Lit	1.60	1.80	2.00	1.60	2.40	2.60	2.20	2.80	3.20	2.60
T5	Bee Q + Molasses @100 g/Lit	1.40	3.00	3.80	3.20	3.60	4.00	3.40	4.60	5.00	4.80
T6	Bee Q + Jaggery @100 g/Lit	2.20	3.80	4.00	3.60	4.40	5.20	4.60	5.00	6.00	5.20
T7	Bee Q + Sugar @100 g/Lit	1.20	2.80	3.00	2.40	3.20	3.80	3.60	4.20	4.40	4.00
T8	Control (without spray)	1.00	1.20	1.40	1.20	1.60	1.80	1.60	1.80	2.00	1.80
	Mean	**1.45**	**2.33**	**2.58**	**2.13**	**2.70**	**3.18**	**2.83**	**3.40**	**3.85**	**3.43**
	Sem ±	**0.02**	**0.03**	**0.05**	**0.03**	**0.03**	**0.07**	**0.04**	**0.05**	**0.05**	**0.05**
	CD	**0.06**	**0.09**	**0.15**	**0.10**	**0.10**	**0.22**	**0.13**	**0.14**	**0.15**	**0.16**
	CV	**2.27**	**2.23**	**3.37**	**2.58**	**2.15**	**3.90**	**2.65**	**2.41**	**2.30**	**2.64**

DBFS - day before first spray, DASS - day after second spray, Significant at 5% level, DATS - day after third spray, DAFS - day after first spray

DISCUSSION

The results of the present investigations carried on the impact of attractants on the pollinating effectiveness of insects on cucumber and Bittergourd yield (Table 2a–c, Figs. 1–3 and Table 3a–c, Figs. 4–6) revealed that in case of all the attractants such as Bee Q, Jaggery, Molasses, Sugar solution, Bee Q + Molasses, Bee Q + Jaggery, Bee Q + Sugar solution and Control (without spray), Bee Q + Jaggery was most effective and sugar least effective as compared to control.

In case of *A. mellifera*, was a considerable increases 1DAFS in the population of bees in all the treatments except control. The data revealed that the combination of Bee Q and Jaggery attracted higher number of bees and the number increased from 5.42–9.00/5 plant/5 min and sugar solution attracted less number of bees which raised from 4.60–4.80. The other treatments were in between the two. Similarly, in 3DAFS and 5DAFS Bee Q + Jaggery attracted large number of bees as com-

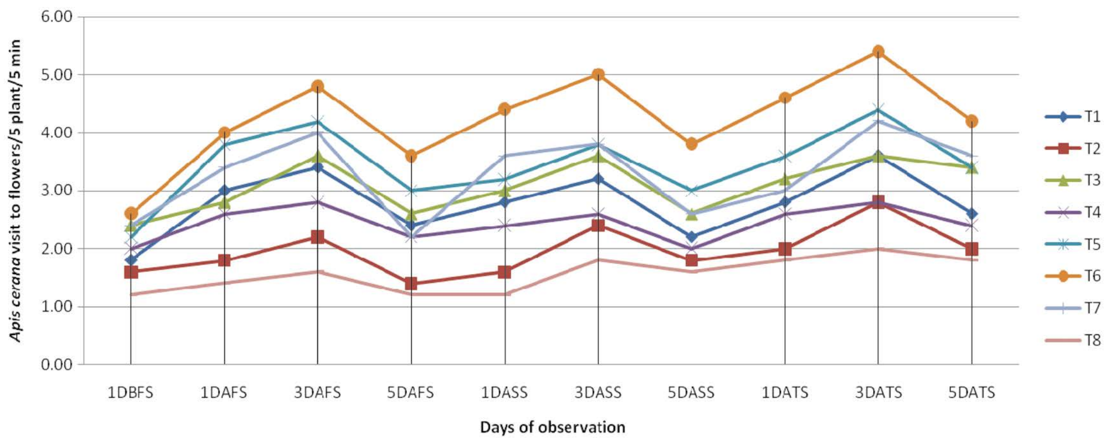

Fig. 6. Impact of attractants on visitation of *Apis cerana* on Cucumber (*Memordica charantia* L.) flowers.

Table 3c. Impact of attractants on visitation of *Apis cerana* on Cucumber (*Memordica charantia* L.) flowers

S. No.	Treatments	*Apis cerana* visit flowers/5 plant/5 min									
		1st spray				2nd spray			3rd spray		
		1DBFS	1DAFS	3DAFS	5DAFS	1DASS	3DASS	5DASS	1DATS	3DATS	5DATS
T1	Sugar solution @100 g/Lit	1.80	3.00	3.40	2.40	2.80	3.20	2.20	2.80	3.60	2.60
T2	Bee Q @100 g/Lit	1.60	1.80	2.20	1.40	1.60	2.40	1.80	2.00	2.80	2.00
T3	Jaggery @100 g/Lit	2.40	2.80	3.60	2.60	3.00	3.60	2.60	3.20	3.60	3.40
T4	Molasses @100 g/Lit	2.00	2.60	2.80	2.20	2.40	2.60	2.00	2.60	2.80	2.40
T5	Bee Q + Molasses @100 g/Lit	2.20	3.80	4.20	3.00	3.20	3.80	3.00	3.60	4.40	3.40
T6	Bee Q + Jaggery @100 g/Lit	2.60	4.00	4.80	3.60	4.40	5.00	3.80	4.60	5.40	4.20
T7	Bee Q + Sugar @100 g/Lit	2.40	3.40	4.00	2.20	3.60	3.80	2.60	3.00	4.20	3.60
T8	Control (without spray)	1.20	1.40	1.60	1.20	1.20	1.80	1.60	1.80	2.00	1.80
	Mean	**2.03**	**2.85**	**3.33**	**2.33**	**2.78**	**3.28**	**2.45**	**2.95**	**3.60**	**2.93**
	Sem ±	**0.02**	**0.05**	**0.04**	**0.04**	**0.04**	**0.05**	**0.04**	**0.06**	**0.05**	**0.04**
	CD	**0.06**	**0.15**	**0.13**	**0.11**	**0.13**	**0.17**	**0.11**	**0.19**	**0.16**	**0.12**
	CV	**1.79**	**3.04**	**2.25**	**2.63**	**2.75**	**2.89**	**2.62**	**3.71**	**2.48**	**2.29**

DBFS - day before first spray, DASS - day after second spray, Significant at 5% level, DATS - day after third spray, DAFS - day after first spray

pared to other attractants but all these treatments was superior to control. A similar trend was observed during second spray and third spray. An overall examination revealed that the efficacy of different attractants was in the order Bee Q + Jaggery @100 g/Lit > Bee Q + Molasses @100 g/Lit > Bee Q + Sugar solution @100 g/Lit > Jaggery @100 g/Lit > Bee Q @100 g/Lit > Molasses @100 g/Lit > Sugar solution @100 g/Lit > control (without spray).

In case of *Apis dorsata*, the initial population, 1DBFS between 1.80–2.80 which was non-significant. The population of *Apis dorsata* bees visiting cucumber flower increased 1DAFS. Of all the treatments Bee Q with combination of Jaggery attracted more number of bees as compared to other treatments but all these treatments were superior over control. Similarly, population increased on 3DAFS and 5DAFS. Similar trend was observed during 2nd and 3rd spray. In general, the overall attractiveness of treatments to *Apis dorsata* was in the order Bee Q + Jaggery @100 g/Lit > Bee Q + Molasses @100 g/Lit > Bee Q + Sugar solution @100 g/Lit > Jaggery @100 g/Lit > Bee Q @100 g/Lit > Molasses @100 g/Lit > Sugar solution @100 g/Lit > control (without spray).

In case of *Apis cerana*, the number of bees visiting cucumber flowers raised from 1.60–2.60. The observation reveals in case of *Apis cerana* also Bee Q + Jaggery attracted highest number of bees as compared to other treatments. The data revealed that in all the treatments number of bees attracted to cucumber flowers was more as compared to 1DBS. All the treatments were superior as compare to control and similar pattern was observed in 2nd and 3rd spray. In case of *Apis cerana*, the attractants was in the order Bee Q + Jaggery @100 g/Lit > Bee Q + Molasses @100 g/Lit > Bee Q + Sugar solution @100 g/Lit > Jaggery @100 g/Lit > Bee Q @100 g/Lit > Sugar solution @100 g/Lit > Molasses @100 g/Lit > control (without spray). Similar trend was observed in bittergourd. It is evident from the above that different attractants have a profound influence on population of bees enhancing pollination efficiency.

In earlier studies also role of different attractants has been well documented. Woodrow *et al.* (1965) screened the natural and synthetic materials as attractants and repellents for *A. mellifera* by observing responses of bees to their vapours. Out of 195 formulations tested, four were rated as weak to moderate attractants and 19 were moderate to very strong repellents *viz*., alcohols and one fatty acid having more carbon atoms. Williams *et al.* (1981) reported that nasonov pheromone of honey bee comprised of seven components and among these, the presence of foot print pheromone enhanced the attractiveness of synthetic nasonov pheromone. They opined that this could prove useful in attracting the honey bees to the crops for better pollination. Allsopp and Cherry (1991) studied the attraction of *A. mellifera* to volatile compounds and they concluded that anetholes and commercial trace Japanese beetle lure (10 : 22 : 11, 2 phenyl ethyl propionate : eugenol : geraniol) exposed in trace in Japanese beetle traps attracted *A. mellifera* but other floral lures and fattyacids did not attract the bees.

Schultheis *et al.* (1994) evaluated two commercial bee attractants like Bee scent and Bee line on cucumber and watermelon. They found that these attractants did increase the yield and also bee visitation. Similarly, Ambrose *et al.* (1995) evaluated Bee line as honey bee feeding stimulant on watermelon and Bee scent as worker bee attractant on both cucumber and watermelon. They found that these attractants neither increased the bee activity on vine crop when compared to untreated control nor they increase the value of subsequent harvest. According to Higo *et al.* (1995) a combination of increased recruitment of foragers and greater time spent by foragers with increased flower visitation contributed to the enhanced pollination of blooming crops treated with Fruit boost. Lingappa *et al.* (1999) reported that increased 21.80 and 31.80 per cent in the number of fruits formed and total yield, respectively, when Bee-Q was sprayed twice on watermelon. Application of Bee-Q @12.50 and 15.00 g/L resulted in higher yield (19.56 and 19.45 t/ha respectively), maximum good fruits, minimum malformed fruits and higher size and weight in watermelon (Sattigi *et al.*, 2001a).

Looper and Rossette (1991) conducted field trail on two adjacent fields of *Citrullus lanatus* L. in Arizona, USA, in which honey bees were introduced at a stocking density of two colonies/acre. Bee scent was sprayed over alternate 18 row strips in one field and the other field was untreated. Though, bee visitation was high on the day of application, but did not reflect in yield. The efficacy of Bee-here (Nasonov pheromone other honey bee attractant and control release formulation aids) as honey bee attractant to marrow crop (*Cucurbita pepo* L.) grown in greenhouse conditions in Almeria, Spain was tested. Honey bee counts were made on plants sprayed with recommended dose of attractant (3.00 mL/Lit), plants sprayed with half the dose, plants sprayed with water and untreated plants. The bees did not exhibit preference for any experimental treatment indicating that this product being ineffective as a honey bee attractant to marrow flowers (Ortiz-Sanchoz, 1993). Henning *et al.* (1992) studied behavioural responses of *A. mellifera* to primary alfalfa floral volatiles in a screened flight chamber. They found that linalool was the only compound attractive to honey bees at the optimized concentration. Two other compounds, 3-octanone and methyl salicylate were repellents. Two application of Bee scent (a liquid formulation containing 9.00 per cent pheromone and 40.00 per cent other natural attractants) was used on watermelon cultivars in Florida. Total fruit yield was increased in one farm with the treatment upto 3,000 fruits/acre compared to 1,500 fruits/acre without treatment and there was apparent increase in early yield in three farms. The soluble solid content of fruit was not affected by the treatment. The number of seeds per fruit was higher with treatment on three frames (Elmstrom and Maynard, 1991). Ortiz-Sanchoz (1993) reported the efficacy of Bee-here (Nasonov pheromone other honey bee attractant and control release formulation aids) as honey bee attractant to marrow crop (*Cucurbita pepo* L.) grown in greenhouse conditions in Almeria, Spain was tested. Honey bee counts were made on plants sprayed with recommended dose of attractant (3.00 mL/Lit), plants sprayed with half the dose, plants sprayed with water and untreated plants. The bees did not exhibit preference for any experimental treatment indicating that this product being ineffective as a honey bee attractant to marrow flowers. Tsirakoglou *et al*. (1997) reported that spraying of Bee-here has no significant effect on bee visitation to kiwi fruit. Number of bees visiting kiwi fruits before spray and 4, 24, 72, 96 or 120 hr after spray was same as water treated control treatments. Feeding sugar syrup and weeding to remove wild plants did not seem to affect kiwi fruit pollen collection.

Viraktamath and Anagoudar (2002) reported that two applications of Bee-Q® (12.5 g/L), Bee-here® (4 mL/L) and sugar solution (10%) on staminate flowers of *Cucumis sativa* enticed more number of bees (4.01 to 4.97 bees per flower per 5 min) up to 5 days after first and second sprays compared to unsprayed crop (3.25 to 3.59 bees). Similarly, higher visitation was recorded on pistillate flowers on the sprayed crop. In earlier studies also, attractants has been shown to enhance visits of bees and increase pollination efficiency. For instance, Viraktamath and Anagoudar (2002) reported that two applications of Bee-Q® (12.5 g/L), Bee-here® (4 mL/L) and sugar solution (10%) on staminate flowers of *Cucumis sativa* enticed more number of bees (4.01 to 4.97 bees per flower per 5 min) up to 5 days after first and second sprays compared to unsprayed crop (3.25 to 3.59 bees). Similarly, higher visitation was recorded on pistillate flowers on the sprayed crop.

Dinesh (2003) reported that spraying of cacambe (10%), jaggery (10%) and Bee-Q (1.25%) had significantly influence in attracting more number of pollinators. Plots sprayed with cacambe (10%) recorded significantly more number of fruits (15.61 fruits/plant vs 7.42 and 3.34 without bees, respectively) and fruit weight (126.11 g/fruit). Nidagundi (2004) reported that spraying of cacambe @10 per cent, Bee-Q @1.25 percent and jaggery solution @10 per cent have significant influence in attracting more number of pollination. Pateel and Sattagi (2007) reported that spraying of cacambe 10 per cent and Bee-Q 1.25 percent attracted maximum number of bees up to third day after first, second and third spray. Jaggery solution 10 per cent and sugar solution were next best attractants. Treatment with cacambe 10 percent, Bee-01.25 per cent, jaggery solution 10 percent and sugar solution 10 per cent were efficient in attracting more bees up to 3rd day after 1st, 2nd, and 3rd spray, whereas their efficacy decreased at 5th day of 1st, 2nd, and 3rd spray.

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