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Effect of bee attractants on foraging activity of honey bees *Apis mellifera* and *Apis cerana* for enhancing seed production of cucumber (*Cucumis sativus* L.)

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Abstract
Studies were conducted at PGI farm, MPKV, Rahuri to study the effects of bee attractants on foraging activity of honey bees *Apis mellifera* and *Apis cerana indica* for enhancing seed production of cucumber. The variety used in such research was Himangi which is released from MPKV, Rahuri. Ten treatments *viz*., T_1 - Open pollination, T_{2-} Pollination Without Insect, T_3 - Sugar solution 5 per cent, T_4 - Sagar solution 10 per cent, T_5 -Sugarcane Juice 5 per cent, T_6 - Sugarcane Juice 10 per cent, T_7 - Jaggery solution 5 per cent, T_8 - Jaggery solution 10 per cent, T_9 - Molasses 5 per cent and T_{10} - Molasses 10 per cent were used for such experiment. The result revealed that a day before the first spray, the number of bee visiting the cucumber flower ranged from 2.13 to 2.31 bees/m^2/min in *Apis mellifera* and 2.11 to 2.21 in *Apis cerana indica* and do not differ significantly among the treatments. A day after the first spray, jaggery solution 10 per cent attracted 3.78 bees/m^2/min in case of *A. mellifera* and 4.10 bees/m^2/min in case of *A. cerana indica* was significantly superior in attracting higher number of bees. After second spray, the effectiveness of attractants was maximum on 3rd day after spray (50 % flowering). Sugar solution 5 per cent, jaggery solution 5 per cent, sugarcane juice 10 per cent and molasses 10 per cent were the next best treatment in attracting more number of bees and open sprayed with bee attractants marginally enhanced of seeds/fruit, test weight and fruit quality.

Keywords: Pollination, honey bees, cucumber, bee attractants

Introduction
Cucumber (*Cucumis sativus* L.) is an important and popular vegetable belonging to Cucurbitaceae family. It is one of the oldest cultivated vegetable crops and has been found in cultivation for 3000-4000 B.C. years.

Overall production of cucumber in the world is 75.00 million tones and led by China with 76%.India is second major producer of vegetables next to china. Cucurbits share about 5.6 % of the total vegetable production of India and according to FAO estimate, cucurbits were cultivated about 74 thousands hectares and production is 161,000 MT.

According to findings, Karnataka is the leading producer of cucumber with 120.77 thousand tones and share of 17.81 %, though Maharashtra stands 11th position in production with 19.28 thousand tones and share about 2.84%.

The variety used for experiment is Himangi which is released by Mahatma Phule Krishi Vidyapeeth, Rahuri (MS) in 1992. Fruits are white in color, 12-15 cm long, resistant to bronzing, crispy flesh with medium seed cavity, free from bitter principle and fruits are cylindrical in shape. Total duration is 100-110 days. Average yield is 158 q/ ha [1].

Commercial bee attractants *viz*., beeline, beehere, bee scent, bee scent 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 indigenous like jaggery solution, sugar solution, honey solution and molasses proved as beneficial to boost the productivity of cross pollinated crops like cucumber.

Honey bees are social insects with which man has established a harmonious co-existence. They are of great importance because; they 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 quality and quantity of seed and fruit yield. Therefore, utilization of pollinators especially honey bees is considered as one of the cheapest and eco friendly approach in maximizing the

yield of cross pollinated crops [5]. Honey bees are most efficient pollinator among various insect pollinators out of which *Apis florea, A. dorsata, A. cerena* and *A. mellifera* are important [3].

As the use of commercial bee attractants is cost prohibitive, the development of indigenous bee attractants is the best solution under Indian condition [6]. Further, though some studies have been made on pollination of cucumber but no attempts have been made for exploring the possible use of bee attractants to boost productivity of cucumber in India

So, the indispensable research on effect of bee attractants on bee activity felt needed and with this view the present investigation has been carried out.

2. Materials and Methodology

The present investigations were carried out in PGI farm at Mahatma Phule Krishi Vidyapeeth, Rahuri. The study was made on crop raised during *Kharif*, 2017-18. The experiment was laid out in Randomized Block Design (RBD) with 10 treatments replicated thrice. For this study following attractants jaggary 10 per cent, jaggary 5 per cent, sugarcane juice 10 per cent and 5 per cent, sugar solution 5 and 10 per cent and molasses 10 and 5 were used for the comparison.

Crop was raised following recommended package of practices. All the attractants were sprayed at 10 per cent flowering and 50 per cent flowering at an interval of 15 days. In each plot, one square meter area was randomly selected and number of different species of pollinators visiting these flowers per five minute were recorded at 0800, 1000, 1200, 1400 and 1600 hr**.** Such observations were made a day before the spray and 1, 3, 5 and 7 days after each spray. Mean of all the observations were pooled for different bee pollinators separately. The data were subjected to suitable statistical analysis for inference after ($\sqrt{x}+0.5$) transformation [7].

3. Results

Data pertaining to the effect of attractant on activity of *A. mellifera* on cucumber is presented in Table 1.

Table 1: Influence of bee attractants on activity of *Apis mellifera* on cucumber

Treatment	Number of bees /m^2/min									
	1st spray at 10 per cent flowering					2nd spray at 50 per cent flowering				
	1DBS	1 DAS	3 DAS	5 DAS	7 DAS	1 DBS	1 DAS	3 DAS	5 DAS	7 DAS
Sugar solution 5%	2.13 (1.63)	3.33 (1.98)	5.78 (2.52)	5.08 (2.36)	4.10 (2.14)	2.81 (1.82)	4.77 (2.30)	5.88 (2.52)	5.00 (2.35)	3.41 (1.98)
Sugar solution 10%	1.78 (1.51)	3.56 (2.14)	6.67 (2.68)	5.91 (2.54)	4.56 (2.25)	3.23 (1.93)	4.80 (2.31)	6.11 (2.58)	5.07 (2.36)	3.49 (2.00)
Sugarcane juice5%	2.00 (1.61)	2.78 (1.81)	5.00 (2.36)	4.78 (2.30)	3.10 (1.90)	2.09 (1.61)	3.88 (2.09)	5.15 (2.38)	3.33 (1.96)	3.09 (1.89)
Sugarcane juice10%	2.22 (1.65)	2.89 (1.84)	5.11 (2.37)	4.93 (2.33)	3.24 (1.93)	2.78 (1.81)	4.07 (2.14)	5.19 (2.39)	3.91 (2.10)	3.29 (1.95)
Jaggery solution 5%	1.89 (1.55)	3.35 (1.96)	6.13 (2.39)	5.14 (2.37)	4.11 (2.15)	2.83 (1.82)	4.79 (2.30)	5.89 (2.53)	5.79 (2.51)	3.42 (1.98)
Jaggery solution 10%	1.67 (1.48)	3.78 (2.07)	7.11 (2.76)	6.10 (2.57)	4.67 (2.27)	3.25 (1.94)	4.81 (2.31)	6.12 (2.57)	5.81 (2.51)	3.51 (2.04)
Molasses 5%	2.10 (1.62)	2.90 (1.84)	5.31 (2.41)	4.81 (2.30)	3.13 (1.91)	2,21 (1.65)	3.96 (2.11)	5.22 (2.39)	3.78 (2.07)	3.13 (1.91)
Molasses 10%	2.23 (1.65)	3.10 (1.90)	5.33 (2.42)	4.94 (2.34)	3.27 (1.94)	2.80 (1.82)	4.11 (2.15)	5.23 (2.39)	3.95 (2.11)	3.37 (1.97)
Open pollination	2.31 (1.68)	2.37 (1.69)	3.33 (1.96)	3.21 (1.93)	2.91 (1.85)	1.89 (1.55)	3.79 (2.07)	5.13 (2.37)	3.37 (1.97)	2.17 (1.63)
S.E. (+)	0.02	0.03	0.04	0.03	0.04	0.02	0.03	0.05	0.04	0.03
C.D.at 5%	NS	0.09	0.13	0.09	0.12	0.06	0.10	0.16	0.12	0.09

Figures in the parentheses are transformed $\sqrt{x+0.5}$ values

DBS = Days before spraying, DAS = Days after spraying

First spray

There was no significant difference in the bee visitation among the various treatments, a day before first spray and it was ranged from 2.13 to 2.31 bees/m^2/min.

A day after the first spray, jaggery solution 10 per cent attracted higher number of bees (3.78 bees/m^2/min).Sugar solution 10 per cent, jaggery solution 5 per cent and molasses 10 per cent were next best treatments attracted 3.56, 3.35 and 3.10 bees/m^2/min, respectively. The least number of bees was recorded in open pollination without spray (2.37 bees/m^2/min).

Similarly on 3rd day after first spray, jaggery solution 10 per cent recorded maximum number of bees (7.11 bees/m^2/min) and found superior over all the treatment except sugar solution 10 per cent which was recorded 6.67 bees/m^2/min. The next best treatments were jaggery solution 5 per cent, sugar solution 5 per cent, and molasses 10 per cent which recorded as 6.13, 5.78 and 5.33 bees/m^2/min, respectively. Open pollination without spray was inferior over all the treatments as it recorded less number of bees (3.33 bees/m^2/min).

On 5th day after first spray, treatment jaggery solution 10 per cent was significantly superior to attract the maximum number of bees (6.10 bees/m^2/min) followed by sugar solution 10 per cent and jaggery solution 5 per cent with 5.91 and 5.14 bees/m^2/min, respectively. The next best treatments were sugar solution 5 per cent, molasses 10 per cent and sugarcane juice 10 per cent which recorded 5.08, 4.94 and 4.93 bees/m^2/min, respectively. Open pollination without spray recorded lowest number of bees as 3.21 bees/m^2/min.

On 7th day after first spray, the plots sprayed with jaggery solution 10 per cent attract the maximum number of bees (4.67 bees/m^2/min) and found at par with sugar solution 10 per cent (4.56 bees/m^2/min). Further, jaggery solution 5 per cent (4.11 bees/m^2/min) was at par with sugar solution 5 per cent (4.10 bees/m^2/min).Molasses 10 per cent was the another best treatment and found significantly superior over open pollination without spray which recorded least number of bees (2.91bees/m^2/min.

\Second spray

The visitation of *A. mellifera* on one day before second spray was in the range of 1.89 to 3.25 bees/m^2/min.

One day after second spray, more number of bees (4.81 bees/m^2/min) was attracted in the treatment jaggery solution 10 per cent and found to be significantly superior over all the treatments except sugar solution 10 per cent (4.80 bees/m^2/min). Jaggery solution 5 per cent and sugar solution 5 per cent were also best treatments which recorded 4.79 and 4.77 bees/m^2/min, respectively Open pollination without spray recorded the lowest number of bees (3.79 bees/m^2/min).

Similarly on 3rd day after second spray, plot treated with jaggery solution 10 per cent attracted maximum number of bees (6.12 bees/m^2/min). The next best treatment was sugar

solution 10 per cent (6.11 bees/m^2/min) followed by jaggery solution 5 per cent and sugar solution 5 per cent with 5.89 and 5.88 bees/m^2/min, respectively. Rest of the treatment also found superior over open pollination without spray which recorded the least number of bees (5.13 bees/m^2/min).

On 5th day after second spray, the treatment jaggery solution 10 per cent (5.81 bees/m^2/min) proved to be superior among treatments of bee attractants. Jaggery solution 5 per cent was another best treatment followed by sugar solution 10 per cent which attracts 5.79 and 5.07 bees/m^2/min, respectively. Molasses 10 per cent was the next best treatment which recorded 3.95 bees/m^2/min and found at par with sugarcane juice 10 per cent (3.91 bees/m^2/min).

On 7th day after second spray, the treatment jaggery solution 10 per cent was successful in attracting highest number of bees (3.51 bees/m^2/min) and it was at par with sugar solution 10 per cent (3.49), jaggery solution 5 per cent (3.42) and sugar solution 5 per cent (3.41).Open pollination without spray recorded least number of bees (2.17 bees/m^2/min).

These findings corroborate the result [8] and showed that bee visitation was lowest in open pollination without spray as compared to the plots sprayed with bee attractants.

Effect of bee attractant on activity of *Apis cerana indica* on cucumber

The observations were recorded on *A. cerana* visitation on cucumber treated with different bee attractants at 10 and 50 per cent of flowering are presented in Table 2.

Table 2: Influence of bee attractants on activity of *Apis cerana indica* on cucumber

Treatment	Number of bees /m2/min									
	1st spray at 10 per cent flowering					2nd spray at 50 per cent flowering				
	1 DBS	1 DAS	3 DAS	5 DAS	7 DAS	1 DBS	1 DAS	3 DAS	5 DAS	7 DAS
Sugar solution 5%	2.11 (1.62)	3.89 (2.10)	6.23 (2.59)	5.67 (2.48)	4.71 (2.18)	3.72 (2.05)	4.73 (2.29)	5.89 (2.52)	3.33 (1.96)	2.33 (1.68)
Sugar solution 10%	1.89 (1.55)	4.00 (2.12)	6.39 (2.61)	5.85 (2.52)	4.80 (2.30)	4.23 (2.18)	4.78 (2.30)	6.10 (2.58)	3.67 (2.04)	2.40 (1.71)
Sugarcane juice 5%	2.34 (1.69)	3.19 (1.92)	5.22 (2.39)	4.83 (2.31)	4.31 (2.19)	3.07 (1.89)	3.38 (1.97)	5.17 (2.38)	2.90 (1.84)	2.10 (1.64)
Sugarcane juice 10%	1.87 (1.54)	3.77 (2.07)	5.44 (2.44)	4.96 (2.34)	4.61 (2.26)	3.81 (2.08)	3.91 (2.09)	5.19 (2.39)	3.23 (1.93)	2.21 (1.65)
Jaggery solution 5%	1.67 (1.47)	3.95 (2.11)	6.28 (2.62)	5.91 (2.53)	5.10 (2.37)	3.78 (2.05)	4.77 (2.30)	5.90 (2.53)	3.37 (1.95)	2.38 (1.70)
Jaggery solution10%	2.22 (1.65)	4.10 (2.14)	6.43 (2.63)	6.00 (2.55)	5.13 (2.38)	4.27 (2.17)	4.80 (2.39)	6.15 (2.57)	3.91 (2.10)	2.67 (1.78)
Molasses 5%	3.67 (2.04)	3.80 (2.07)	5.51 (2.46)	5.00 (2.35)	4.35 (2.19)	3.12 (1.89)	4.11 (2.15)	5.21 (2.39)	3.09 (1.89)	2.13 (1.62)
Molasses 10%	1.84 (1.53)	3.85 (2.09)	5.68 (2.49)	5.21 (2.38)	4.63 (2.27)	3.83 (2.09)	4.17 (2.16)	5.23 (2.39)	3.25 (1.94)	2.31 (1.69)
Open pollination	2.21 (1.65)	3.13 (1.90)	4.56 (2.25)	3.97 (2.10)	3.19 (1.95)	2.85 (1.83)	3.27 (1.94)	5.13 (2.37)	2.17 (1.63)	2.00 (1.60)
S.E. (+)	0.03	0.06	0.05	0.05	0.03	0.04	0.03	0.05	0.03	0.03
C.D.at 5%	NS	0.18	0.14	0.16	0.09	0.13	0.10	0.16	0.11	0.11

Figures in the parentheses are transformed $\sqrt{x+0.5}$ values

DBS = Days before spraying, DAS = Days after spraying

First spray

A day prior to the application of attractants, bee activity was ranged from 2.11 to 2.21 bees/m^2/min and did not differ significantly on various treatments.

A day after the first spray, jaggery solution 10 per cent attracted higher number of bees (4.10 bees/m^2/min) and was significantly superior compared to other treatments. Further this treatment was at par with sugar solution 10 per cent (C.Nithya, 2012) [2].

Jaggery solution 5 per cent (3.95bees/m^2/min) and sugar solution 5 per cent (3.89bees/m^2/min) were next best treatments. Least number of bees was recorded in open pollination without spray (3.13 bees/m^2/min).

On 3rd day after first spray, jaggery solution 10 per cent recorded maximum number of bees (6.43 bees/m^2/min) and found superior over all the treatment except sugar solution 10 per cent which was recorded 6.39 bees/m^2/min.

Further, jaggery solution 5 per cent, sugar solution 5 per cent, sugarcane juice 10 per and molasses 10 per cent attracted 6.28, 6.23, 5.44 and 5.68 bees/m^2/min respectively. Open pollination without spray was inferior over all the treatments as it recorded less number of bees (4.56 bees/m^2/min).

On 5th day after first spray, treatment jaggery solution 10 per cent was significantly superior to attract the maximum number of bees (6.00 bees/m^2/min) followed by jaggery solution 5 per cent and sugar solution 10 per cent with 5.91 and 5.85 bees/m^2/min, respectively. The next best treatments were sugar solution 5 per cent, sugarcane juice 10 per cent, molasses 10 per cent recorded 5.67, 4.96 and 5.21 bees/m^2/min respectively.

Open pollination without spray recorded lowest number of bees (3.97 bees/m^2/min).

On 7th day after first spray, the plots sprayed with jaggery solution 10 per cent attract the maximum number of bees (5.13 bees/m^2/min). The next best treatments were jaggery solution 5 per cent and sugar solution 10 per cent which attracted 5.10 and 4.80 bees/m^2/min. respectively. Sugarcane juice 10 per cent (4.61 bees/m^2/min) and molasses10 per cent (4.63 bees/m^2/min) were the best treatments and found significantly superior over open.

Sugarcane juice 10 per cent (4.61 bees/m^2/min) and molasses 10 per cent (4.63 bees/m^2/min) were the best treatments and found significantly superior over open pollination without spray which recorded least number of bees (3.19 bees/m^2/min).

Second spray

One day before second spray, the visitation of *A. cerana indica* was in the range of 2.85 to 4.27 bees/m^2/min.

A day after second spray treatment with jaggery solution 10 per cent (4.80 bees/m^2/min) was significantly superior over all the treatment except sugar solution 10 per cent (4.78 bees/m^2/min). Jaggery solution 5 per cent (4.77 bees/m^2/min) was the next best treatment and found at par with sugar solution 5 per cent which recorded 4.73 bees/m^2/min. Open pollination without spray found to be least efficient in attracting more number of bees (3.27 bees/m^2/min).

On 3rd day after second spray, plot treated with jaggery solution 10 per cent attracted maximum number of bees (6.15 bees/m^2/min). The next best treatment was sugar solution 10 per cent (6.10 bees/m^2/min) followed by jaggery solution 5 per cent (5.90bees/m^2/min).Rest of the treatments also found superior over open pollination without spray which recorded the least number of bees (5.13 bees/m^2/min).

Similar trend was found in 5th day after second spray, the treatment jaggery solution 10 per cent (3.91 bees/m^2/min) which was proved to be the best treatment. Sugar solution 10 per cent, jaggery solution 5 per cent and molasses 10 per cent was the next best treatment which recorded 3.67, 3.37 and 3.25 bees/m^2/min, respectively.

On 7th day after second spray, the treatment jaggery solution 10 per cent (2.67 bees/m^2/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 (2.00 bees/m^2/min).

These results were similar to the finding of Dinesh (2003) [4] who showed that spraying of jaggary solution 10 per cent attracted more number of pollinators.

4. Conclusion

In conclusion, it appears that the attractants like jaggary solution, sugar solution, sugarcane juice and molasses were effective to attract the more bees on cucumber which resulted into better pollination due to the distribution of pollen and it ultimately enhances the seed yield of cross pollinated crop like cucumber.

Amongst the various attractants jaggary solution 10 per cent and sugar solution 10 per cent were found superior to attract the maximum number of bees on crop and also recorded highest yield as compared to other treatments.

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