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Bee Attractants: Improving Pollination and Crop Yield in Coffee

JAYARAMAPPA K. V*[1], MATHAD G. V[2] and BHARGAV H. R[3]

[1-2] Department of Botany, K. L. E College, Rajajinagar, Bangalore - 560 010, Karnataka, India
[3] Department of Biological Sciences, Garden City University, Bengaluru - 560 038, Karnataka, India

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Abstract

An experimental situation was created in which coffee blooming takes place. The usage of bee attractants, Bee-Q and Fruit Boost™ in the pollination of target crop was evaluated. The bee visitations on coffee flowers were made for two weeks followed by estimation of berry yield / plant. The different concentrations of Bee-Q and Fruit boost™ was evaluated to understand the honeybee visitation pattern of target crop for improving pollination efficiency. The observations indicate that, Bee-Q at 12.5 g/l and Fruit boost at 0.75 ml/l of Coffee plots attracted higher number of bee foragers than the control plots. In addition, the plots sprayed with bee attractants enhanced the berries/plant, berry weight on coffee. The present investigation suggests that the bee attractants increase marginal percentage of bee visitation, berry/plant and berry weight on coffee.

***Key words*:** Bee-attractants, *Coffea arabica* L., *Apis florae, Apis dorsata,* Bee visitation

Coffee, the king of beverages, the genus *Coffea* is an important member of the family Rubiaceae. The pollination biology reveals that, the fragrant whitish flowers are borne in clusters in leaf axils. Usually there are five stamens attached to the corolla between the lobes and the anthers are not necessarily closer to stigma. Anthesis occurs during the early morning hours and pollen dehiscence is almost immediate. Nectar is secreted at the base of corolla; honeybees and several other insects visit coffee flowers for collecting both pollen and nectar. 2 days after opening, the floral parts begin to wither and fall, leaving the ovary intact. Lingering of the withered blossoms on a tree is an indication of non-fertilization, whereas in pollinated flower's petals fall freely and soon, eventually resulting in a good crop [1].

Coffee generally blooms during March to April. Though coffee is one of the most important commercial crops, there have been very few detailed studies on its pollination biology and the role of pollinators in fruit set [2-3]. Carvalho and Krug [4] showed that insects and wind were of equal importance in the cross pollination of coffee in Brazil. Lower [5] in Puerto Rico had indicated that bees benefit coffee and that colonies should be placed in coffee plantations. Coffee growers in East Africa kept honeybee colonies in coffee plantations [6]. Amaral [7] showed that bees increased fruit set of arabica coffee var; 'Mundo Novo' by about 82%. In more recent studies Roubik [8-9] has shown that honeybee, *Apis mellifera* improved fruit set and retention by over 50% in *Coffea arabica*.

Since from many decades the numbers of domesticated honeybee colonies in India are decreasing due to huge number of viral diseases and pests. There is a parallel interest in improving the pollinating efficacy of bees and a pollinator deficit is especially acute if neighboring crops must compete for limited pollinators [10]. Under conditions of compromised pollinator efficacy, honeybee attractants may help focus limited pollinators onto the crop of interest [11]. Of a handful of tested bee attractants [12-17], those based on queen mandibular pheromone (QMP), Fruit boost and Bee-Q based on carbohydrate rich have had the most promising research record [18-20]. Pollination potentiality on experiments were performed and treatment response increased by the use of attractants on ridge gourd [21], on guava [22], on pumpkin [23] on Niger [24], on pigeon pea [25], on ridge gourd [26], on mustard [27], on sunflower [28], and on water melon [29]. The main objective of this work is to attract more bees towards target crop by using bee attractants and to evaluate the extent of their usefulness for increasing pollination efficiency and berry/plant in coffee.

MATERIALS AND METHODS

The experiment was conducted in Coffee Research Station at Madikeri, Karnataka, India during 2018-2020. Coffee crop was raised in an area of two hectare by following suitable agricultural practices recommended by the Agriculture Department. Seven experimental plots of 5 × 5 square meter area with row spacing of 2 meters was set up in the farm. The commercially available bee attractants like Bee-Q were purchased from M.S. Excel Industries, Bombay. Fruit boost from Phero tech Inc, Delta BC Canada. We performed attraction experiments to generate treatment response curves for each pheromone component. Altogether, we tested three concentrations of Bee-Q (10, 12.5 and 15 g/l) and three concentrations of Fruit boost (0.5, 0.75 and 1.00 ml/l) and without any spray as control.

From each plant we selected 10 branches with flowers randomly (three plots per treatment) and were labeled with tags

***Correspondence to:** Jayaramappa K. V., E-mail: jai.ram185@gmail.com; Tel: +91 9945389938

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separately. The crop area was introduced with two colonies of *Apis cerana* each having eight frame populations of honeybees and also there were few natural colonies of *Apis dorsata* and *Apis florea* were found in the vicinity of experimental site. Bee attractants were sprayed on the bloom of coffee with a standard sprayer. Bee-Q was applied in the concentrations of 10, 12.5 and 15 g/l/ plot separately. Similarly, Fruit boost was applied in the concentrations of 0.5, 0.75 and 1.00 ml/l. We used different concentrations between two attractants, because the composition of the two bee attractants differs, hence we used both the attractants on different concentrations**.** However, no bee attractants were applied to the control plots (Op). These attractants were sprayed on flowers of coffee during different intervals. The number of honeybees visiting the coffee flowers sprayed with bee attractants was counted through visual observation. One observer was assigned to each plot and observations were synchronized to run between 08.00 to 16.00 hours at two hourly intervals in a day [30]. Each observer walked down each row for five minutes, recording the number of honeybee flower visits (5min x 3 replicas =15 min per plot, 7 rows x 3 replicas = 21min, 21min x 5min=105 min for all plots with two hourly intervals). A bee landing on an open flower for about 5 to 10 seconds was considered to be a 'visit'. Observations on bee visitation were recorded on first day after spray (08 March, 2018), followed by 3rd day (10 March), 5th day (12 March) after spraying the bee attractants. The first day after second spray (50 percent blooming) of attractants were sprayed on Coffee (14 March) followed by 2nd day (16 March) and 3rd day (18 March 2018) after spray. Each observer recorded by sight the number of honeybee flower visitors in respect of three species of honeybees namely, *Apis cerana, Apis florea and Apis dorsata*.

Harvest parameters

On 18th Nov 2018, the earlier tagged branches with berries were harvested from each treatment and the number of berries per branch was recorded. From these 10 berries were weighed from each replication of treatment and data were statistically analyzed.

Climatic conditions and statistical analysis

The meteorological data in respect of Temperature, Relative humidity, Wind speed and Sunlight for the experimental period was obtained from the Coffee Research Station, Meteorological center. All response variables were analyzed statistically by using SPSS version 11.0 with one way ANOVA and a DMRT (Dun cans Multiple Range Test) [31] with standard errors.

RESULTS AND DISCUSSION

First spray (10% flowering) and bee visitation

Observations pertaining to honeybee-visitation on coffee treated with bee-attractants at 10 and 50% flowering are presented in (Table 1, Fig 1). More number of bees were observed on the 1st, 3rd and 5th day after 1st spray with the treatment fruit boost 0.75 ml/l and Bee-Q 12.5 g/l.

Table 1 Bee-attractants and honeybee-visitation, showing all 7 treatments with first (10% and second (50%) spray on coffee

Treatments	Number of honeybees / 10 flowers/ 5 min						
	First Spray (10% flowering)				Second Spray (50% flowering)		
	1 DBFS	1 DAFS	3 DAFS	5 DAFS	1 DASS	3 DASS	5 DASS
T_1: Bee-Q 10 g/l	1.33 a	4.66 d	3.66 d	3.00 b	4.33 d	3.33 d	3.33 d
T_2: Bee-Q 12.5 g/l	1.00 a	6.66 b	6.33 b	6.00 a	6.00 b	5.66 b	5.66 b
T_3: Bee-Q 15 g/l	1.33 a	5.00 c	4.66 c	6.00 a	4.66 d	4.33 c	4.00 c
T_4: Fruit boot 0.5ml/l	1.33 a	5.33 c	4.33 c	3.66 b	5.00 c	4.66 c	4.33 c
T_5: Fruit boost 0.75ml/l	1.00 a	7.66 a	7.33 a	6.66 a	7.33 a	6.66 a	6.66 a
T_6: Fruit boost 1ml/l	1.33 a	5.00 c	4.33 c	4.00 b	4.66 d	4.33 c	3.66 d
T_7: Open pollination (Control)	1.00 a	2.33 f	2.33 f	1.66 c	1.33 g	2.00 e	1.33 g
F-Value	0.57	24.39	15.89	4.36	17.59	10.37	17.23
SE	0.15	0.163	0.20	0.424	0.216	0.244	0.208
CD at 5%	NS	0.480	0.590	1.250	0.637	0.719	0.613

DAFS – Day after first Spray, DASS-Day after second spray, *Significant at P<0.05, SEm± - Standard error, NS – Non significant, CD- Critical difference, Means followed by the same letter in a column do not differ significantly by DM

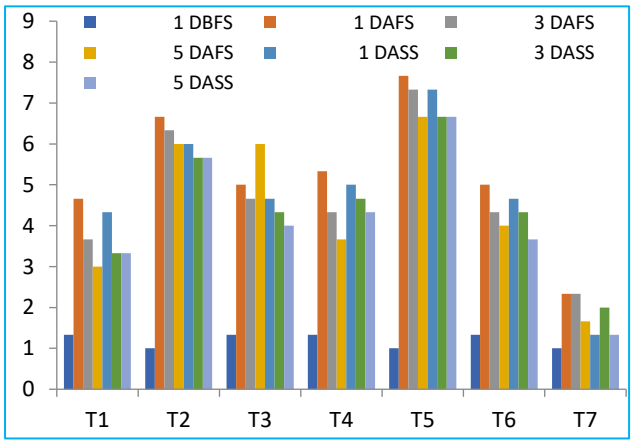

Fig 1 Bee-attractants and their effects on bee-visitation, showing all 7 treatments with first (10% and second (50%) spray on coffee

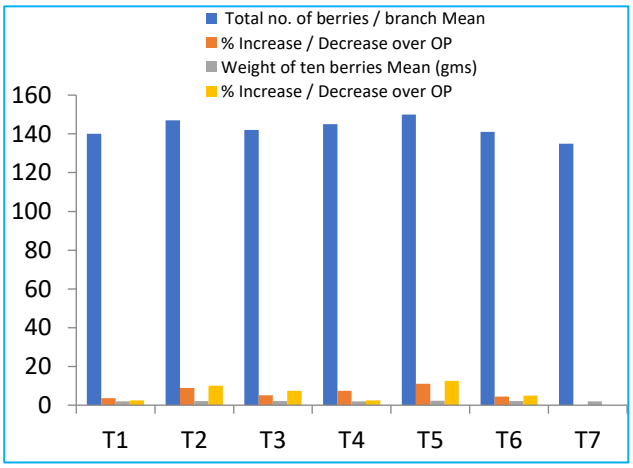

Fig 2 Effect of bee attractants on the yield parameters in coffee

Table 2 Effect of bee attractants on the yield parameters in coffee

Treatments	Total number of berries / branches mean	Percent increase / decrease over OP	Weight of ten berries mean (g)	Percent increase / decrease over OP
T_1: Bee-Q 10 g/l	140.00 c	3.70	2.05 b	2.5
T_2: Bee-Q 12.5 g/l	147.00 b	8.88	2.20 a	10
T_3: Bee-Q 15 g/l	142.00 c	5.18	2.15 b	7.5
T_4: Fruit boot 0.5ml/l	145.00 b	7.40	2.05 b	2.5
T_5: Fruit boost 0.75ml/l	150.00 a	11.11	2.25 a	12.5
T_6: Fruit boost 1ml/l	141.00 b	4.44	2.10 b	5
T_7: Open pollination (Control)	135.00 f	-	2 d	-
F-Value	20.33		28.79	
SE	1.248		0.047	
CD at 5%	3.681		0.138	

SEm± - Standard error; *Significant at P<0.05; CD- Critical difference
Means followed by the same letter in a column do not differ significantly by DMRT

Table 3 Environmental conditions (average) during seven treatments conducted on coffee

Dates	Temperature (°C)	Relative humidity (%)	Cumulative wind (Km)	Sun light (Hours)
March -08-2018	20.0	49	270	8.6
March -10-2018	29.8	58	230	5.8
March -12-2018	27.8	98	230	1.8
March -14-2018	19.2	88	90	1.9
March -16-2018	29.2	95	270	5.5
March -18-2018	29.0	95	140	7.7

Second spray (50% flowering) and bee visitation

First, 3rd and 5th day after the 2nd spray with fruit boost 0.75 ml/l and Bee-Q 12.5 g/l attracted more number of bees.

Harvest parameters

The data on the effectiveness of bee-attractants and yield parameters like total number of berries from each branch, weight of 10 berries of Coffee is given in (Table 2, Fig 2). The total number of berries / branch, and weight of ten berries were more in the plots treated with fruit boost 0.75 ml/l and Bee-Q 12.5 g/l.

Climatic conditions

The data on the climatic factors of coffee is given in (Table 3). This data showed there is temperature co-relation between the bee visitation on 08th and 14th March is favorable for frequent bee visitation on coffee.

Fruit boost 0.75 ml/l and Bee-Q 12.5 g/l were the most effective attractants in enhancing bee visitation on 1st and 2nd spray of bee attractants on target crop. Fruit boost 0.75 ml/l and Bee-Q 12.5 g/l were the effective attractants in enhancing total number of berries / branch and weight of ten berries. These results endorsed the findings of [1] who reported that in arabica coffee the percentage of fruit set in plants that were allowed bees were 62% compared to 35% in caged plots. Roubik [8-9] has shown that 82% of honeybees improved fruit set and retention by over 62% in arabica coffee.

In summary, it appears that Bee-Q 12.5 g/l was effective in increasing bee visitation in coffee. Bee-Q is a food attractant, which is rich in carbohydrate content. It has a phagostimulatory effect which attracted more bees to the flowers. It is thus evident from the present study that fruit boost 0.75 ml/l increased the bee visitation and these attractants utilized the olfactory, visual and other known instinctive behavioural responses of bees. So, the attraction of honeybees is a result of cumulative effect of interactions among honeybees, target crop and applied chemicals. Thus, the use of pheromone sprays and bee attractants shows great promise as a management tool for improving the efficiency and consistency of pollination.

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Conflict of interest

The authors have no conflict of interest.

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