

Effect of Honey Bee Pollination, Bee Attractants and Scents on Yield of Sesamum

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ABSTRACT

Sesamum is a highly cross pollinated crop, rich in oil and protein. Pollination is mostly performed by insects. Any material to increase honey bee visits to specific crop would be of great practical value to harness the benefits of cross pollination. There are very few studies on the role of bee attractants enhancing bee visitation and yield in sesame crop. Hence, the present investigations were undertaken. *Apis cerana* caged plots was best among all treatments showing significant effects. In caged condition with *A. cerana*, plants had more capsules per plant (54.00), capsule length (23.24 mm), capsule width (7.22 mm) number of seeds per capsule (54.57), test weight (3.92 g), germination (92.00 %) and vigour index (1261). Citral-a and Citral-b followed by Geraniol were the next best treatments after caged condition with *A. cerana* colony. Oil content, weight of green capsule did not differ significantly among the various treatments. We conclude that by keeping *Apis cerana* bee colonies in sesame, yield can be enhanced. Application of Citral-a, Citral-b and Geraniol is also beneficial in enhancing the yield.

Key Words: Bee Attractant; *Apis Cerana*; Citral-a; Citral-b; Geraniol; Sesamum

INTRODUCTION

Sesame (*Sesamum indicum* L.), which originated in Africa, is the most ancient oil seed plant cultivated in many parts of the world. Currently, China, India, and Myanmar (Burma) are the world's largest producers of sesame, followed by Sudan, Nigeria, Pakistan, Bangladesh, Ethiopia, Thailand, Turkey and Mexico (Desai 2004). Most of the oilseed crops are cross pollinated and hence, adequate pollination is vital for any significant increase in seed production. Sesame is cross pollinating and different insect pollinators have been reported by Yermanos (1980), Kamel (1997), Rakesh Kumar and Lenin (2000), Ashri (2007), Sarker (2004) and Pashte and Shylesha (2013a, 2013b).

Success of pollination with the help of honey bees depends on their performance on the target crop over other competing plants in the vicinity. The problem in pollination management is to attract bees to target crops and away from more attractive competing blooms (Free 1968). Also, the ability to attract bees from a compatible pollen source to the target crop would be desirable to ensure cross-pollination. Pashte and Shylesha (2013c) indicated that number of bee visits significantly influenced performance of sesame. Attractants help in enticement of pollinator on the targeted crop (Pashte and Shylesha (2013d) which resulted in improvement of yield.

Many substances have been tested as honeybee attractants, some with promising results (Ambrose et al. 1995, Jay 1986, Mayer et al. 1989, Van Praagh and Van

Der 1983, Waller 1970, MCGourty 1992, Winston and Slessor 1993, Sivaram et al. 2013). Some researchers have studied the attractiveness of honeybee pheromones, including the worker Nasanov pheromone (Mayer and Johansen 1982, Mayer et al. 1989,) and queen mandibular gland pheromone (Currie et al. 1992). Some authors have observed increased numbers of honeybees in onion and in apple crops respectively, when citral and geraniol were used (Van Der and Van Praagh 1983). Others have reported significant increases in yield following applications of an attractant; increased forager activity was also reported at pheromone-sprayed plots, but the effect lasted only 1-2 days after applications (Currie et al. 1992). Naik et al. (2005, 2007) evaluated the efficacy of pheromone and plant based indigenous attractants under experimental conditions.

Utilization of pollinators especially honey bees is considered as one of the cheapest and ecofriendly inputs in maximizing the yields of cross pollinated crops (Goswami and Khan 2014). As the use of commercial bee attractants is cost prohibitive, development of indigenous bee attractants is the best option under Indian conditions. There are very few studies on the role of bee attractants enhancing bee visitation and yield parameters in sesame crop. Hence, the present investigations were undertaken and the results are presented in this paper.

MATERIAL AND METHODS

Present studies were undertaken at the Zonal Agricultural Research Station, Gandhi Krishi Vigyan Kendra (G.K.V.K.), situated at 12° 58' N, 77° 31' E and 930 m, altitude. Sesamum crop was raised during *kharif* season of 2010 in 3×4 m plots by following the recommended package of practices. The experiment had eleven treatments and three replications laid out in Completely Randomized Block Design. The treatment details are as follows: T₁: Caged plot without pollinators, T₂: Open pollination, T₃: Plots caged with *Apis lcerana*, T₄: Open pollination treated with Citral-a (10µL L⁻¹), T₅: Open pollination treated with Citral-b (10µL L⁻¹), T₆: Open pollination treated with Geraniol (10µL L⁻¹), T₇: Open pollination treated with Vanilla flavour (200µL L⁻¹), T₈: Open pollination treated with Pineapple flavour (200µL L⁻¹), T₉: Open pollination treated with Rose water flavour (200µL L⁻¹), T₁₀: Open pollination treated with Mango flavour (200µL L⁻¹) and T₁₁: Open pollination treated with Chocolate flavour (200µL L⁻¹).

In case of open pollination, all pollinators were allowed to visit the flower. Whereas, in case of caged pollination, a colony of *A. cerana* was kept in the specific treatment plots (10 × 5 m) and the plots were covered with nylon mesh (1 mm). Whereas, in case of check, the plots were covered with nylon mesh and no pollinators were allowed to visit the flowers. In open pollination different attractants and scents were sprayed for three times to the crops at weekly interval by using hand sprayer. Samples of bee attractants *viz.*, Citral-a, Citral-b, *Geraniol* were obtained from Agharkar Research institute, Pune, Maharashtra.

Ten plants from treated plot were randomly selected for study of yield and yield attributes like Number of capsules per plant, Weight of green capsule, Capsule length and width, Number of seeds per capsule, Test weight (1000 seed weight), Oil content, Germination percentage, Shoot length, root length and seedling length and vigour index or seedling vigour. Immediately after each spray 30 flowers were tagged randomly in attractants and scents treatments and the per cent capsule set was recorded in addition with above parameters of yield. Means of these observations were calculated and later each mean was subjected to $\sqrt{x+0.5}$ transformations. The data was then subjected to ANOVA using MS-Excel programme and means were separated by DMRT (Panse and Sukhatme 1985).

RESULTS AND DISCUSSION

Impact of Different Treatments on Quantitative Yield Parameters

Significantly higher number of capsules per plant was observed in caged condition with *A. cerana* colony treatment followed by Citral-a, Citral-b and Geraniol, whereas, number of capsules per plant was least in control. The lower number of capsules per plant in control (caged) plot might be due to absence of pollinators. Similarly, Chandra Mohan (2002) and Patil (1999) recorded in sesamum that the number of capsules per plant plots treated with 18 g of Bee-Q/lit (54.41) and lowest was in untreated check (30.07). Nithya Chandran (2012) observed higher number of capsules per plant was produced in the crop that received Citral-Z, Citral-E, Fruit Boost and Sugar solution in sesamum. Weight of green capsule varied from (0.504 to 0.651 g) in different treatments, but did not differ statistically from the control (Table 1).

Table 1. Impact of different treatments on quantitative yield parameters of sesamum
(Flower basis = flowers which pollinated on the day of spray)

Treatment	Capsule set (%)	Weight of green capsule (g)	Capsule length (mm)	Capsule width (mm)	No. of seeds per capsule	Seed weight per capsule (g)	1000 seed weight (g)
Control (untreated)	52.22 ^f	0.51 ^b	18.16 ^d	5.52 ^d	36.67 ^c	0.10	2.94 ^c
Citral-a (10 μ L L ⁻¹)	96.67 ^a	0.80 ^a	22.32 ^a	6.59 ^a	52.78 ^a	0.19	3.87 ^a
Citral-b (10 μ L L ⁻¹)	84.44 ^b	0.68 ^{ab}	22.96 ^a	6.11 ^{bc}	48.84 ^c	0.18	3.89 ^a
Geraniol (10 μ L L ⁻¹)	78.89 ^c	0.67 ^{ab}	21.35 ^b	6.23 ^{ab}	50.84 ^b	0.18	3.70 ^{ab}
Vanilla Flavour (200 μ L L ⁻¹)	73.33 ^{de}	0.55 ^{ab}	19.91 ^c	5.79 ^{bcd}	44.01 ^d	0.15	3.31 ^{bc}
Pineapple Flavour (200 μ L L ⁻¹)	83.33 ^b	0.64 ^{ab}	21.25 ^b	6.02 ^{bcd}	47.46 ^c	0.16	3.57 ^{ab}
Mango Flavour (200 μ L L ⁻¹)	71.11 ^e	0.53 ^{ab}	19.23 ^c	5.66 ^{cd}	44.57 ^d	0.15	3.53 ^{ab}
Rose White Flavour(200 μ L L ⁻¹)	74.44 ^{de}	0.53 ^{ab}	20.11 ^c	5.62 ^{cd}	45.13 ^d	0.16	3.48 ^{ab}
Chocolate Flavour (200 μ L L ⁻¹)	76.00 ^{cd}	0.55 ^{ab}	20.10 ^c	5.73 ^{bcd}	43.56 ^d	0.16	3.46 ^{ab}
Mean	76.72	0.61	20.60	5.92	45.98	0.16	3.53
SEM\pm	3.77	0.02	0.30	0.07	1.00	0.01	0.08
CD@5 %	11.29	0.06	0.89	0.22	2.99	NS	0.23

Mean values followed by the same alphabet in the columns do not differ significantly by DMRT at 5% level.

Table 2. Impact of different treatments on qualitative yield parameters of sesamum.
(Flower basis = flowers which pollinated on the day of spray)

Treatment	Germination (%)	Shoot length (cm)	Root length (cm)	Seedling length (cm)	Vigour index
Control (untreated)	80.00 ^d	4.70 ^{ab}	8.04 ^{bc}	12.75 ^{bc}	1018 ^g
Citral- α (10 μ L L ⁻¹)	93.67 ^a	4.49 ^{ab}	9.86 ^a	14.35 ^a	1344 ^a
Citral- β (10 μ L L ⁻¹)	91.67 ^a	4.66 ^{ab}	8.88 ^{ab}	13.49 ^{ab}	1243 ^b
Geraniol (10 μ L L ⁻¹)	89.00 ^{ab}	4.58 ^{ab}	8.86 ^{ab}	13.44 ^{ab}	1195 ^c
Vanilla Flavour (200 μ L L ⁻¹)	84.00 ^c	3.61 ^c	8.49 ^{bc}	12.10 ^{cd}	1017 ^d
Pineapple Flavour (200 μ L L ⁻¹)	85.33 ^c	4.87 ^{ab}	8.76 ^{ab}	13.62 ^{ab}	1162 ^c
Mango Flavour (200 μ L L ⁻¹)	86.67 ^{bc}	5.14 ^a	8.38 ^{bc}	13.52 ^{ab}	1172 ^d
Rose White Flavour(200 μ L L ⁻¹)	85.33 ^c	5.10 ^a	7.89 ^{bc}	12.99 ^{bc}	1109 ^f
Chocolate Flavour (200 μ L L ⁻¹)	84.33 ^c	4.03 ^{ab}	7.51 ^c	11.54 ^d	972 ^h
Mean	86.67	4.58	8.52	13.09	1136.83
SEM\pm	2.01	0.21	0.35	0.33	30.26
CD@5 %	6.02	0.64	1.04	0.99	90.73

Mean values followed by the same alphabet in the columns do not differ significantly by DMRT at 5% level.

Maximum capsule length was observed in caged condition with *A. cerana* colony treatment which was significant followed by Citral-b, Citral-a, and Geraniol. This variation in the capsule length may be due to variation in the development of capsule in control, open pollinated, caged with *A. cerana* and plots receiving treatments of different attractants.

Capsule width was maximum in caged condition with *A. cerana* colony treatment. In other treatments capsule width varied which was significant over control and capsule length was least in control 5.193 mm. The result of number of seeds per capsule was noticed in accordance with Chandra Mohan (2002) and Patil (1999) who recorded increase in number of seeds capsule with

the bee attractant treatment over the control and open pollination.

Under caged condition with *A. cerana* colony recorded a test weight of 3.92 g (1000 seed weight) which was highly significant and this treatment was on par with Citral-a, Citral-b and Geraniol (3.85, 3.79 and 3.54 g, respectively). All the treatments showed significantly higher number of seeds over the control. The present results are in close conformity with the findings of Nithya Chandran (2012), who observed that thousand seed weight was higher in sesamum treated with Citral-Z and Fruit Boost (2.85 g to 3.02 g) and in case of niger, Citral-E, Fruit Boost, Citral-Z, *F. budrunica* and *S. densifolia* (4.64 g to 4.08 g) had greater effect in producing higher seed weight. Similar observations were recorded by Patil (1999), Chandra Mohan (2002), Rakesh Kumar and Lenin (2000), sunflower (Roy, 1997), (Mehmet et al., 2009).

Impact of Different Treatments on Qualitative Yield Parameters

Germination percentage was more in caged condition with *A. cerana* colony treatment (92.00%) followed by Citral-b (91.00%) and Citral-a (90.67%) and these three treatments were on par with each other. Geraniol (87.33%) showed significant difference over other treatments. Vanilla, Pineapple, Mango, Rose white and Chocolate flavour treatments were on par with each other but significantly differ with control (71.67%) (Table 2). Similarly, Patil (1999) recorded that per cent germination of seed was significantly higher in treatments which received Bee-here @ 4 mL (94.83%) and Bee-Q @ 12.5 g/L (91.83%) as against 70.09 percent in open pollinated and 63.00 percent in caged crop.

There was no significant difference between the mean Shoot length in all treatments apart from with Chocolate and Vanilla treatments (3.53 and 3.3 cm). In contrast with, Shoot length was significantly more in the treatment that received Bee-Q and Bee- here showing an increase over open pollinated and caged crop, respectively and root length was influenced by the attractants (Patil, 1999). But in This case we could find only Citral-b was found to increase the root length and Seedling length did not differ statistically from the control.

Results of the present investigation strengthen the earlier finding of Manjunath (2003) who reported enhancement in seedling vigour of sunflower due to increase in bee pollination with the help of attractant.

Oil content did not differ significantly among the various treatments when compared to open pollination and caged crop, indicating inefficacy of attractants, and caged with *A. cerana* treatment. Similarly not much increase was observed in oil content by (Chandra Mohan, 2002), (Patil, 1999), sunflower (Manjunath, 2003). Result of present study contradicts the earlier reports of Viratkmath and Patil, (1999) who obtained significantly higher oil content in case of sesamum in the treatments with Bee here and Bee-Q.

Impact of Different Treatments (On Flower Basis)

Significant increase in the parameter in case of flowers pollinated on the day of spraying over untreated or some increase and decrease observed may be because fluctuation in the bee visits with respective treatment. The bee visitation affects pollination effectiveness and cause changes in the yield parameter of sesamum.

Before, no one had studied on the flower basis with attractant to observe the pollination effect on the day of spray in sesamum. So, comparisons could not be made for supporting above the role of attractant in case of pollination efficacy on flower basis. In case of all the other parameters number of capsules per plant, capsule length, capsule width, number of seeds per capsule, 1000 seed weight under caged conditions with *A. cerana* was found to be effective (Table 3 and 4). This may be attributed to more bee density and also Citral-a, Citral-b and Geraniol attracted more *A. cerana*. Other treatment did not show any significant increase over control.

By considering all results, it can be concluded that by keeping *Apis cerana* bee colonies in sesamum, yield can be enhanced. Application of Citral-a, Citral-b and Geraniol was also beneficial in enhancing the yield. Increase in the yield parameters due to increase in bee visitation and successful pollination. Similarly Nithya (2012) indicated the efficiency of Citral E, Citral Z, *F. budrunica*, *S. densifolia* at par with the commercial bee attractant Fruit boost in enticing more pollinators in sesame. Plant based products are reported to attract the honey bees. Gellert et al. (1985) reported that honey bees were attracted to the lucerne plots sprayed with a crude extract of dried fruit of *evodia hupehensis*. Doull (1974) reported that Benzene extract of the pollen attracted bees. Similarly Henning et al. (1992) found that alfalfa volatile linalool attracted honey bees. Fruit boost and Bee-Q imparts significant increase in Ridge Gourd yield (Jayaramappa et al. 2011). Attractancy of the fruit boost could be attributed to the presence of queen mandibular

Table 3. Impact of different treatments on quantitative yield parameters of sesamum. (on plant basis)

Treatment	Capsule No. per plant	Weight of green capsule (g)	Capsule length (mm)	Capsule width (mm)	No. of seeds per capsule	1000 seed weight (g)
Control (caged)	27.96 ^f	0.48	17.46 ^c	5.19 ^c	30.77 ^f	2.86 ^c
Open pollination	34.37 ^e	0.50	18.47 ^{de}	5.78 ^{de}	37.20 ^e	3.18 ^{bc}
Caged with <i>A. cerana</i> colony	54.00 ^a	0.65	23.24 ^a	7.22 ^a	54.57 ^a	3.92 ^a
Citral-a (10µL L ⁻¹)	51.43 ^b	0.62	21.72 ^b	6.24 ^b	51.50 ^b	3.85 ^{ab}
Citral-b (10µL L ⁻¹)	49.33 ^{bc}	0.61	21.98 ^b	5.89 ^{bc}	50.07 ^{bc}	3.79 ^{ab}
Geraniol (10µL L ⁻¹)	47.47 ^c	0.59	21.50 ^b	5.65 ^{bc}	48.63 ^c	3.54 ^{ab}
Vanilla Flavour (200µL L ⁻¹)	34.57 ^e	0.50	18.54 ^{de}	5.68 ^{bc}	38.37 ^{de}	3.26 ^{bc}
Pineapple Flavour (200µL L ⁻¹)	40.633 ^d	0.57	20.01 ^c	5.99 ^{bc}	40.53 ^d	3.49 ^{bc}
Mango Flavour (200µL L ⁻¹)	36.73 ^e	0.51	19.19 ^{cd}	5.55 ^{bc}	38.47 ^{de}	3.33 ^{bc}
Rose White Flavour(200µL L ⁻¹)	34.73 ^e	0.52	19.26 ^{cd}	5.56 ^{bc}	36.80 ^e	3.38 ^{bc}
Chocolate Flavour (200µL L ⁻¹)	36.267 ^e	0.52	19.51 ^{cd}	5.62 ^{bc}	39.73 ^d	3.38 ^{bc}
Mean	40.68	0.55	20.08	5.85	42.42	3.45
SEM±	1.85	0.02	0.48	0.26	1.73	0.13
CD@5 %	5.45	NS	1.42	0.76	5.10	0.39

Mean values followed by the same alphabet in the columns do not differ significantly by DMRT at 5% level.

Table 4. Impact of different treatments on qualitative yield parameters of sesamum. (on plant basis)

Treatment	Germination (%)	Shoot length (cm)	Root length (cm)	Seedling length (cm)	Vigour index	Oil content (%)
Control (caged)	71.67 ^e	4.52 ^a	6.29 ^c	10.80	773 ^k	49.77 ^{ab}
Open pollination	81.33 ^d	4.90 ^a	6.24 ^c	11.14	907 ⁱ	49.63 ^{ab}
Caged with <i>A. cerana</i> colony	92.00 ^a	5.07 ^a	8.63 ^{ab}	13.70	1261 ^a	49.90 ^{ab}
Citral-a (10µL L ⁻¹)	90.67 ^a	4.88 ^a	8.69 ^{ab}	13.57	1231 ^c	50.50 ^a
Citral-b (10µL L ⁻¹)	91.00 ^a	4.85 ^a	8.97 ^a	13.82	1258 ^b	50.23 ^{ab}
Geraniol (10µL L ⁻¹)	87.33 ^b	4.78 ^a	8.57 ^{ab}	13.35	1167 ^d	50.13 ^{ab}
Vanilla Flavour (200µL L ⁻¹)	81.67 ^d	3.53 ^b	7.56 ^b	11.08	905 ^j	49.9 ^{ab}
Pineapple Flavour (200µL L ⁻¹)	84.67 ^c	4.87 ^a	8.02 ^{ab}	12.89	1090 ^c	49.6 ^{ab}
Mango Flavour (200µL L ⁻¹)	82.00 ^d	5.19 ^a	8.03 ^{ab}	13.23	1085 ^f	49.33 ^b
Rose White Flavour(200µL L ⁻¹)	83.33 ^{cd}	5.00 ^a	7.89 ^{ab}	12.89	1074 ^g	49.37 ^b
Chocolate Flavour (200µL L ⁻¹)	83.00 ^{cd}	3.30 ^b	7.67 ^{ab}	10.98	910 ^h	50.50 ^a
Mean	84.42	4.63	7.87	12.49	1060.01	49.90
SEM±	2.08	0.13	0.47	51.40	0.53	0.24
CD@5 %	6.14	0.39	1.39	NS	1.56	0.72

Mean values followed by the same alphabet in the columns do not differ significantly by DMRT at 5

gland pheromone (QMP) that stimulates the foraging activity of workers (Winston and Slessor, 1993). Honey bees stayed significantly longer time and visited more flowers in queen mandibular pheromone sprayed blueberry and cranberry plots as reported by Higo et al. (1995). Similarly the efficacy of Citral E and Citral Z

was due to the pheromone content. Viraktamath and Patil (1999) and Mahmoud (2012) reported that insect pollination enhance yield of sesame. Present results also endorse that indigenous plant based attractants are the alternate options to the commercial bee attractants.

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