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Influence of bee attractants on foraging activities of honey bees in sunflower

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Abstract
The present investigation was conducted to find out the influence of bee attractants on foraging activity of honey bee in sunflower. The research work was carried out on field of Division of Entomology RCSM College of Agriculture, Kolhapur during summer season 2023. The results obtained are summarized below.

In present study, ten species of pollen and nectar feeders were visited on sunflower during the flowering period, of which seven species were recorded from Hymenoptera, two from Lepidoptera and one from Diptera. Relative abundance of different honey bee species at 10% flowering of sunflower revealed that the maximum number of *Apis cerena indica* was recorded (38.53%) followed by *A. dorsata* (21.64%), *A. florae* (17.39%), *A. mellifera* (12.95%). The maximum bees foraging activity at 50% flowering stage was recorded in the plots treated with jaggery solution 10% and followed by lemongrass oil 1%, lemongrass oil 0.5%, sugar solution 5% and jaggery solution 5% from 1st day after spraying to 7th day after spraying. The normal bee visits were recorded in the plots treated with cumin oil 1%, cumin oil 0.5%, orange oil 1% and orange oil 0.5% from 1st day after spraying to 7th day after spraying. The maximum bees foraging activity was recorded in the plots treated with the jaggery solution 10%. The minimum bees foraging activity was in recorded in Open pollination (Water).

Keywords: Sunflower, honey bees, bee attractants, Jaggery solution 10%, lemongrass oil 1%, pollination without insect, open pollination

Introduction
The sunflower (*Helianthus annus* L.) belongs to the Asteraceae family. Sunflower is a major oil seed crop in India, with both home and commercial applications. It is also known as 'Surajmukhi'. The world's sunflower acreage was 28.74 mh, with 50.70 mt production and a productivity of 2090 kg/ha. In India, total sunflower growing area was 0.28 mh, with 0.25 mt production and 905 kg/ha productivity. The total area of sunflower farming in Maharashtra was 0.03 mh, with a production of 0.01 mt and a productivity of 531 kg/ha (Anon, 2022) [1]. The use of bees in crop production is essential for increasing crop quality and quantity (Pashte and Said, 2015) [11]. Honey bees are among the most crucial and well-known pollinators because of their capacity to transport pollen and their role in the efficient pollination process due to a number of distinctive qualities including body size, hairiness, floral fidelity, and manageable numbers. Sunflower is cross-pollinated crop so, it is essential for bee pollinators to pollinate sunflowers (Goswami, *et al*., 2013; Krishna *et al*., 2014) [3, 5]. Because it produces such a great amount of nectar and pollen incentives for bees, even sunflower attracts a significant number of pollinators. Honey bee pollination boosts sunflower crop yields both qualitatively and quantitatively, according to numerous research. *Apis cerena indica*, a native Asian honey bee that is often referred to as the Indian honey bee, is extensively distributed and has adapted in India. Seasonal management, caring for, and handling techniques for these particular bees are straight forward. Modern agro-ecosystems include various additional bee pollinators in addition to domesticated bees, which are crucial to crop productivity.

According to Jadhav *et al*., (2011) [4], insects played a significant role in pollinating sunflowers and increasing their yield. They also studied the relative abundance of insects that visited sunflower capitula, finding that *Apis* sp. made up 88.85% of all visitors.

This revealed that hymenopterans dominated other types of pollinators for sunflowers. Bee attractant is any material which is used to entice the bee pollinators to the target crop ensuring optimum pollination and productivity. By using these attractants, pollination of the target crop can be achieved at critical time. It can save a crop threatened by poor weather conditions or having less resource in terms of nectar and pollen. In many cases the initial attractant will establish foraging patterns that continue the pollination process.

Bee attractants can be broadly divided into three groups: food-based, pheromone-based, and plant-based. Glucose, maltose, sucrose, lactose, protein, fat, minerals, vitamins, gluconic acid, and other sugars are the key ingredients in food-based attractants. Bee-Line, Bee Lure, Bee-Q, and other commercial items are a few examples. Nasonov gland pheromone (Such as Bee-here, Pollinus, Bee-Scent, etc.) and queen mandibular pheromone are additional divisions of pheromone-based attractants (Fruit boost and Bee boost). Although plant-based pheromones have produced some intriguing outcomes in laboratory research, their evaluation in the field has not yet been completed. Bee-Q and Fruit boost have been shown in studies by Viraktamath and Patil (2002) [15] to improve the yield metrics of sunflower. Field scale evaluation of Bee-Q and Fruit boost in sunflower has been made by Manjunatha (2003) with encouraging results. Potential benefits of the indigenous attractants in increasing yield in an eco-friendly way needs to be transferred to large Indian farming community.

Presently, all the commercial bee attractants *viz*. Bee-Q, Bee-scent, Bee-scent plus, Bee-here, Beeline, Fruit boost, Bee boost, Pollenaid, Bee lure, Pollinus, Api-fix are produced in the countries like France, USA and Canada. However, the Indian companies are involved in importing and marketing some of these, which makes the bee attractants, cost prohibited. Hence, there is a need to develop indigenous bee attractants so that use of attractants could become economically viable.

Materials and Methods

The experiment was conducted in summer season 2022-23 at the farm of Division of Agricultural Entomology Rajarshee Chhatrapati Shahu Maharaj College of Agriculture, Kolhapur and Kolhapur is situated at 16^{o} 41' North Latitude and 74^{0} 14' East Longitude and at an altitude of 545.6 m above the mean sea level (MSL) and has tropical climate. The place lying in Western Ghat Mountain zone (Zone -9), receives an annual rainfall of about 1100-1190 mm with hot and dry summer with cool winter. The field selected for the experiment was uniform with medium laterite soil with medium fertility and good drainage. The experimental field was prepared by deep ploughing once followed by two harrowing. Then field was subsequently cleaned by picking stubbles of previous crops and ridges and furrow made with the help tractor. The seeds were sown by dibbling method in the field. The variety Kaveri champ was used for sowing. Seeds were sown on 31. 01. 2023 at the spacing of 60 cm x 30 cm.

Experimental details

Season	Summer- 2023
Crop	Sunflower
Insect	Honey bee (*Apis cerana indica*)
Variety	Kaveri Champ
Spacing	60×30 cm
Seed rate	6 kg/ha
Plot size	6×4 m
Design	Randomized Block Design
Treatment	11
Replication	3

Treatment Details

Treatment no.	Treatment	Dose/L
T_1	Jaggery solution 5%	50 gm
T_2	Jaggery solution 10%	100 gm
T_3	Lemongrass oil 0.5%	5 ml
T_4	Lemongrass oil 1%	10 ml
T_5	Cumin oil 0.5%	5 ml
T_6	Cumin oil 1%	10 ml
T_7	Orange oil 0.5%	5 ml
T_8	Orange oil 1%	10 ml
T_9	Sugar solution 5%	50 gm
T_{10}	Pollination without insect	Nylon net
T_{11}	Open pollination	water

Methodology

Rearing of honey bee

Colonies were brought by beekeepers of The Madhumrut Agro Company, Kaneri Math, Tal - Karveer, Dist. – Kolhapur. Honey bees (*Apis cerana indica*) were reared in langstroth boxes of size 46.5x36.5x23.8 cm at the experimental farm. Healthy honey bee colonies were maintained with regular monitoring and necessary treatment.

To study the influence of bee attractants on foraging activities of honey bee in sunflower

Relative abundance of pollinators

Insect pollinators visiting sunflower were counted throughout the day at the time of 10% blooming period of the crop. Relative abundance of dominating species of pollinator was worked out by using the following formula and expressed in percentage (Manisha, Zameeroddin and H Khader Khan, 2020) [8].

$$\text{Relative abundance} = \frac{\text{Number of individuals visiting flower}}{\text{Total number of pollinators counted}} \text{x} 100$$

To study the influence of bee attractants on activities of honey bee in sunflower

The experiment was conducted on sunflower crop with the foliar treatment of attractants. Sunflower crop (Var. Kaveri Champ) was grown at spacing of 60 x 30 cm in the plot (6 x 4 m) by following recommended agronomic practices. The experiment was laid out in RBD with three replications. One-meter distance was maintained between the replication. For the studies, the blooming (50% flowering) sunflower crop (Var. Kaveri champ) was sprayed with the recommended dose of attractants with three replications. The control plot was

sprayed with water only. Nylon mosquito nets having 6 m^3 size (Mesh 20 micron) was erected over the plots by using the bamboo sticks for treatment number T_{10}. In the plots under pollination without insect treatments, pollinating insects were not allowed to enter inside the net.

Foraging activity of bees were observed on sunflower during peak activity period (0800 hr, 1000hr, 1500 hr and 1700 hr) and expressed as mean number of bees visited per five flowers per 5 min. The observations were taken one DBS and 1, 3, 5, 7 days after spray of attractants. The values after square root transformation were subjected to ANOVA (Analysis of Variance) (Panse and Sukhatme, 1954) [16]. (DBS- Day before spray, DAS – Day after spray).

Results and Discussions

Pollinator fauna of sunflower

The finding of the present study revealed that, ten species of pollen and nectar feeders were visited on Sunflower during flowering period and they belonged to three insect orders *viz*., Hymenoptera, Diptera and Lepidoptera of which seven species were recorded from Hymenoptera (*Apis cerana indica*, *Apis dorsata*, *Apis florae*, *Apis mellifera*, *Xylocopa violacea*, *Scolia* sp, *Ropalidia* sp), one from diptera (*Eristalis* sp) and two from Lepidoptera (*Pieris* sp and *Papilio demoleus* L.) (Table no.3). Among the seven hymenopteran species recorded, five species belong to family Apidae, one species belongs to Scollidae family and one species belongs to Vespidae family. Order Lepidoptera was represented by two species, one species under family Pieridae and another species under family Papilionidae and order Diptera was represented by one species under family Syrphidae. However, these findings are in conformity with the findings of Jadhav *et al*. (2011) [4], Goswami *et al*. (2013) [3], Ali *et al*. (2015) [2] and Manisha *et al.* (2020) [8] who documented Hymenopteran species were the most dominant visitors to sunflower crop.

Table 1: List of pollinators recorded on sunflower during flowering periods

Sr. No.	Scientific name	Systematic position	
		Family	Order
1	*Apis cerana indica*	Apidae	Hymenoptera
2	*Apis dorsata*	Apidae	Hymenoptera
3	*Apis florae*	Apidae	Hymenoptera
4	*Apis mellifera*	Apidae	Hymenoptera
5	*Xylocopa violacea*	Apidae	Hymenoptera
6	*Scolia* sp	Scollidae	Hymenoptera
7	*Ropalidia* sp	Vespidae	Hymenoptera
8	*Pieris* sp	Pieridae	Lepidoptera
9	*Papilio demoleus* L.	Papilionidae	Lepidoptera
10	*Eristalis* sp.	Syrphidae	Diptera

Relative abundance of pollinators

The relative abundance of pollinators is presented in Table 4 and Fig 3. The observation was made on the relative abundance at 10% flowering of sunflower by selecting five plants randomly observed for the pollinator's visitation for a time period of five minutes at different hours of the day and record abundance of different honey bee species and other pollinating agents. The data revealed that the highest abundance of *A. cerana indica* was found (38.53%) followed by *Apis dorsata* (21.64%), *Apis florea* (17.39%), *Apis mellifera* (12.95%) and other pollinating agent (9.49%). In general, the diversity and abundance of pollinating insects varies from region to region and locality to locality. However, these findings are in conformity with the findings of Jadhav *et al.* (2011) [4], Ali *et al*. (2015) [2] and Raghavendra *et al.* (2018) [12] who documented *Apis* sp. were major insect pollinators on sunflower capitula.

Table 2: Relative abundance of different species of honey bees and pollinating agents

Sr. No.	Name of pollinators	Per cent relative abundance
1	Honey bee	90.51
	A. cerana indica	38.53
	A. dorsata	21.64
	A. florea	17.39
	A. mellifera	12.95
2	Others	9.49

To study influence of bee attractants on activities of honey bee in sunflower

Influence of bee attractants on activities of honey bee in sunflower on day before spraying

The population of *A. cerana indica* species visiting sunflower before spraying of attractants are presented in Table 5 and Fig. 4. The data indicated that the bee population before spraying was at par with other except the treatment pollination without insect which recorded 0.00 bees/5 flowers/5 minutes. One day before spraying at 0800 hrs the activity of bees was similar ranged from 5.00 to 6.67 bees/5 flowers/5 minutes.

At 1000hr the visits were recorded ranged from 7.33 to 8.67 bees /5 flower/5 minutes. At 1500 hrs the visits of bees ranged from 5.33 to 7.00 bees/5 flowers/5 minutes. At 0800 hrs and 1500 hrs the activity of honey bees was less in all treatment due to the effect of temperature and humidity. At 1700 hrs the highest visits of Indian bees were recorded ranged from 9.00 to 10.67 bees/five flowers/5 min. At 1000 hrs and 1700 hrs the highest activity was seen all treatment ranged from 7.33 to 10.67 bees /5 flowers/5 minutes.

Influence of bee attractants on activities of honey bee in sunflower 1st day after spraying

Influence of bee attractants spraying on sunflower and observed the bees activity and narrated in Table 6 and Fig 5. On 1st DAS at 0800 hours, the jaggery solution 10% attracted the highest number of bee visits (12.00 bees/five flowers/5 min). This result was significantly better in attracting the bees compared to the cumin oil 0.5%, cumin oil 1%, orange oil 0.5%, orange oil 1% and open pollination. At 1000 hrs, the highest number of bee visits were observed in the jaggery solution 10% (13.00 bees/five flowers/5 minute) was significantly superior over all treatments except lemongrass 1%, lemongrass 0.5%, sugar solution 5% and jaggery solution 5%. At 1500 hrs, the highest number of bee visits were observed in the jaggery solution 10% (11.33 bees/five flowers/5 minute). This result was significantly better in attracting the bees over other treatments. At 1700 hrs, the highest number of bee visits were recorded in jaggery solution 10% (14.33 bees/five flowers/5 minute). Interestingly, the jaggery solution 10% was found at par with lemongrass oil concentrations of 1% and 0.5%, as well as sugar solution 5% and jaggery solution 5%.

Influence of bee attractants on activities of honey bee in sunflower 3rd day after spraying

Influence of bee attractants spraying on sunflower and the observed the bees activity and presented in Table 7 and Figure 6. On 3rd DAS at 0800 hours, the jaggery solution 10% exhibited the highest bee visits, with a recorded (11.00 bees/five flowers/five minutes). At 1000 hours, highest bee

visits were recorded in jaggery solution 10% (12.00 bees/ five flowers/5 minute) was significantly superior over the rest of the treatments except lemongrass oil 1%, lemongrass oil 0.5%, sugar solution 5%, and jaggery solution 5%. At 1500 hrs, the highest number of bee visits occurred specifically in the jaggery solution 10% (10.33 bees/five flowers/5 minute). This result in attracting the bees was significantly superior over all the treatments. At 1700 hrs, the jaggery solution 10% showed the highest bee visits with a remarkable count (13.00 bees/five flowers/5 minute). This was found to be significantly more effective in attracting the bees compared to the cumin oil 0.5%, cumin oil 1%, orange oil 0.5%, orange oil 1% and open pollination.

Influence of bee attractants on activities of honey bee in sunflower 5th day after spraying

Influence of bee attractants spraying on sunflower and observed the bees activity and narrated in Table 8 and Figure 7. On 5th DAS at 0800 hrs, the highest bee visits were observed in jaggery solution 10% (9.33 bees/five flowers/5 minute). This particular solution exhibited significant superiority in attracting the bees compared to cumin oil 0.5%, cumin oil 1%, orange oil 0.5%, orange oil 1% and open pollination. At 1000 hrs, the jaggery solution 10% showed the highest bee visits with an average (11.33 bees/five flowers/5 minute). At 1500 hrs, the highest bee visits were recorded in jaggery solution 10% (9.67 bees /five flowers/5 minutes). This result was significantly superior over the cumin oil 0.5%, cumin oil 1%, orange oil 0.5%, orange oil 1% and open pollination in attracting the bees. At 1700 hrs, the highest number of bee visits were recorded in the jaggery solution 10% (12.33 bees/five flowers/five minutes). This result was significantly more effective in attracting the bees compared to cumin oil 0.5%, cumin oil 1%, orange oil 0.5%, orange oil 1%, open pollination.

Influence of bee attractants on activities of honey bee in sunflower on 7th day after spraying

Influence of bee attractants spraying on sunflower and recorded the bees activity and presented in Table 9 and Figure 8. It is seen from table 9, on 7th DAS at 0800 hrs, the highest bee visits were recorded in jaggery solution 10% (8.33 bees/five flowers/5 minute). At 1000 hrs, the jaggery solution 10% exhibited the highest bee visits, which recorded (10.33 bees/five flowers/5 minute). This result was significantly superior over rest of the treatments except lemongrass oil 1%, lemongrass oil 0.5%, sugar solution 5%, and jaggery solution 5% in attracting the bees. At 1500 hrs, it was observed that the highest number of bee visits occurred in the jaggery solution 10% (8.00 bees/five flowers/5 minute). This particular treatment showed a significant superiority in attracting the bees compared to the cumin oil 0.5%, cumin oil 1%, orange oil 0.5%, orange oil 1% and open pollination. At 1700 hrs, the jaggery solution 10% showed the highest bee visits, which recorded (11.33 bees/five flowers/5 minute). This result was significantly better in attracting the bees compared to all the treatments.

The observations were made on the foraging activity of Indian bee on sunflower from the DBS to 7 DAS the results were recorded during the observation periods bee attractants was significantly attracts the bees. According to the data analysis, the number of bees attracted/ 5 flowers/ 5 min varied significantly with different bee attractants at 1, 3, 5 and 7 days after the spray. Among the bee attractants plots treated with jaggery solution 10% most successful and superior treatment in attracting more bees and the least successful treatment was open pollination with water spray. However, no significance difference was recorded in treatments with lemongrass oil 1%, lemongrass oil 0.5%, sugar solution 5% and jaggery solution 5% in attracting the bees. Interestingly, plots treated with orange oil 1%, orange oil 0.5%, cumin oil 1% and cumin oil 0.5% attracts the bees higher than open pollination with water spray. The present findings of spraying of bee attractants are useful for attracting the bees are in conformity with findings of earlier workers Manchare *et al*., 2019 [7], More *et al*., 2020 [10], Naik *et al*., 2019 [17], Wankhede *et al*., 2019 [14], Manhare and Painkra 2018 [9], and Kulakarni *et al*., 2017 [6].

Table 3: Influence of bee attractants on activities of honey bee in sunflower on day before spraying

Tr. No.	Treatment	No. of bees /five flowers/5 min.			
		0800 hrs	1000 hrs	1500 hrs	1700 hrs
T_1	Jaggery Solution 5%	6.67 (2.67)	7.33 (2.79)	7.00 (2.72)	9.00 (3.07)
T_2	Jaggery Solution 10%	5.67 (2.46)	8.00 (2.90)	6.00 (2.53)	10.33 (3.28)
T_3	Lemongrass Oil 0.5%	6.00 (2.53)	7.67 (2.85)	6.67 (2.67)	9.67 (3.17)
T_4	Lemongrass Oil 1%	6.67 (2.67)	8.67 (3.00)	7.00 (2.73)	9.33 (3.13)
T_5	Cumin Oil 0.5%	5.33 (2.38)	8.33 (2.96)	5.67 (2.46)	10.00 (3.23)
T_6	Cumin Oil 1%	6.33 (2.61)	7.67 (2.85)	6.67 (2.66)	10.67 (3.33)
T_7	Orange Oil 0.5%	6.00 (2.53)	8.00 (2.89)	6.33 (2.59)	9.67 (3.18)
T_8	Orange Oil 1%	5.67 (2.48)	8.33 (2.96)	5.67 (2.43)	10.33 (3.29)
T_9	Sugar Solution 5%	5.33 (2.38)	7.67 (2.84)	6.00 (2.54)	10.00 (3.23)
T_{10}	Pollination without insect	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_{11}	Open Pollination (Water)	5.00 (2.32)	8.67 (3.00)	5.33 (2.40)	9.33 (3.12)
	SE±	0.164	0.168	0.153	0.177
	CD@5%	0.49	0.50	0.45	0.52
	CV%	12.21	10.81	11.07	10.32

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

Table 4: Influence of bee attractants on activities of honey bee in sunflower on 1st day after spraying

Tr. No.	Treatment	No. of bees /five flowers/5 min.			
		0800 hrs	1000 hrs	1500 hrs	1700 hrs
T_1	Jaggery Solution 5%	9.33 (3.12)	11.00 (3.38)	9.00 (3.34)	11.33 (3.42)
T_2	Jaggery Solution 10%	12.00 (3.53)	13.00 (3.67)	11.33 (3.44)	14.33 (3.84)
T_3	Lemongrass Oil 0.5%	11.00 (3.39)	12.00 (3.52)	10.33 (3.29)	12.33 (3.58)
T_4	Lemongrass Oil 1%	11.33 (3.43)	12.33 (3.58)	10.67 (3.34)	13.33 (3.72)
T_5	Cumin Oil 0.5%	7.67 (2.86)	8.67 (3.02)	7.00 (2.73)	9.67 (3.19)
T_6	Cumin Oil 1%	8.67 (3.02)	9.67 (3.18)	7.33 (2.79)	10.33 (3.28)
T_7	Orange Oil 0.5%	8.33 (2.97)	9.00 (3.07)	6.67 (2.67)	10.00 (3.20)
T_8	Orange Oil 1%	8.67 (3.02)	10.33 (3.22)	7.67 (2.85)	10.67 (3.32)
T_9	Sugar Solution 5%	10.00 (3.19)	11.33 (3.43)	9.67 (3.19)	11.67 (3.48)
T_{10}	Pollination without insect	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_{11}	Open Pollination (Water)	7.33 (2.78)	8.33 (2.96)	7.00 (2.73)	9.00 (3.06)
	SE±	0.165	0.149	0.184	0.172
	CD@5%	0.49	0.44	0.54	0.51
	CV%	9.87	8.42	11.41	9.41

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

Table 5: Influence of bee attractants on activities of honey bee in sunflower on 3rd day after spraying

Tr. No.	Treatment	No. of bees /five flowers/5 min.			
		0800 hrs	1000 hrs	1500 hrs	1700 hrs
T_1	Jaggery Solution 5%	8.33 (2.97)	9.33 (3.12)	8.33 (2.96)	10.00 (3.23)
T_2	Jaggery Solution 10%	11.00 (3.37)	12.00 (3.53)	10.33 (3.28)	13.00 (3.66)
T_3	Lemongrass Oil 0.5%	9.33 (3.13)	11.00 (3.38)	9.00 (3.08)	11.33 (3.42)
T_4	Lemongrass Oil 1%	10.00 (3.24)	11.33 (3.44)	9.33 (3.13)	12.33 (3.58)
T_5	Cumin Oil 0.5%	6.67 (2.67)	7.67 (2.84)	6.33 (2.60)	8.67 (3.01)
T_6	Cumin Oil 1%	7.33 (2.78)	8.33 (2.96)	7.67 (2.85)	9.00 (3.06)
T_7	Orange Oil 0.5%	7.00 (2.73)	8.00 (2.90)	7.33 (2.79)	9.33 (3.13)
T_8	Orange Oil 1%	7.67 (2.84)	9.00 (3.08)	8.00 (2.90)	9.67 (3.19)
T_9	Sugar Solution 5%	9.00 (3.07)	10.00 (3.23)	8.67 (3.02)	10.67 (3.33)
T_{10}	Pollination without insect	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_{11}	Open Pollination (Water)	6.33 (2.58)	7.33 (2.79)	6.00 (2.53)	8.33 (2.94)
	SE±	0.161	0.150	0.129	0.149
	CD@5%	0.48	0.44	0.38	0.43
	CV%	10.21	8.93	8.28	8.52

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

Table 6: Influence of bee attractants on activities of honey bee in sunflower on 5th day after spraying

Tr. No.	Treatment	No. of bees /five flowers/5 min.			
		0800 hrs	1000 hrs	1500 hrs	1700 hrs
T_1	Jaggery Solution 5%	7.67 (2.86)	9.00 (3.06)	8.00 (2.90)	10.00 (3.24)
T_2	Jaggery Solution 10%	9.33 (3.12)	11.33 (3.44)	9.67 (3.19)	12.33 (3.58)
T_3	Lemongrass Oil 0.5%	8.00 (2.90)	10.00 (3.22)	8.33 (2.96)	10.67 (3.34)
T_4	Lemongrass Oil 1%	8.33 (2.96)	10.67 (3.34)	8.67 (3.03)	11.33 (3.44)
T_5	Cumin Oil 0.5%	5.67 (2.47)	7.00 (2.72)	6.00 (2.54)	8.33 (2.96)
T_6	Cumin Oil 1%	7.00 (2.60)	7.67 (2.85)	6.67 (2.66)	9.00 (3.06)
T_7	Orange Oil 0.5%	6.67 (2.67)	7.33 (2.79)	6.33 (2.60)	8.67 (3.01)
T_8	Orange Oil 1%	7.33 (2.76)	8.00 (2.89)	7.00 (2.72)	9.67 (3.16)
T_9	Sugar Solution 5%	8.00 (2.90)	9.33 (3.11)	7.67 (2.85)	10.33 (3.29)
T_{10}	Pollination without insect	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_{11}	Open Pollination (Water)	6.00 (2.54)	6.67 (2.66)	5.33 (2.40)	7.33 (2.77)
	SE±	0.121	0.151	0.135	0.138
	CD@5%	0.35	0.45	0.40	0.41
	CV%	8.03	9.35	9.04	8.10

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

Table 7: Influence of bee attractants on activities of honey bee in sunflower on 7th day after spraying

Tr. No.	Treatment	No. of bees /five flowers/5 min.			
		0800 hrs	1000 hrs	1500 hrs	1700 hrs
T_1	Jaggery Solution 5%	7.00 (2.73)	7.33 (2.78)	6.00 (2.54)	9.00 (3.07)
T_2	Jaggery Solution 10%	8.33 (2.97)	10.33 (3.29)	8.00 (2.90)	11.33 (3.43)
T_3	Lemongrass Oil 0.5%	7.33 (2.78)	8.33 (2.97)	6.67 (2.68)	10.00 (3.23)
T_4	Lemongrass Oil 1%	7.67 (2.84)	9.67 (3.19)	7.00 (2.73)	10.67 (3.33)
T_5	Cumin Oil 0.5%	5.00 (2.30)	5.67 (2.45)	4.50 (2.23)	6.67 (2.66)
T_6	Cumin Oil 1%	6.00 (2.54)	6.33 (2.58)	5.67 (2.46)	7.67 (2.85)
T_7	Orange Oil 0.5%	5.67 (2.48)	6.00 (2.54)	5.00 (2.32)	7.00 (2.73)
T_8	Orange Oil 1%	6.33 (2.57)	6.67 (2.67)	6.00 (2.54)	8.33 (2.97)
T_9	Sugar Solution 5%	7.00 (2.73)	8.00 (2.90)	6.33 (2.60)	9.33 (3.12)
T_{10}	Pollination without insect	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_{11}	Open Pollination (Water)	4.33 (2.20)	5.00 (2.32)	4.00 (2.11)	6.00 (2.54)
	SE±	0.133	0.191	0.112	0.145
	CD@5%	0.39	0.57	0.33	0.43
	CV%	9.45	12.89	8.30	9.01

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

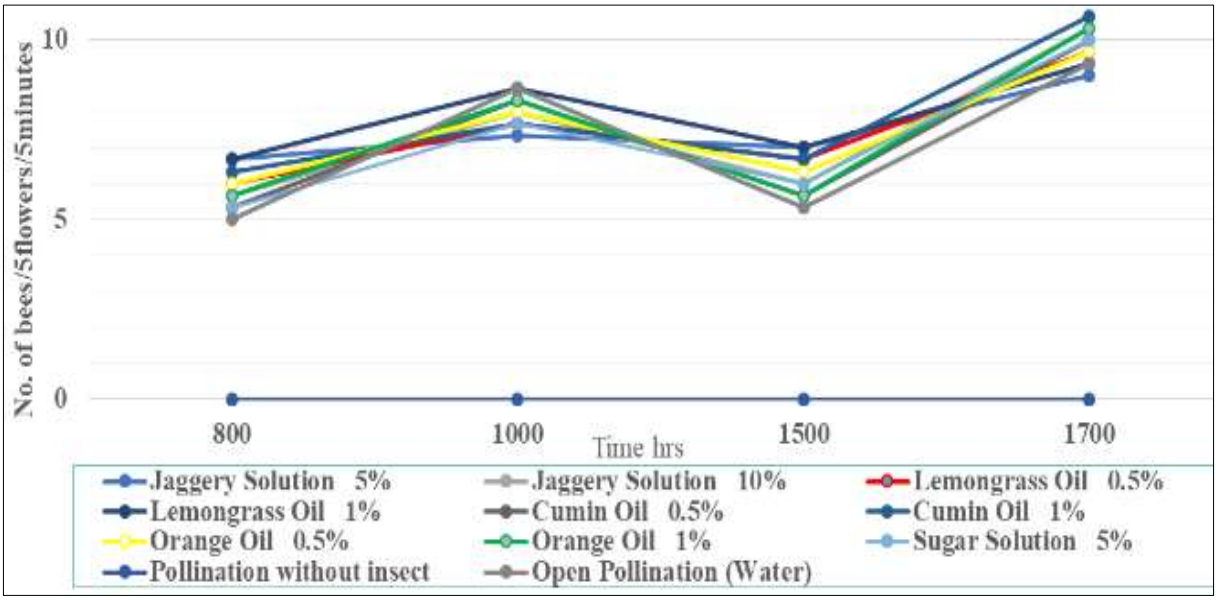

Fig 1: Influence of bee attractants on activities of honey bee on sunflower on day before spraying

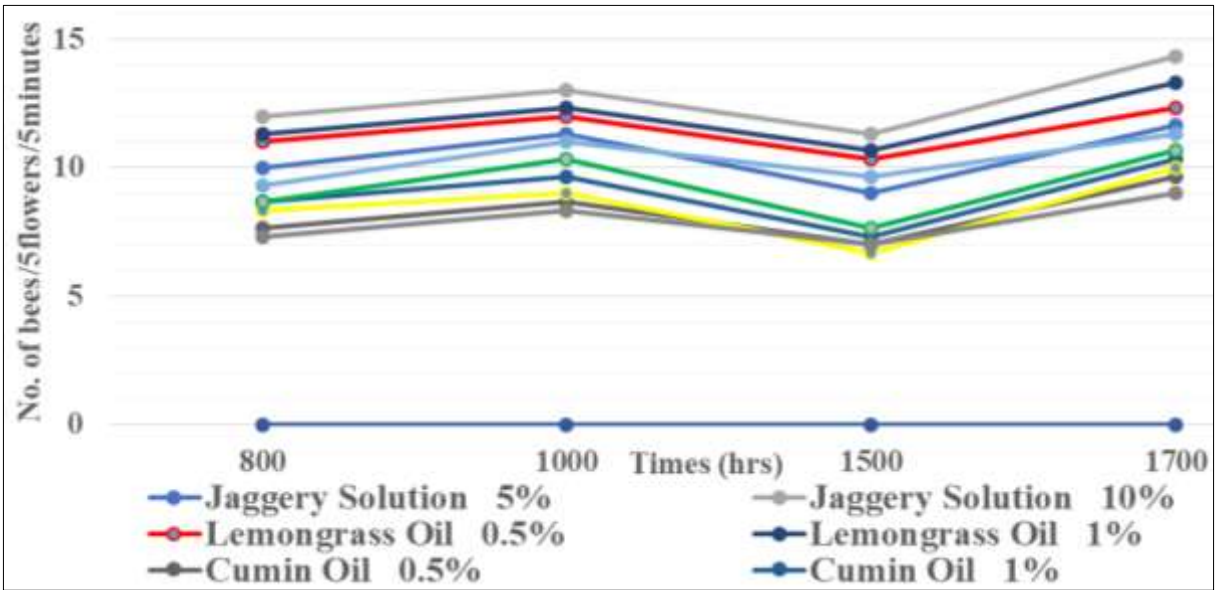

Fig 2: Influence of bee attractants on activities of honey bee on sunflower on 1st day after spraying

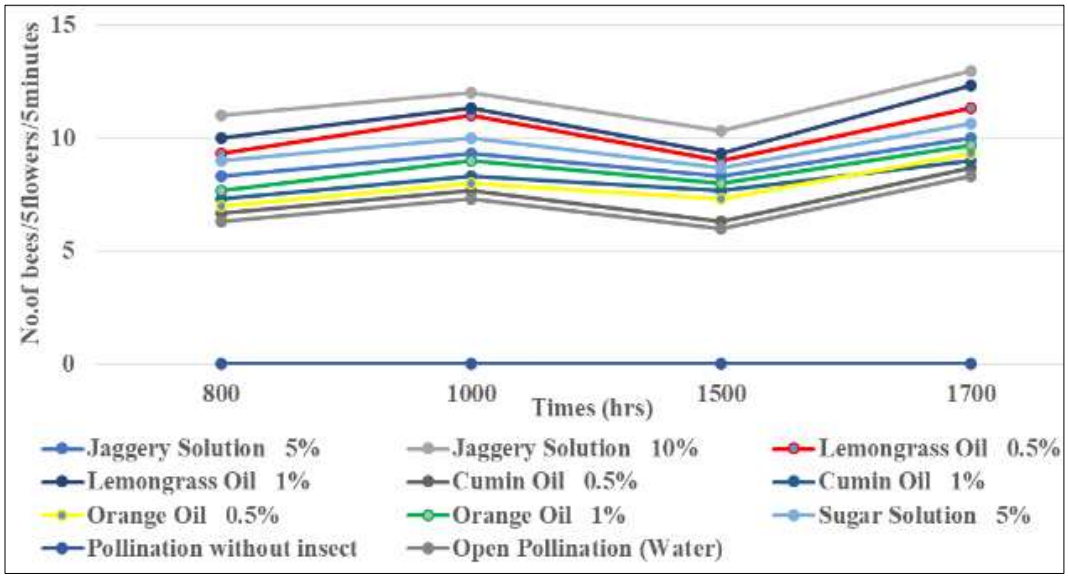

Fig 3: Influence of bee attractants on activities of honey bee on sunflower on 3rd day after spraying

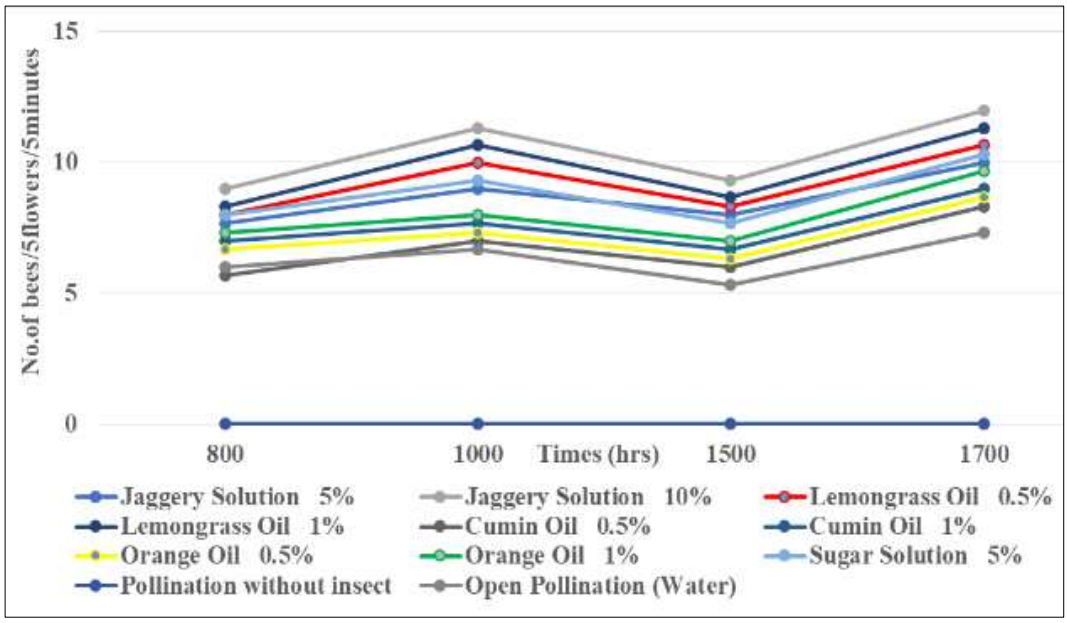

Fig 4: Influence of bee attractants on activities of honey bee on sunflower on 5th day after spraying

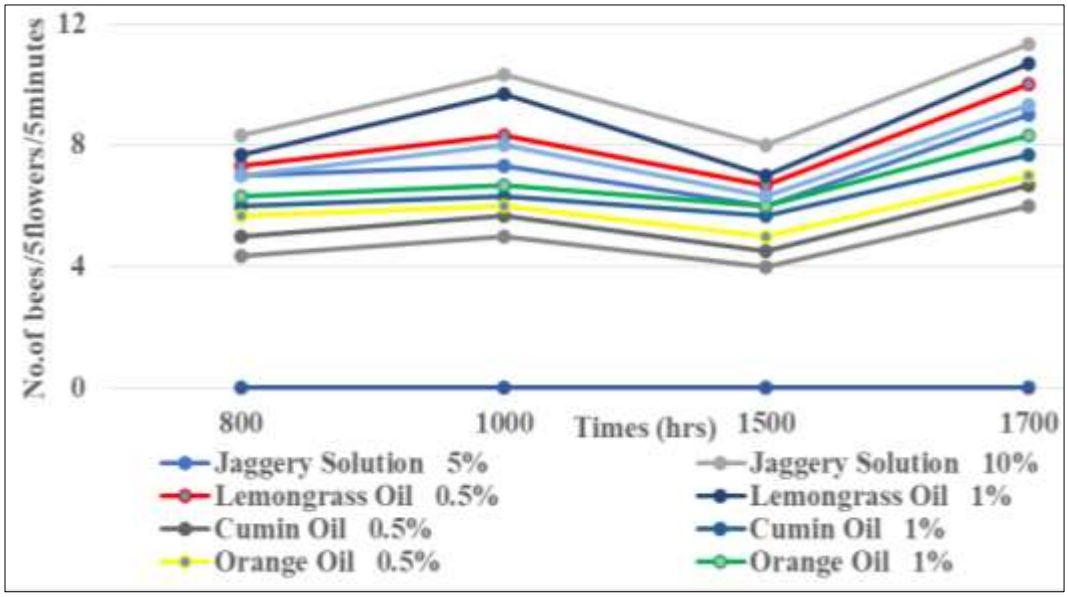

Fig 5: Influence of bee attractants on activities of honey bee on sunflower on 7th day after spraying

Conclusion

The daily foraging activity of different honey bees species will initiate at early morning and cessation at late evening. The daily temperature and humidity determine the activity of honey bees. The findings of the present investigation revealed that, totally ten species belonging to different insect orders forage on sunflower inflorescence. The observation made on the relative abundance the *Apis cerana indica* was recorded highest number which was Indian bees and it is easy for handling and maintenance for farmer. The foraging activity was more during 1000 hrs to 1200 hrs at 10% flowering. However, it appears that the attractants like jaggery solution 10%, lemongrass oil 1%, lemongrass oil 0.5%, sugar solution 5% and jaggery solution 5% were effective to attract the more bees on sunflower which is best for better pollination due to the distribution of pollen and it ultimately enhances the seed yield in cross pollinated crop like sunflower. Among, the various attractants jaggery solution 10 per cent and lemongrass oil 1 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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