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Stingless bees in sunflower pollination

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Abstract
Stingless bees are the small sized bees which fall under the tribe Meliponini. The utilization of stingless bees in pollination is recently gaining lot of scope and importance, since it pollinates wide range of flora and easy to handle. Though reports of stingless bees visiting flowers of many crops are available in India, studies on evaluation of their pollinating efficiency are scarce. The present study was carried out to check the efficiency of stingless bees under closed condition enclosed with sunflower plants as a food source. The results reveal that both quantitative and qualitative parameters of sunflower enclosed with stingless bees were on par with the control.

Keywords: Stingless bees, pollination, Sunflower

1. Introduction
Insect pollinators play an important role in improving the productivity of cross-pollinated crops. The availability of suitable pollinators with sufficient number during the flowering period is an important factor for achieving optimum pollination in cross-pollinated crops. Cross-pollination helps in sustaining the hybrid vigour, creating variation and maintaining the gene flow in the ecosystem. Pollination by insect pollinators is many times taken for granted and very little attention is paid to the need of conserving the pollinator diversity in crop ecosystem (Jadhav *et al.*, 2010) [6].

Use of pollinators is considered as the cost-effective, reliable and eco-friendly method to improve the cross-pollination and to enhance the productivity and quality of crops. Honey bees are considered to be the best pollinating agents because of their optimum body size, thoroughness, hairiness, steadfastness, floral fidelity and manageable populations. Being more flower-constant and polytrophic in nature, they can effectively pollinate a large number of crops. "About one-third of the human diet comes from insect-pollinated plants, and honey bees account for 80 percent of pollination" (Anon., 1995) [2].The economic value of crop pollinators was estimated to be about $14.6 billion in USA. The yield of seed, nut and fruit crops would be drastically reduced without the pollination work that bees provide (Morse and Calderone, 2000) [9].

The poor seed setting in sunflower crop is due to sterile achene, short pollen viability (Seetharam and Kusuma, 1974) [13], self-incompatibility (Khanna, 1971) [7], competition for nutrients among developing florets, deficiency of micronutrients (Annon., 1978) [1], moisture stress at various stages of seed formation and development (Singh, 1977) [15], lack of sufficient growth hormones (Prasad, 1976) [10], and growing the crop in off seasons (Chidananda, 1974) [3]. Many reports say that pollination with insects play a major role in overcoming the poor seed set in sunflower and there is a positive increase in the yield, there are many papers reporting the efficiency of Indian bees, European bees but there is no clear cut study with respect to the stingless bees in closed condition.

Recently, due to decline in bee population the other bees are gaining importance and recognition in pollination one among them is stingless bees. "Stingless bees are the smallest of the honey producing bees. They are eusocial insects like honey bees, living in permanent colonies, nesting in logs, old walls, crevices and such other concealed places" (Sakagami *et al*., 1989) [12]. Due to their small body size, they can penetrate into small flowers and in tropics they are common visitors to flowering plants (Heard, 1999) [5]. The aim of this study was to determine the efficiency of stingless bee as a pollinator under closed condition.

2. Materials and Methods
Field investigations were carried out at the Zonal Agricultural Research Station, GKVK,

Bengaluru during kharif using KBSH-44 sunflower hybrid. The following observations were made to find the role of stingless bees in sunflower pollination enclosed in green house.

2.1 Visits of bees in response to flower opening

The number of bees visited was recorded for sunflower enclosed with *T. iridipennis* colony. Observations were recorded when <25% (2nd day), 25-50% (4th day), 51-75% (6th day) and > 75% (8th day) disc florets opened. The flower opening in sunflower follows "centripetal flower opening" (opening from the border of the capitulum and proceeding towards the centre). Ten flowers were selected in each treatment and time of their efficiency on each flower head starting from arrival on flower till its departure were recorded by using a digital stopwatch. Bees visiting flowers were observed at one hr interval from 06.00 to 18.00 hrs. and the means were calculated.

2.2 Quantitative yield attributes

A. Total number of seeds in sunflower:

Ten plants were selected randomly from each treatment and the capitula were bagged after seed setting was completed. After threshing total number of seed from the sunflower capitulum were counted and subjected to statistical analysis.

The percent unfilled space on capitulum was visually observed and recorded for further analysis. Sunflower seeds setting was started from border and moved towards middle.

B. Total number of filled seeds

Number of filled seeds was counted separately from the total seeds collected from an individual plant in each treatment of all the three replication.

C. Total number of unfilled seeds

Number of unfilled seeds was counted separately, from the total seeds collected of an individual head in each treatment.

D. Kernel and Husk Ratio

100 seeds were selected randomly from each treatment and dried thoroughly and de-husked for calculating husk percentage, kernel percentage and kernel to husk ratio.

E. Seed index

100 seed weight was taken from five individual head in each treatment from all the three replications. Randomly seeds were selected from each treatment to calculate the seed index.

F. Yield per ha

The mean weight of seeds from ten capitulum from each treatment was taken and finally the yield was converted into Kg/ ha.

2.3 Qualitative yield parameters in sunflower

A. Volume weight

Hundred filled seeds were counted from all replications under each treatment and its mean weight was expressed in g/100ml.

B. Oil percentage

Sample weighing about 25-30g of seeds was collected randomly from each treatment and analysed for percent oil content with the help of scientists at Zonal Agricultural Research Station, GKVK, UAS Bangalore by using NMR (Nuclear Magnetic Resonance).

B. Germination percentage

The germination test was carried out for the seeds which were harvested from each treatment. On a germination paper fifty seeds from each treatment were placed and kept in the germination chamber at 20 ºC and 90 percent relative humidity. The germination count was recorded 7days after incubation.

C. Seedling vigor

Ten seedlings from each treatments were selected and the shoot and root length was measured. The following formula was used to compute the value.

$$VI = RL + SL \times GP$$

Where in, VI= Vigour Index; RL= Root length; SL=Shoot length; GP=Germination percentage

A. Test weight (1000 seed weight): Dry weight of 1000 seeds was weighted.

3. Results and Discussion

3.1 Foraging activity of stingless bees

The foraging activity of stingless bees was studied by confining them in greenhouses with sunflower as a food a source; apart from the food reserves in their hive.

Observations recorded on the foraging activity of stingless bees (Table 1) suggest that, when < 25% of disc floret opened, pollen foragers were more during morning time and peak pollen foraging activity was observed between 10.00 to 11.00 (1.68 bees/capitulum/ 5 min) with an average of 0.71 bees/capitulum/ 5 min. Nectar foragers showed peak activity between 15.00 to 16.00 hrs (0.52 bees/capitulum/ 5 min) with a mean of 0.22 bees/capitulum/ 5 min. The number of nectar collectors was comparatively less than pollen collectors during 26-50% of disc floret opened. The nectar collector recorded maximum activity between 14.00 to 15.00 hrs with mean number of nectar collectors was 0.22 bees/ capitulum/ 5 min. The maximum number of pollen collectors was observed from 10.00 to 11.00 hrs (2.65 bees/ capitulum/ 5min) with an average of 1.08 bees/ capitulum/ 5min. During less that 75% of disc floret opened, the pollen forager attained peak activity between 10.00 to 11.00 hrs with an average of 1.20 bees/ capitulum/ 5min. Maximum number of nectar collectors visited during afternoon hours with a peak activity between 13.00 to 14.00 hrs with mean number of nectar collector 0.28 bees/ capitulum/ 5min. When more 75% of disc floret was opened, the number of pollen foragers was maximum between 11.00 to 12.00 hrs with a mean of 1.74 bees/ capitulum/ 5min. Pollen foragers were more abundant compared to nectar collectors. Maximum nectar collectors were recorded between 15.00 to 16.00 hrs with an average of 0.28 bees/ head/ 5 min. More or less similar observations were reported by Roopa (2002) [11] under Bengaluru condition with respect to *T. iridipennis.*

3.2 Floral handling of stingless bee

To check the efficiency of stingless bees the floral handling time was recorded. The average time spent by stingless bee for pollen and nectar forager was 235.8 and 278.6 sec/ capitulum, respectively. In the present study the average time spent by stingless bee was 256.3 seconds/ head for collection of both pollen and nectar that differed from the studies of Roopa (2002) [11] where she reported, 78seconds/head. This variation in time spent may be due to variation in the cropping

season. The present study was taken up during kharif 2017 whereas studies of Roopa were carried out during summer 2001, where the higher temperatures might have made the stingless bees to spend less time per head. Nectar foragers (278.6sec) spent more time when compare with pollen foragers (235.8 sec). Time spent by pollen foragers of all species was maximum during morning hour (06.00 to 12.00 hrs) which was due to availability of pollen (Fig. 1).

3.3 Quantitative and Qualitative parameters of sunflower under different treatments

Significant differences were seen in the yield attributes such as seed setting, weight of seeds per capitulum, yield/plant, test weight, oil percent, volume weight, kernel husk ratio of sunflower seeds, germination percent and vigour index, vigour index among stingless bee pollinated and control plots (Table 2 & 3). Results reveal that sunflower enclosed with stingless bee was on par with respect to both qualitative and quantitative parameters when compared to the sunflower enclosed to control pollinators. Results obtained were similar with report on the yield parameters of cucumber pollinated by stingless bees in closed condition (Krishna *et al.*, 2017) [8].

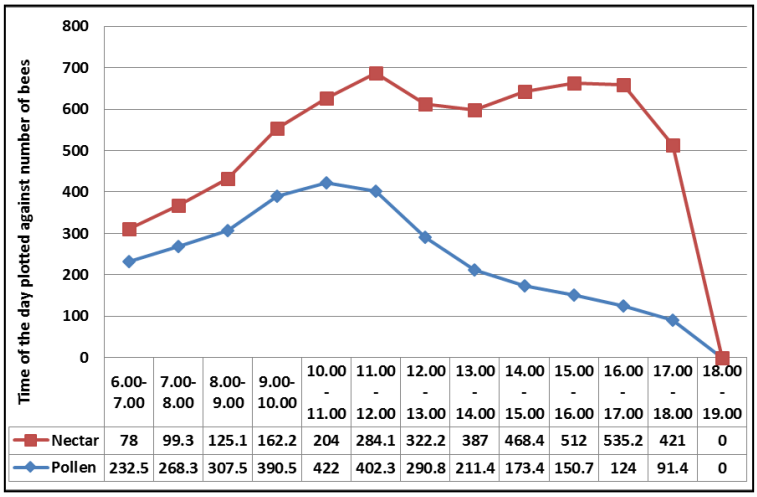

Fig 1: The Mean time spent by stingless bee foragers for collection of pollen/nectar/ sunflower head during different time intervals (sec/ capitulum).

Table 1: Abundance of *Stingless Bees* pollinators during different per cent of disc florets opening (Mean No. / Capitulum/ 5min.)*

Time	*T. Iridipennis*											
	Pollen	Nectar	Total	Pollen	Nectar	Total	Pollen	Nectar	Total	Pollen	Nectar	Total
	25%			26-50%			<75%			>75%		
06.00-07.00	0.12	0.03	0.12	0.72	0.09	0.81	0.64	0.12	0.76	1.02	0.03	1.05
07.00-08.00	0.89	0.08	0.97	1.06	0.16	1.22	1.31	0.16	1.47	1.71	0.07	1.78
08.00-09.00	1.05	0.13	1.18	1.44	0.12	1.56	1.81	0.14	1.95	1.85	0.14	1.99
09.00-10.00	1.46	0.15	1.61	2.03	0.19	2.22	2.07	0.19	2.26	2.42	0.19	2.61
10.00-11.00	1.68	0.28	1.96	2.65	0.25	2.9	2.43	0.36	2.79	2.85	0.17	3.02
11.00-12.00	1.52	0.21	1.73	1.72	0.33	2.05	1.94	0.51	2.45	3.15	0.26	3.41
12.00-13.00	0.73	0.36	1.09	1.37	0.37	1.74	1.75	0.41	2.16	2.36	0.33	2.69
13.00-14.00	0.42	0.48	0.90	1.68	0.42	2.10	1.62	0.75	2.37	2.61	0.41	3.02
14.00-15.00	0.58	0.41	0.99	0.95	0.57	1.52	0.88	0.38	1.26	1.53	0.68	2.21
15.00-16.00	0.45	0.52	0.97	0.21	0.23	0.44	0.37	0.15	0.52	1.19	0.91	2.10
16.00-17.00	0.30	0.21	0.51	0.13	0.08	0.21	0.57	0.41	0.98	1.23	0.37	1.60
17.00-18.00	0.01	0.00	0.01	0.05	0.01	0.06	0.18	0.02	0.20	0.69	0.17	0.86
18.00-19.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	9.21	2.86	12.04	14.01	2.82	16.83	15.57	3.60	19.17	22.61	3.73	26.34
Mean	0.71	0.22	0.93	1.08	0.22	1.29	1.20	0.28	1.47	1.74	0.28	2.02
SD	0.58	0.18	0.63	0.84	0.17	0.93	0.80	0.21	0.93	0.92	0.26	0.97

Table 2: Quantitative parameters of sunflower under different treatments

Treatment	Total seeds	Total filled seeds	Percent filled seeds	Wt. of seeds per Head (g)	Yield/ha(kg)	Test wt.(g)*
T1	1246.7± 367.4	1169.8± 216.6	93.8± 3.56	49.9± 2.0	2770.1± 116.2	46.6± 2.7
T2	1132.5± 342.7	814.2± 287.6	71.9± 8.26	44.7± 4.3	2484.8± 178.7	41.8± 3.6

Table 3: Qualitative parameters of sunflower under different treatments

Treatment	Seed index (g)**	Kernel wt.(g)	Kernel husk ratio	Volume wt. (g)	Oil percent	Germinated seeds	Percent germination	Shoot length (cm)	Root length (cm)	Vigour index	Germinated seeds
T1	5.71± 0.27	4.30± 0.14	3.10± 0.41	45.26± 2.78	33.72	46.66± 1.53	93.33± 3.06	15.06± 0.15	25.4± 1.00	1431	46.66± 1.53
T2	5.27± 0.19	3.77± 0.13	2.56± 0.38	41.74± 1.78	32.96	38.66± 2.51	77.33± 5.03	13.8± 0.30	23.83± 0.25	1090	38.66± 2.51

**100 seed weight

T1: Sunflower enclosed with *T. iridipennis* (stingless bee) colony

T2: Sunflower enclosed to avoid pollinators

Plate 1: Sunflower enclosed with *T. iridipennis* (stingless bee) colony

Plate 2: Sunflower enclosed for avoiding pollinators

Plate 3: *Tetragonula iridipennis* foraging on Sunflower

4. Conclusion

Stingless bees can be one among the best pollinators if we study in deep with their behavioral aspect and adaptability to other crops in green house and controlled environment. The use of stingless bees in green house enclosed with sunflower was on par with control, henceforth ways to utilize the stingless bees must be studied in deep to further recommend these bees for enclosed pollination or for seed production.

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