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Studies on floral handling time of pollinators on different treatments in sunflower (*Helianthus annus* L.)

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Abstract
Sunflower, *Helianthus annus* L. is a valuable crop because of its economic and ornamental benefits. Studies on floral handling time of different pollinators in sunflower were conducted at Anbil Dharmalingam Agricultural College and Research Institute, TNAU, Tiruchirappalli from August, 2019 to October, 2019. Experiment was conducted with seven different treatment such as plants caged with nylon net and allowing *Apis cerana indica* (T1), plants caged with nylon net and allowing *Apis mellifera* (T2), flowers sprayed with sugar syrup 5% (T3), flowers sprayed with Probiotic spray 10% (T4), flowers sprayed with cinnamon spray 10% (T5), flowers dusted with sugar dust (T6), open pollination (control) (T7). Observations were recorded on the floral handling time of pollinators. The overall mean obtained from the observation during 7.00 AM to 4.00 PM indicates the predominance of stingless bees (16.07 seconds), which spend more time on flower heads than all other pollinators studied. It was followed by Italian bees (13.37 seconds) and Indian bees (6.07 seconds) whereas the least time was spent by skipper (0.13 seconds).sugar dust treatment (T6) was identified as the best treatment, as floral handling time of pollinators was higher (6.67 seconds) comparing to all other treatments.

Keywords: floral handling time, pollinators, sunflower, *Helianthus annus* L.

Introduction
Sunflower (*Helianthus annus* L.) is an important cash crop in India, which belongs to the family Asteraceae. In India Sunflower occupies fourth rank among different oilseed crops. Sunflower is native to North and South America and some species are cultivated as ornamentals for their spectacular size of flower heads [1]. It is also a crop of choice for farmers due to its high yield potential, short duration and wider adaptability. Sunflower is cultivated worldwide, in an area of 26.36 million ha with production and productivity of 54.97 million tonnes and 2090 kg ha^{-1} respectively. In India, it is cultivated over 0.25 million ha area with production of 0.22 million tonnes and productivity of 886 kg ha^{-1} [2]. Sunflower occupies an area of 0.01 million ha (3.49%) with an annual production of 0.01 million tonnes (4.73%) and the productivity of 1050 kg ha^{-1} [3].
Sunflower is a cross pollinated crop and it requires assistance of insect pollinators for the successful pollination. Most of the insect pollinators of sunflower belong to the orders *viz*., Hymenoptera, Lepidoptera and Diptera. Some important pollinator species includes *Apis mellifera*, *Apis cerana indica*, *Apis dorsata*, *Apis florea*, *Halictus* sp., *Bombus haemorrhoidalis*, *Xylocopa* sp., *Trigona iridipennis* [4]. Insect pollinators play a major role in enhancing the productivity of cross pollinated crop [5]. As compared to many insect pollinators and visitors, honey bees spent more time on flower head [6]. The important species of honey bees are *Apis mellifera*, *Apis cerana indica*, *Apis dorsata*, and *Apis florea* in different agricultural and horticultural crops. Their close relation with the plants and foraging behaviour makes them as successful insect pollinators [7]. The sufficient numbers of pollinators at flowering time are essential for achieving optimum pollination and seed set. Hence, experiments were carried out to evaluate the floral handling time for identifying the efficient pollinators.

Materials and Methods
The study was carried out from August, 2019 to October, 2019 at Anbil Dharmalingam Agricultural College and Research Institute, TNAU, Tiruchirappalli, Tamil Nadu, India. The experiment was laid out in RBD Randomized block design with seven treatments and three

replications each. The crop was raised in the plots 4×5 m^2, following recommended agronomic package of practices.

The treatments used for the study purpose were plants caged with nylon net and allowing *Apis cerana indica* (T1), plants caged with nylon net and allowing *Apis mellifera* (T2), flowers sprayed with sugar syrup 5% (T3), flowers sprayed with Probiotic spray 10% (T4), flowers sprayed with cinnamon spray 10% (T5), flowers dusted with sugar dust (T6), open pollination (control) (T7).

At the commencement of flowering, three hives of Indian and Italian honey bee colonies were placed in sunflower field. For treatments T1, T2, cages were made by using 40 mesh nylon nets with strong wooden poles at height of 1.5m from the ground level. For the treatments T3, T4, T5, water was used to dilute the contents, and the solutions were treated by using hand sprayer. The treatments were imposed one hour before recording data and observation were taken on bee visit to sunflower floral heads at 10 percent flowering stage. Floral handling time of different pollinators was recorded in each treatment plots at regular time interval of 2 hours. The time of observation were recorded at five different timings such as 7.00 AM, 9.00 AM, 11.00 AM, 2.00 PM and 4.00 PM [8].

Statistical analysis

The data of experimental observations were statistically analyzed by using factorial RBD at 0.05% significant level and the software used was AGRES.

Results and Discussion

A total of eight species of pollinators were recorded during the study. Observed data showed that the sunflower crop attracted various pollinators such as European honey bee (*Apis mellifera* Linnaeus), Rock bee (*Apis dorsata* Fabricius), Indian honey bee (*Apis cerana indica* Fabricius), Indian stingless bee (*Trigona iridipennis* Smith), Greater banded hornet (*Vespa tropica* Linnaeus) and Skipper *Hesperidae* sp. There was a significant in the floral handling time of pollinators at different times as well as in different treatments. Some pollinators were noticed in the flower head only at specified part of the day. Whereas other pollinators were noticed in all the time periods with oscillation in floral handling time.

Mean floral handling time of different pollinators from 7.00 AM to 4.00 PM

Six species of bees, one species of wasp and one species of skipper was recorded in the floral heads during different times. At 7.00 AM stingless bees (27.68 seconds) was found to spend more time in flower heads than other bee species (Table 1). It was followed by Indian bee (10.90 seconds), Italian bee (7.82 seconds), wasp (1.80 seconds), rock bee (0.18 seconds) and carpenter bee (0.12 seconds). No population of little bees and skippers was recorded during 7.00 AM. While at 9.00 AM maximum time spent on flower heads was recorded with Italian bees (17.71 seconds) which was followed by stingless bees (15.81 seconds), wasp (3.75 seconds), Indian bees (2.86 seconds), little bees (0.93 seconds), rock bees (0.46 seconds) and carpenter bees (0.11 seconds). At this time also, no population of skippers was recorded during the observations. Similarly 7.00 AM, 11.00 AM also has stingless bees as a higher time spender on the floral heads than other pollinators with an average time of 10.22 seconds. It was followed by Italian bees (7.08 seconds), Indian bees (2.46 seconds), wasps (2.06 seconds), little bees (0.84 seconds), skippers (0.40 seconds) and carpenter bees (0.22 seconds).

The population of skippers was noticed at this time which was not found at 7.00 and 9.00 AM. At 2.00 PM the Italian bees (22.48 seconds) was recorded to spend more time on floral head than other pollinators. It was followed by stingless bees (15.32 seconds), Indian bees (6.62 seconds), wasps (2.58 seconds), rock bees (1.44 seconds), little bees (0.60 seconds), carpenter bees (0.48 seconds) and skippers (0.20 seconds). At 4.00 PM, the time spent by Italian bees (11.74 seconds) was recorded to be higher than other bees. It was followed by stingless bees (11.30 seconds), Indian bees (7.52 seconds), wasp (2.86 seconds), rock bees (0.72 seconds), little bees (0.56 seconds) and carpenter bees (0.16 seconds). The overall mean obtained from 7.00 AM to 4.00 PM indicates the predominance of stingless bees (16.07 seconds) which spend more time than all other pollinators followed by Italian bees (13.37 seconds) and Indian bees (6.07 seconds). The least time was spent by skipper (0.13 seconds).

Variation in floral handling time of pollinators on different treatments

Among the treatment imposed, the sugar dust treatment (6.67 seconds) showed higher floral handling time of pollinators than all other treatments (Table 2). It was followed by the treatment plants caged with *Apis mellifera* colonies (5.88 seconds), flowers sprayed with sugar syrup 5% (5.17 seconds), and flowers sprayed with probiotic spray 10% (5.17 seconds), plants caged with nylon net and allowing *Apis cerana indica* colonies (5.04 seconds), open pollination (4.00 seconds) and flowers sprayed with cinnamon spray 10% (3.75 seconds). The flowers sprayed with cinnamon spray 10% (T5) recorded as the least performing treatment while comparing with other treatment. Even though the treatments one and two were caged they recorded a higher mean value than treatment five and treatment seven. While comparing the mean floral handling time of Indian and Italian bees alone indicates that treatment one and two as superior treatments than others.

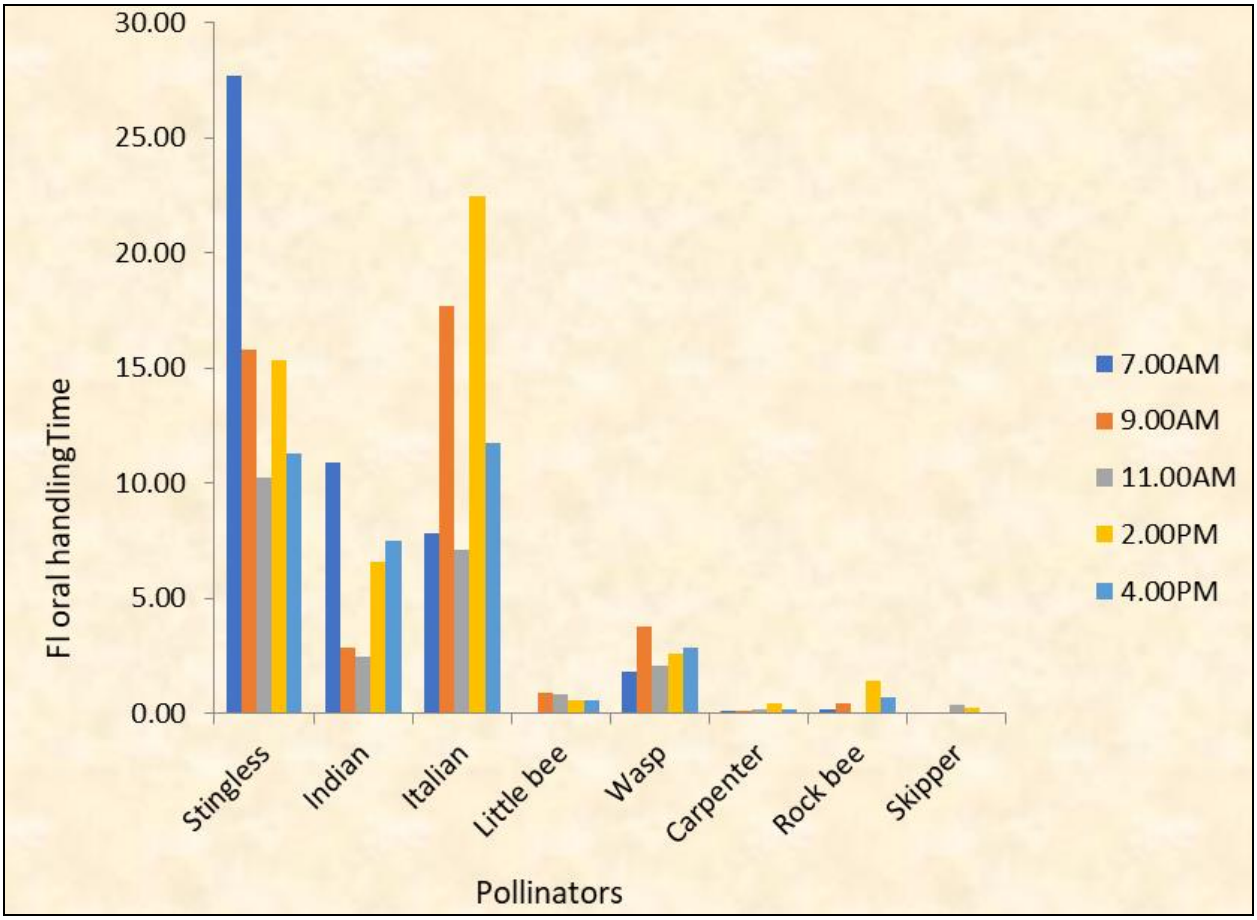
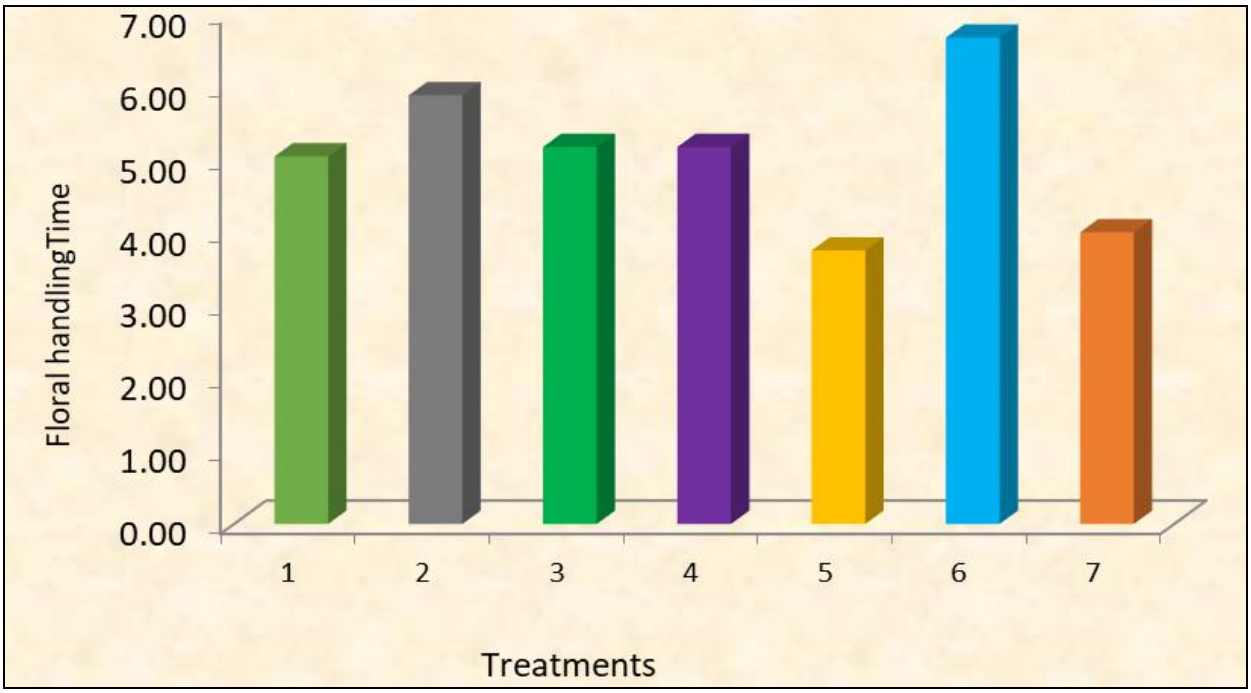


Fig 1: Mean floral handling time of different pollinators in sunflower from 7.00 AM to 4.00 PM



(1) T1 - Plants caged with nylon net and allowing *Apis cerana indica* colonies, (2) T2 - Plants caged with nylon net and allowing *Apis mellifera* colonies, (3) T3 - Flowers sprayed with sugar syrup 5%, (4) T4 - Flowers sprayed with Probiotic spray 10%, (5) T5 - Flowers sprayed with cinnamon spray 10%, (6) T6 - Flowers dusted with sugar dust, (7) T7 - Open pollination (control).

Fig 2: Mean floral handling time of different pollinators in sunflower

Table 1: Mean floral handling time of different pollinators in sunflower from 7.00 AM to 4.00 PM

TIME	Stingless Bees	Indian bees	Italian bees	Little Bees	Wasp	Carpenter bees	Rock Bees	Skipper
7.00AM	27.68 (5.30) [a]	10.90 (3.37) [a]	7.82 (2.88) [d]	0.00 (0.71) [e]	1.80 (1.51) [e]	0.12 (0.78) [d]	0.18 (0.82) [d]	0.00 (0.71) [c]
9.00AM	15.81 (4.03) [b]	2.86 (1.83) [d]	17.71 (4.26) [b]	0.93 (1.19) [a]	3.75 (2.06) [a]	0.11 (0.78) [e]	0.46 (0.81) [c]	0.00 (0.71) [c]
11.00AM	10.22 (3.27) [d]	2.46 (1.72) [e]	7.08 (2.75) [e]	0.84 (1.15) [b]	2.06 (1.59) [d]	0.22 (0.84) [b]	0.00 (0.71) [e]	0.40 (0.94) [a]
2.00PM	15.32 (3.97) [b]	6.62 (2.66) [c]	22.48 (4.79) [a]	0.60 (1.04) [c]	2.58 (1.75) [c]	0.48 (0.98) [a]	1.44 (1.39) [a]	0.20 (0.83) [b]
4.00PM	11.30 (3.43) [c]	7.52 (2.83) [b]	11.74 (3.49) [c]	0.56 (1.02) [d]	2.86 (1.83) [b]	0.16 (0.81) [c]	0.72 (1.10) [b]	0.00 (0.71) [c]
MEAN	16.07 (4.07)	6.07 (2.56)	13.37 (3.72)	0.59 (1.04)	2.61 (1.76)	0.22 (0.84)	0.56 (1.02)	0.13 (0.79)
CD	0.0735	0.0442	0.1081	0.0146	0.0313	0.0043	0.0114	0.0000
SEd	0.0319	0.0191	0.0469	0.0063	0.0136	0.0018	0.0049	0.0000

Tables 2: Mean floral handling time of different pollinators in sunflower

Treatments	7.00 AM	9.00 AM	11.00 AM	2.00 PM	4.00 PM	MEAN
T1	7.25 (2.78)	4.72 (2.28)	2.91 (1.84)	6.85 (2.71)	3.46 (1.98)	5.04 (2.35) [c]
T2	4.58 (2.25)	8.59 (3.01)	3.51 (2.00)	8.19 (2.94)	4.53 (2.24)	5.88 (2.52) [b]
T3	5.41 (2.43)	4.30 (2.19)	3.49 (1.99)	7.38 (2.80)	5.26 (2.40)	5.17 (2.38) [c]
T4	6.10 (2.56)	6.51 (2.64)	1.98 (1.57)	6.86 (2.71)	4.43 (2.22)	5.17 (2.38) [c]
T5	3.54 (2.00)	2.59 (1.75)	1.60 (1.44)	7.38 (2.80)	3.63 (2.03)	3.75 (2.06) [e]
T6	11.05 (3.39)	7.96 (2.90)	4.24 (2.17)	4.93 (2.33)	5.16 (2.37)	6.67 (2.67) [a]
T7	4.21 (2.17)	4.67 (2.27)	3.25 (1.93)	4.58 (2.25)	3.31 (1.95)	4.00 (2.12) [d]

(T1) Plants caged with nylon net and allowing *Apis cerana indica* colonies, (T2) Plants caged with nylon net and allowing *Apis mellifera* colonies, (T3) Flowers sprayed with sugar syrup 5%, (T4) Flowers sprayed with Probiotic spray 10%, (T5) Flowers sprayed with cinnamon spray 10%, (T6) Flowers dusted with sugar dust, (T7) Open pollination (control).

Discussion

The pollinators *Apis dorsata, Apis cerana indica, Trigona irridipenis, Vespa tropica* was the major diurnal visitors on sunflower capitulum [9]. Nderitu *et al*. 2008 revealed that *Apis mellifera* was one of the important pollinator in sunflower crop [10]. Similar results indicate that the time of foraging of *Apis cerena indica* was 06.00 AM to 10.00 AM and 4.00 PM to 6.30 PM [11]. Kumar *et al.* (2020) studied stingless bees in sunflower pollination and reported the higher activity of stingless bees during 10.00 AM to 11.00 AM [12]. Yang *et al*. (2020) studied bee pollination in sunflower and results indicated that pollen foraging summit happened at 11.00 AM for Italian bees [13]. The peak abundance of Italian bee species was remarkable at noon [14].

Krishna (2014) noticed the foraging behaviour of honey bees in sunflower and suggested that *Apis mellifera* was the most frequent pollinator [15]. Kumar *et al*. (2005) recorded the foraging activity of *Apis* species in sunflower and registered that *Apis mellifera* was the superior species and it recorded abundance at 11.00 AM and lesser populations were observed at 4.00 PM [16]. Panchabhavi *et al*. (1978) observed the activity of pollinators in sunflower and higher activity of insect pollinators was registered at 9.00 to 9.30 AM [17]. Kumar *et al*. (2020) recorded greater pollen foraging activity by stingless bees at 10.00 AM to 11.00 AM (1.68 bees/flower) while maximum number of nectar collecting stingless bees were observed at 2.00 to 3.00 PM. (0.52 bees/flower) [18]. Painkra and Kumaranag (2019) recorded the foraging activity of stingless bee on different times on a day. The stingless bees were observed abundantly at 10.00 to 11.00 AM (8.17 bees/ 5 mins/ 5 plants) and 2.00 to 3.00 PM (7.14 bees /5 mins /5 plants) while it was sparsely found during 8.00 to 9.00 AM [19]. Chambo *et al*. (2011) studied about the foraging activity and pollination efficiency of *Apis mellifera* in sunflower. Results showed that *Apis mellifera* mostly visited the flower head on second and third day of flowering during 7.00 to 8.30 AM for nectar collection [20].

Conclusion

Bees make excellent pollinators because most of their life is spend collecting pollens. As a complement as well as to increase the yield it is our duty to provide food, shelter. The present study indicates that stingless bees recorded more floral handling time than other bees and it was followed by Indian and Italian bees. Augmenting bee colony under controlled condition resulted in higher floral handling time spent by Italian bees than Indian bees. It is inerasable fact that there will be no food for without bees for humans and if bees went extinct, ecosystem would collapse.

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