



P-ISSN: 2349-8528

E-ISSN: 2321-4902

www.chemijournal.com

IJCS 2020; 8(3): 1616-1620

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Received: 22-03-2020

Accepted: 24-04-2020

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Studies on flower visitors and their foraging activity on Sunflower (*Helianthus annuus* L.)

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DOI: <https://doi.org/10.22271/chemi.2020.v8.i3v.9425>

Abstract

This study was carried out to determine the role of pollinators in Sunflower and their foraging behaviour in Zonal Agricultural Research Station, GKVK, University of Agricultural Sciences, Bangalore. In present study, twelve species of pollen and nectar feeders were visited on Sunflower during the flowering period, of which nine species were recorded from Hymenoptera, one from Diptera and two from Lepidoptera. Among all, major pollinators were *Apis dorsata* (38.09%) followed by *Apis cerana* (29.52%) and *Apis florea* (21.58%). Maximum activity of *A. dorsata* (6.63 bees) was observed at 9.00AM; *A. cerana* (6 bees) at 10.00AM and *A. florea* (3.00 bees) at 11.00AM. Handling time required for one probing into the flower was different across the *Apis* species and it was more in *A. dorsata* (7.05 Sec) followed by *A. cerana* (4.90 Sec) and *A. florea* (3.13 Sec.). With respect to yield parameter number of filled seeds were 76.56 per cent less in bagged condition compare to open pollination and yield also decreased by 84.94 per cent in bagged condition than open pollination. This study concludes that pollination by different honeybee species is the most significant contribution in production of Sunflower.

Keywords: Sunflower, *Helianthus annuus* L., *Apis cerana* and *Apis florea*

Introduction

In India, oilseeds share 14% of gross cropped area and account for nearly 3% of the gross domestic product and 5.98% of the value of all agricultural products. Despite being the largest cultivator of oilseeds in the world, India imports about 50% of the requirements, because of the life style changes in dietary pattern and increasing per capita income (Varaprasad, 2015)^[9]. Sunflower (*Helianthus annuus* L. compositae) is considered as an important oilseed crop both for domestic and commercial uses and ranking a prime position in the oilseed economy of the country. Sunflower is protandrous and self-incompatible in which male and female parts mature at different times, there appears to be a time lag of 18.24 hrs in the maturity of male and female parts in Sunflower (Singh *et al.*, 2000)^[7]. The cross pollination of these flowers are brought about by insects, as flowers produce abundant quantity of nectar and pollen which attract large number of honey bees for these resources, which favours pollination mechanism (Goswami *et al.*, 2013)^[3]. Honeybee pollination is therefore essential for production of sunflower hybrid seed. The aim of this study was to know the pollinator fauna of Sunflower and foraging behaviour of honeybees and their influence of quantitative and qualitative parameter of Sunflower.

Material and Method

Field investigations were carried out at the Zonal Agricultural Research Station, GKVK, University of Agricultural Sciences, Bangalore.

The sunflower hybrid, GK 2002 was sown at a spacing of 60×30 cm and the crops were raised by following the recommended package of practice University of Agricultural Sciences, Bangalore.

Sweep net method was used for studying the abundance and diversity of pollinators in Sunflower crop. Sampling was done during different parts of the day from morning to evening. The collected insects were transferred to a killing jar containing ethyl acetate. The specimens were brought to the laboratory, pinned, labelled and dried for further identification. All specimens have been deposited in the department of Entomology, UAS, GKVK, Bangalore. Five plants were selected randomly observed for the pollinators visitation for a time period of five minutes at different hours of the day from 07.00 AM to 05.00 PM and diurnal activity of

Pollinator was recorded. Observations were made for the number of species of pollinators visited along with their frequency of visitation at different time hours in a day on Sunflower.

Diversity of pollinators was calculated by using Shannon-Weaver diversity index.

$$H' = -\sum p_i \times \ln p_i$$

Pi - Proportion of individual species

Relative abundance of dominating species of pollinator was worked out by using the following formula and expressed in percentage.

$$\text{Relative abundance of species A} = \frac{\text{Number of individuals of species A visiting flower}}{\text{Total number of individuals of pollinator visited}} \times 100$$

Foraging behaviour of pollinators

Studies on foraging behaviour was done between 07.00AM to 05.00PM for three honey bee species i.e *Apis dorsata*, *Apis cerana* and *Apis florea* and handling time was worked out (Kunte, 2007)^[4].

$$\text{Handling time (Sec)} = \frac{\text{Time spent on flower head for probing}}{\text{Time spent on flower head for probing}}$$

Post-harvest observations in Sunflower

Observation on seed yield, per cent seed filling, test weight, Kernal/Husk ratio, germination per cent, root and shoot length were recorded under this experiment as follows.

Seed yield

The seeds harvested from ten plants were cleaned and weighed in electronic balance and expressed in percentage. The yield from bagged flower head obtained by excluding pollination was compared with open pollination.

Per cent seed filling

In each head total number of filled and unfilled seeds were counted. The ratio of number of filled seeds to the total number of seeds per head was expressed in per cent. The difference between open pollinated and bagged flower head was recorded.

Test weight

Hundred filled seeds were counted from five plants its mean weight was expressed in grams. Test weight was compared between open pollinated and bagged flower head.

Hundred kernel weight, husk weight and Kernel/Husk ratio

Hundred seeds from each of five plants were manually de husked. Both weight of kernel and husk were determined and used to calculate hundred kernel weight, husk weight and kernel to husk ratio and compared with bagged flower head.

Germination per cent

Fifty seeds were placed on moist blotting paper and kept for observation. The germination counts were taken seven days later and seeds germinated were expressed in per cent. Seeds germinated from bagged flower head compared with open pollination.

Root and shoot length

Root and shoot length of five seedlings in sunflower was recorded after seven days of germination.

Per cent oil content

Oil content was analysed by NMR method at Zonal Agriculture Research Station, GKVK, UAS, Bengaluru.

Result and discussion

The finding of the present study revealed that, twelve species of pollen and nectar feeders were visited on Sunflower during the flowering period of which nine species were recorded from Hymenoptera, one from Diptera and two from Lepidoptera (Table.1) Srikanth Nath and Viraktamath (2010)^[8], recorded a total of eight species of pollinators on Morden variety of sunflower, of these five species belonged to Hymenoptera and three species to Lepidoptera and Goswami *et al.* (2013)^[3], observed total 12 insect visitors, of these nine represents order Hymenoptera, one species represents Diptera, Lepidoptera and Coleoptera each on the Sunflower.

Diversity of pollinators at different times of the day in sunflower

The diversity (H') of pollinators in sunflower ranged from 0.14 (7.00AM) to 0.26 (9.00AM). Peak activity of pollinators was recorded during 9.00AM (0.26). The diversity of pollinators was more during morning hours (7.00AM to 1.00PM) and less from 2.00PM to 5.00PM (0.18-0.19) (Fig.1). This variation in diversity in a day length may be due to variation in nectar production pattern in plants. In Sunflower there was increase in nectar production in mid to late morning and in the late evening. Nectar appears to be reabsorbed by the flowers in the afternoon and overnight hours. (Silva and Dean, 2004)^[6].

Table 1: Taxonomical position of pollinators recorded on Sunflower

Order	Family	Subfamily	Tribe	Genus	Species
Hymenoptera	Apidae	Apinae	Apini	Apis Linnaeus	<i>Apis dorsata</i> Fabricius
					<i>Apis cerana</i> Fabricius
		Xylocopinae	Ceratinini	<i>Ceratina</i> Latreille	<i>Ceratina binghami</i> Cockerell
			Xylocopini	<i>Xylocopa</i> Latreille	<i>Xylocopa</i> sp.
	Meghachilidae	Meghachilinae	Megachilini	<i>Megachile</i> Latreille	<i>Meghachile disjuncta</i> Fabricius <i>Meghachile lerma</i> Cameron
	Halictidae	Halictinae	Halictini	<i>Selodonia</i> Robertson	<i>Selodonia</i> sp
	Scoliidae	Scoliinae	Scoliini	<i>Scolia</i> Fabricius	<i>Scolia</i> sp
Lepidoptera	Nymphalidae	Danainae	Danaini	<i>Danaus</i> Kluk	<i>Danaus chrysippus</i> Linnaeus
	Pieridae	Coliadinae	Euremini	<i>Eurema</i> Hübner	<i>Eurema</i> Sp.
Diptera	Syrphidae	Eristalinae	Eristalini	<i>Eristalinus</i> Rondani	<i>Eristalinus arvorum</i> Fabricius

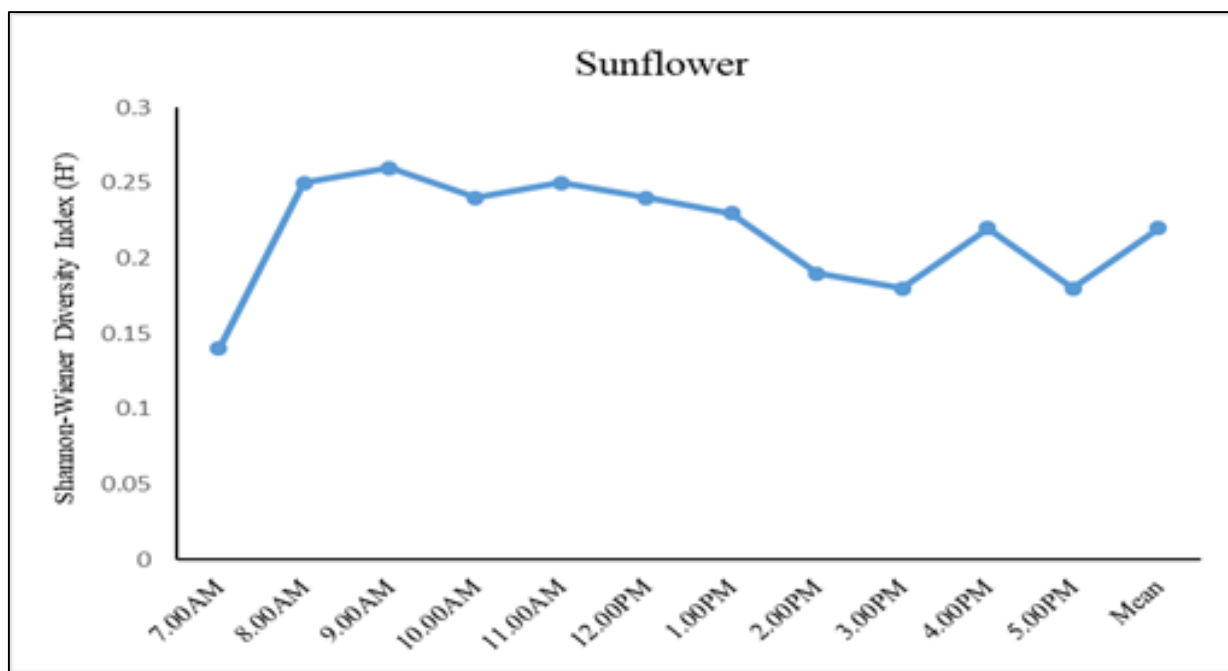


Fig 1: Shannon-Wiener Diversity (H') at different times of the day in sunflower Abundance of pollinators in Sunflower

The per cent composition of Apidae was 89.19% among total Hymenopteran (94.25%) pollinators. Similarly, Goswami *et al.* (2013) [3], recorded 86.09% were Hymenopteran of all insect visitors. Among Apidae, *A. dorsata* (38.09%) was more abundant than *A. cerana* (29.52%), *A. florea* (21.58%) indicating Hymenopterans species were the most important pollinators and honeybees formed 75 per cent of Hymenoptera on Sunflower (Ahmed *et al.* 1989). The abundance of *A. dorsata* was more at 9:00AM (6.33 bees), *A. cerana* at 9:00-10:00AM (6 bees) and *A. florea* at 12:00PM (3.33 bees). The activity of *Xylocopa* was noticed from 9:00AM (0.67) to 11:00AM (0.33) and also evening at 5:00PM (0.33). Leaf cutter bee was observed only during 9:00AM (0.33/flower), 11:00AM (1.00/flower) and 4:00PM (0.33/flower). Halictids were recorded only from 8:00AM (0.67/flower) to 9:00AM (0.33/flower). The activity of Lepidopterans was observed scattered at different time of the day and Dipterans was noticed only during morning hours from 7:00AM (2.33No./flower) to 9:00AM (0.33/flower). With respect to time of the day ranged from least 5.69 No/flower (7:00AM), to peak 12.02/flower (9:00AM) and slightly decreased towards afternoon- evening hours. (Table 2). Basavaraj *et al.*, (2016) [2] studied the species abundance and diversity of bee pollinators in hybrid sunflower (cv. KBSH-53) and observed the peak activity in five out of the six bee species was observed during 11:00AM-12:00PM. The comparative activity of different bee species on different genotype varied at different times of the day.

Foraging behaviour of honeybees in sunflower

The number of probings by *A. dorsata* ranged from 2.60 (12:00 PM) to 6.40 (7:00AM), with 4.79 mean number of probing. The time spent by *A. dorsata* per flower ranged from 26.50 Sec. (2:00 PM) to 44.40 Sec. (7:00 AM) with 35.03 Sec. mean time spent. The time taken for one probing was

highest at 8:00 AM (10.77 Sec.) and lowest at 1:00PM (5.17 Sec.). The mean time required for one probing was 7.05 Seconds. The number of probings by *A. cerana* ranged from 5.20 (4:00PM) to 12.80 (11:00AM), with 8.25 mean number of probing. The time spent by *A. cerana* ranged from 25.20 Sec. (4:00 PM) to 51.20 Sec. (11:00 AM) with 38.94 Sec. mean time spent. The time taken for one probing was highest at 9:00 AM (6.67 Sec.) and lowest at 3:00 PM (3.36 Sec.). The mean time required for one probing was 4.90 Seconds. The number of probing by *A. florea* ranged from 8.50 (7:00AM) to 20.60 (12:00 PM), with 14.97 mean number of probing. The time spent by *A. florea* ranged from 29.00 Sec. (7:00 AM and 4:00 PM) to 58.40 Sec. (10:00 AM) with 44.67 Sec. mean time spent. The time taken for one probing was highest at 9:00 AM (4.56 Sec.) and lowest at 12:00 PM (2.32 Sec.). The mean time required for one probing was 3.13 Sec. (Table 3).

Variation in yield parameters of Sunflower in open and bagged conditions of pollination

This study compares the different qualitative and quantitative parameters in open pollination and bagged condition. It was observed that, number of filled seeds were 76.56% less in bagged condition compare to open pollination therefore total number of seeds were also higher in open pollination and yield also decreased by 84.94% in bagged condition than open pollination (Table. 4). Similar results were found by Mehmet Oz *et al.*, (2009) [5], where 94% less filled seeds in bagged condition than open pollination and recorded increased yield in open pollination in sunflower. The overall parameters were found positive in open pollinated condition when compare with bagged condition (Table. 4) indicating the importance of pollinators majorly honey bees in the successful production of sunflower.

Table 2: Abundance of pollinators in Sunflower

Time	<i>A. dorsata</i>	<i>A. cerana</i>	<i>A. florea</i>	<i>Xylocopa</i> sp.	Leaf cutter bees	Halictids	Lepidoptera	Diptera	Total	% composition	
7.00AM	2.66	2.67	0.33	0.00	0.00	0.00	0.00	2.33	6.00	5.69	
8.00AM	6.00	2.33	2.00	0.00	0.00	0.67	0.33	2.00	12.33	11.70	
9.00AM	6.33	6.00	1.67	0.67	0.33	0.33	0.67	0.33	12.67	12.02	
10.00AM	4.00	6.00	2.67	0.67	0.00	0.00	0.00	0.00	11.67	11.07	
11.00AM	5.33	4.67	3.00	0.33	1.00	0.00	0.00	0.00	12.00	11.39	
12.00PM	3.67	1.00	3.33	0.33	0.00	0.00	0.00	0.00	10.67	10.12	
1.00PM	0.67	0.67	2.00	0.33	0.00	0.00	0.33	0.00	9.67	9.17	
2.00PM	1.67	0.33	1.67	0.00	0.00	0.00	0.00	0.00	7.33	6.96	
3.00PM	1.33	1.67	1.67	0.00	0.00	0.00	0.00	0.00	7.33	6.96	
4.00PM	5.33	2.67	2.67	0.00	0.33	0.00	0.33	0.00	9.00	8.54	
5.00PM	3.00	3.00	1.67	0.33	0.00	0.00	0.00	0.00	6.67	6.32	
Total	40.00	31.00	22.67	2.67	1.67	1.00	1.67	4.67	105.33	100	
Mean	3.64	2.82	2.06	0.24	0.15	0.09	0.15	0.42	9.58		
Sd	1.95	1.98	0.82	0.26	0.31	0.21	0.22	0.87	2.454		
% species composition	38.09	29.52	21.58	2.53	1.58	0.95	1.58	4.44	100		
Total Apidae %	89.19%										
Total Hymenoptera %	94.25%										

Table 3: Foraging behaviour of *Apis* bees in Sunflower

Time	<i>A. Dorsata</i>			<i>A. Cerana</i>			<i>A. Florea</i>		
	No. of probings (No.)	Time spent (Sec.)	Time taken for one probing* (Sec.)	No. of probings (No.)	Time spent (Sec.)	Time taken for one probing* (Sec.)	No. of probings (No.)	Time spent (Sec.)	Time taken for one probing* (Sec.)
7.00 AM	6.40	44.40	6.94	6.00	35.33	5.89	8.50	29.00	3.41
8.00 AM	6.20	42.00	10.77	7.20	47.80	6.64	11.40	42.20	3.70
9.00 AM	5.00	42.20	10.44	7.20	48.00	6.67	11.80	53.80	4.56
10.00 AM	5.80	39.20	6.76	12.40	48.40	3.90	17.00	58.40	3.44
11.00 AM	5.75	38.25	6.65	12.80	51.20	4.00	17.60	55.60	3.16
12.00 PM	2.60	27.40	6.54	8.60	40.20	4.67	20.60	47.80	2.32
1.00 PM	3.00	30.50	5.17	8.80	37.40	4.25	18.40	43.80	2.38
2.00 PM	4.00	26.50	6.63	7.60	31.40	4.13	19.40	46.60	2.40
3.00 PM	3.33	31.33	5.40	9.00	30.20	3.36	19.40	46.40	2.39
4.00 PM	5.20	27.40	5.57	5.20	25.20	4.85	10.80	29.00	2.69
5.00 PM	5.40	36.20	6.70	6.00	33.20	5.53	9.80	38.80	3.96
Mean±SD	4.79±1.33	35.03±6.63	7.05±1.85	8.25±2.46	38.94±8.7	4.90±1.13	14.97±4.5	44.67±9.6	3.13±0.75

Table 4: Seed yield parameters in open and Bagged condition of Sunflower

Yield parameters	Open	Bagged	% variation in bagged over open pollination
Number of filled seed (No.)	961.46	225.33	-76.56
Number of unfilled seeds (No.)	142.26	36.46	-74.37
Total number of seeds (No.)	1103.73	261.8	-76.28
Percent seed filling	87.08	86.12	-1.10
Test weight (g)	4.07	2.42	-40.54
Volume weight (g)	52.34	39.66	-24.22
Kernel weight (g)	3.6	2.06	-42.77
Husk weight (g)	1.29	0.88	-31.78
Kernel:Husk ratio	2.79	2.35	-15.77
Seed yield (Kg/ha)	2342	352.48	-84.94
Germination (%)	92.00	87.676	-4.7
Root length (cm)	21.82	15.12	-30.70
Shoot length (cm)	12.74	7.26	-43.01
Oil content (%)	38.73	29.15	-24.73

*Time spent by bee/ Number of probin

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