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Various attractants affecting bees visits to sunflower, *Helianthus annus* L.

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Abstract
An investigation was carried out for two consecutive *kharif* and *rabi* seasons (2017 and 2017-18) with a view to know the role of honey bees in sunflower, *Helianthus annus* L. Considering the importance of honey bees, *Apis mellifera* L. and *Trigona* sp. increased in production of seed yield with sugar and jaggery solutions (5%) like phagostimulants application during flowering season which attracted more number of bees. The data recorded higher bee visits on first (3.22 to 3.83 bees/5 capitula/2 minutes) and third day (3.34 to 3.78) after spray of both the sprays in kharif and rabi, 2017-18 in sunflower in the treatments of sugar and jaggery solution (5%). But, after three days of sprays, the influences of both the sprays declined.

Keywords: Honeybees, Sunflower, *Helianthus annus* L.

1. Introduction
Sunflower (*Helianthus annus* L.) belongs to the Asteraceae family is an important oil seed crop after soybean in world and it also holds second position in India. It is also known as 'Surajmukhi'. It is cultivated globally on 21.48 million ha area with production of 26.47 million tonnes in recent times (Anon., 2015) [2]. Cultivation of this crop is majorly done in Europe specifically in Russian Federation, Argentina, Ukraine *etc*. Sunflower, being a new oilseed crop in India (introduced in 1969) is mainly grown in Karnataka, Maharashtra, Andhra Pradesh and Gujarat. The crop has great promise because of its short duration, photo and thermal insensitivity as well as wider adaptability and drought tolerance characteristics. Moreover, all these characteristics of this crop lead to grow in any season with good yield. Among all insects, honey bees are the most important insects in the pollination process of sunflower. Unlike other insects, visit flowers only for food, while bees visit flowers to fulfill their colony's members need. Individual florets of sunflower are rarely self-pollinated because of its sticky and heavy pollen. So, it need pollen transferred to other florets which can be carried out by honey bees (Muller *et al*., 2006) [3].

2. Materials and Methods
Field experiment was conducted to study the role of honey bees in seed production of sunflower, *Helianthus annus* L. at Anand Agricultural University, Anand during two consecutive *kharif* and *rabi* seasons of 2017 and 2017-18 in Randomized Block Design with six treatments and four replications. Sunflower variety NSH-10 was sown with a spacing of 45 cm between two rows and 10 cm within the rows. Gross and net plot area was 2.00 x 1.80 m and 1.80 x 0.90 m, respectively. Fine nylon mosquito nets of 6 x 6 feet (mesh 20 micron) size were erected over the sunflower crop for the treatment T_2, T_3 and T_4. Inside the nets of T_3 treatment, one framed box of *A. mellifera* L. and for T_4 treatment, a colony of *Trigona* sp. was kept and T_2 as such under mosquito net covered while remaining T_1, T_5 and T_6 treatments were kept open at five per cent flowering and five per cent sugar and jaggery solutions were applied on crops kept in open in the morning time and subsequent two sprays were given at an interval of 10 days (Krishna *et al*., 2014) [4]. The bee visit was recorded as number of honey bees visiting 5 capitula per 2 minutes at three time intervals *viz*., 08:00 to 10:00, 10:00 to 12:00 and 14:00 to 16:00 hrs. Observations were recorded before spray as well as 1, 3, 5 and 7 days after spray (Ali *et al*., 2015) [1].

3. Results
Observation was recorded on bee visitation on sunflower treated with sugar and jaggery solution five per cent spray during flowering periods.

The results obtained from present investigations are summarized here. Statistical analysis was carried according to Steel & Torrie (1980) [7] methods.

3.1 Bee visitation during *kharif*, 2017

3.1.1 First spray

Observations were recorded on *A. mellifera* and *Trigona* sp. visitation on sunflower capitulum from five per cent flowering periods during *kharif*, 2017 (Table 1).

The observations recorded one day before the first spray indicated that number of bees visited to sunflower ranged from 0.00 to 2.32 bees/ 5 capitula/ 2 minutes which differed significantly among all the treatments. Patil *et al*. (2010) [6] also reported that a day before the first spray, the number of bees visited the flower ranged from 1.66 to 2.50 bees/ 5 capitula/ 2 minutes and did not differ significantly among the treatments.

Following a day after the first spray, maximum number of honey bees visited in the treatment of sugar solution spray 5% (2.23 bees/ 5 capitula/ 2 min) and it was at par with treatment of a colony *Trigona* sp. covered with net (2.23), one framed *A. mellifera* colony covered with net (2.19), jaggery spray 5% (1.97) and treatment of open pollination (1.85).

On third day after the first spray maximum number of honey bees visited in the treatment of sugar solution spray 5% (3.74) and it was at par with treatment of jaggery spray 5% (3.47), one framed *A. mellifera* colony covered with net (3.24) and treatment of a colony *Trigona* sp. covered with net (2.98). However, treatment of a colony *Trigona* sp. covered with net showed equal visitation of bees with open pollination (2.23).

Five days after the first spray, maximum number of honey bees visited in the treatment of jaggery spray 5% (3.14) and it was at par with treatment of sugar solution spray 5% (2.72), a colony *Trigona* sp. covered with net (2.70) and treatment of one framed *A. mellifera* colony covered with net (2.46). While, in the treatment of open pollination minimum visits of honey bees were found among all the treatments (2.00). In the treatment of pollination without insects, no any honey bee visits were recorded during investigations due to net covering.

After seven days after first spray, there was no any bee visit found in outside net and inside net conditions due to severe cold climate. The present results corroborate with the findings of Pateel and Sattagi (2007) [5], who reported that treatment of sugar and jaggery solution attracted more honeybees up to third day of first and second sprays, whereas their activities decreased at fifth day of sprays.

3.1.2 Second spray

Observations were recorded on honey bee visitation on sunflower head during *kharif*, 2017 (Table 2).

The observations recorded one day before the first spray indicated that number of bees visited to sunflower ranged from 0.50 to 3.47 bees/ 5 capitula/ 2 min and difference were found of bee visited among all the treatments.

One day after the second spray, maximum number of honey bees visited in the treatment of sugar solution spray 5% (3.71 bees/ 5 capitula/ 2 min) and it was at par with treatment of jaggery spray 5% (3.47), one framed *A. mellifera* colony covered with net (3.29) and treatment of a colony *Trigona* sp. covered with net (2.98) and open pollination (2.98).

On third day after the second spray, maximum number of honey bees visited in the treatment of sugar solution spray 5% (2.98) and it was at par with treatment of jaggery spray 5% (2.74), one framed *A. mellifera* colony covered with net (2.72) and treatment of a colony *Trigona* sp. covered with net (2.69) and open pollination (2.46).

Five days after the second spray, maximum number of honey bees visited in the treatment of jaggery solution spray 5% (2.52) and it was at par with treatment of a colony *Trigona* sp. covered with net (2.46), one framed *A. mellifera* colony covered with net (2.46) and treatment of sugar solution 5% (2.38) and open pollination (2.23).

Maximum number of honey bees visited in the treatment of one framed *A. mellifera* colony covered with net (2.35) on seven days after the second spray and it was at par with treatment of sugar solution 5% (2.34), jaggery solution spray 5% (1.63), treatment of a colony *Trigona* sp. covered with net (1.60) and open pollination (1.48).

Pateel and Sattagi (2007) [5] reported that treatment of sugar and jaggery solution attracted more honey bees up to third day of first and second sprays, whereas their activities decreased at fifth day of sprays. These results are in accordance with the present findings.

3.1.3 Pooled over sprays during *kharif*, 2017

Results of pooled over sprays revealed that maximum bee activities were recorded on first and three days of both the spray (Table 3) in all the treatments. One day after first day, maximum number of honey bees visited in the treatment of jaggery spray 5% (3.34 bees/ 5 capitula/ 2 min) and it was at par with treatment of sugar solution spray 5% (3.09), one framed *A. mellifera* colony covered with net (3.07), open pollination (2.97) and in treatment of *Trigona* sp. colony covered with net (2.71).

Three days after sprays, maximum number of honey bees visited in the treatment of sugar solution spray 5% (3.92) and it was at par with treatment of jaggery solution spray 5% (3.35), one framed *A. mellifera* colony covered with net (3.10), open pollination (2.98) and treatment of a colony *Trigona* sp. covered with net (2.84).

Maximum number of honey bees visited in the treatment of sugar solution spray 5% (3.08) in five days after sprays and it was at par with treatment of a colony *Trigona* sp. covered with net (2.86), one framed *A. mellifera* colony covered with net (2.60), open pollination (2.60) and treatment of jaggery solution spray 5% (2.46).

After seven days of sprays, maximum number of honey bee visited in the treatment of jaggery spray 5% (1.96 bees/ 5 capitula/ 2 min) and it was at par with treatment of sugar solution spray 5% (1.54 bees/ 5 capitula/ 2 min). However, the treatment of sugar solution spray 5% also found at par with one framed *A. mellifera* colony covered with net (1.46 bees/ 5 capitula/ 2 min), treatment of a colony *Trigona* sp. covered with net (1.35 bees/ 5 capitula/ 2 min) and open pollination (1.26 bees/ 5 capitula/ 2 min).

Here, pooled data of bee visits found maximum in the treatments of sugar and jaggery five per cent spray as earlier said report of Patil *et al*. (2010) [6].

3.1.4 Bee visitation during *rabi*, 2017-18

First spray

Observations were recorded on *Apis mellifera* and *Trigona* sp. visitation on sunflower capitulum at five per cent flowering periods during *rabi*, 2017 (Table 4).

The observations recorded one day before the first spray indicated that number of bees visited to sunflower ranged

from 0.50 to 3.47 bees/ 5 capitula/ 2 min and differed significantly among the treatments.

Following a day after the first spray, maximum number of honey bees visited in the treatment of sugar solution spray 5% (4.47 bees/ 5 capitula/ 2 min) and it was at par with treatment of jaggery spray 5% (4.21) and one framed *A. mellifera* colony covered with net (3.99). The next good treatment was a colony *Trigona* sp. covered with net (2.98) and it was found at par with treatment of open pollination (2.72).

After three days of first spray, maximum number of honey bees visited in the treatment of one framed *A. mellifera* colony covered with net (4.99) and sugar solution spray 5% (4.21). The next good treatment was jaggery spray 5% (3.99) and it was at par with treatment of a colony *Trigona* sp. covered with net (3.74) and open pollination (3.71).

There was no any visitation of honey bees noted on fifth and seventh days after first spray treatments due to adverse climatic conditions in outside and inside of nets treatments.

The present results fall in same line with the findings of Pateel and Sattagi (2007) [5], who reported that treatment of sugar and jaggery solution attracted more honey bees up to three days of first and second sprays, whereas their activities decreased after five days of sprays.

3.1.5 Second spray

Observations were recorded on *A. mellifera* L. and *Trigona* sp. visitation on sunflower capitulum during rabi, 2017-18 (Table 5)

Observations were recorded on *Apis mellifera* L. and *Trigona* sp. visitation on sunflower capitulum during *rabi,* 2017 (Table 5).

The observations recorded one day before the first spray indicated that number of bees visited to sunflower from 0.50 to 3.43 bees/ 5 capitula/ 2 min and differed significantly among the treatments.

Following a day after the second spray maximum number of honey bees visited in the treatment of jaggery spray 5% (4.47 bees/ 5 capitula/ 2 min) and it was at par with treatment of sugar solution spray 5% (3.78 bees/ 5 capitula/ 2 min), one framed *A. mellifera* colony covered with net (3.47 bees/ 5 capitula/ 2 min), a colony *Trigona* sp. covered with net (3.47 bees/ 5 capitula/ 2 min). The next best treatment of bee visits were open pollination (2.98 bees/ 5 capitula/ 2 min).

After three days of second spray, maximum number of honey bees visited in the treatment of sugar solution spray 5% (3.71 bees/ 5 capitula/ 2 min) and it was at par with treatment of jaggery spray 5% (3.19 bees/ 5 capitula/ 2 min), one framed A. mellifera colony covered with net (2.98 bees/ 5 capitula/ 2 min) and open pollination (2.96 bees/ 5 capitula/ 2 min) and treatment of a colony Trigona sp. covered with net (2.69 bees/ 5 capitula/ 2 min).

Maximum number of honey bees visited in the treatment of sugar solution spray 5% (2.98 bees/ 5 capitula/ 2 min) in five days after the second spray and it was at par with treatment of jaggery spray 5% (2.96 bees/ 5 capitula/ 2 min), one framed *A. mellifera* colony covered with net (2.74 bees/ 5 capitula/ 2 min) and open pollination (2.74 bees/ 5 capitula/ 2 min) and treatment of a colony *Trigona* sp. covered with net (2.19 bees/ 5 capitula/ 2 min).

After seven days of the second spray, maximum number of honey bees visited in the treatment of sugar solution spray 5% (2.74) and it was at par with treatment of one framed *A. mellifera* colony covered with net (2.69) and a *Trigona* sp. colony covered with net (2.23). The next good treatment was jaggery spray 5% (2.19) and open pollination (1.84).

In nutshell, maximum number of bee visits were found in the treatments of sugar and jaggery five per cent spray solutions in open plots due to the strong olfactory sensory of bees. So, bees attract more towards those capitula on which sugar and jaggery solutions were sprayed. These present results coincide with the findings of Pateel and Sattagi (2007) [5], who reported that treatment of sugar and jaggery solutions attracted more honey bees up to three days of first and second sprays, whereas their activities decreased at five days of sprays.

3.1.6 Pooled over sprays during *rabi,* 2017-18

The data on pooled over sprays of two sprays given during *rabi,* 2017 indicated that days after sprays were recorded maximum number of bee visit 3.96 bees/ 5 capitula/ 2 min in all the different periods from 1,3,5 and 7 days after spray.

Least number of bee visit on sunflower capitula was found in the treatment of pollination without insect with 0.50 bees/ 5 capitula/ 2 min. Furthermore, visit of bees showed declined with number of days increased of subsequent sprays (Table 6).

Maximum number of honey bee visits were found in the treatment of one framed *A. mellifera* colony covered with net (3.96 bees/ 5 capitula/ 2 min) in a day after both the sprays and it was at par with jaggery spray 5% (3.92), sugar solution spray 5% (3.83), open pollination (3.22) and treatment of a colony *Trigona* sp. covered with net (3.22).

After three days of both the sprays, maximum number of honey bee visited in the treatment of sugar solution spray 5% (3.85) and it was at par with one framed *A. mellifera* colony covered with net (3.79), jaggery spray 5% (3.34) and treatment of a colony *Trigona* sp. covered with net (3.20). There was less number of honey bee visits recorded in the treatment of open pollination (1.05).

Five days after sprays, maximum number of honey bee visited in the treatment of jaggery spray 5% (2.98). One framed *A. mellifera* colony covered with net (1.55), sugar solution spray 5% (1.46), open pollination (1.46) and a colony *Trigona* sp. covered with net (1.26) were significantly at par with each other in respect to honey bee activities.

After seven days of sprays, maximum number of honey bee visited in the treatment of sugar solution spray 5% (1.55). However, treatment of jaggery spray 5% (1.46), one framed *A. mellifera* colony covered with net (1.46), open pollination (1.42) and a colony *Trigona* sp. covered with net (1.22) were also found at par with treatment of sugar spray 5%.

The results of present investigations were found similar with the findings of Pateel and Sattagi (2007) [5], treatments of sugar and jaggery solution attracted more bees up to third day of sprays whereas their efficacy decreased at five days of sprays.

Table 1: Bee visits after first spray on sunflower head during *kharif*, 2017

Treatments	No. of bees/ five capitula/two min days after spray			
	Before spray	1	3	5
Open pollination (OP)	1.54 (1.85)	1.59 (2.00)	1.65 (2.23)	1.42 (2.00)
Pollination without Insect (PWI) covered with net	1.000 (0.50)	1.000 (0.50)	1.000 (0.50)	1.000 (0.50)
One framed *A. mellifera* colony covered with net	1.64 (2.19)	1.80 (2.70)	1.93 (3.24)	1.72 (2.46)
Trigona sp. colony covered with net	1.65 (2.23)	1.72 (2.46)	1.87 (2.98)	1.80 (2.70)
Sugar solution spray (5%) in open plot	1.65 (2.23)	1.92 (3.19)	2.06 (3.74)	1.86 (2.72)
Jaggery solution spray (5%) in open plot	1.57 (1.97)	1.87 (2.98)	1.99 (3.47)	1.82 (3.14)
S. Em. ± T	0.08	0.09	0.07	0.08
C.D. at 5% T	0.23	0.29	0.22	0.24
C.V. %	10.22	11.41	8.06	9.77

Note: Figures in parentheses are retransformed values of $\sqrt{x + 0.5}$

Table 2: Bee visits after second spray on sunflower head during *kharif*, 2017

Treatments	No. of bees/ five capitula/two min days after spray				
	Before spray	1	3	5	7
Open pollination (OP)	1.79 (2.74)	1.87 (2.98)	1.72 (2.46)	1.65 (2.23)	1.42 (1.48)
Pollination without Insect (PWI) covered with net	1.00 (0.50)	1.00 (0.50)	1.00 (0.50)	1.00 (0.50)	1.00 (0.50)
One framed *A. mellifera* colony covered with net	1.87 (2.98)	1.92 (3.29)	1.79 (2.72)	1.72 (2.46)	1.68 (2.35)
Trigona sp. colony covered with net	1.79 (2.69)	1.87 (2.98)	1.78 (2.69)	1.72 (2.46)	1.52 (1.60)
Sugar solution spray (5%) in open plot	1.99 (3.47)	2.05 (3.71)	1.87 (2.98)	1.69 (2.38)	1.66 (2.34)
Jaggery solution spray (5%) in open plot	1.93 (3.21)	1.99 (3.47)	1.79 (2.74)	1.73 (2.52)	1.52 (1.63)
S. Em. ± T	0.10	0.10	0.09	0.08	0.09
C.D. at 5% T	0.30	0.29	0.27	0.24	0.28
C.V. %	11.60	10.63	10.78	9.89	11.61

Note: Figures in parentheses are retransformed values of $\sqrt{x + 0.5}$

Table 3: Bee visits during *kharif*, 2017 (Pooled over sprays)

Treatments	No. of bees/ five capitula/ two min days after spray			
	1	3	5	7
Open pollination (OP)	1.86 (2.97)	1.87 (2.98)	1.76 (2.60)	1.33 (1.26)
Pollination without Insect (PWI) covered with net	1.00 (0.50)	1.00 (0.50)	1.00 (0.50)	1.00 (0.50)
One framed *A. mellifera* colony covered with net	1.88 (3.07)	1.94 (3.10)	1.75 (2.60)	1.39 (1.46)
Trigona sp. colony covered with net	1.79 (2.71)	1.83 (2.84)	1.84 (2.86)	1.35 (1.35)
Sugar solution spray (5%) in open plot	1.89 (3.09)	1.92 (3.92)	1.69 (2.08)	1.42 (1.54)
Jaggery solution spray (5%) in open plot	1.95 (3.34)	1.96 (3.35)	1.71 (2.46)	1.56 (1.96)
S. Em. ± T	0.06	0.06	0.05	0.04
S	0.04	0.03	0.03	0.02
T x S	0.09	0.08	0.08	0.06
C.D. at 5% T	0.19	0.17	0.16	0.13
S	0.11	0.09	NS	0.07
T x S	NS	NS	NS	0.183
C.V. %	10.61	9.61	10.05	9.79

Note: Figures in parentheses are retransformed values of $\sqrt{x + 0.5}$

Table 4: Bee visits after first spray on sunflower head during *rabi*, 2017

Treatments	No. of bees/ five capitula/ two min days after spray		
	Before spray	**1**	**3**
Open pollination (OP)	1.72 (1.60)	1.79 (2.72)	2.05 (3.71)
Pollination without Insect (PWI) covered with net	1.00 (0.50)	1.00 (0.50)	1.00 (0.50)
One framed *A. mellifera* colony covered with net	1.99 (3.47)	2.11 (3.99)	2.34 (4.99)
Trigona sp. colony covered with net	1.72 (2.46)	1.86 (2.98)	2.05 (3.74)
Sugar solution spray (5%) in open plot	1.86 (2.98)	2.23 (4.47)	2.17 (4.21)
Jaggery solution spray (5%) in open plot	1.52 (2.46)	2.17 (4.21)	2.11 (3.99)
S. Em. ± T	0.09	0.07	0.09
C.D. at 5% T	0.27	0.21	0.28
C.V. %	10.71	7.34	9.49

Note: Figures in parentheses are retransformed values of $\sqrt{x + 0.5}$

Table 5: Bee visits after second spray on sunflower head during *rabi*, 2017

Treatments	No. of bees/ five capitula/ two min days after spray				
	Before spray	**1**	**3**	**5**	**7**
Open pollination (OP)	1.72 (2.46)	1.86 (2.98)	1.85 (2.96)	1.79 (2.74)	1.53 (1.84)
Pollination without Insect (PWI) covered with net	1.00 (0.50)	1.00 (0.50)	1.00 (0.50)	1.00 (0.50)	1.00 (0.50)
One framed *A. mellifera* colony covered with net	1.98 (3.43)	1.99 (3.47)	1.86 (2.98)	1.79 (2.74)	1.78 (2.69)
Trigona sp. colony covered with net	1.86 (2.98)	1.99 (3.47)	1.78 (2.69)	1.64 (2.19)	1.65 (2.23)
Sugar solution spray (5%) in open plot	1.86 (2.98)	2.07 (3.78)	2.05 (3.71)	1.86 (2.98)	1.79 (2.74)
Jaggery solution spray (5%) in open plot	1.79 (2.74)	2.23 (4.47)	1.92 (3.19)	1.86 (2.96)	1.64 (2.19)
S. Em. ± T	0.08	0.10	0.10	0.08	0.08
C.D. at 5% T	0.23	0.31	0.29	0.25	0.24
C.V. %	8.99	11.31	11.48	10.15	9.90
Note: Figures in parentheses are retransformed values of $\sqrt{x + 0.5}$					

Table 6: Bee visits during *rabi*, 2017 (Pooled over sprays)

Treatment	No. of bees/ five capitula/ two min days after spray			
	1	**3**	**5**	**7**
Open pollination (OP)	1.99 (3.22)	1.39 (1.46)	1.36 (1.42)	1.24 (1.05)
Pollination without Insect (PWI) covered with net	1.00 (0.50)	1.00 (0.50)	1.00 (0.50)	1.00 (0.50)
One framed *A. mellifera* colony covered with net	2.11 (3.96)	2.07 (3.79)	1.43 (1.55)	1.39 (1.46)
Trigona sp. colony covered with net	1.90 (3.20)	1.92 (3.22)	1.32 (1.26)	1.28 (1.22)
Sugar solution spray (5%) in open plot	2.08 (3.85)	2.04 (3.83)	1.43 (1.55)	1.36 (1.42)
Jaggery solution spray (5%) in open plot	2.08 (3.92)	1.95 (3.34)	1.86 (2.98)	1.39 (1.46)
S. Em. ± T	0.06	0.07	0.04	0.03
S	0.03	0.04	0.03	0.02
T x S	0.08	0.09	0.06	0.05
C.D. at 5% T	0.18	0.19	0.13	0.11
S	NS	0.11	0.07	0.06
T x S	NS	NS	0.17	0.16
C.V. %	9.56	10.21	9.36	4.86

Note: Figures in parentheses are retransformed values of $\sqrt{x + 0.5}$

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