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Electroantennogram and ovipositional responses of *Helicoverpa armigera* (Hubner) and *Chrysoperla carnea* (Stephens) to volatiles of different cultivars of safflower, *Carthamus tinctorius* L.

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Abstract
Electroantennogram and Ovipositional responses of *Helicoverpa armigera* (Hubner) and the predator, *Chrysoperla carnea* (Stephens) to different cultivars of safflower were studied under laboratory and field conditions. The antennae of mated females of both *H. armigera* and *C. carnea* showed significantly better response compared to the mated males. Totally 11 number of cultivars were tested and among them, NARI-6, CO-1, DSH-129, PBNS-58 and MRSA-521 elicited significantly higher electroantennogram response in female *H.* armigera which were at par with 50 per cent honey as a reference check. The antennae of female *C. carnea* showed significantly higher responses to the cultivars like DSH-129, A-1, GMU-2518, NARI-H-15, 11-17-1, MRSA-521 and 50 per cent honey as a reference check. The ovipositional preference of *H.armigera* was studied on different cultivars of safflower and among them highest oviposition was recorded on NARI-6, DSH-129 and CO-1. *Chrysoperla carnea* laid more number of eggs on A-1 followed by GMU-2518, 11-17-1, DSH-129, NARI-H-15. Wind tunnel olfactometer (eight arm) studies under laboratory condition indicated higher orientation of *C. carnea* adults towards the extract of DSH-129, A-1, GMU-2518, NARI-H-15 and NARI-6. All the cultivars were sown under field condition to test their yield potential. The results indicated that the cultivars A-1, 11-17-1, NARI-H-15, PBNS-58, SSF-679, DSH-129 and GMU-2518 recorded significantly higher seed yield compared to the other cultivars of safflower.

Keywords: *Helicoverpa armigera* - *Chrysoperla carnea* – Oviposition – Electroantennogram - Safflower cultivars - Olfactometer.

Introduction

Safflower (*Carthamus tinctorius* L.) is one of the important rabi oilseed crops of the country. For centuries, it has been under cultivation in India either for its orange red dye (carthamine) extracted from its brilliantly coloured florets and or for its much valued oil. Apart from its superior adaptability to scanty moisture conditions, safflower produces oil rich in polyunsaturated faty acids (Linoleic acid 78 %) which play an important role in reducing the blood cholesterol level.
The Safflower capsule borer, *Helicoverpa armigera* (Hubner) is one of the serious pests on safflower causing sever damage on nonspiny & spiny varieties. (Anon. 2006). Chrysopid predators are key natural enemies of soft bodied insects, lepidopteron eggs and early instar larvae (Canard *et al*., 1984; Singh *et al*., 1994) and form an important component in the bio-intensive IPM of safflower pests. Physical and chemical characteristics of different safflower cultivars were found to influence the efficiency of the parasitoids and predators (Singh and Bakthavatsalam, 1996). In the present study the response of *H. armigera* and the predator, *Chrysoperla carnea* (Stephens) to different safflower cultivars was studied through electroantennogram and behavioral studies.

Materials and Methods

Culture of pest and predator:

The early instar larvae of *Helicoverpa armigera* (Hubner) were reared on tender okra fruits and soaked bengal gram seeds. The adults of *H. armigera* were reared on 50 % honey, sugar solution and water in cotton swab. Males and females of *H. armigera* were separated at the pupal stage. The grubs of *Chrysoperla carneae* (Stephens) were reared on eggs of *Corcyra*

cephalonica (Stainton) and the adults were fed on honey (50 %) and protinex mixture as described earlier (Singh *et al.,* 1994). Separation of male and female of *C.carnea* was done immediately after adult emergence (based on facial marking) and was used in different experiments.

Extraction of Plant Kairomones:
The volatiles from safflower were extracted in hexane as per the procedure used by Rambold and Hanstober (1985) for the extraction of pigeon pea kairomon.

Electrophysiological studies:
Electrophysiological studies were conducted with amputated antenna cut along the basal segment (scape & pedicil). The excited antenna was placed between two glass electrodes containing electrical conductivity gel. A wind flow of 50 cm /second and a pulse time of 0.5 sec. were maintained. Stimulus sources of various test compounds were given through filter paper bits of equal size dipped in plant extracts placed inside Pasteur pipettes of 0.5 x 4 cm. Bakthavatsalam *et al*., described the detailed procedures for electroantennogram studies in 2000. The recordings were done for 5 seconds with one-second pre- excitation time. Each antenna was exposed to extracts from all the cultivars and 5 antennae were used for each set of experiments. Totally eleven cultivars along with honey as a standard check and air (empty pasteur pipette) were compared. The data obtained were subjected to $\log_{10}$ transformation and subjected to analysis of variance in completely randomized design.

Ovipositional preference:
For ovipositional preference studies on both pest and predator, the potted plants of safflower raised in net house condition constructed with nylon net of 10 x 20 m with 2.5 m height to accommodate two sets of experiments at ARS, Annigeri. The potted plants were arranged in replication and treatment wise. Healthy pupae of *H. armigera* were selected and sexed in to male and female at pupal stage and were kept in separate cages until adult emergence. Freshly emerged fifteen pairs of healthy male and female of one to two days old *H. armigera* were shifted to rearing cages for mating by providing with 20 per cent honey solution (Butter and Singh, 1996). The next day 15 pairs of pre-mated *H. armigera* moths were released in to the net house for oviposition. The cotton swabs containing 10 per cent honey solution were hung inside net house to facilitate adult feeding. After two days all the moths in side the net house were removed and number of eggs laid by the pest on different cultivars was recorded. In the same way twenty-five pairs six day old adults of *C. carnea* in 1:1 ratio (adults were provided with hanging cotton swabs containing food stuff, 50 per cent honey, water + proteinex) were released in the other net house and number of eggs laid was recorded. The experiments were conducted at open condition of 27^0c and relative humidity of 80 per cent. Each set of experiments was replicated five times. The data obtained were subjected to analysis of variance in completely randomized design.

Observations on number of *H. armigera* and *C. carnea* eggs per plant at pre-flowering stage were recorded on two days after release. Under field condition each of the genotypes was planted in five meter rows with 3 replicates. Grain yield grams per plant was recorded.

Wind tunnel olfactometer studies:
The cotton swabs containing 0.5 ml of hexane extract of different cultivars of safflower were taken and these were kept out side for 30 minutes for evaporation of hexane. Later these cotton swabs containing kairomone were kept in different arms of the olfactometer (Eight arm olfactometer). Twenty five mated adults of *C. carnea* were released in the test chamber and the observations were recorded at 12 hr. interval for number of adults entering in the treated (kairomone) arm.

Results and Discussion
Electroantennogram responses:
The adults of both *H. armigera* and *C. carnea* showed typical EAG response to kairomonal substances. Among the sexes, the mated female of both pest and predator showed highest

response to the safflower kairomones. Mated females of *H. armigera* had significantly stronger EAG responses to allelochemicals of cotton, maize and peanut than virgin females, suggesting that these plant released chemicals capable of promoting oviposition (Ding *et al*., 1997; Bakthavatsalam *et al*., 2000 and Bakthavatsalam *et al*., 2002).

Among the cultivars tested A1, GMU-2518, NARI-H-15, MRSA-521 and 11-17-1 evoked significantly lower EAG response to *H. armigera* than compared to rest of the entries. Since, these entries were given lower preference to the pest, *H. armigera* can be consider as a better for minimizing the *H. armigera* and getting higher yield. There was no significant difference in male *H. armigera* to different volatile compound of safflower cultivars (Table 1).

The male and female *C. carnea* showed better response to plant volatiles than *H. armigera.* The cultivars, DSH-129, A-1, GMU-2518, NARI-H-15 and PBNS-58 evoked higher response and were on par with 50 % honey as check reference. Least response was noticed in CO-1, 11-17-1 and GMU-1364. In case of male *C. carnea* also DSH-129, CO-1, GMU-2518 and 50 per cent honey solution evoked greater response compared to the remaining cultivars but they are non significant (Table-1).

Chrysoperla carnea was found to show electroantennogram response to kairomones (Boo *et al*., 1998; Zhu *et al*., 1999 and Bakthavatsalam *et al*., 2000). EAG response of female *C. carnea* antenna to extract of corn leaves was greater than that of males (Zhu *et al*., 1999). Females, of both *H. armigera* and *C. carnea* showed better response than male, obviously because of the preference for ovipositions induced by an array of kaiomones/chemicals from the host plants and host insects, respectively.

Ovipositional preference of *H. armigera* and *C. carnea*:
The ovipositional preference of *H. armigera* and *C. carnea* to different cultivars was tested under free choice in net house conditions. The highest oviposition by *H. armigera* was observed on the variety CO-1, NARI-6, and DSH-129 and was statistically on par with each other. Least oviposition was recorded on SSF-679, A-1, 11-17-1, GMU-2518 and PBNS-58 (Table-2). In similar studies MCU-9 of cotton variety was the most preferred and LK-861 the least preferred for *H. armigera* (Mohite and Uthamasamy, 1998). *Chrysoperla carnea* showed significantly better ovipositional response on A-1, GMU-2518 and 11-17-1, which were on par with NARI-H-15, DSH-129, MRSA-521 and PBNS-58 (Table-2). Such preference of predators (chrysopids and coccinollids) was observed on open pollinated cultivars of cotton (Vennila, 1998).

The studies suggested that the cultivars A1, GMU-2518 and 11-17-1 are highly preferred by *C. carnea* may be recommended for cultivation with the natural enhanced activity of chrysopids. However, it is also necessary to find out the impact of these cultivars on other natural enemies. Significantly highest yield gram per plant was recorded in A-1, 11-17-1, NARI-H-15, PBNS-58, GMU-2518 and DSH-129. The orientation of *C. carnea* towards the extracts of different genotypes of safflower leaf extract using eight arm olfactometer revealed that, significantly highest number of *C. carnea* adults moved towards the arm containing the leaf extract of A-1, DSH-129, NARI-6, GMU-2518, 11-17-1, NARI-H-15 and on par with Honey (50%) as reference check. The cultivars with moderate attraction may also be selected for breeding by plant breeders for natural enhanced activity of the entomophages. The role of other volatiles in attracting entomophages need to be further studies and the genes controlling the traits need to be investigated to incorporate these traits in further breeding programmes.

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Table1: Electroantennogram responses of *H. armigera* and *C. carnea* to leaf extracts of safflower cultivars.

Safflower cultivars	***Helicoverpa armigera***		***Chrysoperla carnea***	
	Female(-mv)	**Male(-mv)**	**Female(-mv)**	**Male(-mv)**
PBNS-58	1.456 (0.163)	1.120(0.048)	2.421 (0.384)	1.400 (0.146)
MRSA-521	1.420 (0.152)	1.146(0.059)	2.558 (0.408)	1.420 (0.152)
NARI-6	1.506 (0.178)	1.106 (0.044)	2.520 (0.401)	1.382 (0.140)
CO-1	1.551 (0.191)	1.220 (0.086)	2.502 (0.398)	1.422 (0.153)
DSH-129	1.461 (0.165)	1.162 (0.065)	2.780 (0.444)	1.420 (0.152)
A-1	1.401 (0.033)	1.062 0.026)	2.702 (0.432)	1.282 (0.108)
GMU-2518	1.402 (0.147)	1.161 (0.063)	2.601 (0.415)	1.402 (0.147)
NARI-H-15	1.450 (0.137)	1.006 (0.003)	2.700 (0.431)	1.381 (0.140)
11-17-1	1.422 (0.215)	1.202 (0.080)	2.552 (0.407)	1.280 (0.107)
SSF-679	1.432 (0.156)	1.162 0.065)	2.464 (0.392)	1.422 (0.153)
GMU-1364	1.460 (0.164)	1.122 (0.049)	2.501 (0.398)	1.424 (0.154)
HONEY (50%)	1.554 (0.191)	1.208 (0.081)	2.582 (0.412)	1.482 (0.171)
AIR(empty pasteur pipette)	0.032 (-1.486)	0.022 (-1.660)	-0.048 (-1.319)	0.042 (-1.380)
CD(P=0.05)	**0.05**	**0.06**	**0.04**	**0.03**

Table2: Ovipositional preference of *H. armigera* and *C. carnea* on different cultivars of safflower.

Safflower cultivars	**No. of eggs laid/ plant by**	
	Helicoverpa armigera	***Chrysoperla carnea***
PBNS-58	18.0	10.40
MRSA-521	18.6	10.20
NARI-6	26.8	6.00
CO-1	27.0	5.60
DSH-129	26.0	10.90
A-1	20.4	12.60
GMU-2518	16.2	12.00
NARI-H-15	22.0	10.80
11-17-1	16.2	11.20
SSF-679	15.0	7.20
GMU-1364	18.7	10.00
CD (P=0.05)	**1.02**	**0.71**

Table3: Orientation of *C. carnea* to different volatile compounds of Safflower and their yield components.

Safflower cultivars	No. of adults reached the kairomone source	Yield (g/pl)
PBNS-58	4.00	8.20
MRSA-521	4.00	6.80
NARI-6	4.60	4.50
CO-1	2.80	0.20
DSH-129	5.00	7.80
A-1	5.20	9.20
GMU-2518	4.80	8.40
NARI-H-15	4.60	8.40
11-17-1	4.80	9.00
SSF-679	2.80	8.60
GMU-1364	3.20	8.00
Honey (50%)	5.20	-
AIR(empty Pasteur pipette)	1.20	-
CD (P=0.05)	0.95	1.15

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