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Toxicity of some insecticides against *Bracon hebetor* (Say): A potential Lepidopterous parasitoid

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ABSTRACT

Six insecticides (endosulfan, Thiodon 35EC; triazophos, Hostathion 40EC; cypermethrin, Arrivo 10EC; indoxacarb, Steward 150SC, λ-cyhalothrin, Boxer 2.5EC and spinosad, Tracer 240SC) which are commonly used against *Helicoverpa armigera* (Hubner), have been evaluated against the potential larval parasitoid Bracon *hebetor* (Say) for their suitability of release in the integrated pest management (IPM) in cotton crops. The experiment was done under laboratory conditions (27 ± 3Co and 65 ± 5% RH) by using freshly emerged (one day old) adults for bioassays using the vial method. Spinosad was proved to be the most toxic insecticide against *B. hebetor,* having the lowest LC_{50} (86.96 ppm after 12 h exposure; 77.97 ppm after 24 h exposure and 57.75 ppm after 48 h exposure) and LT_{50} (4.05 h) values. Spinosad also caused the highest percentage of mortalities (> 90%) of *B. hebetor* at field-recommended doses. However, all the tested insecticides caused above 70% mortality, particularly after 48 h exposure. The results reveal that spinosad should be used carefully in the management of *H. armigera*. The possible releasing time of *B. hebetor* after insecticidal sprays in the field is discussed.

Keywords: Insecticides; *Helicoverpa armigera; Bracon hebetor;* IPM.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is a major fiber and cash crop of Pakistan and ranks at the top as foreign exchange earner, providing livelihood to millions of people engaged in the trade and textile sector (Arif *et al*., 2004). Every year, the cotton crop is attacked by a number of lepidopterous insects, and is intensively sprayed with various insecticides for the control of these insect pests (Ahmad & Ahmad, 2006). *Bracon hebetor* (Say) (Hymenoptera: Braconidae) is a potential parasitoid of various lepidopterous larvae and can easily be mass-reared in the laboratory (Baker *et al*., 1995). In the past, mass releases of this parasitoid were done in the field for the control of *Heliothis* spp (Heimpel *et al*., 1997).

Many researchers have investigated the effect of insecticides on this parasitoid (Guddewar *et al.,* 1997; Baker *et al*., 1995; Reddy *et al*., 1997; Ahmad & Ahmad, 2006) and found variable results; however, no one has shown the clear picture of selectivity of insecticides to be used along with the *B*. *hebetor*, nor the time of release, if used in an integrated pest management (IPM) program (Khan *et al*., 2009). The present study has therefore been planned to screen out the most commonly used insecticides on cotton for their effect on *B*. *hebetor*.

MATERIALS AND METHODS

Rearing of the B. hebetor

The rearing of the larval parasitoid, *Bracon hebetor* (Say) was done in the laboratory at set conditions of $27 \pm 3C^{o}$ and RH $65 \pm 5\%$. *Galleria mellonella* (Lepidoptera: Pyralidae), natural host of the B. hebetor, was used to rear the parasitoid (Khan *et al*., 2005). *G*. *mellonella* was collected from infested bee hives and were reared in plastic jars (10 cm diameter and 30cm depth) following the methodology described by Khan *et al*. (2009). The larvae of the *G*. *mellonella* obtained in this process were used for rearing B. hebetor. The adults of *B*. *hebetor* were obtained from the biological control laboratory at the University of Agriculture, Faisalabad, and were used to parasitize the larvae of *G*. *mellonella* by following the procedure described by Ahmad & Ahmad (2006) and Khan *et al*. (2009). One pair of parasitoid was introduced in each glass vial having 3 larvae of the 5^{th} instar of *G*. *mellonella*. A cotton swab, soaked with 20% honey solution, was inserted in glass vials for adult parasitoid feeding. The parasitized larvae were incubated in a growth chamber at $27 \pm 3C^{o}$ and RH $65 \pm 5\%$. This process was continued all the time female parasitoid remained alive (Khan *et al*., 2009).

Bioassays

Commercial formulations of six insecticides, viz., endosulfan (Thiodon 35EC, Bayer cropScience); triazophos (Hostathion 40EC, Bayer CropScience); cypermethrin (Arrivo 10EC, FMC); indoxacarb (Steward 150SC, Du pont); λ-cyhalothrin (Boxer 2.5EC) and spinosad (Tracer 240SC, Bayer CropScience) were selected for bioassays and prepared in concentrations ranging from 1-1000 ppm, i.e., 62.5ppm, 125ppm, 250ppm, 500ppm, 1000ppm. The vial method was used for toxicological bioassays (Khan *et al*., 2009). One ml of each insecticide concentration was applied on the inner lining of the vials with the help of a dropper, and they were used for bioassays immediately after the insecticide solution had dried up. Thirty adult parasitoids of uniform age (one day old) were then introduced in treated vials by using an aspirator. The vial openings were covered with muslin to prevent the escape of the parasitoids. These insecticide-treated vials, having parasitoids, were kept in growth chambers at set conditions of $27 \pm 3C^{o}$ and $65 \pm 5\%$ RH. The adult parasitoids were also exposed to field-recommended doses of insecticides against *H. armigera*. Mortality data was recorded with the help of a binocular compound microscope after 12, 24 and 48 h exposures of the parasitoids to the treated vials. The entire experiment was done in quadruplicate, including controls. The tested insecticides were later on categorized as Harmless (below 50% mortality); Slightly harmful (50-79% mortality); Moderately harmful (80-89% mortality) and Extremely harmful (90 and above 90% mortality) (Khan et al., 2009).

Statistical Analysis

The mortality data so obtained was subjected to Probit analysis (Finney, 1971), by using the software Polo-PC (LeOra Software, 1987) for dose and time mortality lines. The data regarding percent mortality at field application rates was subjected to analysis of variance (ANOVA) using SPSS 10 for windows (SPSS Inc., 1999), and means were compared by the least significant difference (LSD) test at a 5% probability level. The response of *B. hebetor* against different insecticides was considered to be signi?cantly different if their respective 95% fiducial limits (FL) did not overlap (Saeed *et al*., 2007).

RESULTS AND DISCUSSION

Table 1 shows that spinosad was the most toxic to *B. hebetor* by having the least LC_{50} values after 12, 24 and 48 h exposures (86.96 ppm; 77.97 ppm and 57.75 ppm, respectively) followed by indoxacarb, lambdacyhalothrin and cypermethrin. Triazophos was proved to be the least toxic insecticide by having highest LC_{50} values at all time durations, followed by Endosulfan.

Table 1. LC_{50} of insecticides against adults of *B. hebetor* reared in the laboratory.

Insecticide	Mortality (h)	LC_{50} (95% FL)	Slope ± SE	χ^2	d.f.	*P*
Cypermethrin	12	329.32 (314.12-345.81)c	2.25 ± 0.37	0.09	4	0.99
Indoxacarb	12	234.31 (219.18-265.73)b	1.85 ± 0.37	0.97	4	0.91
λ-cyhalothrin	12	237.33 (204.32-257.86)b	1.71 ± 0.30	0.65	4	0.96
Triazophos	12	716.71 (587.38-788.82)d	2.03 ± 0.39	0.22	4	0.99
Spinosad	12	86.96 (82.72-93.55)a	2.12 ± 0.37	0.02	4	0.99
Endosulfan	12	710.99 (646.04-752.84)d	4.89 ± 0.69	5.97	4	0.20
Cypermethrin	24	280.56 (257.02-296.18)c	2.26 ± 0.38	0.04	4	0.99
Indoxacarb	24	192.73 (179.69-204.56)b	1.75 ± 0.36	0.09	4	0.99
λ-cyhalothrin	24	216.06 (182.03-237.44)b	1.92 ± 0.32	2.24	4	0.69
Triazophos	24	677.82 (573.92-741.61)d	2.82 ± 0.46	0.25	4	0.99
Spinosad	24	77.97 (74.13-81.73)a	2.23 ± 0.37	0.35	4	0.99
Endosulfan	24	605.66 (327.49-694.09)d	5.46 ± 1.80	1.27	4	0.87
Cypermethrin	48	232.21 (208.97-247.30)c	4.33 ± 0.62	2.54	4	0.64
Indoxacarb	48	146.06 (125.07-158.62)b	2.32 ± 0.40	0.52	4	0.97
λ-cyhalothrin	48	193.87 (144.36-213.49)bc	5.39 ± 1.45	1.00	4	0.91
Triazophos	48	535.09 (328.18-640.88)d	2.80 ± 0.67	4.83	4	0.31
Spinosad	48	57.75 (51.35-61.90)a	3.12 ± 0.46	4.01	4	0.40
Endosulfan	48	206.68 (180.11-237.23)bc	1.79 ± 1.92	5.82	4	0.21

LC_{50} (lethal concentration to kill 50% of the population of a subjected organism) data recorded after the same time interval within an insecticide treatment denoting the same letter are not different at 5% level of significance (Saeed *et al.*, 2007). **FL**: upper and lower limits of the respective LC_{50} value.

Significant differences were found among different tested insecticides at?eld application rates in relation to time-to-kill (Table 2). Spinosad proved to be the fastest killer followed by indoxacarb and cypermethrin, while triazophos and endosulfan took almost 18 and 20 h respectively, to kill 50% of the population (Table 2).

Table 2. Time mortality response of B. hebetor against insecticides at field-recommended doses of insecticides for H. armigera.

Insecticide	LT_{50}	95% FL	Slope ± SE	χ^2	d.f.	*P*
λ-cyhalothrin	13.32	(11.97-14.57)c	0.87 ± 0.06	5.3	2	0.07
Endosulfan	19.64	(17.85-21.42)d	0.69 ± 0.05	4.70	2	0.10
Cypermethrin	8.01	(6.48-9.36)b	0.79 ± 0.09	3.90	2	0.14
Indoxacarb	5.00	(3.47-6.43)a	0.68 ± 0.07	2.83	2	0.24
Triazophos	17.56	(15.98-19.08)d	0.76 ± 0.05	1.71	2	0.42
Spinosad	4.05	(2.47-5.41)a	1.21 ± 0.17	0.05	2	0.98

LT_{50} (lethal time to kill 50% population of the subjected organism) data recorded within an insecticide treatment denoting the same are not different at 5% level of significance (Saeed *et al.*, 2007). **FL**: upper and lower limits of the respective LT_{50} value.

Exposures of the adult parasitoids to the field-recommended doses showed that spinosad caused the highest percentage of mortalities, at all the time durations, followed by indoxacarb, while triazophos caused the lowest percentage of mortalities. These were followed by endosulfan and indoxacarb (Table 3).

Table 3. Percent mortality of B. hebetor after 12, 24 and 48 h exposure to field-recommended doses of insecticides for *H. armigera*.

Insecticide	Dose/acre (ml)	Mortality (%)*		
		12 h	24 h	48 h
λ-cyhalothrin	300	49.67d	63.16d	89.50b
Triazophos	1000	38.33f	52.00e	75.00d
Cypermethrin	250	66.33c	73.83c	95.67a
Indoxacarb	175	73.50b	83.83b	94.66a
Endosulfan	1000	42.50e	51.50e	81.67c
Spinosad	80	90.5a	98.00a	98.91a
$LSD_{\alpha=0.05}$	-----	3.26	2.00	4.11
F ratio	-----	338	760	42.6
P value	-----	000	000	000
C.V.	-----	3.66	1.91	3.10

* Means sharing the same letters within a column do not differ significantly at 5% level of significance (Least Significant Difference [LSD] test, SPSS 10).

After 12 h exposure, triazophos, endosulfan and lambdacyhalthrin proved to be the most harmless insecticides (< 50% mortality), cypermethrin and indoxacarb were slightly harmful (50-79% mortality), except for indoxacarb and spinosad which were moderately harmful and exteremely harmful, respectively. After 48 h exposure, cypermethrin, indoxacarb and spinosad were extermely harmful insecticides (> 90% mortality), while the remaining insecticides were moderately harmful (80-89% mortality), excepting triazophos which was slightly harmful to *B. hebetor* (Table 3).

Our results indicate that all the insecticides gave significant mortality of the parasitoid, and spinosad proved to be the most toxic insecticides among the tested insecticides by having lowest LC_{50} values at all the time durations. Kovalankov (2002) reported that spinosad revealed marginal-to-excellent selectivity but was extremely toxic to *B. mellitor*. Our results are not in agreement with those reported by Ahmed & Ahmad (2006), who reported that spinosad is harmless to *B. hebetor*. Spinosad, moreover, gave the highest percent mortalities and proved to be the fastest killer among all the tested insecticides. The results are in partial agreement with those reported by Reddy *et al.* (1997) who reported the harmless action of endosulfan towards *B. hebetor*, but in our study endosulfan proved harmless up to 12 h exposure. All the tested insecticides gave more than 75% mortalities, particularly after 48 h exposure, and half of the tested insecticides, such as cypermethrin, endosulfan and spinosad, caused more than 90% mortalities of the subjected parasitoid.

CONCLUSION

Maximum percent mortality of the parasitoid was observed in the first 12 h exposure, while after 24 and 48 h exposure, there was observed a slow increase in mortality rate when compared to the rate in first 12 h exposure (Table 3). This phenomenon of slow increase in mortality with the passage of time might be due to decreases in residual effects of insecticides over time. In conclusion, we suggest that there should be a judicious use of insecticides in the field, and parasitoid should be released after at least 24 h of insecticidal spray (Khan *et al.*, 2005), and most preferably releases should be done after 48 hours of insecticidal spraying.

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سمية بعض المبيدات الحشرية ضد Bracon hebetor (Say) : طفيل محتمل من قشريات الجناح

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خلاصة

تم تقييم تأثير سمية ستة من المبيدات الحشرية التي تستخدم عادة ضد Helicoverpa armigera على يرقات الطفيل المحتمل Bracon Hebetor وذلك للتوصية بإدراجهم ضمن المكافحة المتكاملة للآفات في محاصيل القطن. ولقد أجريت تجارب التحليل البيولوجي في القوارير على الطور البالغ للطفيل (حديث الظهور) في درجة حرارة 27 ± 5% . أثبتت النتائج أن سمية المبيد الحشري Spinosad هي الأعلى حيث تسبب في وفيات طفيل B. hebetor بنسبة أعلى من 90٪، بينما تسببت المبيدات الحشرية الأخرى في نسبة وفيات تقدر بـ 70٪، خاصة بعد 48 ساعة من التعرض. توصي الدراسة بأهمية العناية عند استخدام المبيد الحشري Spinosad في مكافحة طفيل H. armigera، كما تناقش الزمن المحتمل لظهور طفيل B. hebetor في الحقول بعد استخدام المبيدات.