THE EFFECTS OF IMIDACLOPRID, INDOXACARB AND DELTAMETHRIN ON SOME BIOLOGICAL AND DEMOGRAPHIC PARAMETERS OF *HABROBRACON HEBETOR* SAY (HYMENOPTERA: BRACONIDAE) IN ADULT STAGE TREATMENT

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ABSTRACT: The effect of field recommended doses of imidacloprid, indoxacarb, and deltamethrin (290, 125, and 83 ppm based on active ingredient, respectively) were studied on some biological and demographic parameters of adult *Habrobracon hebetor* Say. The experiments were conducted at 26±1°C, 60±5% RH, and a photoperiod of 12 L:12 D h. Thirty, one-day-old females were treated using paper disc method for 24 h. Distilled water plus Triton X-100 was used in control treatment. Females survived in each treatment were transferred individually to 6 cm Petri dishes. One adult male was added to each Petri dish for mating. Three last instar larvae of *Anagasta kuehniella* (Zeller) were offered to each female daily as host. The number of eggs produced per female per day were counted until all of the females died. Stable population growth parameters were estimated using Carey's (1993) procedure. Gross and net reproductive rates in control and imidacloprid, indoxacarb, and deltamethrin treatment were 206.31±13.38 and 73.46±5.5; 186.82±21.39 and 46.81±6.52; 164.71±14.47 and 51.75±5.22; 102.39±9.84 and 19.95±2.56, respectively. Mean generation time and doubling time in control and insecticidal treatments were 21.22± 0.2 and 3.43±0.04; 22.49±0.32 and 4.07±0.13; 21.87±0.31 and 3.85±0.06; 22.41±0.36 and 5.21±0.2, respectively. Intrinsic rate of increase and finite rate of increase were estimated 0.2023±0.0025 and 1.2242±0.0031; 0.1706±0.0054 and 1.186±0.0064; 0.1802±0.0027 and 1.9746±0.0033; 0.1332±0.0052 and 1.1425±0.0059, respectively. Deltamethrin had the most adverse effect on stable population parameters of this wasp (P<0.05). There was no significant difference between indoxacarb and imidacloprid in this regard.

KEY WORDS: Insecticides, *Habrobracon hebetor,* biology, demographic parameters.

Most insecticides have harmful effects on non-target organisms including natural enemies (Croft, 1990). Biocontrol agents are commonly susceptible to insecticide applications. In recent years, integrated pest management systems attempt to use natural enemies in combination with lower doses of insecticides for pest control. Integrating the application of biocontrol agents and insecticides for pest management requires knowledge about impact and selectivity of the insecticides on natural enemies (Croft, 1990; Dent, 1995; Banks & Stark, 1998). Several natural enemies can be used for biological control of lepidopteran pests. Among these, *Habrobracon* spp. are used as effective parasitoids of different pests specially in stored products (Navaei et al., 2002).

Habrobracon hebetor Say is an ectoparasitoid and has been studied as a biocontrol agent of various lepidopteran pests in several countries (Gerling, 1971; Youm & Gilstrap, 1993; Magro & parra, 2001). In recent years, the mass rearing program of *H. hebetor* has been initiated in Iran and it has been used to control *Helicoverpa armigera* (Hübner) and *Ostrinia nubilalis* (Hübner) specially in Moghan region of Ardabil province in Iran (Navaei et al., 2002). Limited information are available on lethal and sublethal effects of commonly used insecticides in cotton fields on this biocontrol agent (Rafiee-Dastjerdi et al., 2008, 2009a, 2009b).

Estimation of lethal and sublethal effects of pesticides on a natural enemy is necessary to recognize their effects of it (Walthal & Stark, 1996; Stapel et al., 2000; Stark & Banks, 2003). Demographic toxicology is usually considered to be the best way to evaluate total effects of pesticides on a target insect. So, stable population parameters have been recommended to evaluate the overall effects of pesticides, because it is based on both survivorship and fecundity parameters (Stark & Wennergren, 1995). This study was carried out to evaluate the sublethal effects of three commonly used insecticides against *H. armigera* in cotton fields of Moghan region including imidacloprid, indoxacarb, and deltamethrin on its natural enemy, *H. hebetor*, and to determine the possibility of integrating the application of this species with insecticides in IPM program of this key pest.

MATERIALS AND METHODS

Insects

Habrobracon hebetor was obtained in adult stage from the insectarium of Plant Protection Bureau of Bilehsavar in Ardabil province in Iran. The colony of *H. hebetor* was reared on 5th instar larvae of *Anagasta kuehniella* Zeller reared on wheat flour in semi-clear plastic boxes (40×25×15 cm) in the laboratory. Fifth instar larvae of *A. kuehniella* were used for both rearing the colony of wasp and applying experiments. Bioassay and rearing conditions were 26 ± 1 °C, 60 ± 5 % RH and a photoperiod of 12: 12 h (L: D).

Insecticides

Insecticides tested were imidacloprid (Confidor® 350 SC), indoxacarb (Avaunt® 150 SC) and deltamethrin (Decis® 2.5 EC).

Bioassay

Whatman filter papers (90 mm in diameter) were dipped in aqueous solutions of field recommended doses of imidacloprid, indoxacarb, and deltamethrin (290, 125, and 83 ppm based on active ingredient, respectively). Triton X-100 was used as the surfactant at a concentration of 555 ppm in the experiment. The control was treated with distilled water plus Triton X-100. Treated paper discs were transferred to 90 mm Petri dishes. After the emergence of adult wasps, 60 females and 60 males were let to mate for 24 h in glass tubes. Then, mated adult females were transferred into Petri dishes including treated paper discs. After 24 h, randomly selected 30 alive females were transferred individually to plastic Petri dishes (60 mm in diameter) and three last instar host larvae were offered to each female daily for oviposition in new Petri dishes. The survival of each female wasp and its fecundity was recorded daily. Females were moved to new Petri dishes every 24 h to determine daily and lifetime fecundity (the number of eggs laid by a female daily and over her lifetime).

Data analysis

The biological data were submitted to analysis of variance and the means were compared by the Tukey test, using SPSS 14.0 software program (SPSS, 2004). The demographic parameters and their corresponding standard errors were estimated by the Jackknife technique (Meyer, 1986; Sokal & Rohlf, 1981), and the means were compared by the Tukey test, using SPSS 14.0 software program (SPSS, 2004).

RESULTS

Number of eggs laid by *H. hebetor* was significantly affected by insecticides (Table 1). In control, it was approximately 1.3, 1.8 and 2.5 times more than indoxacarb, imidacloprid and deltamethrin, respectively, which indicate harmful effects of insecticides on the fecundity of the wasp. The mean of female longevity in control treatment had no significant difference with that of indoxacarb and deltamethrin, but imidacloprid had the lowest female's longevity ($F=5.26$; $df=3,12$; $P<0.01$). Difference in sex ratio (male/male+female) of *H. hebetor* offspring was not significant between insecticides.

Effects of field recommended doses of imidacloprid, indoxacarb, and deltamethrin on *H. hebetor* life table parameters are shown in Table 2. Gross reproductive rate (GRR) in deltamethrin was significantly lower than other insecticides as well as control treatments ($F=8.68$; $df=3,12$; $P<0.01$). Control had the highest GRR; however there were no significant differences between GRR obtained in imidacloprid and indoxacarb treatments with that in the control. Both the net reproductive rate (R_o) and intrinsic rate of increase (r_m) in control were significantly higher than insecticide treatments ($F=18.29$; $df=3,12$; $P<0.01$ and $F=47.44$; $df=3,12$; $P<0.01$, respectively). No significant difference was observed between R_o estimated for indoxacarb and imidacloprid treatments, but difference between these two compounds and deltamethrin was significant. Similar result was obtained for r_m parameter. Finite rate of increase (λ), which is an indicator of population increase in each day compared with previous day, also was adversely affected by insecticides compared to the control treatment ($F=47.96$; $df=3,12$; $P<0.01$). Treatment of deltamethrin resulted in the lowest value of λ. There was no significant difference in mean generation time (T) between insecticide treatments. But, the values of T obtained for imidacloprid and deltamethrin were significantly higher than that of the control ($F=3.77$; $DF=3,12$; $P<0.05$). Doubling time (DT) of the population was also affected adversely by insecticide treatments ($F=37.36$; $DF=3,12$; $P<0.01$); it was lowest in control and highest in deltamethrin treatment.

DISCUSSION

The present study demonstrated that the insecticides significantly and adversely affected fertility, longevity and life table parameters of *H. hebetor*. However, the sex ratio of offspring was not significantly affected by the insecticides. Galavan et al. (2005) reported that indoxacarb caused a simultaneous reduction in adult fertility and also the survivorship of the first instar and adult of *Harmonia axyridis* (Pallas) in laboratory. Studebaker & Kring (2001) reported that imidacloprid and indoxacarb insecticides affected the survival of the third instar and adult of *Orius insidiosus* (Say). Rezaei et al. (2007) reported that imidacloprid had no significant effect on the fecundity of *Chrysoperla carnea* (Stephens). In the present study, there were no significant difference in the biological parameters obtained for indoxacarb and control treatments. Difference between the present and above-mentioned studies indicates an insecticide can show different effects on different organisms. Grosch & Hoffman (1973) suggested that the reduction in fertility of *H. hebetor* treated with some pesticides could be related to decreased food uptake, change in physiology or cytotoxic destruction of eggs. The similar effects might have appeared for imidacloprid and deltamethrin insecticides on *H. hebetor* in the present study.

In all treatments, net reproductive rates (R_0) were very lower than gross reproductive rates (GRR) that indicates the survivorship (l_x) has been strongly affected by insecticides. Intrinsic rate of increase (r_m) is the most important parameter for evaluation of population development, because of inclusion of age, survival rate (l_x) and female offspring's (m_x) effects in its calculation (Carey, 1993). Higher intrinsic rate of increase (r_m) in control in comparison with the insecticide treatments indicated the adverse effects of insecticides on this parameter. The lower mean generation time (T) is an advantage for parasitoids compared with their hosts, because they can produce more generations in a given time. It would be harmful effect on parasitoid, if an insecticide causes increase its generation time. There was no significant difference in mean generation time between insecticide treatments but the generation time values obtained for imidacloprid and deltamethrin were significantly higher than the control. It indicates that the wasp will need longer time to increase her population as R_0 times when it is exposed to field recommended doses of these two insecticides.

Saber et al. (2005) showed that fenitrothion and deltamethrin had no significant effects on biological parameters such as adult longevity and offspring sex ratio of *Trissolcus* grandis (Thomson), but they adversely affected r_m and λ parameters. Rafiee-Dastjerdi et al. (2009a) studied the effects of sublethal dose of profenofos, spinosad, thiodicarb and field recommended dose of hexaflumuron on biological and demographic parameters of *H. hebetor* and reported that the r_m values obtained for the first three compounds and fertility in all insecticides tested were significantly different in comparison with the control. Similar results were obtained in the present study and it is possible that *H. hebetor* is sensitive to broad spectrum insecticides.

In the present study, deltamethrin showed significantly difference in some demographic parameters including r_m, λ and DT in comparison with other insecticides. Also, the fecundity of *H. hebetor* was lower when it was treated with this insecticide. On the other hand, indoxacarb had the lowest negative effects on the biological and demographic parameters of *H. hebetor*. Even though results obtained in small laboratory arenas may not be realized under natural conditions (Kareiva, 1990), these kinds of investigations under the laboratory conditions can be helpful in selecting insecticides for additional studies under more natural conditions and for application of suitable insecticides along with natural enemies in the pest management programs.

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Table 1. The means of biological parameters (±SE) of *Habrobracon hebetor* exposed to the field recommended doses of imidacloprid, indoxacarb, and deltamethrin in adult stage.

parameters	control	indoxacarb	imidacloprid	deltamethrin
fecundity (number)	466.1[a†] (±54.99)	337.69[ab] (±47.37)	252.43[b] (±36.8)	180.63[b] (±29.79)
hatched eggs (number)	463.93[a] (±54.92)	320.83[ab] (±45.12)	239.63[b] (±35.83)	167.43[b] (±28.69)
Female longevity (day)	29.33[a] (±2.13)	25.86[ab] (±2.06)	20.3[b] (±1.47)	29.23[a] (±2.39)
sex ratio (male/male+female)	0.51 (±0.05)	0.55 (±0.06)	0.45 (±0.05)	0.51 (±0.06)

[†]Values within the rows followed by different letters are significantly different.
[ns] and [**] indicating non significant and significantly different at P<0.01, respectively.

Table 2. The means of stable growth population parameters (±SE) of *Habrobracon hebetor* exposed to the field recommended doses of imidacloprid, indoxacarb, and deltamethrin in adult stage.

parameters	control	indoxacarb	imidacloprid	deltamethrin
GRR	206.31[a†] (±13.38)	164.70[a] (±14.47)	186.82[a] (±21.39)	102.39[b] (±9.84)
R_0	73.45[a] (±5.5)	51.75[b] (±5.22)	46.8[b] (±6.52)	19.94[c] (±2.56)
r_m	0.202 [a] (±0.003)	0.180 [b] (±0.003)	0.170 [b] (±0.005)	0.133 [c] (±0.005)
λ	1.224[a] (±0.003)	1.197[b] (±0.003)	1.186[b] (±0.006)	1.142[c] (±0.006)
T	21.22[b] (±0.2)	21.87[ab] (±0.31)	22.49[a] (±0.32)	22.4[a] (±0.36)
DT	3.42[c] (±0.04)	3.84[bc] (±0.06)	4.06[b] (±0.13)	5.21[a] (±0.2)

[†]Values within the rows followed by different letters are significantly different.
[*] and [**] indicating significantly different at P<0.05 and P<0.01, respectively.