

RESIDUAL TOXICITY OF SOME PESTICIDES ON THE LARVAL ECTOPARASITOID, *HABROBRACON HEBETOR* SAY (HYMENOPTERA: BRACONIDAE)

Vahid Mahdavi*

Young Researchers Club, Parsabad Moghan Branch, Islamic Azad University, 5691853356, Parsabad, Iran

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Abstract: *Habrobracon hebetor* Say is an idiobiont and gregarious larval ectoparasitoid of many moths. In this study, the effects of field recommended concentrations (FRC) of seven biorational and conventional pesticides in cotton fields (imidacloprid, thiacloprid, deltamethrin, thiodicarb, carbaryl, abamectin and spinosad) were studied on the larval ectoparasitoid, *H. hebetor*. Exposure cages were used for the bioassay experiments. The experiments were carried out in the laboratory at $26\pm 1^\circ\text{C}$, $60\pm 5\%$ relative humidity (RH) and with a photoperiod of 16:8 (L:D). Experiments were done in three replications. The results showed that all pesticide treatments had significant differences compared to the control treatment. The results also showed that synthetic and biorational pesticides had lower toxicity than conventional pesticides. We demonstrated that imidacloprid and thiacloprid had lower adverse effects on the parasitoid and could be used as compatible chemical materials with the parasitoid in Integrated Pest Management (IPM) programs.

Key words: bioassay, biological agent, *Habrobracon hebetor*, IPM, pesticides

INTRODUCTION

The cotton bollworm, *Helicoverpa armigera* Hübner (Lepidoptera: Noctuidae) is a major threat to intensive agriculture (Sigsgaard *et al.* 2002). This pest is a highly polyphagous and mobile insect best known for damaging cotton (*Gossypium* spp.), corn (*Zea mays* L.), tomato (*Lycopersicon esculentum* L.), soybean (*Glycine max* Merr), and bean (*Phaseolus* spp.) crops in Iran (Farid 1986; Capinera 2004). Early instars are foliar feeders and later instars attack seeds, fruits, and bolls leading to economic loss (Fitt 1989). The infestations cause severe economic losses as a result of crop yield reduction (Soomro *et al.* 1992). Chemical control is a major strategy in the Integrated Pest Management (IPM) program. Chemical control is known for being quick, efficient, easy to use, cost-effective and reliably effective against the insect (Endo and Tsurumachi 2001). On the other hand, indiscriminate application of chemical pesticides might be accountable for the outbreaks of the pest because of the heavily applied, extensive and intensive use of pesticides. Also, intense application of broad-spectrum chemical pesticides may cause the mortality of a wide range of more natural enemies than the target pest (Way and Heong 1994; Tanaka *et al.* 2000).

H. hebetor is one of the most important parasitoids of the larval stage of many important agricultural pests such as the Noctuid and Pyralid moths (Baker *et al.* 1995; Dweck *et al.* 2008). In 1961, in Varamin, Iran, the *H. hebetor* was first collected by Farahbakhsh, and used as a biological control agent for controlling *Heliothis* sp. (Navaei *et al.* 2002).

This parasitoid can easily be mass reared, and it has been released in the field for effective control of *Heliothis* and *Helicoverpa* spp. (Heimpel *et al.* 1997). In Iran, mass rearing of *H. hebetor* is done on the Mediterranean flour moth, *Anagasta kuehniella* (Zeller). The adult wasps are then released to parasitize *H. armigera* larvae in cotton fields in the Ardabil and Golestan provinces. These provinces are in the northern part of Iran (Attaran 1996; Navaei *et al.* 2002).

Chemical control and biological control are the two important strategies used in an IPM program (Zhao 2000). Integration of chemical and biological control systems is a key to the success of any IPM program (Wright and Verkert 1995). Chemical control should be used only when it is necessary and when it can be least disruptive to biological control (Jepson 1989). On the other hand, integrated pest management systems attempt to use natural enemies and may also use pesticides, for pest control (Dent 1995; Banks and Stark 1998). Integrating the application of biocontrol agents and pesticides for pest management requires knowledge about the impact and selectivity of the pesticides, on natural enemies (Croft 1990).

Relatively few studies have been carried out on parasitoids belonging to the genus *Habrobracon* (Rafiee-Dastjerdi *et al.* 2008; Abedi 2012). In this study, seven pesticides were selected to investigate lethal effects on adult *H. hebetor*, the parasitoid of the *H. armigera*, to examine their acute toxicity. The potential compatibility of biological and chemical control was examined to find improved IPM of cotton pests.

*Corresponding address:
mahdavi_vahid@ymail.com

MATERIALS AND METHODS

Insect rearing

The *H. hebetor* colony was obtained from an insectarium maintained by the Plant Protection Bureau of Kaleibar, Iran. The colony was maintained in the laboratory at $26\pm 1^\circ\text{C}$, $60\pm 5\%$ relative humidity (RH) and under a photoperiod of 16:8 (L:D), on the *A. kuehniella*. Parasitoid wasps were reared on 5th instars larvae of *A. kuehniella* for five generations and used for all the experiments. As food for the adult parasitoids, honey was provided on strips of paper (Rafiee-Dastjerdi *et al.* 2009).

Pesticides

The pesticides used in the present study were thiacloprid, spinosad, abamectin, carbaryl, deltamethrin, imidacloprid and thiodicarb. Information about the pesticides is listed in table 1.

Bioassay experiments

Mated young adult females (< 24 h old) of the parasitoid were exposed to freshly prepared pesticide residues. These residues had been sprayed on glass plates, as described below. Exposure cages were used for the bioassay experiments (Saber *et al.* 2005). The cages used to expose the adult females to the pesticide residue, had a frame, and two glass plates were used for the ceiling and floor. Two sides of the frame contained five ventilation holes (5 mm in diameter), covered with black netting. Two openings on the fourth side of the frame were used for placing in the water tube and food for the wasps. Appropriate amounts of each pesticide were diluted with 200

ml of distilled water to provide the field recommended concentrations (FRC). On table 1, the FRC of pesticides are given. These concentrations of the pesticides are used in cotton fields in Iran. The glass surfaces (13x13 cm) were sprayed with 3 ml of aqueous solutions of the pesticides, using a potter spray tower (BURKARD MFG. CO. LTD, UK). Control plates were sprayed with Tween 80 plus water. Tween 80 (Merck, Darmstadt, Germany) was used at a concentration of 200 ppm in all dilutions as a spreader (Rosenheim and Hoy 1988). The plates were placed in the laboratory for 1 h and allowed to dry completely. The exposure cages were assembled after drying the plates. Before completely assembling the cages, 10 young female adults (< 24 h old) were anesthetized by CO_2 and placed in each of the exposure cages, and the ceiling was placed and fixed. Then, the cages were transferred to the growth chamber for 48h. In the growth chamber, the conditions were as mentioned above. Each experiment was replicated three times.

The wasps in the experiment cages were supplied with honey as food. The honey was placed on a small strip of paper. The number of dead and alive wasps in each cage was counted 12, 24, 36, and 48 h after the initial exposure to the pesticides residue. Those parasitoids that appeared extremely lethargic or unable to maintain equilibrium at this time also were recorded as dead.

Statistical analysis

Data obtained were subjected to ANOVA ($p < 0.05$) after checking for normality. Means were compared by Tukey's test, admitting significant differences at $p < 0.05$. For all the analyses, SAS software was used (SAS Institute 2002).

Table 1. Pesticides screened for toxicity to *H. hebetor*

Pesticide	Trade name	Formulation	% of active ingredient	FCR [ppm]	Manufacturer
Imidacloprid	Confidor	SC	35	500	AriaShimi
Thiacloprid	Calypso	SC	48	600	Bayer
Deltamethrin	Decis	EC	2.5	1000	AriaShimi
Abamectin	Vermitec	EC	1.8	200	Gyah
Spinosad	SpinTor	SC	24	333	DowAgroScience
Thiodicarb	Larvin	DF	80	2000	MoshkFamFars
Carbaryl	Sevin	WP	85	6000	GhazalShimi

FRC – Field recommended concentrations

WP – Wetttable powders

Ppm – part per million

SC – Solution Concentrates

EC – Emulsion Concentrates

DF – Dry Flowable

RESULTS

The data on percentage mortality of *H. hebetor* adults were recorded after 12, 24, 36, and 48 h of treatment with the different pesticides which had been applied at field recommended concentrations. The data have been analyzed statistically, and presented in table 2. The results showed that the field recommended concentrations of the

chemicals significantly affected the adults of parasitoid at 12 h ($F = 55.97$; $df = 7, 23$; $p < 0.0001$), 24 h ($F = 43.44$; $df = 7, 23$; $p < 0.0001$), 36 h ($F = 906.66$; $df = 31.3$; $p < 0.0001$), and 48 h ($F = 44.07$; $df = 7, 23$; $p < 0.0001$) (Table 2). The cumulative mortality related to pesticide treatments and the control group is shown in figure 1.

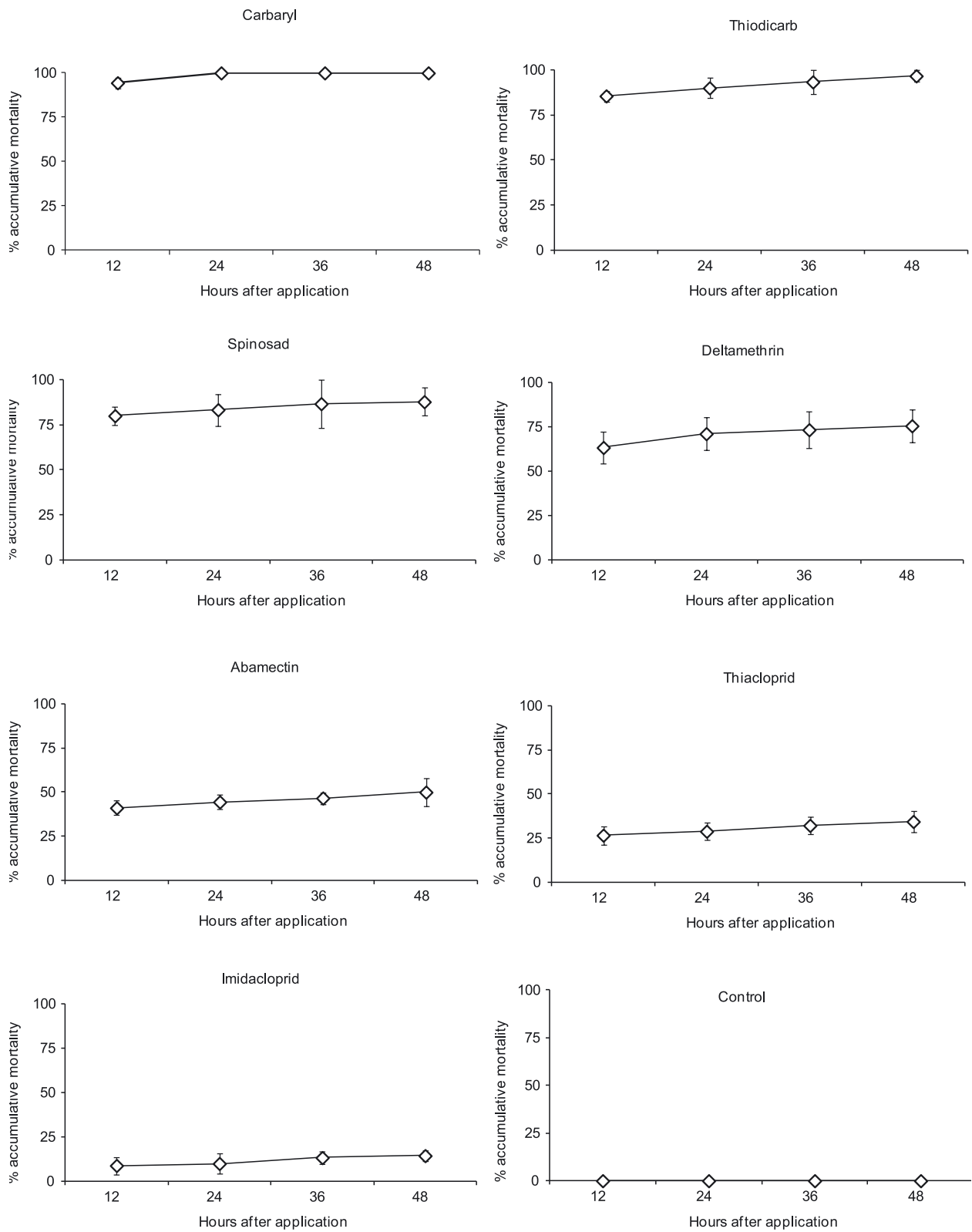


Fig. 1. The accumulative mortality percent of parasitoid adults exposed to pesticides and control treatments at 12, 24, 36, and 48 h after application

Table 2. % Cumulative mortality of parasitoid adults exposed to pesticides and control treatments at 12, 24, 36 and 48 hours after application

Treatments	Different times after application			
	12 h	24 h	36 h	48 h
Carbaryl	94.44±2.94 a	100±0 a	100±0 a	100±0 a
Thiodicarb	85.56±2.94 ab	90±5.77 ab	93.33±6.67 a	96.67±3.33 a
Spinosad	80±5.09 ab	83.33±8.82 ab	86.67±13.33 a	87.78±7.78 a
Deltamethrin	63.33±8.82 bc	71.11±9.1 bc	73.33±10.19 ab	75.56±9.49 ab
Abamectin	41.11±4.01 cd	44.45±4.01 cd	46.66±3.33 bc	50±7.70 bc
Thiacloprid	26.67±5.09 de	28.89±4.84 de	32.22±4.84 cd	34.45±6.19 cd
Imidacloprid	8.89±4.84 ef	10±5.77 ef	13.33±3.33 cd	14.44±2.94 de
Control	0±0 f	0±0 f	0±0 d	0±0 e

Values within column followed by the different letters are significantly different. ANOVA with Tukey post hoc test ($p < 0.05$)

DISCUSSION

Biological control agents in IPM are very important. It is also necessary to take into consideration, the adverse impact of chemical pesticides on natural enemies used in fields. For this reason, our study evaluated the effects of some conventional and biorational pesticides used in cotton fields in which the fields had the ectoparasitoid *H. hebetor*.

The effects of different pesticides on adult parasitoids showed at different times, that the cumulative mortality of parasitoid increased with time. With each pesticide treatment, mortality increased with the increase of time – from 12 to 48 h. In figure 1, this can be clearly seen. These results are confirmed by the results of Rasool *et al.* (2005). They studied the impact of pesticides on the parasitoid *Bracon hebetor*. They reported that as time increased, mortality also increased due to pesticides, and this may indicate a direct relationship between these two parameters. The investigations undertaken showed that biorational pesticides are less toxic on natural enemies than the conventional pesticides. The results of the present study also showed that biorational pesticides (such as spinosad and abamectin) are less toxic than conventional pesticides (such as carbaryl and thiodicarb). The results also confirm the results of Abedi (2012), who reported that biological pesticides had less of an impact on natural enemies. Also, Rafiee-Destjerdi *et al.* (2009) reported that carbamate pesticides are more toxic than pyrethroid and synthetic chemical compounds. The results of our study confirm this issue, which means that pyrethroid pesticides (such as imidacloprid and thiacloprid) are less toxic than carbamate pesticides (such as carbaryl and thiodicarb). The results of the study by Faal-MohammadAli (2010) are in line with the results of this study, as conventional pesticides such as chlorpyrifos were reported to be highly toxic on *H. hebetor*. Hooshmandi *et al.* (2012) also investigated the effects of new pesticides on *H. hebetor* and reported that the thiacloprid pesticide can be used in integrated pest management programs. The results of the present study showed that the spinosad pesticide has a less adverse impact on natural enemies than the conventional insecticides. These results of ours are consistent with the results of Rafiee-Dastjerdi *et al.* (2008). Also, the results of Sarmadi (2008) showed that imidacloprid has

a lower negative impact on the parasitoid *H. hebetor*. The results of our evaluation showed little contact toxicity for the imidacloprid pesticide, at different times.

According to the results, carbaryl and thiodicarb used at various times, had the most adverse effect on *H. hebetor* adults, and the imidacloprid and thiacloprid treatments had lower toxicity than the other treatments. The results of our study showed that among the studied pesticides, the carbaryl and thiodicarb treatments were associated with the highest mortality. After conducting advanced field studies, we found that imidacloprid and thiacloprid could be used as compatible chemical materials along with biological control agents in integrated pest management (IPM) programs.

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REFERENCES

- Abedi Z. 2012. Lethal and sub-lethal effects of azadiactin, pyridalil, cypermethrin and methoxyfenozide on biological parameters of *Habrobracon hebetor* Say (Hym.: Braconidae). M.Sc. thesis, University of Maragheh, Iran, 104 pp.
- Attaran M.R. 1996. Effects of laboratory hosts on biological attributes of parasitoid wasp *Bracon hebetor* Say. M.Sc. thesis. Tarbiat Modarres University, Tehran, Iran, 74 pp.
- Baker J.E., Weaver D.K., Throne J.E., Zettler J.L. 1995. Resistance to protectant insecticides in two field strains of the stored-products insect parasitoid, *Bracon hebetor* (Hymenoptera: Braconidae). J. Econ. Entomol. 88 (3): 512–519.
- Banks J.E., Stark J.D. 1998. What is Ecotoxicology? An Ad-Hoc Grab Bag or an Interdisciplinary Science? Integrative Biol. 1 (5): 195–204.
- Capinera J.L. 2004. Encyclopedia of entomology. Kluwer Academic, New York, 4346 pp.
- Croft B.A. 1990. Arthropod Biological Control Agents and Pesticides. John Wiley and Sons, New York, 723 pp.
- Dent D. 1995. Integrated Pest Management. Chapman and Hall, London, 356 pp.

- Dweck H.K.M., Gadallah N.S., Darwish E. 2008. Structure and sensory equipment of the ovipositor of *Habrobracon hebetor* (Say) (Hymenoptera: Braconidae). *Micron* 39 (8): 125–126.
- Endo S., Tsurumachi M. 2001. Insecticide susceptibility of the brown planthopper and the white-back planthopper collected from Southeast Asia. *J. Pestic. Sci.* 26 (1): 82–86.
- Faal-MohammadAli H. 2010. The sub-lethal effects of chlorpyrifos and fenpropratin on the biological parameters and functional response of *Habrobracon hebetor* Say (Hymenoptera: Braconidae) in the laboratory condition. M.Sc. thesis, Shahid Chamran Ahvaz University, Khozestan, Iran, 128 pp.
- Farid A. 1986. Study of bollworm *Heliothis armigera* (Hub.) on tomato in Jyroft and Khnuj. *Appl. Entomol. Phytopathology* 54: 15–24.
- Fitt G.P. 1989. The ecology of *Heliothis* species in relation to agroecosystems. *Annul. Rev. Entomol.* 34: 17–52.
- Heimpel G.H., Antolin M.F., Franqui R.A., Strand M.R. 1997. Reproductive isolation and genetic variation between two "strains" of *Bracon hebetor* (Hym: Braconidae). *Biol. Control.* 9 (3): 149–156.
- Hooshmandi M., Aliche M., Minaei K., Aleosfoor M. 2012. Toxicity estimation of insect growth regulators insecticides (IGR); match, lufox and calypso on adult parasitoid wasp (*Habrobracon hebetor*) (Hym. Braconidae) under laboratory condition. In proceedings of the 20th Iranian Plant Protection congress. University of Shiraz, Fars, Iran, 25–28 August, 381 pp.
- Jepson P.C. 1989. The temporal and spatial dynamics of pesticide side-effects on non-target invertebrates. p. 95–128. In: "Pesticides and Non-Target Invertebrates" (P.C. Jepson, ed.). Wimborne: Intercept Ltd., 240 pp.
- Navaei A.N., Taghizadeh M., Javanmoghaddam H., Oskoo T., Attaran M.R. 2002. Efficiency of parasitoid wasps, *Trichogramma pintoi* and *Habrobracon hebetor* against *Ostrinia nubilalis* and *Helicoverpa* sp. On maize in Moghan. In: Proc. 15th Iranian plant protection congress. Razi University of Kermanshah, Iran, 7–11 September, 327 pp.
- Rafiee-Dastjerdi H., Hejazi M.J., Nouri-Ghanbalani G., Saber M. 2008. Toxicity of some biorational and conventional insecticides to cotton bollworm, *Helicoverpa armigera* (Lepidoptera: Noctuidae) and its ectoparasitoid, *Habrobracon hebetor* (Hymenoptera: Braconidae). *J. Entomol. Soc. Iran* 28: 27–37.
- Rafiee-Dastjerdi H., Hejazi M.J., Nouri-Ghanbalani G.H., Saber M. 2009. Effects of Some Insecticides on Functional Response of Ectoparasitoid, *Habrobracon hebetor* (Say) (Hym.: Braconidae). *J. Entomol.* 6 (3): 161–166.
- Rasool Khan R., Ashfaq M., Rana S.H.A. 2005. Some studies on the toxicity of conventional and new chemistry insecticides against *Bracon hebetor* Say (Hym.: Braconidae) under laboratory conditions. *Pak. Entomol.* 27 (1): 19–21.
- Rosenheim J.A., Hoy M.A. 1988. Sublethal effects of pesticides on the parasitoid *Aphytis melinus* (Hymenoptera: Aphelinidae). *J. Econ. Entomol.* 81 (2): 476–483.
- Saber M., Hejazi M.J., Kamali K., Moharramipour S. 2005. Lethal and sub-lethal effects of fenitrothion and deltamethrin residues on the egg parasitoid *Trissolcus grandis* (Hymenoptera: Scelionidae). *J. Econ. Entomol.* 98 (1): 35–40.
- Sarmadi S. 2008. Laboratory investigation on lethal and sublethal effects of imidacloprid, indoxacarb and deltamethrin on parasitoid wasp *Habrobracon hebetor* Say (Hymenoptera: Braconidae). M.Sc. thesis, University of Mohaghegh Ardabili, Ardabil, Iran, 103 pp.
- SAS Institute. 2002. The SAS System for Windows. SAS Institute, Cary, NC, 58 pp.
- Sigsgaard L., Greenstone M.H., Duffield S.J. 2002. Egg cannibalism in *Helicoverpa armigera* on sorghum and pigeonpea. *Biol. Control.* 47 (2): 151–165.
- Soomro M.H., Khalid S., Aslam M. 1992. Outbreak of banana bunchy top virus in Sindh, Pakistan. *FAO Tech. Plant Prot. Bull.* 40 (3): 5–99.
- Tanaka K., Endo S., Kazano H. 2000. Toxicity of insecticides to predators or rice. planthoppers: spiders, the mirid bug and the dryinid wasp. *Appl. Entomol. Zool.* 35 (1): 177–187
- Way M.J., Heong K.L. 1994. The role of biodiversity in the dynamics and management of insect pests of tropic irrigated rice: a view. *Bull. Entomol. Res.* 84: 567–587.
- Wright D.J., Verkert R.H.J. 1995. Integration of chemical and biological control systems for arthropods; evaluation in a multitrophic context. *Pestic. Sci.* 44: 207–218.
- Zhao S.H. 2000. *Plant Chemical Protection*. China Agricultural Press, Beijing, China, 337 pp.