Pakistan J. Zool., vol. 44(5), pp. 1197-1201, 2012.

Toxicity of Some Commonly Used Synthetic Insecticides Against *Spodoptera exigua* (Fab) (Lepidoptera: Noctuidae)

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Abstract.- *Spodoptera exigua* (Lepidoptera: Noctuidae) is one of the major pests of many crops in Pakistan. Effectiveness of different insecticides was evaluated against field populations of 2nd instar larvae of *S. exigua* under laboratory conditions because in lepidopterous pests resistance is developed in 3rd instars. Bioassays were performed through leaf dip method to evaluate the dose- and time-mortality response for emamectin benzoate, lufenuron, chlorpyrifos and cypermethrin. Significant variation was revealed in lethal concentration and lethal time values. Among all the tested insecticides emamectin benzoate gave the lowest LC_{50} value *i.e.,* 0.005 mg/l (95% FL: 0.004–0.007 mg/l) followed by lufenuron *i.e.,* LC_{50} value 0.65 mg/l (95% FL: 0.38–0.93 mg/l). While there was a non significant difference in the LC_{50} values of cypermethrin and chlorpyrifos *i.e.,* 146 mg/l (95% FL: 108–188 mg/l) and 175 mg/l (95% FL: 113–256 mg/l), respectively. LT_{50} values showed that cypermethrin was more effective compared to chlorpyrifos; however, both required less than half the time required by emamectin to kill 50% population of 2nd instar larvae of *S. exigua*. Lufenuron, however, required more time as compared to all tested insecticides. The order of effectiveness in terms of LT_{50} values was; cypermethrin > chlorpyriphos > emamectin benzoate > lufenuron. Responsiveness of *S. exigua* larvae provides important information with dose- and time-mortality for selection of insecticides in field for better pest management.

Key words: *Spodoptera exigua*, insecticides, dose-mortality, time-mortality.

INTRODUCTION

Xenobiotics like insecticides are important constituent of our daily life from preservation of food materials to insect pest management. These xenobiotics have beneficial as well as deleterious effects on our food, air, water and surrounding environment. Hazardous effects like decreased egg hatching have been observed not only in insect pests like *Spodoptera exigua* and *Spodoptera frugiperda* but also the predatory beetle like *Poecilus cupreus* L. and *Hippodamia convergens* (Adamski *et al.*, 2009; Alvarez *et al.*, 2009a,b; Antwi and Peterson, 2009). These chemicals are also the constituents of plants on which these insects feed and are ultimately affected in terms of development and reproduction etc (Adamski *et al.*, 2005).

Insecticides are important tool for insect pest management. Determination of their effective dose and time mortality factors are important for spray systems. Selection of *S. exigua* with conventional insecticides has been reported in different parts of the world (Meinke and Ware, 1978; Chaufaux and Ferron, 1986; Yoshida and Parrella, 1987; Brewer and Trumble, 1989). Exposure to these insecticides increase the larval survival and delimits their effective use (Kim *et al.*, 1998). Similarly, resistance to conventional and some new chemistry insecticides have also been reported, hindering the proper pest management (Perez *et al.*, 2002; Ahmad *et al.*, 2009).

S. exigua is a serious insect pest many crops in Southeast Asian region. Being polyphagous, strong migratory capabilities and wide distribution (Metcalf and Flint, 1962; Aarvik, 1981; Stewart *et al.*, 2002), it can infest large areas of field crops and horticultural cultivations. (Mitchell, 1979; Han *et al.*, 2008). It has been recorded from more than 50 genera of over ten plant families (Smits *et al.*, 1987). Although its outbreaks are sporadic yet its population develops rapidly because of inefficient management at late larval stages. Its short life span and multivoltine nature makes its control rather difficult if not monitored regularly. Effective doses and time related factor are important for selection of

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0030-9923/2012/0005-1197 $ 8.00/0

insecticides depending on severity of infestation. So the present study was conducted to determine the lethal/ effective dose and lethal time of commonly used insecticides. Some commonly used insecticides were used in this experiment to evaluate susceptibility and time trends in mortality against S. *exigua* under laboratory conditions.

MATERIALS AND METHODS

Insect collection and rearing

S. exigua egg batches were collected from cauliflowers in Multan during 2010 and transported in well-ventilated plastic box at the Post Graduate Laboratory in the Department of Agricultural Entomology, University College of Agriculture, Bahauddin Zakariya University Multan, Pakistan. The hatched larvae were further reared on castor (*Ricinus communis*) leaves to complete their life cycle. Castor leaves were collected at morning time, washed thoroughly with tap water and air-dried. Castor leaves were changed daily till the pupation started. Pupae were kept individually in separate Petri dishes lined with filter papers. Newly emerged adults were placed in cylindrical transparent plastic jars (4 kg capacity) having cotton balls soaked in 10% honey solution as adult diet. Nappy liner strips of about 1–2 inch wide and 6–7 inch long were suspended with the help of rubber bands in the jars as egg substrate and were collected every 24 h and kept in batches separately in plastic jars. Second instar larvae of F_1 laboratory generations were used for bioassays throughout the present experimentations.

Insecticides

Commercial formulations of different insecticides used for bioassays comprised emamectin benzoate (Proclaim® 1.9EC, Syngenta, Pakistan), lufenuron (Match® 05EC, Syngenta, Pakistan), chlorpyrifos (Lorsban® 40EC; Dow AgroSciences, Pakistan), cypermethrin (Arrivo® 10EC, FMC, Pakistan) A non-ionic surfactant (Stapple®Dupont, Pakistan) was added @ 5 mg ml^{-1} to each insecticide to enhance their adhesiveness to leaf surface.

Bioassays for LC_{50} and LT_{50}

Bioassays were conducted on 2nd instar larvae of *S. exigua* (3–6 h after moulting) using a standard leaf disc bioassay method (Sayyed *et al.,* 2000; Ahmad *et al.,* 2009). Castor leaves were collected from unsprayed plants, washed and air-dried and made 5 cm diameter leaf discs with the help of a leaf cutter. Stock solution of each tested insecticide was made from the formulation available with different concentrations (emamectin benzoate (Proclaim® 1.9EC, Syngenta, Pakistan), lufenuron (Match® 05EC, Syngenta, Pakistan), chlorpyrifos (Lorsban® 40EC; Dow AgroSciences, Pakistan), cypermethrin (Arrivo® 10EC, FMC, Pakistan)) and then 6–8 serial concentrations (chlorpyriphos: 1024–32ppm, cypermethrin: 1024–32 ppm, lufenuron: 0.13–2.0ppm, emmemectin benzoate: 0.03–0.001875ppm) were prepared by calculation the field doses from the available insecticides in the market. Leaf discs were dipped for 10 s in a test solution and allowed to dry at ambient temperature for about 20–30 min in a fume hood. Test solutions were prepared fresh in distilled water and then Stapple® (5 mg ml^{-1}) was added as surfactant. Leaf discs immersed in distilled water were labeled as control. Air-dried leaf discs were then placed in individual plastic Petri dishes (5 cm diameter) containing moistened filter paper. Each treatment (concentration) including controls were replicated eight times. Five 2nd instar *S. exigua* larvae were placed on each leaf disc and thus total numbers of tested larvae per concentration were 40. The bioassays were kept at a temperature of 28±2°C, 50-60±5% relative humidity and 14:10 (light–dark) photoperiod. Larval mortality at the end point was assessed after 48 and 72 h of insecticidal exposure.

Time-mortality data for the tested insecticides were observed at 12 h interval at their respective LC_{50} levels. Time taken for 50% mortality was used to measure lethal time (LC_{50}) values.

Data analysis

Mortality as endpoint was corrected for analysis by Abbott's formula using POLO-PC software (LeOra Software, 1987). Fiducial limits at 95% interval were used for differentiation of significance levels (Litchfield and Wilcoxon, 1949).

RESULTS

LC_{50}

All the insecticides tested in the present studies caused concentration–dependent mortality in 2nd instar larvae of field population of *S. exigua*. The slopes of regression lines and the lethal concentration values at 50% kill were significantly different from each other. Slopes of cypermethrin and chlorpyrifos were non-significant to each other due to overlapping of their regression lines (Table I). The LC_{50} values of lufenuron and emamectin were, however, significant not only from each other but also from cypermethrin and chlorpyrifos (Table I). Their slope values were also steeper than cypermethrin but less than that of chlorpyrifos.

LT_{50}

The time-mortality studies for the four tested insecticides at their respective LC_{50} values were performed. Cypermethrin required the least time to kill the 50% population followed by chlorpyrifos and emamectin, respectively. Lufenuron, however, required the maximum time of 32 h to kill 50% exposed insects (Table II). Fiducial values of all the insecticides were non-significant to each other; however, it was least in cypermethrin making it the most effective. There existed steeper slopes in cypermethrin and chlorpyrifos making them both as effective as other insecticides (Table II).

DISCUSSION

Similar mode of action as nerve toxicity can be attributed for similar results with respect to the lethal time factor. Cypermethrin, chlorpyrifos and emamectin benzoate being nerve poisons have similar modes of action as effectors of nerve impulses with rapid action against insect pests. These insecticides have been found effective in terms of dose and time factor against leaf worm, *S. litura* (Ahmad *et al.*, 2006) like that of *S. exigua*. No cross resistance was observed between methomyl and chlorpyrifos against *S. exigua* suggesting the effectiveness of organophosphates as well as carbamates (Argentine *et al.*, 2002). Byrne and Toscano (2001) suggested target site insensitivity as major mechanism of resistance to methomyl. However, they observed insensitive acetylcholine esterase activity against a number of organophosphates like profenofos, chlorpyrifos and sulprofos (Byrne and Toscano, 2002). Increase in mortality rate with prolonged larval duration, delay in pupal formation and adult emerge were significant when *S. frugiperda* larvae were provided diet incorporated with insect growth inhibitors as flavinoids. Variation may exist due to stage, feeding pattern and requirement and behaviour of the insect with respect to particular insecticide. However, these factors were not considered as endpoint during this study.

Table I.- Probit analysis of dose-mortality data for different insecticides against 2nd instar larvae of *Spodoptera exigua* field population

Insecticide	LC_{50} (mg/l)	FL at 95% level[a]	Slope±SE[b]	χ^2
Cypermethrin	146	108–188	2.49±0.39	2.01
Chlorpyrifos	175	113–256	1.50±0.17	6.15
Lufenuron	0.65	0.38–0.93	1.84±0.40	2.90
Emamectin benzoate	0.005	0.004–0.007	1.74±0.24	1.69

[a]FL, fiducial limits at 95% confidence level; SE, Standard error.

Table II.- Probit analysis of time-mortality data for different insecticides against 2nd instar larvae of *Spodoptera exigua* field population at their respective LC_{50}

Insecticide	LC_{50} (mg/l)	FL at 95% level[a]	Slope±SE[b]	χ^2
cypermethrin	7.20	2.43–12.9	1.44±0.16	13.4
chlorpyrifos	14.7	9.54–22.3	1.75±0.16	8.77
lufenuron	32.3	20.8–56.5	2.54±0.23	16.1
emamectin benzoate	26.0	23.2–8.9	4.23±0.38	1.49

[a]FL, fiducial limits at 95% confidence level; [b]SE, Standard error.

Emamectin benzoate, a derivative of abamectin, is quite effective against a number of lepidopteran insect pests including *S. exigua* and *S. litura* (Ahmad *et al.*, 2006). This insecticide is not only photostable but also has translaminar efficacy with lack of cross-resistance with many commercial insecticides (Mrozik, 1994; White *et al.*, 1997). Its foliar application as insecticide was observed many folds toxic as compared to diet incorporation against important lepidopteron insect pests including *S. exigua* (Argentine *et al.*, 2002). However, the results of LC_{50} values and LT_{50} values are species specific and need to be performed for *S. exigua* (Thomsen and Eilenberg, 2000). Lack of resistance has been observed for this insecticide against different insect pests worldwide which stresses its incorporation into resistance management programs (Shad *et al.*, 2010).

The discovery of insect growth regulators in the last two centuries has created a new class of insecticides for their effective control (Wing, 1988; Wing *et al.*, 1988). Factors like lack of larval molting to next instar, cessation of feeding and slow movements followed by ultimate death has been observed due to their acute dose application in certain insect pests (Wing *et al.*, 1988; Smagghe and Degheele, 1994a). Lufenuron required maximum time of 32 h to kill 50% population which was due to its mode of action through ingestion and affecting the physiological processes. However, disorders in oogenesis and spermatogenesis have also been main features at their chronic dose rates (Smagghe and Degheele, 1994b). These results are very similar to those of the xenobionts which affect the hatching success of *S. exigua* eggs (Adamski *et al.*, 2009).

Integrated pest management approach combining insecticides with regular field monitoring of their respective resistance levels are important not only to keep these insecticides for their long term usage but also for regulation of insecticide registration with respect to a particular insect pest species (Thomsen and Eilberg, 2000; Perez *et al.*, 2002). Presence of cross-resistance among different insecticide groups with different mode of action also requires regular monitoring programs (Ahmad *et al.*, 2006; Ahmad *et al.*, 2009). Incorporation of new chemistry insecticides especially for the pests like *S. exigua* of vegetables need safer insecticides like emamectin benzoate with least phytotoxic effects with efficient control of the inset pests (Clarke and Fleischer, 2003).

This study provides basic information regarding the concentration and time for *S. exigua* mortality under laboratory conditions. Field studies can foster the effectiveness of these and other insecticides for long term and effective management of *S. exigua*.

ACKNOWLEDGEMENTS

The first author is thankful to the Higher Education Commission for financing fellowship for his PhD studies under the supervision of Prof. Mushtaq A. Saleem and Bahauddin Zakariya University Multan for providing laboratory facilities to conduct the experiments.

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(Received 23 January 2011, revised 3 July 2012)