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Potentiality of Buprofezin, an insect growth regulator on the mortality of *Spodoptera litura* (Fabricius)

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Abstract
Buprofezin (Award 40 SC) was evaluated at the concentrations of 200, 400 and 600 ppm on the mortality of *Spodoptera litura* (Fab.) larvae under laboratory conditions in Bangladesh from July 2015 to June 2016. The 2nd instar larvae were treated with selected concentrations through three different application methods viz. direct or topical, indirect or leaf-dip and combined. The larval mortality was recorded at 1, 3, 5 & 7 days after treatment (DAT) application. The mortality was clearly dose, method and time dependent. The highest larval mortality about 66.67% from combined method, 63.88% from leaf-dip and 56.70% from topical application method was recorded at 7 DAT through 600 ppm which was followed by 400 and 200 ppm respectively. Mortality increased with increasing time & at 7 DAT it was maximum which was followed by 5, 3 & 1 DAT. So from this study, it can be concluded that Buprofezin had significant effect for controlling *Spodoptera litura* (Fab.) larvae.

Keywords: *Spodoptera litura*, larvae, Buprofezin, mortality, laboratory

1. Introduction

The *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae), which is known as common cutworm or armyworm is the most notorious insect pest that causes heavy losses in many agricultural crops including tobacco, tomato, cotton, chilly, okra, cauliflower, castor, groundnut, soybean, maize and black gram etc. thus, deprives the farmers from getting high yield [4]. *Spodoptera litura* (Fabricius) is an economically important and polyphagous insect and is considered as one of the major threats to the present-day intensive agriculture and changing cropping patterns worldwide. The leafworm, *Spodoptera litura* (Fabricius) causes economic losses of crops from 25.8-100% [8] based on crop stage and its infestation level in the field. It has a large host range of more than 120 host plants including crops, vegetables, weeds and ornamental plants [22]. The major ones include tobacco, cotton, groundnut, jute, maize, rice, soybeans, tea, cauliflower, cabbage, capsicum, potato and castor [23]. In controlled experiments on soybeans in India, crops chemically protected from *S. litura* (Fab.) and other pests yielded over 42% more than crops which were not sprayed [26]. On tobacco, in India, it was estimated that two, four and eight larvae per plant reduced yield by 23-24, 44.2 and 50.4%, respectively [20]. On *Colocasia esculenta,* an average of 4.8, 4th-instar larvae per plant reduced yield by 10%, while 2.3 and 1.5 larvae reduced yield of aubergines and Capsicum in glasshouses by 10% also [18]. Insect pests are mainly controlled with synthetic insecticides over the last 50 years. But at present it is very difficult to control this noctuid insect because of the development of high level of resistance to almost all conventional insecticides.

As *Spodoptera litura* (Fab.) developed high level of resistance to many conventional insecticides and these conventional insecticides have deleterious effects on the environment, thus scientific community has been trying best since last few years to overcome resistance problems using target-based biopesticides such as compounds based on bacteria, fungi, insect growth regulators and botanical pesticides [3,17,23,25]. Insect growth regulators (IGRs) offer good control option to combat this problem. In general, IGRs, which act as chitin synthesis inhibitors have been regarded as excellent integrated control insecticides because of their specificity to the target pest, their relative non-toxicity to beneficial organisms and their general safety to vertebrates, mollusks and plants [5, 9, 13, 29]. Chitin synthesis inhibitors (CSIs) are broadly IGRs those specially do functions in the cuticle. The major component of the insect cuticle is chitin, a structural polysaccharide consisting of N-acetyl glucosamine units. Chitin syntheses inhibitors (CSIs) are potentially inhibit chitin bio-synthesis and deposition in insect body. Consequently, no formations of new cuticle and old cuticle become fractured and insect finally die [10].

Among different chitin synthesis inhibitors (CSIs), Buprofezin is one the potential chitin synthesis inhibitor (CSI) that reduces the population of *Spodoptera litura* (Fab.) larvae by inhibiting the bio-synthesis of chitin during moulting process [15]. Buprofezin also affects the population of *Spodoptera litura* (Fab.) by reducing fecundity, egg hatchability, egg sterility, production of abnormal larvae and pupae [21]. Buprofezin was found to be effective against hemipteran pests, some lepidopteran larvae, spider [6, 14, 19]. The use of IGRs compounds in insect control is known as insect developmental inhibition, which inhibits or prevents normal metamorphosis of immature stages to the adult stage. These compounds have been tested successfully against several insect species e.g. *Spodoptera litura* [28] and *S. littoralis* [10]. Chitin synthesis inhibitors (CSIs) interfere with chitin biosynthesis in insects [11] and thus prevent moulting or produce an imperfect cuticle [12, 27]. The present study evaluated the potentiality of Buprofezin (Award 40 SC) for effective larval control of *Spodoptera litura* (Fab.) without causing any harm to non-target organism and environment and its effectiveness in integration with other components in IPM packages individually or combindly rather than its individual application.

2. Materials and Methods

Experiments were conducted in the laboratory of the Department of Entomology, Bangladesh Agricultural University, from July 2015 to June 2016.

2.1 Mass rearing of *Spodoptera litura*

The egg masses of *Spodoptera litura* (Fab.) were collected from soybean field and were kept in petridishes for hatching. After hatching, fresh soybean leaves were supplied to the neonate larvae for feeding and this helped the larvae for its proper growth. This feeding was continued until the larvae became matured and when the larvae reached to the final instar, they were transferred to the plastic container filled with soil for pupation. After emergence of adult from pupa, male & female moth was kept in a rearing chamber with previously growth aroid plants. After mating, female moths laid eggs in masses on the lower and upper surface of the aroid leaves. The leaves containing egg masses were cut & then kept in sterilized petridishes with wet cotton to prevent the drying of leaves. After 3-4 days, the eggs were hatched and neonate larvae were come out. Fresh and insecticides free soybean leaves were provided every day for larval rearing. When the larvae reached to 2nd instar with uniform size were used for treatment applications. Rearing was continued until the end of the experiments to get sufficient larvae for the experiments.

2.2 Specifications of treatments

In the laboratory three treatments along with control were used in different application methods. Each treatment was replicated thrice and ten 2nd instar larvae of *Spodoptera litura* (Fab.) were used for each replication.

Table 1: Specification of treatments, their chemical and group name**.**

Treatments	Chemical name	Group
1. Award 40 SC @ 200 ppm	Buprofezin	Insect Growth regulator
2. Award 40 SC @ 400 ppm	Buprofezin	Insect Growth regulator
3. Award 40 SC @ 600 ppm	Buprofezin	Insect Growth regulator
4. Control	----	---

2.3 Methods of treatment application

For this experiment three different application methods were used. Descriptions are presented below:

2.3.1 Topical application method (Direct method)

In this method, the larvae were directly treated (using micropipette) with different concentrations of Award 40 SC (Buprofezin). Then the treated larvae were immediately transferred into a sterilized petridish using a sterilized fine brush. In this case, fresh soybean leaves were supplied into the petridish for feeding the larvae. A moist filter paper was placed into the petridish to avoid desiccation. Then the petridish was covered with sterilized lid allowing proper air circulation & avoiding larvae from escape. As the larvae became bigger in size later it was transferred in a sterilized plastic box with lid that was perforated and covered with net avoiding larvae from escape.

2.3.2 Leaf-dip method (Indirect method)

In this case, soybean leaves were treated with Award 40 SC (Buprofezin) with different concentrations as experimental specifications. Following that the treated leaves were kept open to avoid wetting of the leaves. The proper dried leaves were placed on moist filter paper in a sterilized petridish. Then the untreated larvae of definite number were transferred into the sterilized petridish using fine sterilized brush and covered with sterilized lid. As the larvae became bigger in size later it was transferred in a sterilized plastic box with lid that was perforated and covered with net avoiding larval escape.

2.3.3 Combination method (Direct method + indirect method)

In case of combination method, both larvae and soybean leaves were treated with different concentrations of Award 40 SC (Buprofezin). After that the treated leaves were properly dried & placed on moist filter paper in a sterilized petridish. The petridish & brushes, hand and working surface that were used in this experiment all were sterilized with alcoholic solution before work. The treated larvae were then transferred on treated leaves using fine brush & covered with sterilized lid. As the larvae became bigger in size later it was transferred in a sterilized plastic box with lid that was perforated and covered with net avoiding larvae from escape.

2.4 Data collection

Data of larval mortality was observed at 1, 3, 5 and 7 DAT (days after treatment) application. Died larvae were separated and alive larvae were further provided with fresh or treated soybean leaves based on treatment application method. The percentage of larval mortality were calculated using the following formula;

% Mortality = Po/Pr x 100

Where,

Po = Number of larvae died

Pr = Number of treated or untreated larvae provided

2.5 Statistical analysis

The recorded data were compiled and tabulated for statistical analysis. Analysis of variance (ANOVA) was done with the help of computer package MSTAT. The mean differences among the treatments were adjudged with Duncan`s Multiple Range Test (DMRT) and Least Significant Difference (LSD).

3. Results

3.1 Efficacy of different concentrations of Award 40 SC (Buprofezin) on the mortality of *Spodoptera litura* larvae through topical application method

Mortality of *S. litura* (Fab.) larvae following treated with different concentrations of Award 40 SC through topical application method is shown in Table 2. The results clearly indicated that Award 40 SC was effective against *Spodoptera litura* (Fab.) larvae and the effect was clearly dose and time dependent. No mortality was found at 1 and 3 days after treatment (DAT) application, the significant ($P<0.01$) effect was found at 5 DAT which was consistent up to 7 DAT ($P<0.01$). The maximum, 56.70% mortality was recorded at 7 DAT from 600 ppm which was followed by 400 ppm (46.70%) and 200 ppm (36.70%) respectively compared to control. At 5 DAT, all the treatments also significantly increased larval mortality compared to control but there had insignificant differences between the concentration of 200 and 400 ppm although highest mortality was observed at 7 DAT.

Table 2: Mortality of *S. litura* larvae following treated with different concentrations of Award 40 SC (Buprofezin) through direct or topical application method.

Treatments	Mean percent of larval mortality at different Days After Treatment (DAT)			
	1	3	5	7
Award 40 SC @ 200 ppm	0.00	0.00	10.00b	36.70b
Award 40 SC @ 400 ppm	0.00	0.00	10.00b	46.70c
Award 40 SC @ 600 ppm	0.00	0.00	20.00c	56.70d
Untreated /control	0.00	0.00	6.67a	10.00a
P-level	NS	NS	**	**
CV (%)			19.67	15.78
SE (±)			0.427	1.321

In a column, means of similar letter (s) do not differ significantly. DAT = Days After Treatment, ** = Significant at 1% level of probability, NS = Not significant, P-level = Probability Level, CV = Co-efficient of Variation, SE = Standard Error.

3.2. Larval mortality through leaf-dip/indirect application method

The effect of indirect application method of different concentration of Award 40 SC on the mortality of *S. litura* (Fab.) larvae are shown in Table 3 ($P<0.01$). From the results it was cleared that the mortality of *S. litura* larvae were dose and time dependent and the maximum mean larval mortality (63.88%) was found from 600 ppm at 7 DAT that was followed by 400 (55.50%) and 200 ppm (41.66%) respectively. No mortality was found at 1 DAT but significant effect was found at 3 DAT ($P<0.01$), 5 DAT ($P<0.01$) which was consistent up to 7 DAT ($P<0.01$). But at 3 DAT larval mortality was comparatively weaker for all concentrations but the effect was statistically significant compared to the control. In case of topical application method, no mortality was found at 3 DAT but in case of leaf-dip application method significant mortality was found at 3 DAT and it was increased with time (5 and 7 DAT) because of accumulation of higher amount of Buprofezin in the insect body through leaf-feeding. In topical application method, the maximum mortality (56.70%) was found @ 600 ppm while it was increased to 63.88% in case of leaf-dip method with the same doses. So it was confirmed that indirect application method was more effective than the topical application method for the mortality of *Spodoptera litura* (Fab.) larvae.

Table 3: Mortality of *S. litura* larvae following treated with different concentrations of Award 40 SC (Buprofezin) through leaf-dip method.

Treatments	Mean percent of larval mortality at different Days After Treatment (DAT)			
	1	3	5	7
Award 40 SC @ 200 ppm	0.00	11.08b	36.08b	41.66b
Award 40 SC @ 400 ppm	0.00	16.66c	41.67c	55.50c
Award 40 SC @ 600 ppm	0.00	22.17d	52.75d	63.88d
Untreated /control	0.00	0.00a	5.50a	8.33a
P-level	NS	**	**	**
CV (%)		16.11	11.57	17.35
SE (±)		0.569	1.212	1.458

In a column, means of similar letter (s) do not differ significantly. DAT = Days after Treatment, ** = Significant at 1% level of probability, NS = Not significant, P-level = Probability Level, CV = Co-efficient of Variation, SE = Standard Error.

3.3. Larval mortality through combined application method

The maximum percent of larval mortality was found when both the larvae and the soybean leaves were treated with different concentrations of Award 40 SC (Buprofezin) compared to contol (Table 4). The highest percent of larval mortality was observed from 600 ppm at 7 DAT (66.67%) followed by 400 (58.33%) and 200 ppm (41.66%) respectively compared to control. In case of individual application method maximum mortality percent was found from 600 ppm at 7 DAT like direct (56.70%) and indirect (63.88%) but in combination application method mortality percent was (66.67%) higher than the direct and indirect application method. No mortality was found at 1 DAT application but significant mortality of the larvae was found at 3 DAT ($P<0.01$) which was further increased at 5 and 7 DAT

(P<0.01) application. According to the experimental results, direct application method and low dose (200 ppm) of Award 40 SC (Buprofezin) was less effective for larval mortality but the effectiveness was gradually increased with the increasing of dose (400 & 600 ppm) and time. From this result it was also cleared that indirect application method was found more effective than direct application method while combined application method showed the best regarding the larval mortality.

Table 4: Mortality of *S. litura* larvae following treated with different concentrations of Award 40 SC (Buprofezin) through combined application method.

Treatments	Mean percent of larval mortality at different Days After Treatment (DAT)			
	1	3	5	7
Award 40 SC @ 200 ppm	0.00	11.08b	38.92b	41.66b
Award 40 SC @ 400 ppm	0.00	19.41c	44.42c	58.33c
Award 40 SC @ 600 ppm	0.00	22.17d	55.58d	66.67d
Untreated control	0.00	0.00a	5.50a	8.33a
P-level	NS	**	**	**
CV (%)		14.7	9.84	86.6
SE (±)		0.599	1.291	1.546

In a column, means of similar letter (s) do not differ significantly. DAT = Days after Treatment, ** = Significant at 1% level of probability, NS = Not significant, P-level = Probability Level, CV = Co-efficient of Variation, SE = Standard Error.

4. Discussion

Due to the appearance of high resistance of *Spodoptera litura* (Fab.) to many chemical pesticides and resurgence of chemical pesticides there is growing interest in the use of bioinsecticides. IGRs have been reported to possess a specific activity spectrum with a novel insecticidal mechanism not based on a neurotoxic action. They disrupt the physiology and development of target pest insects and show no or low toxicity towards non-target organisms, making them ideal in combination with biological control and also to circumvent insecticide resistance [7].

The chitin synthesis inhibitors; (Buprofezin) caused appreciable toxic effect in larvae of *S. litura*. The response of larval mortalities caused by these CSI in the present study was observed. The present work showed that the mortality was clearly caused by moulting failure of *S. litura* larvae; this effect is mainly induced by inhibiting chitin formation [1] thereby causing abnormal endocuticular deposition and abortive moulting [16]. Buprofezin is a chitin synthesis inhibitor involved in insect growth and development during molting, due to its lipophilic properties it can interfere with the exoskeleton chitin by contact. Furthermore higher concentrations have antifeeding effect. A series of experiments were conducted in the laboratory to evaluate the efficacy of Award 40 SC (Buprofezin) on the mortality of *Spodoptera litura* (Fab.) larvae. This growth regulator was evaluated using three concentrations viz. 200, 400 and 600 ppm through different application methods like topical, leaf-dip and combination method. The 2nd instar larvae were used for all the experiments. Data were collected at 1, 3, 5 and 7 DAT based on experimental specifications.

The present study confirmed that the Award 40 SC (Buprofezin) has significant effect on the mortality, of *S. litura* larvae. The effect was clearly dose, time and method dependent. No mortality was found after 1 DAT in case of all the three doses irrespective of application methods which confirmed that the IGR has no any acute effect on the mortality. However, the mortality was significantly increased at 3 DAT that further increased at 5 and 7 DAT. It was observed that the mortality was clearly dose-dependent and the highest percentage of mortality was found at 7 DAT @ 600 ppm of Award 40 SC where 56.70%, 63.88% and 66.67% larvae were died in case of topical, leaf-dip and combined application methods respectively. This was followed by 400 ppm with the mortality of 47.70%, 55.5% and 58.33% in case of topical, leaf-dip and combination application methods respectively and 200 ppm with the mortality of 36.70%, 41.66% and 41.66% in case of topical, leaf-dip and combined application methods respectively. The lowest percentage of mortality was found in case of untreated or in control condition (8-10%). The higher mortality in case of combined application method may be linked with the accumulation of higher amount of Buprofezin molecule in insect body through cuticular adsorption as well as feeding with leaf that finally disrupted the chitin formation through endocrinological or iter-biochemical process.

This finding could be linked with a researcher [24] who reported that the mortality decreased progressively with the decrease in concentrations of insecticide Novaleuron (IGR). At the concentrations of 600, 500, 400, 300, 200 and 100 ppm, the mortality of *S.litura* recorded was 77.35, 67.45, 52.63, 47.44, 30.32 and 24.12 percent, respectively. The LC50 value of the Novaluron against *S.litura* was established to be 350.45 ppm.

This experiment related with an experiment [2] in which it was reported that amongst new chemistry insecticides, emamectin benzoate and lufenuron (IGR) resulted in maximum mortality of *S. litura* followed by spinosad and indoxacarb, respectively in their time-oriented mortality at three concentration levels against *S. litura*.

5. Conclusion

From the present study, it was concluded that Buprofezin has significant effect on the larval mortality (60-68%) as well as inhibition of growth and development of different instars of *S. litura* larva. The effect was clearly dose, method and time dependent. The best efficacy was found from 600 ppm which was followed by 400 and 200 ppm respectively. On the other hand, the combination method was found to be the best compared to leaf-dip or topical application methods. Considering all results, the application of Buprofezin would be more effective when it will apply in integration with other components rather than its individual application.

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7. References

1. Abdel Rahman SM, Hegazy EM, Elwey AE. Direct and Latent Effect of Two Chitin Inhibitors to *Spodoptera littoralis* (Boisd) larvae. American-Eurasian Journal of Agricultural and Environmental Science. 2007; 2(40):457-464.
2. Ahmad M, MA Saleem. Comparative efficacy of ten conventional and new chemistry insecticides against armyworm, *Spodoptera litura* (Fab.) (Lepidoptera: Noctuidae) under laboratory conditions. Pakistan Entomologist. 2004; 26(2):1-4.
3. Atwa WA, Adel MM, Salem NY, Abdou WL, Ibrahim SS. Some Physiological and Histopathological Studies of Neem Azal T/S and Two Wild Egyptian Plant Extracts on the Black Cutworm *Agrotis ipsilon* (Hufn.) (Lepidoptera: Noctuidae). Bulletin of NRC. Egypt. 2010; (35):1.
4. CABI. Crop protection compendium: global module. Commonwealth Agricultural Bureau International, Wallingford, UK, 2009. http://www.cabi.org/compendia/cpc/.
5. Deakle JP, Bradley JR Jr. Effects of early season applications of diflubenzuron and azinphosmethyl on population levels of certain arthropods in cotton fields. Journal of the Georgia Entomological Society. 1982; 17:200-204.
6. Deng L, Xu M, Cao H, Dai J. Ecotoxicological effects of buprofezin on fecundity, growth, development, and predation of wolf spider *Pirata piratoides* (Schenkel). Archives of Environmental Contamination and Toxicology. 2008; 55:652-658.
7. Dhadialla TS. A Retnakaran, Smagghe. Insect growth- and developmental-disturbing insecticides, in: LI Gilbert, K Iatrou, SK Gill (Eds.), Comprehensive Insect Molecular Science. Elsevier, Oxford. 2005; 6:55-116.
8. Dhir BC, Mohapatra HK, Senapati B. Assessment of crop loss in groundnut due to tobacco caterpillar, *Spodoptera litura* Fabricius. Indian Journal of Plant Protection. 1992; 20(7-10):215-217.
9. Frank WD. Chemical control In R.E. Pfadt (ed.), Fundamentals of applied entomology. MacMillan, New York. 1978, 209-240.
10. Gelbic I, Adel MM, Hussein HM. Effects of nonsteroidal ecdysone agonist RH-5992 and chitin biosynthesis inhibitor lufenuron on *Spodoptera littoralis* (Boisduval, 1833). Central European Journal of Biology. 2011; 6(5):861-869.
11. Gijswijt MJ, Deul DH, DeJong BJ. Inhibition of chitin synthesis by benzoylphenylurea insecticides, III. Similarity in action in *Pieres brassicae* (L.) with polyxin D. Pesticides Biochemistry and Physiology. 1979; 12:84-94.
12. Hammock CD, Quisted GB. Meabolism and mode of action of juvenile hormone, juvenoids and other insect growth regulators. In “Progress in pesticide Biochemistry” (Hutson, D.H. and Roberts, T.R. eds.), John Wiley & Sons Ltd. 1981; 1:1-85.
13. Horn DJ. Ecological approach to pest management. Guilford, New York, 1988.
14. Izawa Y, Uchida M, Sugimoto T, Asai T. Inhibition of chitin biosynthesis by buprofezin analogs in relation to their activity controlling *Nilaparvata lugens.* Pesticides Biochemistry and Physiology. 1985; 24:343-347.
15. Manal M. Lufenuron Impair the Chitin Synthesis and Development of *Spodoptera littoralis* Bosid (Lepidoptera: Noctuidae). Journal of Applied Sciences Research. 2012; 8(5):2766-2775.
16. Mulder R, Gijswigt MJ. The laboratory evaluation of two promising new insecticides which interfere with cuticle deposition. Pesticide Science. 1973; 4:737-745.
17. Mourad LS, Osman S, Salama O, Ayoub A. Insecticidal effect of *Chrysanthemum coronarium* L. flowers on the pest *Spodoptera littoralis* (Boisd.) and its parasitoid *Microplitis rufiventris* Kok. With identifying the chemical composition. Journal of Applied Sciences. 2008; 12:1859-1866.
18. Nakasuji F, Matsuzaki T. The control threshold density of the tobacco cutworm *Spodoptera litura* on eggplants and sweet peppers in vinylhouse. Journal of Applied Entomology and Zoology. 1977; 12:184-189.
19. Nagata T. Timing of buprofezin application for control of the brown planthopper, *Nilaparvata lugens* (Stal.) (Homoptera: Delphacidae). Journal of Applied Entomology and Zoology. 1986; 14:357-368.
20. Patel HK, Patel NG, Patel VC. Quantitative estimation of damage to tobacco caused by the leaf-eating caterpillar, *Prodenia litura*. PANS 1971; 17:202-205.
21. Ragaei M, Sabry KH. Impact of spinosad and buprofezin alone and in combination against the cotton leafworm, *Spodoptera littoralis* under laboratory conditions. Journal of Biopesticides. 2011; 4(2):156-160.
22. Ramana VV, Reddy GPV, Krishnamurthy MM. Synthetic pyrethroids and other bait formulation in the control of *Spodoptera litura* (Fabricius) attacking rabi groundnut. Pesticide. 1988; 1:522-524.
23. Rao NV, Reddy AS, Reddy PS. Relative efficacy of some new insecticides on insect pests of cotton. Indian Journal of Plant Protection. 1990; 18:53-58.
24. Shaila O, Rao SRK, Ramesh Babu T. Chemical Compatibility of Avermectins and Chitin Synthesis Inhibitors with Common Fungicides against *Spodoptera litura.* European Journal of Zoological Research. 2013; 2013, 2(4):116-123.
25. Sharma RK, Bisht RS. Antifeedant activity of indigenous plant extracts against *Spodoptera litura* Fabricius. Journal of Insect Science. 2008; 2156-60.
26. Srivastava OS, Malik DS, Thakur RC. Estimation of losses in yield due to the attack of arthropod pests in soybean. Indian Journal of Entomology. 1972; 33:224-225.
27. Verloop A, Ferrel CD. Benzoylureas – A new group of larvicides interferring with chitin deposition. In "Pesticide chemistry in the 20thCentury" (Plummer, J.R., ed.). Washington, D.C., American Chemical Society. Acs symposium series. 1977; 37:237-270.
28. Wang J, Tian D. Sublethal effects of Methoxyfenozide on *Spodoptera litura*. Cotton Scien. 2009; 21(3):212-217.
29. Wilkinson JD, Biever KD, Ignoffo CM, Pons WJ, Morrison RK, Seay RS *et al.* Evaluation of diflubenzuron formulations on selected insect parasitoids and predators. Journal of Georgia Entomology Society. 1978; 13:227-236.