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Potentiation of some insecticides by sesamol on cotton leafworm, *Spodoptera littoralis*

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ABSTRACT

The effectiveness of sesamol as a natural product and certain insecticides, three organophosphates (fenitrothion, chlorpyrifos-methyl, dimethoate), two carbamates (methomyl, thiodicarb) and one pyrethroid (deltamethrin) as well as the joint action of their mixtures were investigated against the fourth-instar larvae of the laboratory strain of cotton leafworm, *Spodoptera littoralis* (Boisd). The results showed that deltamethrin was the most toxic insecticide followed by methomyl, thiodicarb, chlorpyrifos-methyl and fenitrothion, while dimethoate was the least toxic one. The results also indicated that sesamol even at the highest concentration (10,000 ppm) did not show any insecticidal activity against larval stage. The joint action between these insecticides at the LC_{50} levels and sesamol at 1000 ppm indicated that deltamethrin, methomyl or thiodicarb and sesamol mixtures produced high level of synergism, while the mixtures of sesamol and dimethoate or fenitrothion had moderate degree of synergism. However, chlorpyrifos-methyl had an additive effect. The results also revealed that increasing sesamol concentration increased the synergistic activity. It might be concluded that the application rates of pyrethroid and carbamate insecticides could be reduced when combined with sesamol to the control of cotton leafworm.

INTRODUCTION

Cotton leafworm, *Spodoptera littoralis* (Boisd) has been considered a serious economic pest of cotton and various vegetable and field crops allover the year in Egypt (Emara, 1999). It causes severe crop damage in infested areas due to control failure caused by the development of resistance in such insect to the insecticides being acquird as well as the destruction of predators and parasites. This insect pest has developed high level of resistance and a wide range of multiple-resistance to almost all the conventional insecticides used for control.

Great efforts had been devoted by several authers to prove the development of insecticides resistance by whether laboratory or field strains of the cotton leafworm *S. littoralis* (El-Sebae *et al.*,1973; Moustafa *et al.*,1976; 1980 & 2001; and Moustafa, 1981). Unfortunately, it is becoming increasingly difficult to find compounds, which are safe and highly potent to overcome this problem. Consequently, investigators are directing their efforts to improve the effectiveness of existing products. Practically, this is possible threw two ways, first by the use of synergists and second by the use of insecticide mixtures which may delay or retard the development of resistance (Fahmy and Miyata, 1998).

The significance of synergism studied arise for two main reasons: the first is that synergists may be used as a rapid and reliable method to predict the enzyme system (s) responsible for insecticide degradation when the proper enzyme inhibitor is used (Miyata and Saito, 1984). The second is that there is a possibility of improving the performance of efficacy of insecticide and lso reducing the insecticide doses might help to diminish the impact of insecticide to the environment e.g. less pollution to the environment, spare parasites, predators and biotic control agents and decrease the cost of control which is one of the main target of Integrated Pest Management (IPM) program. When insecticide/synergist mixtures show potentiation in their joint action and/or if they can retard or prevent the development of resistance, then the application of these mixtures could be considered as a possible resistance management tool.

Sesame oil, obtained from the seed of *Sesamum indicum* (L.). One of the constituents of this oil responsible for synergism was found by Haller *et al.* (1942) to be sesamin. Later, Berosa *et al.* (1954) found that sesamolin, a phenolic ether and another constituent of sesame oil, was characterized and more potent pyrethrum synergist, five times as effective as sesamin. In the same year, sesamol is 3,4-methylenedioxyphenol which caused no synergistic effect with pyrethrins against the housefly, *Musca domestica* (Gersdorff *et al.*, 1954). However,synergistic action was observed with synthetic pyrethroids against different insects (Devakumar *et al.*, 1985 and Chung *et al.*,1992). The aim of this work is to evaluate the synergistic effects and joint action of sesamol as a synergist with some of the common insecticides against the cotton leafworm *S. littoralis* under laboratory conditions.

MATERIALS AND METHODS

Insects : A laboratory colony of the Egyptian cotton leafworm, *S. littoralis* (Boisd) was reared on castor been leaves as described by El-Defrawi *et al.*, (1964).

Chemicals :

A) Insecticides: Six formulated insecticides represent three main groups (organophosphates, carbamates and synthetic pyrethroids) were used in this study and indicated as follows:

1- **Organophosphates :** (a) Fenitrothion (Sumithion) 50% EC [*0,0*-dimethyl *0*-4-nitro-*m*-tolyl phosphorothioate]. It was supplied by Agro Chemical Industries Ltd. (b) Dimethoate 40% EC. [*0,0* dimethyl *S*-methyl carbamoylmethyl phosphorodithioate].It was supplied by Agro Chemical Industries Ltd. (c) Chlorpyrifos-methyl (Reldan) 50% EC. [*0,0*-dimethyl *0*- (3,5,6-trichloro - 2 - pyridinyl) phosphorothioate]. It was supplied by Dow Co.

2- **Carbamates:** (a) Methomyl (Lannate) 90% S.P. S-Methyl N-[(methyl carbamoyl)oxy]thioacetimidate. It was supplied by Dupont Chemical Co. (b) Thiodicarb (Larvin) 85% S.C. N,N -[Thiobis [(methylimino)carbonyl-oxy]]bis ethanimidothioate)]. It was supplied by Union Carbide.

3- **Synthetic pyrethroids:** Deltamethrin (Decis) 2.5 EC. [(S) - α - cyano -3- phenoxybenzyl (1R, 3R) -3- (2,2-dibromovinyl)-2,2-dimethylcyclopropanecarboxylate] It was supplied by Agro Chemicals Industries Ltd.

B) **Synergist:** Sesamol: 3,4- methylenedioxyphenol was purchased from Sigma Co. All insecticides preparations were diluted with water.

Testing technique: The leaf dipping technique was carried out in the laboratory as follows: Castor bean leaves were dipped in aqueous pesticidal preparations for 5 second and allowed to dry. The fourth- instar larvae of cotton leafworm were placed on treated leaves. Concentration series of each insecticide were prepared. Four replicates were used (ten larvae each). Mortality percentages were recorded after 24 hours and corrected using

Abbott`s formula (1925). The $LC_{50}$ values expressed as ppm were determined directly from the log-concentration mortality regression line. Slope and confidence limits of $LC_{50}$`S were calculated according to Finney (1971).

To determine the potentiation effects of sesamol (which has no effect at the experimental concentration) and the tested compound, the expected LC_{50} of such compound was applied together with 1000 ppm sesamol.

The degree of potentiation of the different mixtures was evaluated by the equation of Co-toxicity Factor (C.F) as described by Mansour *et al.*, (1966) as follows:

$$C.F = \frac{\text{Observed mortality \% - Expected mortality \%}}{\text{Expected mortatity\%}} \times 100$$

This factor was used to classify results into three categories. A positive factor of 20 or more is considered potentiation, a negative factor of 20 or more means antagonism, and the intermediate values between -20 and 20 is an additive effect.

RESULTS AND DISCUSSION

Toxicity studies : The relative toxicity of six insecticides, three organophosphates (fenitrothion,chlorpyrifos-methyl,dimethoate) two carbamates (methomyl, thiodicarb) and one pyrethroid (deltamethrin) beside sesamol to 4^{th} instar larvae of *S. littoralis* was calculated as LC_{50} values (Table 1). LC_{50} values were expressed as mg/liter. Based on LC_{50} values, the results indicated that deltamethrin was the most toxic insecticide with LC_{50} of

0.024 mg/l followed by methomyl, thiodicarb and chlorpyrifos-methyl with LC_{50}'s of 29, 41 and 120 mg/l, respectively.

Fenitrothion come next in its toxicity followed by dimethoate with LC_{50}'s of 520 and 1350 mg/l, respectively. On the other hand, sesamol did not show any insecticidal activity up to 10000 µg/ml under the experimental conditions.

Table (1): Toxicity of different insecticides against 4*th* instar larvae of *Spodoptera littoralis*.

Insecticide	LC_{50} (mg/l)	Confidence limits		Slope
		Upper	lower	
deltamethrin	0.024	0.03	0.019	2.2
methomyl	29	59.06	42.37	2.9
thiodicarb	41	47.15	35.63	1.6
chlorpyrifos-methyl	120	138.0	104.35	3.5
fenitrothion	520	587.6	460.18	4.2
dimethoate	1350	2146.5	849.06	6

Potentiation studies: The joint action of sesamol with the tested insecticides was studied against fourth instar larvae of the laboratory strain of *S. littoralis* (Table 2). The combinations of sesamol (1000 ppm) with LC_{50} values of insecticides caused different degree of synergism on *S. littoralis*. The highly synergistic action was obtained by the mixtures of sesamol with each of deltamethrin, methomyl or thiodicarb with Co-toxicity factors of 100. The mixture of sesamol and either dimethoate, or fenitrothion had moderate degree of synergism (C.F = 46.6 and 26.6), respectively. On the other hand, chlorpyrifos-methyl had an additive effect. These results are in agreement with the results of (Chung *et al.* 1992) who showed that sesamol was active with pyrethroids when used in binary combination with three pyrethroid insecticides to treat 4*th* instar larvae of ***Plutella** xylostella*. Moreover, Devakumar *et al.* (1985) synthesized several methylenedioxyphenyl ethers from sesamol and methoxy substituted sesamols and used them as synergists of pyrethroids against the tenebrionid *Tribolium castaneum*. Also, Sun *et al.* (1986) showed that carbofuran and carbosulfan (carbamate insecticides) selected strains exhibited more than 30 fold cross-resistance to fenvalerate (pyrethroid insecticide) in diamond back moths, *Plutella xylostella* (L.). Their cross-resistance mechanism to carbofuran, carbosulfan is probably the same as the resistance mechanism to pyrethroids and sesamol may act as a synergist through similar mechanism. These results may explain the high level of synergism between sesamol and deltamethrin methomyl or thiodicarb.

Table (2): The joint action between LC_{50} values of insecticides and (1000 ppm) sesamol against the 4^{th} instar larvae of *Spodoptera littoralis*.

Combination	Observed mortality %	Co-toxicity factor (C. F)
deltamethrin + sesamol	100	100
methomyl + sesamol	100	100
thiodicarb + sesamol	100	100
chlorpyrifos-methyl + sesomal	51.6	3.2
fenitrothion + sesamol	63.3	26.6
dimethoate + sesamol	73.3	46.6

Another reason for sesamol synergism is its ability to inhibit oxidase enzymes (Virapong Noppun *et al.*, (1989). Also, sesamol is a potent inhibitor of lipid biosynthesis and accumulation in *Fusarium moniliforme* (Alix Jacklin *et al.*, 2000).

The effect of sesamol concentrations (1000, 2000 and 3000 ppm) on the insecticidal activity of the tested compounds against *S. littoralis* was recorded in Table (3). The binary combinations caused different degree of synergism on *S.*

littoralis. Sesamol at 3000 ppm increased the toxicity of allexperimental insecticides with Co-toxicity factors ranging between 3.2 and 100. The highest levels of synergism were achieved by mixing sesamol at the concentration of 3000 ppm with the LC_{50} values of dimethoate and fenitrothion where the degree of synergism was 100 and 46.8%, respectively. So the increasing of sesamol concentration increased the synergistic activity. It may be concluded that the use of sesamol as a synergist increases the efficiency of pyrethroid and carbamate insecticides represented by deltamethrin, methomyl and thiodicarb with consequent decrease in their rates of applications. Moreover, the reduced levels of sesamol /insecticide combinations, would minimize the environmental risk, overcome pest resistance and reduce the cost of pest control which are the main targets of IPM programs.

Table (3): Toxicity of certain insecticides and their mixtures with sesamol at different concentrations against *Spodoptera littoralis*.

Insecticide	LC_{50} values of insecticides in admixture with different sesamol concentrations					
	LC_{50} + 1000 ppm sesamol		LC_{50} + 2000 ppm sesamol		LC_{50} + 3000 ppm sesamol	
	Observed Mortality %	C.F	Observed Mortality %	C.F	Observed Mortality %	C.F
Deltamethrin	100	100	--	--	--	--
Methomyl	100	100	--	--	--	--
Thiodicarb	100	100	--	--	--	--
Chlorpyrifos-methyl	51.6	3.2	63.3	26.6	70	40
Dimethoate	73.3	46.6	93.3	86.7	100	100
Fenitrothion	63.3	26.6	65	30	98.4	96.8

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الملخص العربى

التأثير المشترك للسيزامول
مع بعض المبيدات على دودة ورق القطن

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تم دراسة الفعل التنشيطى بالإضافة إلى سمية السيزامول وهو مركب غير زيتى لزيت بذرة السمسم على ثلاثة مبيدات تابعة لمجموعة الفوسفور العضوية ومبيدين من مجموعة الكارباميت ومبيد من مجموعة البيروثرويدات على العمر اليرقى الرابع لسلالة معملية من دودة ورق القطن . وقد أظهرت النتائج أن مبيد الدلتامثرين كان أكثر المبيدات سمية يليه مبيد الميثوميل ثم الثيوديكارب ثم الكلوربيريفوس ميثايل ثم الفنتروثيون بينما كان مبيد الدايمثويت أقل المبيدات سمية على دودة ورق القطن . أما مركب السيزامول فلم يعطى أى تأثير على دودة ورق القطن حتى عند إستخدام التركيزات المرتفعة منه ١٠,٠٠٠ جزء فى المليون .

ولقد أظهرت نتائج التأثير المشترك لمخاليط الدلتامثرين والميثوميل والثيوديكارب عند التركيز القاتل لـ ٥٠% من الأفراد مع السيزامول (١٠٠٠ جزء فى المليون) درجة تنشيط مرتفعة بينما أظهر مخلوط السيزامول مع الدايمثويت والفنتروثيون درجة تنشيط متوسطة بينما مخلوط كل من الكلوربيريفوس ميثايل مع السيزامول فقد أعطى تأثير إضافة . وأوضحت النتائج أيضا أن زيادة تركيزات السيزامول حتى ٣٠٠٠ جزء فى المليون عند خلطها بالمبيدات قد زادت من درجات التنشيط ضد العمر اليرقى الرابع لدودة ورق القطن .