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Use of Tank-mix Adjuvants to Improve Effectiveness and Persistence of Chlorpyrifos and Cyhalothrin Formulations

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ABSTRACT

The use of adjuvants enhances the insecticide efficiency and increases the persistence of insecticides. In this study, the effect of adjuvants on the toxicity of chlorpyrifos and cyhalothrin formulations were investigated under laboratory and field conditions. The comparative toxicity of two chlorpyrifos [(48% Emulsifiable concentrate (EC)] formulations (Dursban and Pyrifos El Nasr), two cyhalothrin (5% EC) formulations (Halothrin Gold El Nasr and Lambada Mox) and two adjuvants (Top Film and Tritone K) were examined against the second and the fourth larval stages of *Spodoptera littoralis*. The effect of adjuvants on the toxicity of chlorpyrifos and cyhalothrin formulations were investigated under laboratory and field conditions. The results showed that Dursban exhibited the highest toxicity against the second and fourth larval stages of *S. littoralis* with LC_{50} values of 0.2 and 1.11 mg L^{-1}, respectively. In contrast, Pyrifos El Nasr had the lowest toxicity against both larval stages. The results of joint toxic effect between adjuvants and insecticides indicated that adjuvants revealed potentiating effect on the toxicity of four insecticide formulations as co-toxicity factor values were greater than +20. Mixing the adjuvants with chlorpyrifos and cyhalothrin formulations in spraying tank before application of insecticides in field strongly increased the toxicity and the persistence of insecticides. Cyhalothrin formulations mixed with adjuvants gave continued significant mortality through 21 days, while chlorpyrifos gave continued significant mortality through 15 days of treatment. However, chlorpyrifos and cyhalothrin formulations without mixing with adjuvants gave significant mortality through 3 to 4 days of treatments. These results indicated that adjuvants increased efficiency and residual effect of chlorpyrifos and cyhalothrin commercial formulations. Therefore, the adjuvants can be used for reducing the number of applications in the season and the application rates of insecticides.

Keywords: Insecticides, Pesticide application, *Spodoptera littoralis*, Toxicity of insecticides.

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INTRODUCTION

Decreasing the pesticide application rates and number of application times by adding the adjuvants either during formulation (ready mix products) or mixing in spraying tank (tank mix products) is a universal acceptable approach. Adjuvant choice varies according to the properties of the pesticide, its mode of action and the type of formulation used, as well as the nature of the intended target (Holloway, 1998). The use of adjuvants enhances the pesticide efficiency and increases the persistence of pesticides. This may reduce the effective pesticide dose as much as 10-fold (Green and Green, 1993; Hammami *et al.*, 2014).

Cotton is one of the major fibre crops of global significance. It is cultivated in tropical and subtropical regions of more than eighty countries of the world occupying nearly 33

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million hectares with an annual production of 26 million tonnes of bales in 2012. China, India, USA, Pakistan, Brazil, Uzbekistan, Australia, and Turkey are the major cotton producing countries. These countries contribute nearly 86% of the global cotton production (FAO, 2012).

In Egypt, cotton is attacked by numerous pests. However, the most destructive insect is Egyptian cotton leafworm, *Spodoptera littoralis* (Boisd). This insect species cause a severe reduction in cotton yield and quality (Hosny *et al*., 1986; Lohag and Nahyoon, 1995; Emara, 1999).

The heavy use of organophosphate and pyrethroid insecticides in controlling the cotton leafworm has led to serious number of problems, among them, insect resistance. Insect control by reduced rates and lower number of insecticide applications is a useful strategy to overcome the development of resistance and decreasing pest control cost. Additionally, resistance can be overcome by several strategies such as crop rotation and insecticide rotation and use of IPM programs. Therefore, the objectives of this study were to evaluate the toxicity of some chlorpyrifos and cyhalothrin formulations against the second and fourth larval stages of *S. littoralis* in laboratory, to study the joint toxic effect of adjuvants Top Film and Tritone K on chlorpyrifos and cyhalothrin formulations, and to examine the effect of these adjuvants on the efficacy and persistence of the insecticide formulations in cotton field.

MATERIALS AND METHODS

Insect

A laboratory strain of the cotton leafworm, *Spodoptera littoralis* (Boisd.) (Lepidoptera: Noctuidae), was reared under laboratory conditions on caster bean leaves, *Ricinus communis* L. (Euphorbiaceae), at 26±2°C and 70±5% relative humidity (El-Defrawi *et al.*, 1964). The second and fourth larval instars were used in the experiments.

Insecticides and Adjuvants

Two commercial formulations of chlorpyrifos (48% EC), namely, Dursban (Dow Agrosciences, USA) and Pyrifos El Nasr (El Nasr Company for Intermediate Chemicals, Egypt), and two commercial formulations of cyhalothrin (5% EC), namely, Halothrin Gold El Nasr (El Nasr Company for Intermediate Chemicals, Egypt) and Lambada Mox (Alexandria for Chemicals Company, Egypt) were used in this study. These four insecticide formulations are commonly used for the control of different insect species attacking cotton in Egypt. Two NonIonic Surfactants (NIS), Top Film adjuvant and Tritone K adjuvant, were obtained from El-Helb Misr for Pesticides and Chemicals Co. and Chema Industries Co., respectively.

Laboratory Experiments

Leaf dipping method was used to evaluate the insecticidal activity of chlorpyrifos and cyhalothrin formulations against the second and the fourth instar larvae of *S. littoralis* in laboratory. A series of concentrations of each insecticide formulation was prepared in distilled water. Leaves of castor bean were immersed for 5 seconds in the prepared concentrations. The treated castor bean leaves were left to dry and then transferred to Petri-dishes (15 cm diameter) with 10 larvae of 2^{nd} or 4^{th} instar larvae. Four replicates were carried out for each treatment. Larvae in the control treatment were fed on leaves treated only with distilled water. The mortality percentages were recorded after 24 hours of treatment. The lethal concentrations causing 50% mortality (LC_{50}) expressed in mg L^{-1} were calculated from log-concentration mortality regression lines (Finney, 1971).

Joint Toxic Effect Assay

The assay was conducted to examine the joint toxic effect of adjuvants on the toxicity of chlorpyrifos and cyhalothrin formulations against *S. littoralis*. Mortality percentages corresponding to LC_{25} were determined from regression lines. The summation of mortality percentages of adjuvants and insecticide formulations was considered as the expected mortality. A binary mixture of adjuvants and insecticide formulations was prepared at a ratio of $LC_{25}:LC_{25}$ (1:1). The resulting mixtures were tested against *S. littoralis* larvae. Mortality (%) caused by these mixtures was recorded after 24 hours of treatment and considered as the observed mortality. A co-toxicity factor was taken as a criterion for evaluation of the joint toxic effect as follows:

$$Co\text{-}toxicity\ factor = [(OM - EM)/EM] \times 100, \quad (1)$$

Where, *OM* was the observed mortality (%) and *EM* was the expected mortality (%). A positive factor of +20 or higher means potentiation, a negative factor of -20 or lower means antagonism, and values between -20 and +20 imply an additive effect (Mansour *et al*., 1966).

Field Experiments

The experiments were carried out at Faculty of Agriculture Farm, Abees, Alexandria Governorate (31° 12' N, 29° 57' E) to evaluate the efficiency of insecticide formulations, adjuvants, and their mixtures against *S. littoralis*. The field area was cultivated with Giza-86 cotton variety during the summer seasons of 2010 and 2011. The experimental area was 0.74 hectare and the plot area was 42 m^2. The treatment was arranged in Randomized Complete Blocks Design (RCBD) with four replicates each. The application of the insecticide formulations was carried out by knapsack hand-sprayer (CP3) having a hollow-cone nozzle. The insecticide formulations were applied at recommended rates (2.38 L ha^{-1} for chlorpyrifos formulations and 952 cm^3 ha^{-1} for cyhalothrin formulations), as described in pest control program, Ministry of Agriculture, Egypt (2009). The adjuvants (Top Film and Tritone K) were applied at the rate of 30 cm^3 100 L^{-1} water. Each replicate was thoroughly sprayed using 6 liters of each insecticide formulation solution. Control plants were sprayed with an equal volume of water. Leaves of 5 plants of treated and control plots were collected randomly and transferred in perforated paper bags to the laboratory. Leaves were placed in cups (100 ml) with 10 larvae of 2^{nd} or 4^{th} instars larvae of *S. littoralis*. Leaves were collected at zero time and 1, 2, 4, 6, 9, 12, 15, 18, and 21 days after application. The mortality percentages of *S. littoralis* larvae were determined after 24 hours of feeding on treated leaves at each collection interval.

Statistical Analysis

Data were subjected to one-way analysis of variance followed by Student–Newman–Keuls test; Cohort software Inc. to determine significant differences among mean values at the probability levels of 0.01. The concentration–mortality data were subjected to Probit analysis to calculated the LC_{50} values using the Statistical Package for the Social Sciences (SPSS) 14.0 software program. The values of LC_{50} were considered significantly different, if the 95% confidence limits did not overlap.

RESULTS AND DISCUSSION

Insecticidal Activity of Chlorpyrifos and Cyhalothrin Formulations

The LC_{50} values (mg L^{-1}), 95% confidence limits and other regression analysis parameters of insecticide formulations and adjuvants against the 2^{nd} and 4^{th} instars larvae of *S. littoralis* are given in Table 1. Dursban was the most effective insecticide among the tested formulations with LC_{50} values of 0.2 and 1.11 mg L^{-1} on the 2^{nd} and 4^{th} instars larvae, respectively, followed by Lambada Mox with LC_{50} values of 0.54 and

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Table 1. Toxicity of insecticides and adjuvants against the 2nd and 4th instars larvae of *Spodoptera littoralis* using leaf dipping technique.

Insecticide/ adjuvant	LC_{50} (mg L^{-1})	95% Confidence limits (mg L^{-1})		Slope±SE
		Lower	Upper	
Second instar larvae				
Dursban	0.2	0.09	0.35	1.84 ± 0.14
Pyrifos El Nasr	1.4	1.12	1.67	4.86 ± 0.38
Halothrin Gold El Nasr	1.26	1.16	1.37	3.43 ± 0.3
Lambada Mox	0.54	0.02	1.81	1.55 ± 0.14
Top Film	1361.48	1175.76	1576.53	6.69 ± 0.46
Tritone K	5236.71	5146.05	5324.35	18.4 ± 1.39
Fourth instar larvae				
Dursban	1.11	0.79	1.44	4.01 ± 0.3
Pyrifos El Nasr	3.78	3.68	3.87	11.95 ± 0.94
Halothrin Gold El Nasr	3.18	3.04	3.31	6.77 ± 0.7
Lambada Mox	2.48	2.06	3.05	5.69 ± 0.51
Top Film	2556.84	2300.99	2843.98	8.54 ± 0.58
Tritone K	7245.46	7154.24	7333.41	25.32 ± 1.92

2.48 mg L^{-1} on the 2nd and 4th instars larvae, respectively. On the other hand, Pyrifos El Nasr was the least effective formulation with LC_{50} values of 1.4 and 3.78 mg L^{-1} on the 2nd and 4th instars larvae, respectively. In addition, the two adjuvants showed a very weak insecticidal activity. However, the Top Film was more toxic than Tritone K against the two larval stages.

The toxicity of Dursban formulation against the fourth instar larvae was higher than that reported by El- Sheikh (2012) against the same larval stage. The second instar larvae were more susceptible to the tested insecticide formulations and adjuvants than the fourth instar larvae. This finding is in agreement with reported studies on the effect of insecticides on different larval stages of *S. littoralis* (Osman and Mahmoud, 2008; Abd El-Mageed and Shalaby, 2011). The results showed that, among the formulations of chlorpyrifos 48% EC, Dursban was more potent than Pyrifos El Nasr; despite both formulations containing the same concentration of the active ingredient. Similarly, Lambada Mox was more potent than Halothrin Gold El Nasr indicating that the toxicity of insecticide formulation is highly dependent on manufacturing company. In our previous study, the fungicidal activities of mancozeb formulations were varied based on the manufacturers (El-Bakry *et al.,* 2012).

Joint Toxic Effect of Adjuvants and Insecticide Formulations

Effect of adjuvants, Top Film and Tritone K, on the toxicity of chlorpyrifos and cyhalothrin formulations against the 2nd and 4th instars larvae of *S. littoralis* are shown in Table 2. In the case of the second instar larvae, the co-toxicity factors of Dursban mixed with both adjuvants were +30, while co-toxicity factors of Pyrifos El Nasr mixed with both adjuvants were +20. In addition, co-toxicity factors of cyhalothrin formulations ranged from +26.3 to +42.1. In the case of the fourth instar larvae, the co-toxicity factors of chlorpyrifos formulations mixed with adjuvants ranged from +25 to +44.44 and the co-toxicity factors of cyhalothrin formulations ranged from +33.33 to +64.7. In general, adjuvants displayed potentiating effect on the toxicity of the four insecticide formulations as co-toxicity factor values were equal or more than +20. These results indicated that adjuvants enhanced the toxicity of chlorpyrifos and cyhalothrin commercial formulations. It has been reported that

Table 2. Effect of adjuvants on the toxicity of chlorpyrifos and cyhalothrin commercial formulations towards the 2nd and 4th instars larvae of *Spodoptera littoralis.*

Binary mixture (1)+(2)	Calculated mortality (%) at LC_{25} (mg L^{-1})		Expected mortality (%) (1) + (2)	Observed mortality (%)	Co-toxicity factor
	(1)	(2)			
Second instar larvae					
Top Film+Dursban	22.5	27.5	50	65	30
Top Film+Pyrifos El Nasr	22.5	27.5	50	60	20
Top Film+Lambada Mox	22.5	27.5	50	70	40
Top Film+Halothrin Gold El Nasr	22.5	25	47.5	67.5	42.1
Tritone K+Dursban	22.5	27.5	50	65	30
Tritone K+Pyrifos El Nasr	22.5	27.5	50	60	20
Tritone K+Lambada Mox	22.5	27.5	50	67.5	35
Tritone K+Halothrin Gold El Nasr	22.5	25	47.5	60	26.31
Fourth instar larvae					
Top Film+Dursban	20	25	45	65	44.44
Top Film+Pyrifos El Nasr	20	27.5	47.5	62.5	31.57
Top Film+Lambada Mox	20	22.5	42.5	70	64.7
Top Film+Halothrin Gold El Nasr	20	25	45	65	44.44
Tritone K+Dursban	22.5	25	47.5	60	26.31
Tritone K+Pyrifos El Nasr	22.5	27.5	50	62.5	25
Tritone K+Lambada Mox	22.5	22.5	45	60	33.33
Tritone K+Halothrin Gold El Nasr	22.5	25	47.5	65	36.842

adjuvants exhibited potentiating effect on the toxicity of insecticides pirimiphosmethyl, carbosulfan, and malathion (El-Sobki, 2010). The additive effect of some surfactants on the toxicity of organophosphorous insecticides against *Gammarus italicus* were described by Pantani *et al.* (1990).

Field Efficiency of Insecticide Formulations and Their Mixtures with Adjuvants

Mortality percentages of the 2nd and 4th instars larvae of *S. littoralis* fed on treated cotton leaves with insecticide formulations and insecticide formulations/adjuvant mixtures (in tank) at the recommended rate under field conditions in 2010 season are shown in Table 3. All insecticides and insecticides mixed with adjuvants gave over 95% mortality of the second larval stage at zero time, while, Top Film and Tritone K gave mortality of 45 and 42.5%, respectively. In addition, chlorpyrifos formulations gave mortalities ranging from 72.5 to 92.5%, 17.5 to 75%, and 12.5 to 45% after one, two, and four days of treatment, respectively. Cyhalothrin formulations mortality ranged from 42.5 to 62.5%, and 2.5 to 20% after one and two days of treatment, respectively, while their mortality percentages were zero after four days of treatment. The adjuvants mortality ranged from 30 to 32.5%, 17.5 to 22.5%, and 5 to 7.5% after one, two, and four days, respectively. On the other hand, all insecticide mixtures gave mortality ranged from 97.5 to 100%, 87.5% to 100, and 70 to 100% after one, two, and four days of treatment, respectively. The most interesting finding in these results was the great enhancement of insecticidal activity of cyhalothrin formulations after mixing with adjuvants, where, the mean of mortality was 100% through the 4 days of treatment compared with cyhalothrin formulations alone, in which the mean of mortality ranged from 35 to 45.6%. Similarly, chlorpyrifos

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Table 3. Mortality percentages of the 2^{nd} and 4^{th} instars larvae of *Spodoptera littoralis* treated with different commercial insecticides/adjuvant mixtures at the recommended rate under field conditions in 2010 season.

Insecticides/adjuvants	% Mortality of larvae 24 hours after feeding on treated leaves collected after different intervals[a]											
	Second instar larvae						Fourth instar larvae					
	0 day	1 day	2 days	4 days	Mean of 4 days	Mean of 21 days	0 day	1 day	2 days	4 days	Mean of 4 days	Mean of 21 days
Top Film	45^{b}	32.5^{e}	22.5^{d}	7.5^{ef}	26.8^{i}	10.7^{j}	30^{d}	20^{f}	10^{d}	0^{g}	15^{h}	6^{k}
Tritone K	42.5^{b}	30^{e}	17.5^{d}	5^{ef}	23.7^{i}	9.5^{j}	20^{e}	12.5^{fg}	5^{d}	0^{g}	9.3^{i}	3.7^{kl}
Dursban	100^{a}	92.5^{a}	75^{c}	45^{d}	78.1^{e}	32^{g}	100^{a}	90^{b}	60^{c}	37.5^{f}	71.8^{de}	28.7^{h}
Pyrifos El Nasr	100^{a}	72.5^{b}	17.5^{d}	12.5^{e}	50.6^{f}	20.2^{h}	82.5^{bc}	52.5^{d}	12.5^{d}	0^{g}	36.8^{f}	14.7^{i}
Lambada Mox	100^{a}	62.5^{c}	20^{d}	0^{f}	45.6^{g}	18.2^{h}	90^{b}	45^{d}	12.5^{d}	0^{g}	36.8^{f}	14.7^{i}
Halothrin Gold El Nasr	95^{a}	42.5^{d}	2.5^{e}	0^{f}	35^{h}	14^{i}	75^{c}	30^{e}	5^{d}	0^{g}	27.5^{g}	11^{j}
Top Film+Dursban	100^{a}	100^{a}	100^{a}	85^{b}	96.2^{ab}	60.5^{d}	100^{a}	92.5^{ab}	80^{b}	57.5^{d}	82.5^{c}	42.2^{d}
Top Film+Pyrifos El Nasr	100^{a}	100^{a}	87.5^{b}	77.5^{bc}	91.2^{cd}	55.5^{e}	100^{a}	80^{c}	67.5^{c}	45^{e}	73.1^{de}	35.2^{f}
Top Film+Lambada Mox	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	77^{a}	100^{a}	100^{a}	95^{a}	87.5^{a}	95.6^{a}	59.2^{a}
Top Film+Halothrin Gold El Nasr	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	73.7^{b}	100^{a}	100^{a}	90^{ab}	82.5^{ab}	93.1^{ab}	54.7^{b}
Tritone K+Dursban	100^{a}	97.5^{a}	95^{ab}	82.5^{b}	93.7^{bc}	58.7^{d}	100^{a}	77.5^{c}	67.5^{c}	52.5^{d}	74.3^{d}	37.7^{e}
Tritone K+Pyrifos El Nasr	100^{a}	97.5^{a}	87.5^{b}	70^{c}	88.7^{d}	52.7^{f}	100^{a}	72.5^{c}	62.5^{c}	40^{ef}	68.7^{e}	32.5^{g}
Tritone K+Lambada Mox	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	74.7^{ab}	100^{a}	100^{a}	87.5^{ab}	77.5^{bc}	91.2^{ab}	54.7^{b}
Tritone K+Halothrin Gold El Nasr	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	71.2^{c}	100^{a}	100^{a}	90^{ab}	72.5^{c}	90.6^{b}	51.5^{c}
Control	2.5^{c}	2.5^{f}	2.5^{e}	5^{ef}	3.1^{j}	3.2^{k}	0^{f}	5^{g}	2.5^{d}	2.5^{g}	2.5^{j}	2^{l}

[a] Means with different letter (s) in columns are significantly different at 0.01probability level.

formulations mixed with adjuvants were more toxic than chlorpyrifos formulations alone. The mean of mortality of chlorpyrifos formulations ranged from 50.6 to 78.1% through 4 days of treatment, while mean of mortality of chlorpyrifos mixed with adjuvants ranged from 88.7 to 96.2%. Moreover, cyhalothrin formulations mixed with adjuvants gave continued significant mortality through 21 days of treatment and the mortality ranged from 10 to 20% after 21 days of treatment. The chlorpyrifos formulations mixed with adjuvants caused significant mortality through 15 days of treatment and the mortality ranged from 30 to 32.5% after 15 days of treatment. Finally, Lambada Mox mixed with each of Top Film and Tritone K adjuvants were the highest efficiency as the total mean of mortality through 21 days after treatment were 77 and 74.7%, respectively. On the other hand, the total mean of mortality of chlorpyrifos formulations mixed with adjuvants through 21 days after treatment ranged from 52.7 to 60.5%.

The toxicity results of insecticide formulations and their mixtures with adjuvants against the fourth larval stage of *S. littoralis* showed that the tested formulations and mixtures were less effective compared with the second larval stage. In general, the mixing of adjuvants with cyhalothrin and chlorpyrifos formulations enhanced the insecticidal efficiency and persistence.

Mortality percentages of the 2nd and 4th larval stages of *S. littoralis* fed on cotton leaves treated with insecticide formulations and their mixtures with adjuvants at the recommended rates under field conditions in season 2011 are shown in Table 4. All insecticides and insecticides mixed with adjuvants gave over 97.5% mortality, while, Top Film and Tritone K gave mortality of 30 and 20%, respectively. In addition, cyhalothrin formulations mixed with each of Top Film and Tritone K gave complete mortality through four days of treatment, followed by Dursban mixed with each of Top Film and Tritone K, as mean of total mortality were 95.6 and 92.5%, respectively. In addition, Pyrifos El-Nasr mixed with Top Film gave a strong toxicity, as mean of total mortality through four days of treatment was 90.6%. On the other hand, the mean of total mortality through four days of treatment of Dursban, Pyrifos El Nasr, Lambada Mox, and Halothrin Gold El Nasr were 80.6, 59.3%, 52.5, and 46.2%, respectively. Moreover, cyhalothrin formulations mixed with adjuvants gave continued significant mortality through 21 days of treatment, while, chlorpyrifos formulations mixed with adjuvants caused significant mortality through 15 days of treatment. Finally, Lambda Mox mixed with Top Film had the highest efficiency as its general mean of mortality through 21 days was 76.2%, followed by Halothrin Gold El Nasr mixed with Top Film and Lambada Mox mixed with Tritone K that gave mortalities of 72.2 and 72.7%, respectively. All of the tested insecticide formulations and mixtures showed lower toxicity against the fourth larval stage than the second larval stage. In general, the mixing of adjuvants with cyhalothrin and chlorpyrifos commercial formulations increased insecticidal efficiency and lengthened the residual toxic effect against both larval stages.

These results are in good agreement with several investigators. Klein (1984) mentioned that chlorpyrifos showed high activity to control young larvae of *S. littoralis* after one day of treatment, but its efficiency was decreased with time. Moreover, Ahmed *et al*. (2004) stated that chlorpyriphos registered about 87% reduction in number of *S. littoralis* on the basis of pre-spray data. Also, Shivankar *et al*. (2008) indicated that chlorpyrifos 20 EC recorded high reduction (94.1%) of *S. litura* in sugar beet. Mourad *et al*. (1988) mentioned that the 2nd instar larvae of the noctuid were more affected than the 4th instar larvae. Brady *et al.* (1980) mentioned that Nu-film and Triton X-100 increased the persistence of chlorpyrifos. In addition, Wills and McWhorter (1982) stated that adjuvants can be used to increase the bioactivity of pesticides. Osipow (1964)

Table 4. Mortality percentages of the 2nd and 4th instars larvae of *Spodoptera littoralis* treated with different commercial insecticides/adjuvant mixtures at the recommended rate under field conditions in 2011 season.

Insecticides/adjuvants	% Mortality of larvae 24 hours after feeding on treated leaves collected after different intervals [a]											
	Second instar larvae						Fourth instar larvae					
	0 day	1 day	2 days	4 days	Mean of 4 days	Mean of 21 days	0 day	1 day	2 days	4 days	Mean of 4 days	Mean of 21 days
Top Film	30^{b}	17.5^{e}	7.5^{g}	0^{f}	13.7^{h}	5.5^{k}	20^{d}	10^{f}	5^{g}	0^{f}	8.7^{i}	3.5^{k}
Tritone K	20^{c}	10^{f}	2.5^{g}	0^{f}	8.1^{i}	3.2^{kl}	12.5^{e}	5^{g}	0^{g}	0^{f}	4.3^{j}	1.7^{kl}
Dursban	100^{a}	97.5^{a}	77.5^{d}	47.5^{d}	80.6^{d}	34.2^{g}	100^{a}	90^{b}	62.5^{e}	40^{e}	73.1^{f}	29.7^{h}
Pyrifos El Nasr	100^{a}	80^{b}	40^{e}	17.5^{e}	59.3^{e}	23.7^{h}	90^{b}	60^{d}	20^{f}	5^{f}	43.7^{g}	17.5^{i}
Lambada Mox	100^{a}	72.5^{c}	32.5^{ef}	5^{f}	52.5^{f}	21^{i}	90^{b}	60^{d}	17.5^{f}	5^{f}	43.1^{g}	17.2^{i}
Halothrin Gold El Nasr	97.5^{a}	62.5^{d}	25^{f}	0^{f}	46.2^{g}	18.5^{j}	80^{c}	50^{e}	7.5^{g}	0^{f}	34.3^{h}	13.7^{j}
Top Film+Dursban	100^{a}	100^{a}	97.5^{ab}	85^{b}	95.6^{b}	62^{d}	100^{a}	100^{a}	85^{bc}	70^{c}	88.7^{d}	46.5^{d}
Top Film+Pyrifos El Nasr	100^{a}	100^{a}	85^{cd}	77.5^{c}	90.6^{c}	56.2^{ef}	100^{a}	90^{b}	75^{d}	55^{d}	80^{e}	39.2^{f}
Top Film+Lambada Mox	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	76.2^{a}	100^{a}	100^{a}	95^{a}	87.5^{a}	95.6^{a}	59.5^{a}
Top Film+Halothrin Gold El Nasr	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	72.2^{b}	100^{a}	100^{a}	90^{ab}	85^{a}	93.7^{ab}	55.2^{b}
Tritone K+Dursban	100^{a}	100^{a}	90^{bc}	80^{bc}	92.5^{bc}	57.5^{e}	100^{a}	90^{b}	77.5^{cd}	55^{d}	80.6^{e}	41.5^{e}
Tritone K+Pyrifos El Nasr	100^{a}	100^{a}	85^{cd}	75^{c}	90^{c}	54^{f}	100^{a}	77.5^{c}	70^{de}	42.5^{e}	72.5^{f}	35.7^{g}
Tritone K+Lambada Mox	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	72.7^{b}	100^{a}	100^{a}	90^{ab}	80^{ab}	92.5^{bc}	55.7^{b}
Tritone K+Halothrin Gold El Nasr	100^{a}	100^{a}	100^{a}	100^{a}	100^{a}	68.7^{c}	100^{a}	100^{a}	87.5^{ab}	75^{bc}	90.6^{cd}	52.2^{c}
Control	2.5^{d}	2.5^{g}	0^{g}	5^{f}	2.5^{j}		0^{f}	2.5^{g}	0^{g}	2.5^{f}	1.2^{k}	1.2^{l}

[a] Means with different letter (s) in columns are significantly different at 0.01 probability level.

indicated that the decrease in surface tension caused an increase in wetting and spreading characteristics. The enhancement of insecticides efficiency caused by adding adjuvants may be attributed to their effects of increasing atomization and droplet sizes of insecticide, retention of insecticides on the treated surfaces, spreading and coverage of insecticide solutions, uptake and translocation of insecticides, and the effect of decreasing the surface tension between insecticide and treated surface (Chow *et al*., 1989).

In summary, the results of this study indicated that the use of adjuvants, Top Film and Tritone K, strongly enhanced the efficiency and persistence of cyhalothrin and chlorpyrifos commercial formulations and, consequently, the number of insecticide application in the season and the rate of application of insecticides can be decreased. This will reduce the environmental pollution and overcome the pests' resistance problem.

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کاربرد آمیخت-مخزنی ماده ی کمکی برای بهبود کارآیی و تداوم اثر فرمولاسیون های Chlorpyrifos و Cyhalothrin

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چکیده

کاربرد ماده ی کمکی منجر به افزایش کارآیی و تداوم اثر حشره کش ها می شود. در این پژوهش، اثر ماده ی کمکی روی سمیت فرمولاسیون های Chlorpyrifos و Cyhalothrin در شرایط آزمایشگاهی و مزرعه ای بررسی شد. سمیت نسبی وتطبیقی دو فرمولاسیون Chlorpyrifos (۴۸EC٪) به نام Dursban و Pyrifos El Nasrو ودو فرمولاسیون Cyhalothrin (EC ۵ ٪) به نام های Halothrin Gold El Nasr و Lambada Mox و دو ماده کمکی (Top Film و Tritone K) بر علیه مرحله لاروی دوم و چهارم حشره *Spodoptera littoralis* (برگخوار پنبه) مطالعه شد. اثر ماده های کمکی روی سمیت Chlorpyrifos و Cyhalothrin در شرایط آزمایشگاهی و مزرعه ای بررسی شد. نتایج نشان دادکه Dursban بیشترین سمیت را بر علیه مرحله دوم و چهارم لاروی *S. littoralis* داشت و LC_{50} آن به ترتیب برابر ۰/۲ و ۱.۱۱ میلی گرم بر لیتر بود. در

مقایسه با این ماده، فرمولاسیون Pyrifos El Nasr کمترین سمیت را بر علیه هر دو حالت لاروی نشان داد. نتایج اثرات مسموم کنندگی مخلوط ماده کمکی و حشره کش ها چنین گواهی میداد که ماده های کمکی سمیت هر چهار فرمولاسیون حشره کش را افزایش داد و ارقام عامل سمی-کمکی بیشتر از ۲۰+ بودند. مخلوط کردن ماده های کمکی با فرمولاسیون های Chlorpyrifos و Cyhalothrin در داخل تانکر سمپاش قبل از سمپاشی در مزرعه منجر به افزایش شدید سمیت و تداوم اثر حشره کش ها شد. مخلوط فرمولاسیونCyhalothrin با ماده کمکی، به طور معنی داری باعث مرگ ومیر پیوسته در طی ۲۱ روز بعد از مصرف شد در حالی که در مورد chlorpyrifos این مدت ۱۵ روز بود. اما، فرمولاسیون های Chlorpyrifos و Cyhalothrin بدون مخلوط کردن با ماده های کمکی فقط تا ۳ الی ۴ روز بعد از مصرف منجر به مرگ و میر معنی دار شدند. بر پایه این نتایج می توان گفت که کاربرد ماده های کمکی باعث افزایش کارآیی و اثرات باقیمانده فرمولاسیون های تجاری Chlorpyrifos و Cyhalothrin شد. بنا براین، برای کاهش تعداد سمپاشی ها در طی فصل و کم کردن مقدار مصرف حشره کش ها می توان از ماده های کمکی استفاده کرد.

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