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IMPROVEMENT OF INSECTICIDAL PERFORMANCE USING CERTAIN ADDITIVES AGAINST COTTON LEAFWORM, *Spodoptera littoralis*

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ABSTRACT

The effects of additives of different groups : acetic acid, phosphoric acid (acidity modifier agent), glue and Arabic gum (thickening and sticking agent), castor oil, CAPL-2 (lipophilic agent), DL600 (polyethylene Glycol 600 Dilaurate) and sodium lignosulfonate (spreading agents) on physico-chemical properties and insecticidal efficiency of esfenvalerate, chlorpyrifos and thiodicarb against *Spodoptera littoralis* were studied.

Results obtained indicated that all tested adjuvants were physically compatible with tested insecticides and showad improvement in their properties when they added at 0.3 %.

Toxicological studies indicated that there were enhanced insecticidal efficiency of esfenvalerate when mixed with glue, gum, phosphoric acid and castor oil, thiodicarb when mixed with castor oil, phosphoric acid and acetic acid for chlorpyrifos when mixed with glue, gum, phosphoric acid acetic acid and sodium- lignosulfonate since they showed high synergistic effect values when they mixed with the previous additives.

Latent effect studies recorded reduction in mean weight of larvae in a mixture of esfenvalerate with glue and castor oil, thiodicarb with glue and CAPL-2 and chlorpyrifos with glue, phosphoric acid and acetic acid, also all tested adjuvants increased the effectiveness of esfenvalerate in decreasing of average weight of pupa, as well as the same indication was recorded in case of addition castor oil and acetic acid to thiodicarb and when gum, sodium lignosulfonate and castor oil were added to chlorpyrifos especially in females.

INTRODUCTION

Synthetic organic insecticides are important component of modern agriculture (Croft, 1990). However, their use is increasingly criticized because of problems associated with low performance and efficacy properties, besides increasing rates of application. These problems are compounded by the increasing cost of insects control.

Consequently, use of adjuvant agents with chemical insecticides may provide a tool to achieve high efficacy insecticidal properties and decreasing their application rates, pollution and costs.

Adjuvants are defined as ingredient that improve the properties of pesticide formulation. This includes wetting agents, spreaders, emulsifiers, dispersing agents, foam suppressants, penetrants, and correctives (Ware, 1978). Some additives to insecticides for insect control includes attractants, feeding stimulants, the toxin, and a number of conditioners and enhancements for optimal formulate mixture, viscosity, pH, and other

characteristics desirable for application and function under field conditions (Mangan and Moreno, 2001).

In the study reported here, laboratory bioassay of some chemical insecticides in combination with certain adjuvant compounds were done to determine their physical and biological compatibility also to indicate which of these additives were effective in enhancing the toxicity of the used chemical insecticides against the cotton leafworm, *Spodoptera littoralis* larvae, as well as, determination the physico-chemical properties.

MATERIALS AND METHODS

1- Pesticides used :

a- Chlorpyrifos (Dursban 48 % EC) : O, O-diethyl O-3, 5, 6-trichloro-2-pyridyl phosphorothioate.

b- Thiodicarb (Larvin 80 % WP) : 3, 7, 9, 13- tetramethyl-5, 11-dioxa-2, 8, 14-trithia-4, 7, 9, 12- tetra-=azapentadeca-3, 12-diene-6, 10-dione.

c- Es-fenvalerate (Sumi-gold 20 % EC) : α-cyano-3-phenoxybenzyl (S)-2- (4-chlorophenyl)-3-methyl-butyrate

2- Local additive used :

* Lipophilic agents :

a- Castor bean oil : crude castor bean oil (plant oil) supplied by El-Salam Co. for Oil, Cairo.

b- CAPL-2 : local mineral oil prepared as emulsifiable concentrate contained 96.62 % (v/v), produced by Central Agricultural Pesticides Lab.

* Surface active agent :

c- Polyethylene Glycol 600 Dilaurate (PEG 600 DL) produced by the National Co. for Starch, Yeast and Detergents, Alexandria.

Acidifying agents :

a- Phosphoric acid (6.6 N) mineral acid, supplied by El-Gomhoriya Co., Cairo, Egypt.

b- Acetic acid 6 % organic acid supplied by Egyptian Co. for Sugar and Refining.

Thickening agents :

a- Glue (granules) supplied by El-Sabaa Co., Cairo.

b- Arabic gum; plant gum supplied by El-Gomhoriya Co., Cairo.

c- Lignosulfonate : The basic functional constituent of the products is lignosulfonate which is an anionic polyelectrolyte whose molecular weight varies between 5000 to 100000, supplied by BASF Co., Germany.

Physical properties determination :

Physical compatibility between the used pesticides and additives was studied by the determination of their emulsion stability for esfenvalerate and chlorpyrifos and suspension stability for thiodicarb according to WHO (1979) specification (visually method).

The physico-chemical properties of pesticide solution alone or mixed with additive were determined according to CIPAC Hand Book as the following :
pH value using Schott Gerate pH-meter CG818. Viscosity using Ostwald viscometer where m poise is the unit of viscosity measurement and surface tension using Du Nouy tensiometer where dyne/cm is the unit of surface tension measurement. Conductivity and salinity was measured using the conduct meter YSI model 33S-C-T meter (m MHOS is the unit of electrical conductivity measurement).

Insects used :

The laboratory colony of the Egyptian cotton leafworm, *Spodoptera littoralis* (Boisd.) larvae were reared on castor bean leaves as described by El-Defrawi *et al.* (1964). All stages were maintained under standard environmental conditions with a temperature of 25±2°C, a photoperiod of 12 : 12 (L : D) h, and 70±5 % R.H. Egg-masses were collected daily and kept in Petri- dishes and provided with castor bean leaves for larvae feeding. After hatching, the larval were transferred to 1-liter capacity glass jars, covered with muslin. Larvae were provided daily with fresh food. The number of larvae in each jar was adjusted according to the larval development. Larvae were allowed to pupate. The pupae were kept in cage (40 x 40 x 40 cm), where the emerged moths were allowed to mate. The adults were fed on 10 % sugar solution. The cages were supplied with leaf of *Nerium oleander* that served as oviposition site.

Determination of LC_{50} values :

Castor bean leaves were dipped in a series of solutions with varying concentrations. The leaves were then air dried for 1 h. Fourth instar *S. littoralis* were allowed to feed on treated leaves. The range- finding trials for determining the mortality curve of larvae employed 5-8 different concentrations. Each concentration was done with five replicates of 10 larvae. After a feeding period of 24 h on treated leaves, the mortality larvae was recorded. Mortality percentages were corrected using Abbott's formula (1925). The LC's value of the various insecticides found in these assays were estimated by probit analysis (Finney, 1952).

Design for formulation testing :

Each test consists of a series of insecticide treatments plus adjuvants as mention before and control (insecticide alone) or check (water only without adjuvants).

Non of the adjuvants tested were known to have measurable toxicity to insects in the absence of insecticides. The calculated LC_{50} of insecticides (Table 1) was used with 0.3 % of the adjuvants. The survivors larvae were transferred into clean jars and provided daily with fresh untreated leaves until larvae either dead or successfully pupated, mean of pupation, pupal weight, and adult emergence were recorded for each treatment. Emerged moths were sexed in pair (1 : 1). Egg-masses deposited on *N. oleander* leaves were collected daily. Fecundity was subsequently estimated by counting total eggs

within egg-masses deposited in each treatment. Percent fertility was then used as indicator of the insecticides used and adjuvants on resulting egg-masses of *S. littoralis*.

Table (1). Toxicity data for the tested insecticides against 4*th* instar larvae of cotton leafworm.

Insecticides	LC_{50} (% 95 FL) (ppm)	LC_{90} (% 95 FL) (ppm)	Slope ±SE
Chlorpyrifos	11.10 (7.15-16.09)	52.06 (28.39-450.70)	1.91±0.57
Es-fenvalerate	2.69 (2.19-3.35)	6.32 (4.70-11.36)	3.46±0.66
Thiodicarb	69.68 (57.29-83.48)	144.6 (114.47-220.42)	4.04±0.72

RESULTS

Result in Table (2) show clearly that all tested adjuvants affected the physico-chemical properties of the water that will be used for dilution of pesticides when they added at 0.3 %. They caused decreasing its pH value and surface tension, whereas some of them caused increasing of conductivity such as in case of phosphoric acid, acetic acid and sodium lignosulfonate. Also, some of them increased viscosity such as sodium lignosulfonate, phosphoric acid and castor oil.

Table (2) : Physico-chemical properties of some certain additives at concentration 0.3 %.

Additives	pH	Viscosity mps	Surface tension dyne/cm	Conduc-tivity	% Salinity	Foam
Glue	7.68	10.6	63.0	350	0.2	-
Gum	7.69	9.7	72.0	370	0.2	-
Phosphoric acid	1.64	11.2	84.0	6000	4.0	-
Acetic acid	4.86	11.0	84.0	320	0.2	-
Sodium ligno-sulfonate	7.74	10.1	84.0	800	0.4	-
DL-600	5.75	9.7	36.9	300	0.2	-
CAPL-2	7.73	10.2	54.0	330	0.2	-
Castor oil	7.35	10.7	36.9	340	0.2	-
Water	7.24	10.0	72.0	320	0.1	-

mps : millpoise

Results in Tables (3, 4 & 5) indicated that each of the insecticides, adjuvants and their combination showed no appreciable foaming, also there are a physical compatibility between all additives and insecticides since they gave good emulsion for esfenvalerate and chlorpyrifos mixtures and good suspension stability for thiodicarb mixtures. All additives used decreased pH value of spray solution of all tested pesticides. Phosphoric acid showed the highest decreasing followed by acetic acid and DL600. On the other hand, DL600, CAPL-2 and castor oil decreased the surface tension of the spray solution of all pesticides, whereas most additives showed low increase in viscosity of chlorpyrifos and esfenvalerate.

Table (3) : Efect of certain additives on physico-chemical properties of esfenvalerate spray solution.

Additive	Emulsion stabillty test	pH	Viscosity mps	Surface tension dyne/cm	Conduc-tivity	% Salinity	Foam
Es-fenvalerate alone	*P	7.62	10.4	75.6	330	0.2	-
Es-fenvalerate + Glue	P	7.44	10.0	68.7	360	0 2	-
Gum	P	7.60	11.2	79.6	370	0.2	-
Phosphoric acid	P	1.64	11 3	84.0	6000	4 0	-
Acetic acid	P	4.92	9.9	68.7	350	0 2	-
Sodium lignosulfonate	P	7.63	10.3	65.7	700	0.4	-
DL600	P	5.75	10.3	30.2	310	0.2	-
CAPL-2	P	7.66	9.4	33.6	350	0.2	-
Castor oil	P	7.46	11.0	48.8	330	0.2	-
Water		7.24	10.0	72.0	320	0.1	

* P : Passed emulsion stability test mps : milipoise.

Table (4) : Efect of certain additives on physico-chemical properties of chlorpyrifos spray solution.

Additive	Emulsion stability test	pH	Viscosity mps	Surface tension dyne/cm	Conduc-tivity	% Salinity	Foam
Chlorpyrifos alone	*P	7 24	10.7	72.0	430	0.3	-
Chlorpyrifos + Glue	P	7.50	10.0	63.0	440	0.4	-
Gum	P	7.42	10.2	79.6	420	0.3	-
Phosphoric acid	P	1.09	8 5	84.0	6000	4.0	-
Acetic acid	P	4.30	10.1	84.0	420	0.3	-
Sodium lignosulfonate	P	7.57	10.8	68.7	1000	1.0	-
DL600	P	5.44	11.0	32.9	340	0 2	-
CAPL-2	P	7.26	8.9	42.0	350	0.2	-
Castor oil	P	7.33	9.9	52.1	430	0.3	-
Water		7.24	10.0	72 0	320	0 1	

* P : Passed emulsion stability test mps : milipoise.

Table (5) : Efect of certain additives on physico-chemical properties of thiodicarb spray solution.

Additive	Suspensi-bility test	pH	Viscosity mps	Surface tension dyne/cm	Conduc-tivity	% Salinity	Foam
Thiodicarb alone	*P	7.72	9.8	79.6	360	0.2	-
Thiodicarb + Glue	P	7.64	9.1	75.6	360	0.2	-
Gum	P	7.66	10.5	84.0	350	0.2	-
Phosphoric acid	P	1.62	10.2	84.0	6000	4.0	-
Acetic acid	P	4.78	9.5	84.0	340	0 2	-
Sodium lignosulfonate	P	7.78	9 9	79.6	800	0.4	-
DL600	P	5.79	10.6	34 4	310	0.2	-
CAPL-2	P	7.61	9.6	65.7	340	0.2	-
Castor oil	P	7.62	10.1	52.1	340	0.2	-
Water		7.24	10.0	72.0	320	0.1	

* P : Passed emulsion stability test mps : milipoise.

Data in Table (6) indicated that at LC_{50} level toxicity of esfenvalerate was highly enhanced after their application in admixture with glue, gum, phosphoric acid and castor oil at level 0.3 %, all showed synergistic effect

Table (6) : Effect of some certain additives on the toxicity of the tested insecticides against 4*th* instar larvae of cotton leafworm.

Pesticides	Chlorpyrifos			Thiodicarb			Es-fenvalerate		
Additives	% Mortality	Co-toxicity factor	Final effect	% Mortality	Co-toxicity factor	Final effect	% Mortality	Co-toxicity factor	Final effect
Glue	93.3	21.64	Synergism	46.7	0.00	Additive	86.7	85.65	Synergism
Gum	90.0	17.34	Additive	26.7	-42.83	Antagonism	76.7	64.24	Synergism
Phosphoric acid	76.7	0.00	Additive	63.3	35.55	Synergism	90.0	92.72	Synergism
Acetic acid	76.7	0.00	Additive	66.7	42.83	Synergism	76.7	64.24	Synergism
Sod. lignosulfonate	60.0	-21.77	Antagonism	40.0	-14.35	Antagonism	50.0	7.07	Additive
DL600	0.00	0.00	--	36.7	-21.41	Antagonism	6.7	-85.65	Antagonism
CAPL-2	33.3	-56.58	Antagonism	40.0	-14.35	Antagonism	50.0	7.07	Additive
Castor oil	26.7	-65.19	Antagonism	76.7	64.24	Synergism	66.7	42.83	Synergism
Insecticide alone	76.7			46.7			46.7		

whereas the combination of CAPL-2 and sodium lignosulfonate with the same pesticide exhibited additive effect. The co-toxicity factor was ranged from 42.83 to 92.72. Also, castor oil, phosphoric acid and acetic acid exhibited fairly high synergism when mixed with thiodicarb. On contrary the rest adjuvants apparent antagonistic effect.

CAPL-2, DL600 and castor oil antagonized the pesticidal action of chlorpyrifos. On the other hand, the synergistic effect was recorded when chlorpyrifos mixed with glue, gum, phosphoric acid, acetic acid and sodium lignosulfonate.

Generally, DL600 recorded antagonistic effect with all tested pesticides.

The efficacy of the tested adjuvants and insecticides on the latent effect are shown in Table (7). The results proved that all treatments induced increasing in the mean weight of larval stage except for glue and castor oil with esfenvalerate. On contrary, all adjuvants except glue and CAPL-2 induced reduction in the mean weight of larvae when mixed with thiodicarb.

Table (7) : Latent effect for insecticides alone and mixed with additives against cotton leafworm.

Additive	A.W.L.	A.W.P.	A.W.P.		A.E.	% S.R.	
			Female	Male		Female	Male
Chlorpyrifos							
Glue	9.8	322.3	322.3	-	406	100	0
Gum	46.6	268.7	-	268.7	-	0	100
Phosphoric acid	28.7	337.5	319.4	344.5	630.3	50	50
Acetic acid	18.3	435.4	435.4	-	387.0	100	0
Sodium lignosulfonate	35.5	264.8	-	264.8	-	0	100
DL-600	61.6	328.5	352.0	320.2	423.3	26	74
CAPL-2	43.0	336.3	370.9	322.5	223.0	29	71
Castor oil	31.3	312.3	326.1	304.0	968.0	38	62
Insecticide alone	30.9	322.6	-	322.6	-	0	100
Thiodicarb							
Glue	42.2	370.5	387.8	353.3	947.3	50	50
Gum	37.0	353.4	347.9	361.3	1199.5	59	41
Phosphoric acid	35.1	371.4	381.4	364.8	1714.0	40	60
Acetic acid	28.6	304.4	321.4	2874.0	-	50	50
Sodium lignosulfonate	33.5	343.6	323.2	367.0	125.0	53	47
DL-600	40.0	331.0	375.0	321.2	559.0	18	82
CAPL-2	43.0	388.6	377.8	359.4	580.7	50	50
Castor oil	31.9	286.6	285.7	287.0	-	33	67
Insecticide alone	41.3	321.7	328.7	312.1	492.4	58	42
Es-fenvalerate							
Glue	29.2	354.4	347.0	358.1	97	33	67
Gum	43.0	350.0	-	350.0	-	0	100
Phosphoric acid	45.6	289.6	256.2	323.0	-	50	50
Acetic acid	35.5	357.7	359.7	353.6	526.0	67	33
Sodium lignosulfonate	47.9	339.9	346.6	306.4	1014.0	83	17
DL-600	46.0	352.5	354.3	350.7	347.8	50	50
CAPL-2	50.4	366.4	351.2	388.7	872.3	57	43
Castor oil	24.6	333.4	343.5	318.4	395.3	60	40
Insecticide alone	31.1	369.4	391.5	350.9	638.4	45	55

A.W.L. : Average weight of larva/mg **A.W.P. : Average weight of pupa/mg**
A.E. : Average weight of eggs/mg **S.R. : Sex ratio**

Mean weight of larvae increased at result to treated with mixture of chlorpyrifos with gum, sodium lignosulfonate, DL600 and castor oil and decreased when chlorpyrifos mixed with glue, phosphoric acid and acetic acid. Table (7) shows also the delayed effect in average weight of pupae. The results indicated that all adjuvants increased the effectiveness of esfenvalerate in decreasing of average weight of pupa, the same indication was recorded when acetic acid and castor oil were added to thiodicarb and when gum, sodium lignosulfonate and castor oil were added to chlorpyrifos, especially in females case.

Generally, the female were more affected than males in most treatment. Moreover, an effect on fecundity in survivors was noted for all treatment. The number of eggs deposited per female were highly reduced, compared to that of untreated control. As shown in Table (7), treatment affected on sex ratio of the survival. However, the females are more affective than males, following decline was apparently induced by more effective adjuvants on sex ratio of all treatment.

DISCUSSION

The role of adjuvants in increasing the effectiveness of candidate insecticides could be explained by their ability to change the physico-chemical properties of the water that will be used for dilution pesticide. Such as decreasing pH value with increasing its conductivity, decreasing surface tension and increasing viscosity.

In the present investigation, the synergistic effect which exhibited by addition the phosphoric acid and acetic acid to tested pesticide was connecting with decreasing in pH values and increasing in conductivity. El-Attal *et al.* (1984) indicated that the increase of electric conductivity of insecticidal spray solution would lead to deionization of insecticide and increase its deposit and penetrate in the treated plant surfaces, then increase with the insecticidal efficiency.

Also, the increasing in effectiveness of esfenvalerate and thiodicarb as result to addition of castor oil was compatible with decrease in surface tension of the spray solution, this indicate improving wettability and spreading on the treated surface then increasing deposit and activity of pesticides (Furmidge, 1962).

On the other hand, addition of tested thickening and sticking agents (glue and Arabic gum) to chlorpyrifos and esfenvalerate increased their pesticidal activity against *S. littoralis*. The same indication was recorded by several investigator, *i.e.* Mostafa and El-Sisi (1988), El-Sisi *et al.* (1989) and El-Fateh Radwan *et al.* (1994).

The previous results are in complete agreement with those obtained by Wills and McWhorter (1983), Abdallah *et al.* (1989) and El-Metwally *et al.* (1989), they concluded that the proper adjuvants greatly affected the biological activity of pesticides, also these adjuvants may be contribute in decreasing the application rate of insecticides.

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تحسين فاعلية بعض المبيدات الحشرية باستخدام بعض الاضافات لمكافحة دودة ورق القطن

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تم دراسة تأثير عدد من الإضافات التابعة لمجاميع مختلفة : حمض الخليك وحمض الفوسفوريك (مواد حامضية)، الغراء والصمغ العربى (مواد لاصقة ومغلظة)، زيت الخروع، كابل-٢ (مواد ليبوفيليك)، DL600 (بولى إيثيلين جليكول داى ليورات)، وكذلك الصوديوم ليجنوسلفونات (مادة ناشرة) على الفاعلية الإبادية لكل من مبيدات إسفينفاليرات، كلوربيريفوس، ثيوديكارب ضد دودة ورق القطن.

أوضحت النتائج أن كل الإضافات المختبرة أظهرت توافق طبيعى عند خلطها بتركيز ٠,٣ % مع المبيدات المختبرة، كما أنها أدت إلى تحسين صفات هذه المبيدات.

أدى إضافة كل من الغراء والصمغ وحمض الفوسفوريك وزيت الخروع بتركيز ٠,٣ % إلى مبيد إسفينفاليرات بتركيز الجرعة النصف مميته إلى تحسين التأثير السام لهذا المبيد بينما كان هناك تأثير تنشيطى لسمية الثيوديكارب عندما أضيف إليه كل من زيت الخروع وحمض الفوسفوريك وحمض الخليك أيضا لمبيد الكلوربيريفوس عندما أضيف إليه كل من الغراء والصمغ وحمض الفوسفوريك وحمض الخليك والصوديوم لجنوسلفونات. ولقد وجد أن إضافة كل من الغراء وزيت الخروع إلى مبيد إسفينفاليرات وإضافة الغراء و كابل-٢ إلى الثيوديكارب وإضافة الغراء وحمض الفوسفوريك وحمض الخليك إلى مبيد الكلوربيريفوس أدى إلى نقص متوسط وزن اليرقات المعاملة مقارنة بالكنترول.

من ناحية أخرى فقد زادت فاعلية مبيد إسفينفاليرات عند خلطه بجميع الإضافات المختبرة من حيث قدرته على إنقاص متوسط وزن العذراء. نفس التأثير لوحظ فى حالة إضافة زيت الخروع وحمض الخليك إلى مبيد الثيوديكارب، وكذلك عند إضافة كل من الصمغ العربى والصوديوم لجنوسلفونات وزيت الخروع إلى مبيد الكلوربيريفوس. كما لوحظ أن الإناث كانت أكثر تأثرا منها فى حالة الذكور.