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Effectiveness of some New Water Based Insecticides Against Locust and Grasshoppers Applied As LV and ULV Spray Techniques in Egypt

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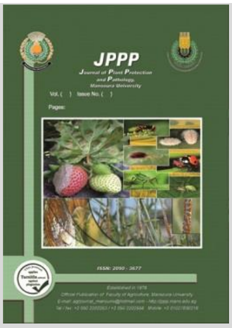

ABSTRACT

Efficacy of five water based insecticides on *Schistocerca gregaria* (Forskal), *Locusta migratoria* (Linnaeus), and multiple grasshoppers species applied as low volume (LV) and Ultralow volume (ULV) were tested. Obtained data indicated that descending order of insecticides efficacy were as follow: chlorpyrifos, thiamethoxam + chlorantraniliprole, spinetoram + methoxyfenozide, chlorantraniliprole then pyridalyl, in case of *S. gregaria* both spinetoram + methoxyfenozide and chlorantraniliprole were quite similar. Concerning spray characteristics, the effectiveness of spraying tested water based pesticides diluted with 30% Propylene glycol water mixture as ULV spray technique was obvious, where the droplets size, relative span, and number of droplets per cm^2 were suitable for locust control.

Keywords: *Schistocerca gregaria*, *Locusta migratoria*, novel insecticides, ULV, LV, Grasshoppers.

INTRODUCTION

Egypt recently began an ambitious plan to reclaimed one and have million fadan, throughout the Sustainable Development Strategy SDS (Egypt Vision 2030). It is expected that such newly reclaimed lands may be infested with many insect species e.g. locust and grasshoppers. Locust and grasshoppers females usually prefer sandy soil to lay there egg pods (Popove 1958) along with availability of vegetation that could create favorable habitat for locust and grasshoppers in the newly reclaimed lands (Uvarov1962). Locusts and grasshoppers have been one of the most destructive insects to agriculture, it could consume large amount of vegetation which resulted in great loose of cultivated crops (Inglis, *et, al.,* 2000). Chemical control has been the main control method in the preventive control strategy of locust and out breaks of grasshoppers (Rachadi, 2010). Chemical pesticides and it is application techniques used for locust and grasshoppers control have been changed since 1940s tell now several times, sodium arsenite baits was used in the early stages, then replaced by the newly discovered at that time organochlorine compounds as baits or dusting, but due to labor difficulties and slow application rate, the spray of liquid pesticides aroused as perfect solution to treat wide are quickly (Duranton *et, al.,* 1987). Dieldrin proved to be the perfect pesticide for the control operations when applied as barriers spray, however it was prohibited as a result of it is high mammalian toxicity and bio-accumulation and replaced with other lower risk synthetic organic compounds such as organophsphrus, pyrhroids, carbamets and IGRs, in spite of their low risk environmental hazards keep showing in sensitive and protected zones (Meinzingen 1997). During their last meeting in 2014 Pesticide Referee Group (independent group of experts that advises FAO on the efficacy and the health and environmental risks of insecticides used in locust control), strongly recommended conducting trials for testing new low risk insecticides against locust and grasshoppers, PRG (2014). ULV spray technique is the most widely used in locust and grasshoppers management, while all new pesticides compound now day formulated as water soluble base, which are not suitable for ULV spray techniques because of the highly evaporation rate of the ultra-low volume droplets of the spray solution, (Rachadi, 2010 and Matthews *et, al.*, 2014), therefore it's strongly recommended to investigate for new compounds to be used as anti-evaporation additive. Propylene glycol may be good solution as anti-evaporation additive; it is used as mixture with water to elevate the boiling point of the coolant fluids of the cars engines, also conceder as nontoxic martial, Yadav and Singh (2011). Therefore the aims of the present work to evaluate some registered insecticides in Egypt for their effect on locust and grasshoppers under field condition, an attempt to use propylene glycol- water mixture as spray solution for ULV spray technique of water based pesticides.

MATERIALS AND METHODS

The present study were conducted at Abu Minqar oasis south west of Egypt (26 32 18 N, 27 39 20 E). The experimental area were cultivated with Alfalfa *Medicago sativa*, heavily infested with locust and grasshoppers, population were mixed of adult and nymphs of *S. gregaria* (17.4%), *L. migratoria* (35.8%) and multiple grasshoppers species (46.8%), the average number of insects/m^2 were 16.53 (ranged between 11 -23 insects/m^2).

Tested insecticides

Five waters based insecticides registered in Egypt according to the Agricultural Pesticides Committee (APC,

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2020), were used in the present investigation, as following active ingredients, trade names and rates of application.

1- Chlorantraniliprole (Coragen) 20% SC, at rate 12 g a.i./feddan (28.5 g a.i./ha).
2- Pyridalyl (Pleo 50) 50 % EC, at rate 50 g a.i./feddan (119 g a.i./ha).
3- Thiamethoxam + Chlorantraniliprole (Voliam Flexi) 40 % (20+20) WG, at rate 32 g a.i./ feddan (76.16 g a.i./ha)
4- Spinetoram + Methoxyfenozide (Uphold) 36 % (6+30) SC, at rate 45 g a.i./feddan (107 g a.i./ha).
5- Chlorpyrifos (Dursban H) 48% EC, at rate 100 g a.i./feddan (240 g a.i./ha).

Also Chlorpyrifos (Locban) 45% ULV, at rate 100 g a.i./feddan (240 g a.i./ha) were applied as standard recommended pesticides against locust and grasshoppers.

Spray equipment and calibration

Motorized knapsack mist blower was used in the present investigation. Normal spray nozzle was used for LV application and Micronair AU8000 head was attached to the air hoes for ULV application. Spray solution flow rates and swath width, were measured according to (Dobson, 2001 and Cressman and Dobson 2001), using water and oil sensitive papers manufactured by Syngenta at the same spray condition as possible.

Field trials

Each water based insecticides were applied twice as low and ultralow volume (LV and ULV) spray technique - except in case of chlorpyrifos 45% ULV formulation applied only as ultralow volume- into 3 replicates, in case of LV technique tested insecticides were diluted in water while in ULV technique insecticides were diluted in 30% Propylene glycol (Pg) water mixture, each replicate was 1600 M^2 (40X40M). Three plots placed upwind used as control treatment, while other treatment was distributed in completely randomized pattern with 50 m separation distance between each plot. Application criteria are shown in Table (1).

Spray quality measurements

Water and oil sensitive papers were used to collect droplets in each plot. The sensitive papers were fixed on top of metal holders and lined facing wind with 5 meter spacing. Then the sensitive papers were collected carefully after allowing 1 hr. for spray to dry, and scanned using Canon LiDE 400 scanner. Scanned images were subjected to DepositScan free analytical software according to Zhu *et, al.,* 2011. The average volume median diameter (VMD or $D_{v\,0.5}$), and both $D_{v\,0.1}$ and $D_{v\,0.9}$ were estimated, also coverage of droplet deposits expressed as number of droplets (N) per cm^2. The relative span equation was used to evaluate the volume distribution as follow: Span = $[(D_{v\,0.1} - D_{v\,0.9}) \div (D_{v\,0.5})]$, Bateman, (1993).

Mortality assessment

One hundred and fifty insects were collected randomly by using sweeping net two hr. after treatment from the center area of each treated plot. The treated insects were placed in 3 cages, those cages were placed under field conditions in shade area and were feed dally on plants from the relevant treated plots, daily mortality were recorded and corrected according to Schneider-Orelli's formula (Püntener, 1981).

Statistical analysis

Collected data were subjected to analysis of variance, while data expressed as percentages were subjected to square root transformation according to Sokal and Rohlf, (1969), then to analysis of variance.

Table 1. Application criteria of water based formulations sprayed as LV and ULV spray technique and ULV formulation.

Criteria	Water based formulation		ULV
	LV	ULV	
Diluent	water	30% (Pg) water mixture	Diesel
Flow rate (L/min.)	1.25	0.6	0.4
Track spacing (m)	5	10	10
Speed (km/hr)		2.4	
Spray volume (l/fed)*	26.26 (62.50)	6.30 (15.00)	4.20 (10.00)
Spray height (m)		0.5	
Wind speed (m/sec)		2-3	
Temperature (C)		18-25	

* Numbers in Bracket = Spray volume (l/ha)

RESULTS AND DISCUSSION

Results

Efficacy of tested insecticides against desert locust, migratory locust and grasshoppers presented in Tables 2, 3 and 4 respectively. Chlorpyrifos showed that, the highest efficacy during the experimental period, followed by thiamethoxam + chlorantraniliprole, spinetoram + methoxyfenozide, chlorantraniliprole then pyridalyl, such order have been noted in case of *L. migratoria*, and grasshoppers species while in case of *S. gregaria* both spinetoram + methoxyfenozide and chlorantraniliprole were almost the same, the average reduction of *S. gregaria* population during the experimental period were 96.47, 90.24, 84.02, 83.27, and 80.37 %, such reduction in *L. migratoria* were 96.85, 90.70, 85.44, 80.59, and 77.96 %, and for grasshoppers species it was 95.87, 91.34, 85.69, 82.11, and 77.72 %, respectively. Chlorpyrifos was the fastest acting pesticide, where it caused reduction over 90% after 24 hr. post treatment, followed by thiamethoxam + chlorantraniliprole which achieved over 90% reduction after 48 hr., the remaining pesticides caused same reduction after 72 hr. in all species population. Chlorpyrifos in the present work was applied as water based formulation using ULV and LV spray technique and ULV formulation, results indicate that the efficacy of chlorpyrifos were quite the same in all treated species, in the same way there were no significant differences between ULV and LV spray technique.

Table 2. Effect of different insecticides against Desert Locust *Schistocerca gregaria* after 24, 48, 72, and 96 Hrs. post treatment when applied using ULV and LV technique.

Insecticide active ingredients	Spray Technique								Average*
	ULV				LV				
	Time post Treatment (hrs.)								
	24	48	72	96	24	48	72	96	
Chlorantraniliprole	60.45	85.94	91.17	95.41	60.64	87.37	91.89	93.25	83.27 c
Pyridalyl	54.13	84.96	91.31	92.70	52.58	83.93	90.37	92.93	80.37 d
Thiamethoxam + chlorantraniliprole	71.92	92.58	97.85	100	72.11	91.65	96.77	99.02	90.24 b
Spinetoram + methoxyfenozide	66.33	86.63	93.05	93.05	65.40	85.85	90.15	91.67	84.02 c
Chlorpyrifos	91.98	94.76	100	100	91.85	95.04	99.07	99.07	96.47 a
Average**	87.21 A				86.53 A				
Chlorpyrifos ULV	91.29	96.08	99.02	99.02					96.35

*** Means with same small letter did not differ significantly.**
**** Means with same capital letter did not differ significantly.**

Table 3. Effect of different insecticides against Migratory Locust *Locusta migratoria* after 24, 48, 72, and 96 Hrs. post treatment when applied using ULV and LV technique.

Insecticide active ingredients	Spray Technique								Average*
	ULV				LV				
	Time post Treatment (hrs.)								
	24	48	72	96	24	48	72	96	
Chlorantraniliprole	57.68	84.33	88.28	92.23	57.62	83.92	89.23	91.46	80.59 d
Pyridalyl	53.06	82.02	87.73	91.68	52.31	81.54	86.15	89.23	77.96 e
Thiamethoxam + chlorantraniliprole	72.38	94.31	97.81	98.70	72.31	93.85	97.62	98.64	90.70 b
Spinetoram + methoxyfenozide	69.74	88.47	92.38	92.42	69.23	87.69	91.28	92.31	85.44 c
Chlorpyrifos	92.08	96.46	98.67	99.56	92.13	96.92	98.97	100	96.85 a
Average**	86.50 A				86.12 A				
Chlorpyrifos ULV	91.97	96.91	98.67	99.56					96.78

*** Means with same small letter did not differ significantly.**
**** Means with same capital letter did not differ significantly.**

Table 4. Effect of different insecticides against multiple grasshoppers species after 24, 48, 72, and 96 Hrs. post treatment when applied using ULV and LV technique.

Insecticide active ingredients	Spray Technique								Average*
	ULV				LV				
	Time post Treatment (hrs.)								
	24	48	72	96	24	48	72	96	
Chlorantraniliprole	59.34	87.45	91.51	92.63	57.58	86.53	89.90	91.91	82.11 d
Pyridalyl	52.97	82.61	88.15	89.63	52.53	81.81	85.86	88.22	77.72 e
Thiamethoxam + chlorantraniliprole	71.71	95.61	98.44	99.63	71.71	95.96	97.99	99.66	91.34 b
Spinetoram + methoxyfenozide	67.42	89.26	91.13	92.25	67.68	90.91	92.93	93.94	85.69 c
Chlorpyrifos	91.09	95.20	97.06	97.80	92.19	96.29	98.31	98.99	95.87 a
Average**	86.54 A				86.55 A				
Chlorpyrifos ULV	91.44	95.55	97.42	98.16					95.64

*** Means with same small letter did not differ significantly.**
**** Means with same capital letter did not differ significantly.**

Data arranged in Table (5) revealed that, spray quality of tested insecticides, it is clear that LV spray technique, produced the largest droplet size and the highest span value, the average of those values were 425 µ and 1.07, respectively, while in case of ULV spray of water based insecticides those values were 208µ and 0.75 and for chlorpyrifos ULV formulation it were 103 µ and 0.62, respectively. The coverage represented as number of droplets /cm^2 showed same trend where those values were 148.67, 64.80 and 47, respectively.

Table 5. Spray droplet characteristics for tested insecticides with ULV and LV technique.

Insecticide active ingredients	Spray Technique *					
	ULV			LV		
	VMD	Span	N/cm^2	VMD	Span	N/cm^2
Chlorantraniliprole	209	0.72	61.83	428	1.03	151.68
Pyridalyl	207	0.68	56.25	426	1.11	146.50
Thiamethoxam + Chlorantraniliprole	208	0.80	75.55	418	1.08	139.15
Spinetoram + Methoxyfenozide	209	0.83	53.15	428	1.13	151.80
Chlorpyrifos	207	0.74	77.20	426	1.01	154.20
Average *	208 A	0.75 A	64.80 B	425 B	1.07 B	148.67 A
Chlorpyrifos (ULV)	103	0.62	47			

*** There were no significant differences between each insecticide treatment in same spray technique.**
**** Means of same criteria with same capital letter did not differ significantly.**

Discussion

Efficacy of chlorpyrifos in the present study agrees with previous work of Harb *et, al.,* 1988 and Abdel-Fattah and Abdelatef 2013 against grasshoppers and Abdel-Fattah *et, al.,* 2012 against desert locust, concerning speed of toxic action chlorpyrifos, showed moderate speed, also thiamethoxam + chlorantraniliprole showed same speed of toxic action while chlorantraniliprole alone was slow in it is action, this result may be due to that thiamethoxam + chlorantraniliprole when applied at the recommended dose led to increase of chlorantraniliprole dose, which suggest the possibility of increase the dose of chlorantraniliprole to achieve faster action, this result may be also due to synergetic action between thiamethoxam and chlorantraniliprole, so far there are no sufficient data about effect of Thiamethoxam against locust and grasshoppers. Spinetoram + methoxyfenozide showed unexpected low performance, where spinetoram alone showed 78.34 % reduction in *Diabolocatantops axillaris* population after 24 hrs. post treatment in Egypt, El-Gammal, and Mohamed, (2008), this results may be due to susceptibility differences between the grasshoppers species, also methoxyfenozide is working as insect growth regulator and may be need more time to kill nymphal stages and it is effect on adults is low, or may be due it is activity limited to Lepidoptera and Coleoptera, Anonymous (2013). Efficacy of chlorantraniliprole were proved against rangeland grasshoppers when applied as Reduced Agent Area Treatments (RAATs) the applied dose was about 14.6 g a.i./ha, (Foster *et, al.,* 2010 Bradshaw *et, al.,* 2013), also against *S. gregaria* when applied in field with rate of 24 g a.i./ha Soliman *et, al.,* 2019 and against *S. gregaria* and *L. migratoria* under laboratory conditions Soliman *et, al.,* 2019. Pyridalyl showed novel mode of action against many lepidopterous and thysanopterous pests (Sakamoto *et, al.,* 2004), it was suggested that pyridalyl insecticidal activity may be due to it is selective inhibition of cellular protein synthesis (Moriya *et, al.,* 2008), also in two laboratory studies on effect of pyridalyl on *S. gregaria* it was noticed that pyridalyl caused significant decrease in most amino acids of the haemolymph of 5^{th} nymphal instar and adults, (Mostafa *et, al.,* 2008), also there were disruption in activities of the Alkaline phosphatase, glutamic pyruvic transaminase and glutamic oxaloacetic transaminase in haemolymph and fat bodies of 5th nymphal instar and newly emerged adults, (Teleb *et, al.,* 2012). In the present study pyridalyl showed the lowest effect and the slowest speed of action, may be due it is high selectivity to certain insects (Anonymous 2013). Current investigation proved that addition of propylene glycol to diluent water, could prevent droplets evaporation when water based pesticides applied as ULV spray technique, where the droplets size were significantly reduced as well as relative span, also produced sufficient droplets per cm^2, these criteria were suitable for locust control (Rachadi, 2010 and Matthews *et, al.,* 2014), in the present work chlorpyrifos were applied as water based formulation in LV and ULV spray techniques, also as oil based formulation in ULV spray technique, the resulted efficacy were almost identical which prove the effectiveness of spraying tested water based pesticides diluted with 30% Propylene glycol water mixture in ULV spray technique.

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فاعلية بعض المبيدات ذات القاعده المائية على الجراد و النطاطات عند تطبيقها بتقنية الحجوم الصغيره والمتناهية فى الصغر فى جمهورية مصر العربية

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اختبرت كفائة خمسة مبيدات ذات قاعده مائية على الجراد الصحراوى و الجراد الأفريقى المهاجر أو الروسى وانواع متعددة من النطاطات عند تطبيقها بتقنية الحجوم الصغيرة و المتناهية فى الصغر. اظهرت النتائج المتحصل عليها ان ترتيب المبيدات المستخدمه من حيث الكفاءة كان كما يلى: الكلوربيرفوس ثم ثياميثوكسام مع الكلورانترانيليبرول ثم سبينيتورام مع ميثوكسيفينوزيد ثم الكلورانترانيليبرول ثم البيريداليل. و فى حالة الجراد الصحراوى كان فعل سبينيتورام مع ميثوكسيفينوزيد متساوى مع الكلورانترانيليبرول. من الملاحظ ان كفائة رش المبيدات ذات القاعده المائية المخففه بمحلول مائى من البروبلين جليكول بنسبة 30% بتقنية الحجوم المتناهية فى الصغر كانت جيده, حيث كان حجم قطيرات الرش و تجانسها وعددها فى السنتيمتر المربع مناسبة لعمليات مكافحة الجراد و النطاطات.