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The relationship between formulation of insecticides and droplet distribution of cetain ground spraying equipment and controlling *Heteracris annulosa* (Orthoptera: Acrididae) infesting alfalfa plants

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Abstract:

Field experiments were carried out in an area of about 1.1 feddans planted with alfalfa *Medicago sativa* during season of 2019 in 5th September at El-Baharia Oasis, Western Desert, Giza Governorate. The selected area was split into 7 plots including control plot. Chlorpyrifos EC and U.L.V., deltamthrin E.C. and U.L.V., spinosad and chlorpyrifos +lufenuron were sprayed with recommended rate and one treatment left without spraying as un treated check by using motorized knapsack sprayer (solo) (52.5 L./fed.) and economy micron ULVA + sprayer (3.15 L/fed.). Data indicated that, all tested compounds induce a significant negative influence on *Heteracris annulosa* (Walker) (Orthoptera: Acrididae) nymphs survival. The most effective compounds is deltamthrin E.C. and chlorpyrifos E.C. followed by other compounds. It could be recommended to use those compounds with LV spraying equipment with not less than (3.15L/fed.).The data showed that motorized knapsack sprayer (solo) (52.5 L./fed.) was the most efficient equipment to control the 4th, 5th instar nymphs of *H. annulosa* on alfalfa ha plants.The rate of performance of motorized knapsack sprayer (solo) was 15.2 fed./day. But the lowest rate of performance was recorded with economy micron ULVA + sprayer since it could spray only 9.1 fed. /day.

Introduction

Locusts and grasshoppers (Orthoptera: Acrididae) were considered as a serious agricultural pests that cause considerable damage to different crops in Africa especialy during outbreaks (Showler, 1993). The major insect pests in Western Desert of Egypt were the species of family Acrididae. In the region of El-Baharia Oasis, it was found that the berseem grasshopper ***Heteracris annulosa*** **(**Walker**)** (Orthoptera: Acrididae) was the most dominant insect pest in this area. Much attention has been focused in compounds which disrupt the normal process of insect development. They are known as Insect Growth Regulators (IGR's). The use of bio agents to control pests has been known and practiced for a long time. In Egypt, majority of interest was directed to the type, dosage of insecticides used, while a lesser attention was given to the application methods. A comparative studies on the efficiency of certain ground sprayers was carried out by

(Hindy, 1992) , who recorded significant variation in the spray deposit due to arrangement of the nozzles, spray technique and rate of application. The world attention was directed to minimization of spraying volumes and the costs of control pests which may be achieved by using a cheap and effective insecticide or using developmental ground spraying technique with low cost of application per feddan (Magdoline *et al.* , 1992 and Matthews, 1992). The present work aimed to determine the most effective insecticide, formulation and equipment controlling *H. annulosa* on alfalfa plants.

Materials and methods

1. Tested compounds:

1.1. Chlorpyrifos - (Renocam®48% E.C.) 1 Liter/fed., Acetylcholinesterase inhibitor.
1.2. Chlorpyrifos – (Locban 45% U.L.V.) 400 cm^3\fed., Acetylcholinesterase inhibitor.
1.3. Deltamthrin (Deltafan®1.25% U.L.V.)400 cm^3\fed. (Axonic excitotoxins).
1.4. Deltamthrin (Kafrothrin ®2.5% E.C.)350 cm^3\fed. (Axonic excitotoxins).
1.5. Spinosad (Tracer ®24% S.C.) 50 cm /fed., Neuronal excitation.
1.6. Chlorpyrifos 25%+Lufenuron 5% (Tembo AX®30%E.C.)500cm^3\fed., Acetylcholinesterase inhibitor+Chitin synthesis inhibitor.

2. Spraying equipment tested on alfalfa plants:-

Two ground application machines were selected to perform the scope of this work as follows:
2.1. Economy micron ULVA + sprayer (3.15L./fed.).
2.2. Motorized knapsack sprayer (solo) (52.2 L./fed.) .
As commonly used equipment in applying pesticides on alfalfa plants, the tested equipment could be represented according to the technical categorization mentioned in Table (1). Calculations of productivity and rate of performance were recorded as described by **Hindy (1992).**

3. Execution of field experiments:

3.1. Arrangements of the experiments:

Field experiments were carried out during season 2019 on 5thSeptember in private alfalfa (*Medicago sativa*) field , located at El-Baharia Oasis, Western Desert, Giza Governorate. The experiments were done under local meteorological conditions of 29±2ºC average temperature, 35% average RH.% and 4-6 m/sec. average wind velocity , at 7 am. The selected area of 1.1 feddans was split into 7 plots including control plot , each plot about (35 x 15) = 525 m^2. The plots were isolated by a wide belt of 10 X 15 = 150 m^2 as barrier zones to avoid pesticide drift. Plots laying up wind of treatments were used as a control. The untreated cheek plot were not sprayed, suitable infested sites with the grasshoppers were selected at valley El-Baharia Oasis. These sites were characterized by high population density of grasshoppers (more than 15 insect/ m^2). The studied nymphs were 4th, 5th instars. Numbers of grasshoppers were collected, counted and placed in each cage.

Spraying operations have not been done with any insecticides before execution the field experiment. The experimental fields were sprayed with recommendeded rate of chloropyrifos E.C. and U.L.V., deltamthrin E.C. and U.L.V., spinosad and chloropyrifos + lufenuron, respectively. The spraying was done between 7 and 10 am in the morning.

3.2. Bioassay procedure:

To define *H. annulosa* nymphs numbers, each treatment was represented by three replicate cages 0.5m X 0.5m The insects were collected randomly from the same treatment after application directly by using sweep-net and placed 30 insects in each cage. The cages were kept and fed with treated plants (alfalfa) to the insects treated. Mortality counts were after different period of treatment, i.e., 1, 6, 12, 24 and 48 hrs. post treatment to insecticide treatments. Assessments: in cages daily, routine work includes removing the previous uneaten food, faces and dead nymphs and counting the

living insects before introducing the fresh food.

3.3. Phytotoxic effect:

It was determined by recording any color change, leaf curling or flaming up to 8 days after spraying, according to Badr *et al*. (1995).

3.4. Calculation and data analysis:

3.4.1. The percentage of reduction in the field experiment was calculated according to Henderson and Tilton (1955).

3.4.2. Statistical analysis of results was done according to SAS (1996) for biological studies: Duncan's for biological evaluation of insecticides in field.

4. Calibration and performance adjustment of the tested equipment:

4.1. Collection of spray deposit:

Before spraying each **alfalfa** field treatments, water sensitive paper size 26x76 mm. developed by (Novartis®) were hanged on **alfalfa** plants and on ground selected on parallel position to the ground wire collectors, Hindy (1992) at about one meter between two adjusted plants in order to estimate the spray lost on the ground between plants in diagonal line through the tested field. Measurements of size and number of spots were carried out by means of a scaled monocular (Strüben)® (X15) lens. All necessary corrections and calculations connected with such technique of measurements and determination of droplets were conducted according to Anonymous (1978). Sizing of droplets is a necessary and frequent routine procedure for the assessment of agricultural spray applications (Johnstone and Huntington, 1970). The spread factor of used sensitive paper was 2.2 (Ciba Geigy, 1990).

Table (1): Techno-Operational data of certain ground sprayers applied on alfalfa during season, 2019.

Items	Motorized knapsack (solo) sprayer	Hand-held spining disc ULVA^{+} sprayer
Type of atomization	Mechanical Pneumatic	Centrifugal (Rotary disc)
Nozzle type	Pneumatic-Flow rate 3	One restirector (Red)
Pump type	Centrifugal fan	-
Number of nozzles	1	1
Pressure (bar)	-	-
Spray tank (L.)	20	1+10
Rate of application (L/fed.)	52.5	3.15
Working speed (Km/h.)	2.4	2.4
Swath width (m.)	5	3
Flow rate (L/min.)	2.5	0.09
Spray height (m.)	0.5	0.5
Type of Spraying	Target in all sprayres	
Productivity * (fed./h.)	2.86	1.7
Rate of performance* (fed./day)	15.2	9.1

*** Number of spraying hours = 8 hours daily.**
*** Calculations of productivity and rate of performance.**
***Number of workers =2.**

Results and discussion

1. Bioresidual activity of chlorpyrifos (U.L.V.) against *Heteracris annulosa* on alfalfa plants:

Efficiency of chlorpyrifos (U.L.V.) represented as mortality percentages after 1 and 2 days of treatments was indicated in Tables (2 and 4) .The general mean reduction% in population of *H. annulosa* 4 th ^{a}nd 5th instar nymphs was 77.3 using Economy Micron ULVA^{+} sprayer (3.15L./fed.). The droplet size was 143 µm and N/cm^{2} was 155 for recommended rate sprayed with economy micron ULVA^{+}sprayer (3.15L./fed.).

2. Bioresidual activity of chlorpyrifos (E.C.) against *Heteracris annulosa* on alfalfa plants:

Efficiency of chlorpyrifos (E.C.) represented as mortality percentages after 1 and 2 days of treatments was indicated in Tables (2 and 4). The general mean reduction% in population of *H. annulosa* 4 th and 5th instar nymphs was78 using motorized knapsack sprayer (solo)(52.2 L./fed.).The droplet size was 159 μm and N/cm^2 was 140 for recommendeded rate sprayed motorized knapsack sprayer (solo)(52.2 L./fed.) .

3. Bioresidual activity of spinosad against *Heteracris annulosa* on alfalfa plants:

Efficiency of spinosad (E.C.) represented as mortality percentages after 1 and 2 days of treatments was indicated in Tables (2 and 4) .The general mean reduction% in population of *H. annulosa* 4 th and 5th instar nymphs was 63.2 using motorized knapsack sprayer (solo)(52.2 L./fed.).The droplet size was 146 μm and N/cm^2 was 130 for recommendeded rate sprayed motorized knapsack sprayer (solo) (52.2 L./fed.)

4. Bioresidual activity of deltamethrin (U.L.V.) against *Heteracris annulosa* on alfalfa plants:

Efficiency of deltamethrin (U.L.V.) represented as mortality percentages after 1 and 2 days of treatments was indicated in Tables (2 and 4). The general mean reduction% in population of *H. annulosa* 4 th and 5th instar nymphs was 70 using economy micron ULVA$^+$ sprayer (3.15L./fed.).The droplet size was 150 μm and N/cm^2 was 160 for recommendeded rate sprayed with economy micron ULVA$^+$sprayer (3.15L./fed.).

5. Bioresidual activity of deltamethrin (E.C.) against *Heteracris annulosa* on alfalfa plants:

Efficiency of deltamethrin (E.C.) represented as mortality percentages after 1 and 2 days of treatments was indicated in Tables (2 and 4). The general mean reduction % in population of *H. annulosa* 4 th and 5th instar nymphs was 85 using motorized knapsack sprayer (solo) (52.2 L./fed.). The droplet size was 125 μm and N/cm^2 was 127 for recommendeded rate sprayed motorized knapsack sprayer (Solo)(52.2 L./fed.) .

6. Bioresidual activity of chlorpyrifos + iufenuron against *Heteracris annulosa* on alfalfa plants:

Efficiency of chlorpyrifos+ lufenuron (E.C.) represented as mortality percentages after 1 and 2 days of treatments was indicated in Tables (2 and 4) .The general mean reduction% in population of *H. annulosa* 4 th and 5th instar nymphs was 62 using motorized knapsack sprayer (solo) (52.2 L./fed.).The droplet size was 141 μm and N/cm^2 was 135 for recommendeded rate sprayed motorized knapsack sprayer (solo)(52.2 L./fed.) .

Table (2): The relation between droplet distributions obtained by the tested ground spraying equipment and the corresponding mortality of 4th and 5th instar nymphs of *Heteracris annulosa*, using the total recommended rate of insecticides on alfalfa plants during season 2019 in Giza Governorate.

Insecticide	Tested sprayer and formulation and dose rate\fed.	VMDμm	N / cm^2	% Mortality	
				Initial	Residual
Chlorpyrifos	Micron ULVA$^+$(U.L.V.) (400cm^3)	143	155	90	100
	Solo (sprayer)(E.C.)(1 L.)	159	140	96.6	100
Deltamethrin	Micron ULVA$^+$(U.L.V.) (400cm^3)	150	160	80	83.3
	Solo (sprayer)(E.C.) (350cm^3)	125	127	100	100
Spinosad	Solo (sprayer)(E.C.) (50cm^3/fed.)	146	130	76.6	83.3
Lufenuron+Chlorpyrifos	Solo (sprayer)(E.C.) (500cm^3)	141	135	80	83.3

VMD = Volume Mean Diameter. N / cm^2 = Number of droplets per square centimeter

Data in Table (3) showed that there were a negative correlation between lost spray on ground equipment and the bioresidual activity of insecticides used.

7. Economy micron ULVA^{+} sprayer (3.15 L/fed) :

Data in Table (3) showed that the lost spray percentages were 4.3 and 4.8 % from the total spray volume in the case of chlorpyrifos and deltamethrin.The general mean reduction% in population of *H. annulosa* 4 th and 5th instar nymphs were 77.3 and 70 % at total recommendeded rate, respectively.

8. **Motorized knapsak (solo) sprayer(52.5L/fed):**

Data in Table (3) showed that the lost spray percentages were 9 ,9.3 , 9.7 and 10 % from the total spray volume in the case of chlorpyrifos , deltamethrin, spinosad and chlorpyrifos+ lufenuron.The general mean reduction% in population of *H. annulosa* 4 th and 5th instar nymphs were 78 , 85 , 63.2 and 62 % at total recommended rate, respectively.

9. Relationship between the tested chemicals, formulation, techniques and the mortality percentages of *Heteracris annulosa* on alfalfa plants:

9.1. Bioassay evaluation:

Tables (2 ,3 and 4) showed that, the percentages of reduction of *H. annulosa* 4 th and 5th instar nymphs on alfalfa plants affected by certain insecticides sprayed with certain ground application techniques during the season of 2019 using total recommendeded rate. The productivity of motorized knapsack sprayer (solo) (52.2 L./ fed.) sprayer was 15.2 fed./day. Reviewing the obtained result it could be proved that solo achieved the superior equipment, but the lowest productivity was recorded with economy micron ULVA^{+} sprayer (3.15L./fed.) since it could spray only 9.1 fed./day.

Table (3): Lost spray on ground, as produced by low volume ground spraying equipment, by using certain insecticides at total recommendeded rate against 4th and 5th instar nymphs of *Heteracris annulosa* during season (2019).

Insecticide	Tested sprayer&Formulation and spray volume (L / fed.)	*N/ cm^2 of total spray droplets	N / cm^2 droplets (on ground)	% $\frac{\text{N/cm}^2\text{ (ground)}}{\text{N/Cm}^2\text{ (Plants+ground)}}$ x 100	% Mortality	
					Initial	Residual
Chlorpyrifos	Micron ULVA^{+}(U.L.V.)(3.15)	162	7	4.3	90	100
	Solo (sprayer)(E.C.)(52.5)	154	14	9	96.6	100
Deltamethrin	Micron ULVA^{+}(U.L.V.)(3.15)	168	8	4.8	80	83.3
	Solo (sprayer)(E.C.)(52.5)	140	13	9.3	100	100
Spinosad	Solo (sprayer)(E.C.)(52.5)	144	14	9.7	76.6	83.3
Lufenuron+Chlorpyrifos	Solo (sprayer)(E.C.)(52.5)	150	15	10	80	83.3

N / cm^2 = Number of droplets per square centimeter. * On alfalfa **plants and lost spray on ground**

Statistical analysis showed that, there was a significant differences between both the distribution percentages of droplet sizes (LSD= 9.405 for levels and 16.29 for compounds), for the droplets number/cm^2 (LSD= 5.8188 for levels and 10.078 for compounds) and for reduction percentages (LSD=2.5739 for compounds).

Table (4): Reduction percentages in *Heteracris annulosa* nymphs affected by insecticides sprayed with certain ground equipment during season 2019.

Treatments	Pretreat-ment	Post 1		Post 6 hours		Post 12		Post 24		Post 48		General	
		C	R %	C	R %	C	R %	C	R %	C	R %	C	R %
Chlorpyrifos EC (1L/fed.)	30	15	50	11	63.3	5	83.3	3	90	0	100	6.8	77.3
ChlorpyrifosULV (400cm3/fed.)	30	22	26.6	8	73.3	2	93.3	1	96.6	0	100	6.6	78
Spinosad (50cm3/fed.)	30	26	13.3	17	43.3	13	56.6	7	76.6	5	83.3	16.3	63.2
Deltamthrin E.C.(350 cm3/fed.)	30	10	66.6	5	83.3	3	90	0	100	_	_	4.5	85
Deltamthrin U.L.V.(400 cm3/fed.)	30	17	43.3	10	66.6	7	76.6	6	80	5	83.3	9	70
Chlorpyrifos+LufenuronE. C.30% (50cm3/fed.)	30	27	10	12	60	7	76.6	6	80	5	83.3	11.4	62
Untreated (control)	30	30	_	30	_	30	_	30	_	30	_	30	_

C = Count of life nymphs after treatment. R = % Reduction of nymphs

Field experiment was carried out on infested area with grasshopper *H. annulosa* nymph sat early season on alfalfa. For evaluation the field performance of low-volume spraying machines, motorized knapsack sprayer (solo) (52.5 L/fed.) and ultra low volume economy micron ULVA^{+} sprayer (3.15L./fed.); to spray chlorpyrifos E.C. and U.L.V.; deltamthrin E.C. and U.L.V.; spinosad and chlorpyrifos + lufenuron, with full recommended dose. A satisfactory coverage was obtained on alfalfa plants , the droplets spectrum was obtained in field experiment was agreed with the optimum droplet sizes which mentioned by Himel (1969).

The best obtained result was (52,5 L/fed.) as spray volume and droplet spectrum were 144μm and 141 droplets/cm^2 , these results agreed with (Himel and Moore, 1969) in the optimum droplet size to control insects in fields by ground equipment. Deltamthrin E.C. and chlorpyrifos E.C. revealed the best bioefficiacy results with motorized knapsack sprayer (solo) (52.5 L/fed.) followed by the other compounds and these results agreed with Hindy *et al.* (2004). Genidy *et al.* (2005) recommended KZ oil and pyriproxyfen followed by agerin by using low volume spraying because of reducing the time lost in process filling the machines, improve the homogeneity of the spray solution on the plant leaves and saving the lost spray on the ground. These results also in agreement with Bakr *et al*. (2014*),* they recommended by using profenofos followed by pyriproxyfen and spinosad with agromondo motorized knapsack sprayer(20L/fed.) and Morsy *et al*.(2015) whom recommended using carbosolvan, acetamiprid and deltamethrin with low volume machines not less than (15 L/fed.). Also Dar (2016), recommended whenever using lufenuron followed by spinosad in controlling cotton leafworm on clover with low volume machines. Acetamiprid, thiaclopride, thiamethoxam, profenofos, flupyradifurone, revealed successeful results in controlling both *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) , *Empoasca decipiens* (Paoli) (Hemiptera: Cicadellidae) nymphs . Dar (2019) and Dar *et al*. (2019) whom achived best control results, spray volume per feddan , productivity and rate of performance with motorized knapsack sprayers.

Finnally, it could be recommended that using those compounds with LV spraying equipment with not less than (52.5 L./fed.). The data showed that motorized knapsack sprayer (solo) (52.5 L. fed.) was the best equipment to control *H. annulosa* on alfalfa. The rate of performance of motorized knapsack sprayer (solo) was 15.2 fed./day, it was the best equipment, the low spray volume and the low percentages of lost

spraying between plants about 9.5%, but the lowest rate of performance was economy micron ULVA^{+} sprayer (3.15L./fed.); since it could spraying only 9.1 fed./day and spray lost about 4.5% , these results were agreed with Hindy *et al.* (1997), they mentioned that, there was a positive correlation relationship between rate of application and lost spray on ground. There was a negative complete correlation between droplet sizes and the mean residual of mortality of *H. annulosa* nymphs and while there was a positive complete correlate between N/cm² and the mean residual of mortality of *H. annulosa* nymphs in all treatments.

It could be concluded that, using deltamthrin E.C. and chlorpyrifos E.C. followed by other compounds with low volume (LV) ground spraying equipment with not less than (3, 15 L. /fed.) by using recommended doses which revealed successful management against grasshoppers on alfalfa under our local conditions.

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