Egypt. J. Plant Prot. Res. Inst. (2023), 6 (4): 473 –482

Egyptian Journal of Plant Protection Research Institute

www.ejppri.eg.net

Time of spraying effects on insecticidal activity and droplet distribution of certain insecticides controlling *Hetracris annulosa* and *Locusta migratoria* (Orthoptera: Acrididae) on *Zea mays*

Saeed, S.M. and Rehab, A.A. Dar

Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt.

ARTICLE INFO

Article History

Received: 19/10 /2023

Accepted: 20/12/2023

Keywords

Zea mays, *Hetracris annulosa*, *Locusta migratoria migratorioides*, insecticides and ground technique.

Abstract

Field experiments were carried out in an area of about 10 feddans planted with *zea mays* during season of 2023 on 18th July at Bashiar Elkhaier farm, El-Farafra Oasis, New Valley Governorate. The selected area was split into 10 plots including control plot. Thiamethoxam, Imidacloprid, Deltamthrin, Alpha-Cypermethrin Acetamiprid, Spinosad, Lambda-Cyhalothrin, Chlorfenapyr, and Emamectin benzoate 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.) at 7am and 6 pm. Data indicated that, all tested compounds induce a significant negative influence on *Hetracris annulosa* Walker and *Locusta migratoria migratorioides* (Fairmaire and Reiche) (Orthoptera : Acrididae) nymphs survival. The most effective compounds are Alpha-Cypermethrin, Deltamthrin E.C. Lambda-Cyhalothrin and Spinosad followed by other compounds at both times of spraying 7 am and 6 pm; where there was no significant difference between the biological efficiency between two times spraying. It could be recommended to use these compounds with LV spraying equipment with a Motorized Knapsack sprayer (Solo) (52.5 L./Fed.). The data showed that spraying at 7 am was a more excellent time than 6 pm for better droplet coverage, distribution, increasing number of droplets per square centimeter and decreasing Volume Mean Diameter these may be due to lower temperature and lower Relative Humidity %. The rate of performance of a Motorized Knapsack sprayer (Solo) was 15.2 Fed./day.

Introduction

Locusts and grasshoppers (Orthoptera:Acrididae) were considered one category of important agricultural pests that inflict significant harm to many crops in Africa, particularly during outbreaks (Showler, 1993). The Acrididae family was the most common insect pest in Egypt's Western Desert, Bashiar Elkhair farm, Farafra Oasis, New Valley Governorate. The most common insect pests in this area were discovered to be the berseem grasshopper, *Hetracris annulosa* Walker and the African locust, *Locusta migratoria migratorioides*

(Fairmaire and Reiche) (Orthoptera : Acrididae). The use of bio substances to manage pests has long been known and practiced. In Egypt, most of the attention was focused on the type and dosage of insecticides employed, with little emphasis on application methods. Hindy (1992) conducted a comparative study on the performance of various ground sprayers, observing significant variance in the spray deposit related to nozzle arrangement, spray technique, and rate of application. The world's emphasis has been focused on reducing spraying volumes and pest control costs, which can be accomplished by utilizing a cheap and effective insecticide or developing a ground spraying technology with a low cost of application per feddan (Magdoline *et al.*, 1992 and Matthews, 1992). Spraying time is critical because changes in atmospheric conditions like temperature, relative humidity, and wind velocity affect droplet coverage, distribution, number of droplets per square centimeter, and volume mean diameter.

The present work aimed to determine the most effective insecticide, preferred time of saying controlling *H. annulosa* and *L. migratoria* on *z. mays* plants.

Materials and methods

1.The tested compounds:

Table (1) presents tested compounds including their insecticide groups, recommended doses and trade names.

Table (1): The tested compounds and their recommended doses.

No.	Common name	Group	Dose	Trade name
1	**Thiamethoxam**	Neonicotinoids	25 gm\100 L water.	Mobictar25%WG
2	**Imidacloprid**	Neonicotinoids	300 cm^3 \Fed.	Emi bower 35%SC
3	**Deltamethrin**	Pyrethroids	250 cm^3 \Fed.	Shot 2.5%EC
4	**Alpha-Cypermethrin**	Pyrethroids	250 cm^3 \Fed.	Alfasiber 10% EC
5	**Acetamiprid**	Neonicotinoids	25cm\100 L water.	Autolock 20% SL
6	**Spinosad**	Spinosyns	100 cm\20 L water.	Canza sad 48%SC
7	**Lambda-Cyhalothrin**	Pyrethroids	250 cm^3 \Fed.	Sambrator 10%SC
8	**Chlorfenapyr**	Pyrroles	150 cm^3 \Fed.	Fanti extra 24%SC
9	**Emamectin benzoate**	Avermectin	60 gm\Fed.	Biocleam 5.7 %WG

2. Spraying equipment tested on Zea *mays* plants:

One ground application machine was selected to perform the scope of this work, a Motorized Knapsack sprayer (Solo) (52.2 L./fed.). As commonly used equipment in applying pesticides on *z. mays* 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 2023 on 18th July at Bashiar Elkhair farm, El-Farafra Oasis, New Valley Governorate. An ecological survey was done before experiments execution, the maize plants surrounded by medicinal and aromatic plants about 600 feddans were cultivated from a total of 5000 feddans. There were 80-100 insects per m^2, all types of Acrididae grasshoppers and locusts such as, (*H. annulosa*), *L. migratoria***,** Anacridium *egyptiam* and *schistocerca gregaraia*. Grasshoppers were about 75% of insects found, *H. annulosa* was 60% of grasshoppers, locusts were about 25% of all insects *L. migratoria* was 90% of locusts.

The experiments were done under local meteorological conditions two times in the morning, 7 a.m. 32±2ºC average temperature, 19-25% average RH. % and 2-4 m/sec average wind velocity and in the evening 6 p.m. 38ºC average temperature, 45-48% average RH% and 3-4 m/sec average wind velocity. The selected area of 10 Feddans was split into 10 plots including a control plot, each plot about (50x 84) = 4200m^2 (Feddan). The plots were isolated by a wide belt of 10 X 50= 500 m^2 as barrier zones to avoid pesticide drift. Plots laying up the wind of treatments were used as a control. The untreated cheek plot was not sprayed.

Spraying operations have not been done with any insecticides before the execution of the field experiment. The experimental fields were sprayed with a recommended dose of Thiamethoxam, Imidacloprid, Acetamiprid, Deltamthrin, Alpha-Cypermethrin, Lambda-Cyhalothrin, Spinosad, Chlorfenapyr, and Emamectin benzoate, respectively. The spraying was done two times at 7 am and 6 pm.

3.2. Bioassay procedure:

To define *H. annulosa* and *L. migratoria* numbers, five replicate cages 0.5m X 0.5m were used for each treatment. The insects were gathered at random from the same treatment after application immediately using a sweep-net, and 30 insects were placed in each cage. The cages were kept, and the insects were fed medicated plants. Mortality counts were taken after various treatment periods, namely 24 and 48 hrs. following pesticide applications. Assessments: Every day regular work in cages includes removing old food, faces, and dead individuals, as well as counting the living insects before providing 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:

Collection of spray deposit:

Before spraying each *Z. mays* field treatment, water sensitive paper size 26x76 mm. developed by (Novartis®) was hung on *Z. mays* plants and on the ground selected parallel positions 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 a 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 techniques 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 2).

Table (2): Techno-Operational data of certain ground sprayers applied on *Zea mays* field during season (2019).

Items	Motorized Knapsack (Solo) sprayer
Type of atomization	Mechanical Pneumatic
Nozzle type	Pneumatic-Flow rate 3
Pump type	Centrifugal fan
Number of nozzles	1
Pressure (bar)	-
Spray tank (L.)	20
Rate of application (L/fed.)	52.5
Working speed (Km/h.)	2.4
Swath width (m.)	5
Flow rate (L/min.)	2.5
Spray height (m.)	0.5
Type of Spraying	Target
Productivity * (fed./h.)	2.86
Rate of performance* (fed./day)	15.2

*** Number of spraying hrs. = 8 hrs. daily. ***
Calculations of productivity and rate of performance after Hindy (1992).
***Number of workers =2.**

Results and discussion

1. Bioresidual activity of Thiamethoxam against *Hetracris annulosa* and *Locusta migratoria* on *Zea mays* plants:

The efficiency of Thiamethoxam represented as mortality percentages after 1 and 2 days of treatments was indicated in Tables (5 and 6). The general mean reduction % in population sprayed at 7th a.m. was 83.7, 83.9 for *H. annulosa* and *L. migratoria* 4th and 5th instar nymphs, respectively. The droplet size was 147 μm and N/cm^2 was 168 (Table3), while the general mean reduction% in population sprayed at 6th p.m. was 83.6 ,84.4 for *H. annulosa* and *L. migratoria* 4th and 5th instar nymphs, respectively. The droplet size was 159 μm and N/cm^2 was 130 for the recommended rate sprayed with a Motorized Knapsack sprayer (Solo) (52.2 L./fed.).

2. Bioresidual activity of Imidacloprid against *Hetracris annulosa* and *Locusta migratoria* on *Zea mays* plants:

The efficiency of Imidacloprid represented as mortality percentages after 1 and 2 days of treatments was indicated in Tables (5 and 6). The general mean reduction % in the population sprayed at 7th a.m. was 82.9, 82.8 for *H. annulosa* and *L. migratoria* 4th and 5th instar nymphs, respectively. The droplet size was 143 μm and N/cm^2 was 159 (Table 3), while the general mean reduction% in population sprayed at 6th p.m. was 83.7, 83 for *H. annulosa* and *L. migratoria* 4th and 5th instar nymphs, respectively. The droplet size was 160 μm and N/cm^2 was 125 for the recommended rate sprayed with a Motorized Knapsack sprayer (Solo) (52.2 L./fed.).

3. Bioresidual activity of Deltamethrin against *Hetracris annulosa* and *Locusta migratoria* on *Zea mays* plants:

The efficiency of Deltamethrin represented as mortality percentages after 1 and 2 days of treatments was indicated in Tables (5 and 6). The general mean reduction % in the population sprayed at 7th a.m. was 96.2, 96.6 for *H. annulosa* and *L. migratoria* 4th and 5th instar nymphs, respectively. The droplet size was 158 μm and N/cm^2 was 180, while the general mean reduction% in population sprayed at 6th p.m. was 96.2, 97 for *H. annulosa* and *L. migratoria* 4th and 5th instar nymphs, respectively. The droplet size was 160 μm and N/cm^2 was 132 for the recommended rate sprayed with a Motorized Knapsack sprayer (Solo) (52.2 L./fed.).

4. Bioresidual activity of Alpha-Cypermethrin against *Hetracris annulosa*

and *Locusta migratoria* on *Zea mays* plants:

The efficiency of Alpha-Cypermethrin represented as mortality percentages after 1 and 2 days of treatments was indicated in Tables (5 and 6). The general mean reduction % in the population sprayed at 7th am. was 97.8, 97.6 for *H. annulosa* and *L. migratoria* 4th and 5th instar nymphs, respectively. The droplet size was 143 µm and N/cm^2 was 185 (Table 3), while the general mean reduction% in population sprayed at 6th p.m. was 98.3, 97.4 for *H. annulosa* and *L. migratoria* 4th and 5th instar nymphs, respectively. The droplet size was 157 µm and N/cm^2 was 134 for the recommended rate sprayed with a Motorized Knapsack sprayer (Solo) (52.2 L./fed.).

5. Bioresidual activity of Acetamiprid against *Hetracris annulosa* and *Locusta migratoria* on *Zea mays* plants:

The efficiency of Acetamiprid represented as mortality percentages after 1 and 2 days of treatments was indicated in Tables (5 and 6). The general mean reduction % in the population sprayed at 7th a.m. was 87.5, 83.7 for *H. annulosa* and *L. migratoria* 4th and 5th instar nymphs, respectively. The droplet size was 143 µm and N/cm^2 was 144 (Table 3), while the general mean reduction% in population sprayed at 6th p.m. was 87 ,83.4 for *H. annulosa* and *L. migratoria* 4th and 5th instar nymphs, respectively. The droplet size was 167 µm and N/cm^2 was 124 for the recommended rate sprayed with a Motorized Knapsack sprayer (Solo) (52.2 L./fed.).

6. Bioresidual activity of Spinosad against *Hetracris annulosa* and *Locusta migratoria* on *Zea mays* plants:

The efficiency of Spinosad represented as mortality percentages after 1 and 2 days of treatments was indicated in Tables (5 and 6). The general mean reduction % in the population sprayed at 7th a.m. was 89.3 for both *H. annulosa* and *L. migratoria* 4th and 5th instar nymphs. The droplet size was 144 µm and N/cm^2 was 165 (Table 3), while the general mean reduction% in population sprayed at 6th p.m. was 88.9, 89.3 for *H. annulosa* and *L. migratoria* 4th and 5th instar nymphs, respectively. The droplet size was 167 µm and N/cm^2 was 141 for the recommended rate sprayed with a Motorized Knapsack sprayer (Solo) (52.2 L./fed.).

7. Bioresidual activity of Lambda-Cyhalothrin against *Hetracris annulosa and Locusta migratoria* on *Zea mays* plants:

The efficiency of Lambda-Cyhalothrin represented as mortality percentages after 1 and 2 days of treatments was indicated in Tables (5 and 6). The general mean reduction % in the population sprayed at 7th a.m. was 96.8, 97.2 for *H. annulosa* and *L. migratoria* 4th and 5th instar nymphs, respectively. The droplet size was 143 µm and N/cm^2 was 172 (Table 3), while the general mean reduction% in population sprayed at 6th p.m. was 96.9 ,97.2 for *H. annulosa* and *L. migratoria* 4th and 5th instar nymphs, respectively. The droplet size was 166 µm and N/cm^2 was 140 for the recommended rate sprayed with a Motorized Knapsack sprayer (Solo) (52.2 L./fed.).

8. Bioresidual activity of Chlorfenapyr against *Hetracris annulosa* and *Locusta migratoria* on *Zea mays* plants:

The efficiency of Chlorfenapyr represented as mortality percentages after 1 and 2 days of treatments was indicated in Tables (5 and 6). The general mean reduction % in the population sprayed at 7th a.m. was 80.7, 77.8 for *H. annulosa* and *L. migratoria* 4th and 5th instar nymphs, respectively. The droplet size was 130 µm and N/cm^2 was 153 (Table 3), while the general mean reduction% in population sprayed at 6th p.m. was 78.9, 78 for *H. annulosa* and *L. migratoria* 4th and 5th instar nymphs, respectively. The droplet size was 146 µm and N/cm^2 was 125 for the recommended rate sprayed with a Motorized Knapsack sprayer (Solo) (52.2 L./fed.).

9. Bioresidual activity of Emamectin benzoate against *Hetracris annulosa* and *Locusta migratoria* on *Zea mays* plants:

The efficiency of Emamectin benzoate represented as mortality percentages after 1 and 2 days of treatments was indicated in Tables (5 and 6). The general mean reduction % in population sprayed at 7th a.m. was 87.2 ,86.6 for *H. annulosa* and *L. migratoria* 4th and 5th instar nymphs, respectively. The droplet size was 137 μm and N/cm^2 was 180 (Table 3), while the general mean reduction% in population sprayed at 6th p.m. was 88, 86.8 for *H. annulosa* and *L. migratoria* 4th and 5th instar nymphs, respectively. The droplet size was 158 μm and N/cm^2 was 143 for the recommended rate sprayed with a Motorized Knapsack sprayer (Solo) (52.2 L./fed.).

Table (3): The relation between droplet distribution obtained by the tested ground spraying equipment and spraying time, using the total recommended rate of insecticides on *Zea mays* plants, during season (2023) at New Valley.

Insecticide	Sprayed at 7 a.m.			Sprayed at 6 p.m.		
	VMDμm	**N / cm^2**	**Spray quality**	**VMD**μm	**N/cm^2**	**Spray quality**
Thiamethoxam	147	168	0.88	159	130	1.2
Imidacloprid	143	159	0.9	160	125	1.28
Deltamethrin	158	180	0.88	160	132	1.2
Alpha-Cypermethrin	143	185	0.77	157	134	1.17
Acetamiprid	143	144	0.99	167	124	1.3
Spinosad	144	165	0.87	167	141	1.18
Lambda-Cyhalothrin	143	172	0.8	166	140	1.19
Chlorfenapyr	130	153	0.85	146	125	1.16
Emamectin benzoate	137	180	0.76	158	143	1.1
LSD	4.43	4.08	_	4.43	4.06	_
Significance	***	***	_	***	***	_

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

10. Lost spray on ground produced by Motorized Knapsak (Solo) sprayer (52.5 L/fed):

Data in Table (4) showed that there was a negative correlation between lost spray on ground equipment and the bioresidual activity of insecticides used. Lost spray percentages were 10.6, 10, 11.3, 10.6, 10.5, 10.3, 10.8, 10.5 & 10.8% sprayed at 7th a.m., while were 11, 10.7, 11.4, 11.8, 10.8, 10.8, 9.7, 11.3 & 11.7% from the total spray volume in the case of Thiamethoxam, Imidacloprid, Deltamthrin, Alpha-Cypermethrin Acetamiprid, Spinosad, Lambda-Cyhalothrin, Chlorfenapyr, and Emamectin benzoate, respectively sprayed at 6th p.m.

11. Relationship between the tested chemicals, spraying time and the mortality percentages of *Hetracris annulosa* and *Locusta migratoria* on *Zea mays* plants:

Bioassay evaluation:

To study the influence of various compounds and spraying techniques before and after application Henderson and Tilton's formula (1955) was adopted to calculate the reduction percentages in the population. Tables (3,5 and 6) showed that, the percentages of reduction of *H. annulosa* and *L. migratoria* 4th and 5th instar nymphs on *zea mays* plants affected by certain insecticides sprayed with certain ground application techniques during the season of 2023 using the total recommended rate. The productivity of the Motorized Knapsack sprayer (Solo) (52.2L./fed.) Sprayer was 15.2 Fed./day.

Table (4): Lost spray on ground, as produced by low volume ground spraying equipment, by using certain insecticides at total recommended rate against 4th and 5th instar nymphs of *Hetracris annulosa* and *Locusta migratoria* during season (2023).

Insecticide	Sprayed at 7 a.m.			Sprayed at 6 p.m.		
	*N /cm² of total spray droplets	N/cm² droplets (on ground)	%N/cm² (ground) / N/Cm² (Plants+ground) x 100	*N/cm² of total spray droplets	N/cm² droplets (on ground)	%N/cm² (ground) / N/Cm² (Plants+ground) x 100
Thiamethoxam	188	20	10.6	146	16	11
Imidacloprid	177	18	10	140	15	10.7
Deltamethrin	203	23	11.3	149	17	11.4
Alpha-Cypermethrin	207	22	10.6	152	18	11.8
Acetamiprid	161	17	10.5	139	15	10.8
Spinosad	184	19	10.3	158	17	10.8
Lambda-Cyhalothrin	193	21	10.8	155	15	9.7
Chlorfenapyr	171	18	10.5	141	16	11.3
Emamectin benzoate	202	22	10.8	162	19	11.7

N / cm² = Number of droplets per square centimeter. * On *zea mays* plants and lost spray on ground

The following remarks and results were obtained:

There was no Phytotoxic effect on *zea mays* leaves after treatments, no change in the leaves color, no leaf curling or flaming up phenomena has happened. Insecticides treated plants revealed the lowest *zea mays* yield loss in comparison with untreated plots; their application reduced the incidence of *H. annulosa* and *L. migratoria* infestation on *zea mays* and decreased the percent loss of *zea mays* yield in all treatments.

Table (5): Reduction percentages in *Hetracris annulosa* nymphs affected by certain insecticides sprayed with certain ground equipment during the season (2023) data were averages of five replicates.

Spraying time treatments	Sprayed at 7 a.m.			Sprayed at 6 p.m.		
	R% Post 24 hours	R% Post 48hours	R% %General Mean	R% Post 24 hours	R% Post 48 hours	R% General Mean
Thiamethoxam	80.6	86.8	83.7	79.2	88	83.6
Imidacloprid	80.4	85.4	82.9	80.6	86.8	83.7
Deltamethrin	93.6	98.8	96.2	93	99.4	96.2
Alpha-Cypermethrin	96.2	99.4	97.8	97.2	99.4	98.3
Acetamiprid	85.4	89.6	87.5	84.6	89.4	87
Spinosad	87.6	91	89.3	87.2	90.6	88.9
Lambda-Cyhalothrin	95.2	98.4	96.8	94.6	99.2	96.9
Chlorfenapyr	78.4	83	80.7	75.4	82.4	78.9
Emamectin benzoate	85	89.4	87.2	85.4	90.6	88
LSD	_	_	4.4366	_	_	6.0385
Significance	_	_	***	_	_	***

R = % Reduction of nymphs

Table (6): Reduction percentages in *Locusta migratoria* nymphs affected by certain insecticides sprayed with certain ground equipment during the season (2023) data were averages of five replicates.

Spraying time treatments	Sprayed at 7 a.m.			Sprayed at 6 p.m.		
	R% Post 24 hours	R% %Post 48hours	R% %General Mean	R% Post 24 hours	R% Post 48 hours	R% General Mean
Thiamethoxam	80	87.8	83.9	80.4	88.2	84.4
Imidacloprid	78.4	87.2	82.8	78	88	83
Deltamethrin	93.8	99.4	96.6	94.4	99.6	97
Alpha-Cypermethrin	95.6	99.6	97.6	95	99.8	97.4
Acetamiprid	79	88.4	83.7	78.2	88.6	83.4
Spinosad	87	91.6	89.3	87.2	91.4	89.3
Lambda-Cyhalothrin	95.8	99.2	97.2	95.2	99.2	97.2
Chlorfenapyr	74.2	81.4	77.8	74.6	81.4	78
Emamectin benzoate	85.2	88	86.6	85	88.6	86.8
LSD	_	_	4.67	_	_	3.8588
Significance	_	_	***	_	_	***

R = % Reduction of nymphs

Field experiments were carried out on infested areas with grasshoppers, *H. annulosa* and *L. migratoria* nymphs in the early season on *z. mays*. For evaluation of the field performance of a Low-Volume spraying machine; a Motorized Knapsack sprayer (Solo) (52.5L/fed.); to spray Thiamethoxam, Imidacloprid, Deltamthrin, Alpha-Cypermethrin Acetamiprid, Spinosad, Lambda-Cyhalothrin, Chlorfenapyr, and Emamectin benzoate, with full recommended dose.

A satisfactory coverage was obtained on *Z. mays* plants, the droplets spectrum obtained in the field experiment was agreed with the optimum droplet sizes mentioned by Himel (1969). Droplet spectrum was 143µm and 167 droplets/cm^2 sprayed at 7th am, 160µm and 133 droplets/cm^2 sprayed at 6th pm, these results agreed with Himel and Moore (1969) in the optimum droplet size to control insects in fields by ground equipment. Alpha-Cypermethrin, Deltamthrin E.C., Lambda-Cyhalothrin and Spinosad 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) and Genidy *et al.* (2005) recommended KZ oil and Pyriproxyfen followed by Agerin by using low volume spraying because reduces the time lost in the process of filling the machines, improves the homogeneity of the spray solution on the plant leaves and saves the lost spray on the ground.

These results are also in agreement with Bakr *et al*. (2014*)* recommendation of using Profenofos followed by Pyriproxyfen and Spinosad with Agromondo motorized knapsack sprayer (20L/fed.) and Morsy *et al.* (2015) who recommended using Carbosolvan, Acetamiprid and Deltamethrin with low volume machines not less than (15 L/fed.) also, Dar (2016) recommendation whenever using Lufenuron followed by Spinosad in controlling cotton leafworm on Clover with low volume machines.

Acetamiprid, Thiaclopride, Thiamethoxam, Profenofos, Flupyradifurone, revealed successful results in controlling both *B. tabaci, E. discipiens* nymphs. Our Dar (2019) and Dar *et al.* (2019) achieved best control results, spray volume per fedan, productivity and rate of performance with Motorized Knapsack sprayers.

The low spray volume and the low percentages of lost spraying between plants about 10.6 %, these results were agreed with Hindy *et al*. (1997), who mentioned that there was a positive correlation relationship between the rate of application and lost spray on the ground. There was a negative complete correlation between droplet sizes and the mean residual of mortality of *H. annulosa* and *L. migratoria* nymphs, and while there was a positive complete correlate between N/cm² and the mean residual of mortality of *H. annulosa* and *L. migratoria* nymphs in all treatments. Spraying at 7^{th} a.m. or 6^{th} p.m., there were no significant differences in mortality percentages for both *H. annulosa* and *L. migratoria* nymphs. Increased droplet numbers per square cm. and decreased volume median diameter were achieved by spraying at 7^{th} a.m., this may be due to low temperature and low relative humidity at this time.

It could be concluded that, using Alpha-Cypermethrin, Deltamthrin E.C., Lambda-Cyhalothrin and Spinosad followed by other compounds with low volume (LV) ground spraying equipment with not less than (52.5 L./fed.) by using recommended doses which revealed successful management against grasshoppers and locusts on *Z. mays* under our local conditions preferred at 7^{th} a.m. for increasing droplet numbers per square cm. for excellent foliage coverage and small volume median diameter made them more stable on plants and easier penetrating insects cuticle for improving grasshoppers and locusts control.

References

Anonymous (1978): Application news for pest control products.Tech.Rep.Ac.6.21, Ciba Geigy, pp. 6.

Badr, A.N.; El-Sisi, G.A. and Abdel Meguid, M.A. (1995): Evaluation of some locally formulated petroleum oils for controlling cotton leaf worm. J. Agric. Sci. Mansoura Univ., 20(5): 2557-2562.

Bakr, R. F.; Hindy, M. A.; Ahmed, N. S.; Genidy, N. A. and Dar, R. A. (2014): Field comparison between droplet distribution and the bioresidual activity of different insecticides against *Spodoptera littoralis* (Boisd) by using certain ground spraying equipment on cotton plants. J. Egypt. Acad. Soc. Biolo. Sci., 7(1):187-193.

Ciba-Geigy (1990): International training courses for the safe and efficient handling and application of plant protection agents. Basle, Swizerland, Application Advisory Service, (12), pp 200.

Dar, R.A. (2016): The relationship between droplet distribution of certain ground sprayers and controlling cotton leafworm *Spodoptera littoralis* (Boisd.) On clover plants. Egyptian Scientific Journal of Pesticides, 2(2): 96-101.

Dar, R.A. (2019): The effect of droplets distribution of insecticides on bioresidual activity of piercing sucking insects (Hemiptera) infesting eggplant by using ground spraying equipment. Egypt. J. Plant Prot. Res. Inst., 2 (2): 278 – 290.

Dar, R.A.; Moustafa, H.Z. and Salem, M.S. (2019): Field studies of different insecticides on cotton seedling pests and their natural enemies by using certain ground spraying equipment at qalyubia governorate. International Journal of Entomology Research ,4 (4): 132-140.

Genidy, N.A.; Bakr, R. F.; Hindy, M. A. and Dar, R. A. (2005): Bioresidual activity of certain insecticides against *Spodoptera littoralis* (Boisd) by using low volume ground spraying equipment on cotton plants. J. Egypt.

Acad. Soc. Enviro. Develop., (A-Entomology), 6(1): 1-21.

Henderson, C. F. and Tilton, E.W. (1955): Tests with acaricides against the brown wheat mite. J. Econ. Entomol., 48:157-161.

Himel, C. M. (1969): The optimum size for insecticide spray droplets. J. Econ. Entomol., 62 (4): 919-925.

Himel, C. M. and Moore, A. D. (1969): Spray droplet size in the control of Spruce. budworm, Boll weevil, Bollworm and Cabbage looper. J. Econ. Entomol. 62 (4): 916-918.

Hindy, M. A. (1992): Qualitative distribution of watery dyed spray produced by certain ground sprayers in cotton. Bull. Ent. Soc., Egypt., 19:221-227.

Hindy, M. A.; El-Sayed, A. M.; Abd El-Salam, S. M. and Samy, M. A. (1997): Qualitative Assessment of certain insecticides applied by different ground sprayers against whitefly, *Bemicia tabaci* (Geen.) on eggplant. Egypt. J. Agric. Res., 75 (3): 565-577.

Hindy, M. A.; Bakr, R. F.; Genidy, N.A. and Dar, R.A. (2004): Qualitative distribution of certain insecticides deposits and artificial targets on the cotton leafworm larvae by using certain ground spraying equipment on cotton plants. J. Egypt. Acad. Soc. Environ. Develop. (A. Entomology), 5 (2): 91-112.

Johnstone, D. R. and Huntington, K. A. (1970): A comparison of visual microscopic methods of spray droplet size measurement using eyepieces employing the image shearing principle and the globe and circle eyepiece graticule. J. Agric. Engene. Res.,15(1):1-10.

Magdoline, A. S.; Mohamed, K. E. and Safwat, H. Y. (1992): Less soil contamination with pesticides through modification and implementation of ground application techniques.Egypt.J.Appl.Sci.,7(7): 157-170.

Matthews, G. A. (1992): Pesticide application methods.2nd edition, Longman Harlow Publ., U.K.,405 PP.

Morsy, A. R.; Dar, R. A. and Hiekel, N. S. (2015): Field comparison between the bioresidual activity and droplets distribution of different insecticides against some piercing and sucking insects infesting tomato seedling by certain ground spraying equipment. Journal Of American Science, 25(4): 1-7.

SAS, (1996): Statistical analysis system. SAS user's guide: statistics. SAS Institute Inc. Editors, Cary, NC.

Showler, A. T. (1993): Desert locust, *Shistocerca gregaria,* Forskal (Orthoptera: Acrididae) campaign in Tunisia,1988. Agricultural Systems,42:311-325.