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Field studies of different insecticides on cotton seedling pests and their natural enemies by using certain ground spraying equipment at qalyubia governorate

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Abstract
Field experiments were carried out in an area of about 16 kirats planted with Cotton varity (Giza 86) during two successive seasons 2018 and 2019 in 12thMay at Qaha Research Station, Plant Protection Research Institute, Qalyoupia governorate. The selected area was split into 10 plots and control plots. Five products were sprayed Acetamiprid, Thiaclopride, Thiamethoxam (Neonicotinoids), Profenofos (OP), and Flupyradifurone (Butenlides) of recommended dose rates and one treatment left without spraying as control by using Motorized Knapsack sprayer (Agromondo) (20 L./Fed.) and Hydraulic sprayer (Matabi) (56 L/Fed.). Data indicated that, all tested compounds induced significant negative influenced on both *Bemisia tabaci* and *Empoasca discipiens* nymphs survival. Profenofos and Flupyradifiurone revealed successful results followed by the other compounds. Results showed that Thiamethoxam and Acetamiprid have lower toxicity and more safe on both *Coccinella undecimpunctata* and *Chrysoprla carnea* Larvae, the natural enemies existed. It could be recommended that using those compounds with LV spraying equipment with not less than (20L/Fed.). The data showed that Motorized Knapsack sprayer (Agromondo) (20 L. Fed.) was the best equipment to control both *Bemisia tabaci* and *Empoasca discipiens* on Cotton.The rate of performance of Knapsack motor sprayer (Cifarilli) was 12 Fed./day. It was the best equipment, but the lowest rate of performance was Hydraulic sprayer (Matabi) since it could spraying only 3.4 Fed. /day.

Keywords: cotton, bio-residual activity, *Bemisia tabaci*, *Empoasca discipiens*, *Coccinella undecimpunctata* and *Chrysoprla carnea* acetamiprid, thiacloprid, thiamethoxam, profenofos, flupyradifurone and, LV ground equipment

1. Introduction
Piercing and sucking insects are dangerous pests which infested Cotton seedling, *Gossypium barbadense*. and cause great hazarads to it. In Egypt, major interest was directed to the type, dosage rate of insecticides used, while a lesser attention was taken to the application methods. A comparative study on the efficiency of different ground sprayers was carried out by (Hindy, 1992 and 1997) [10, 11], who detected a significant variation in the spray deposit due to arrangement of the nozzles, spray volume, spraying type and rate of application. The world global attention was directed to minimization of spraying volumes and the control costs which may be happened by using a cheap and effective insecticides or using developmental ground spraying technique with low application costs per feddan (Magdoline *et. al*., 1992) [13] and (Mathews, 1992). Maintaining sprayers for pesticide application in an excellent state of repairing and proper working in order to reduce their harmful effects on human health and environment Dokic *et al.* (2018) [5] Insects of the family Chrysopidae (Neuroptera) have been reported as having high predatory capacity and adaptation to different ecosystems (Souza and Carvalho 2002; Costa *et al*. 2010) [18, 4]. This work aimed to determine the best insecticide and the best equipment controlling *Bemisia tabaci* and *Empoasca discipiens* nymphs on Cotton with the least hazard to *Coccinella undecimpunctata* and *Chrysoprla carnea* Larvae, the natural enemies of those pests with conservation of agricultural environment.

2. Materials and Methods
2.1 The Tested Compunds
1. Thiaclopride (Calypso ®), 48% S.C. 120 cm^3/ fed., (Neonicotinoids), Acetylcholinesterase inhibitor. Acetamiprid (Plan ex®), 70% W.G., 50 gm /fed, (Neonicotinoids), Acetylcholinesterase inhibitor.
2. Thiamethoxam (Actara®), 25% W.G., 20 gm/100L. (IGRs), (Neonicotinoids), Acetylcholinesterase inhibitor.
3. Profenofos (Feba Croun ®), 72% E.C., 750cm^3/fed. (Organophosphorous) Acetylcholinesterase inhibitor.
4. Flupyradifurone (Sivanto prim ®), 20% S.L.,200cm^3/ fed. (Butenlides) Acetylcholinesterase inhibitor.

2.2 Spraying equipment tested on Cotton
Two ground application equipment were selected to perform the scope of this work as follows
1. Hand-held Hydraulic sprayer (Matabi)Spraying volume (56 L./fed.), Espine made.
2. Pneumatic Motorized Knapsack sprayer (Agromondo) Spraying volume (20 L./fed.), Italy made.

2.3 Execution of field experiments
2.3.1 Arrangements of the experiments
Field experiments were carried out during two successive seasons 2018 and 2019 on 12thMay in Cotton field located at Qaha Research Station, Plant Protection Research Institute, Qalyoubia Governorate. The Cotton cultivated varity was (Giza 86) planted at 15th of Mars in the two seasons, the experiments were done under local meteorological

conditions of 30°C average temperature, 50% average RH and 2 m/sec.as an average wind velocity during spraying operations. The selected area of 16 kirats was split into 10 plots and control plot. The area of each plot was 1.5 kirats, two rows of Cotton plants between treatments were not sprayed as barrier zones to avoid drift spray between treatments, spraying operations have not been done with insecticides before execution the field experiment. All treatments were sprayed with recommended dose rate, eccept one treatment left separated without spraying as a control, with five alternative insecticides, Acetamiprid,,Thiaclopride,Thiamethoxam,Profenofos,Flupy radifurone, respectively. All treatments sprayed as target spraying technique.In each plot five Cotton plants were selected and remarked to define *Bemisia tabaci* and *Empoasca discipiens* nymphs numbers,both *Coccinella undecimpunctata* and *Chrysoprla carnea* Larvae,the natural enemies existed and follow the results before and after one, and five days from spraying.

2.3.2 Bioassay Procedure

Field experiments were conducted on Cotton field highly infested with *Bemisia tabaci*, *Empoasca discipiens*, nymphs and *Coccinella undecimpunctata*, *Chrysoprla carnea* larvae.In order to evaluate the tested compounds on them, pre-treatment count were recorded before spraying at five marked plants for each treatment, and post-treatment counts was recorded after 1,4 days from spraying treatments to determine the effect of the tested chemicals by different spraying equipment.

i) Phytotoxic effect

Determined by recording any colour change, leaf curling or flaming up to 8 days after spraying, according to Badr *et al*. (1995) [2].

ii) Calculation and data analysis

a. Reduction percentages in the field experiment was calculated according Henderson and Tilton (1955) [7] at two seasons.
b. The statistical analysis of results was achived according to SAS (1996) [17] program for Biological studies: Duncan's for biological evaluation of insecticides in field.

iii) Spraying equipment tested on Cotton field

Two ground application equipment were selected to perform the scope of this work, as commonly used equipment in applying pesticides on Cotton. 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) [10].

Table 1: Techno-Operational data of certain ground sprayers applied on Cotton field during seasons (2018-2019).

Equipment	Motorized Knapsack sprayer (Agromondo)	Hydraulic sprayer(Matabi)
Type of atomization	Mechanical Pneumatic	Hydraulic
Nozzle type	Pneumatic	Hollow cone nozzle 80º
Pump type	Centrifugal fan	Hydraulicair pump
Number of nozzles	1	1
Pressure (bar)	-	5
Spray tank (L.)	20	20
Rate of application (L/fed.)	20	56
Working speed (Km/h.)	2.4	2.4
Swath width (m.)	5	1.5
Flow rate (L/min.)	1	0.8
Spray height (m.)	0.5	0.5
Type of Spraying	Target in all sprayers	
Productivity * (fed./h.)	2.85	0.86
Rate of performance* (fed./day)	12	3.4

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

2.4 Calibration and performance adjustment of the tested equipment

2.4.1 Collection of spray deposit

Before spraying each Cotton field treatments, a sampling line was constructed of five wire holder fixed in diagonal line at each treatment to collect the lost spray between plants; each wire holder top has a fixed with water sensitive paper (Novartis Cards) on it. Also, each five Cotton plants, the water sensitive paper cards were put at plant; to collect the droplets deposit on Cotton seedling leaves, were designed according to the method described by Hindy (1989). All cards were collected and transferred carefully to the laboratory for measuring and calculating the number of droplets/cm² and its volume (VMD) µm in all treatments.

2.4.2 Determination of spray deposit

Number and size of blue spots (deposited droplets) on water sensitive papers (Novartis cards) measured with a special scaled monocular Japanies lens (Strüben)® (15X). The volume mean diameter (VMD) µm and number of droplets in one square centimeter (N/cm²) were estimated according to Hindy (1992), the spread factor of sensitive paper was 2.2.

3. Results

3.1 Bioresidual activity of Acetamiprid against *B. tabaci, E. discipiens, C. undecimpunctata* and *C. carnea* on Cotton

Efficiency of Acetamiprid represented as mortality percentages after 24 hours of spraying as presented in Tables (2, 3). The highest reduction in population of *B. tabaci* nymphs was occurred by Motorized Knapsack sprayer (Agromondo) (20 L/fed.) the droplet sizes were 134&156 and N/cm² were 163 &147.The mean mortality percentages after one day of the two seasons (2018,2019) were 94& 89.8 % for initial for recommended dose sprayed with Motorized Knapsack sprayer (Agromondo) and Hydraulic sprayer (Matabi) and the general mean reduction

percentages of two seasons 97 & 94.9% for residual sprayed with Motorized Knapsack sprayer (Agromondo) and Hydraulic sprayer (Matabi), respectively. The highest reduction in population of *E. discipiens* nymphs were occurred by Motorized Knapsack sprayer (Agromondo). The mean mortality percentages of *E. discipiens* nymphs of the two seasons (2018 and 2019) after one day of treatment were 92.7&89.7 % for initial and the general mean reduction percentages of two seasons were 96.4 & 94.9% for residual for recommended dose sprayed with Motorized Knapsack sprayer (Agromondo) and Hydraulic sprayer (Matabi), respectively. The mean mortality percentages of *C.undecimpunctata* larvae of the two seasons (2018,2019) after one day of treatment by using Acetamiprid formulation were 63.5&54,8 % for initial and the general mean reduction % of two seasons were 57.8& 47.6 5% for residual for recommended dose sprayed with Motorized Knapsack sprayer (Agromondo), and Hydraulic sprayer (Matabi), respectively. The mean mortality percentages of *C.carnea* larvae of the two seasons (2018,2019) after one day of treatment by using Acetamiprid formulation were 59.7&56.3 % for initial and the general mean reduction percentages of two seasons were 50 & 45.9% for residual for recommended dose sprayed with Motorized Knapsack sprayer (Agromondo) and Hydraulic sprayer (Matabi), respectively.

Table 2: The relation between droplets distribution obtained by the tested ground spraying equipment and the corresponding mortality of *Bemicia tabaci* on Cotton seedlings during seasons (2018-2019) at Qalubyia.

Insecticide & dose rate/ fed.	Tested sprayer	VMDμm	N / cm^2	% Mortality	
				Initial mean *	Residual mean *
Acetamiprid (50 gm)	Agromondo	134	163	94	97
	Matabi	156	147	89.8	94.9
Thiclopride ($120cm^3$)	Agromondo	122	187	96	98
	Matabi	144	155	92.3	96.2
Thiamethoxam (80 gm)	Agromondo	117	180	92	96
	Matabi	140	162	88.8	94.4
Profenofos ($720 cm^3$)	Agromondo	126	161	100	100
	Matabi	143	150	100	100
Flupyradifurone ($200 cm^3$)	Agromondo	127	163	97.7	98.9
	Matabi	137	154	96	98

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

Table 3: The relation between droplets distribution obtained by the tested ground spraying equipment and the corresponding mortality of *Empoasca dicipiens* on Cotton seedlings during seasons (2018-2019) at Qalubyia.

Insecticide & dose rate/ fed.	Tested sprayer	VMDμm	N / cm^2	% Mortality	
				Initial mean *	Residual mean *
Acetamiprid (50 gm)	Agromondo	134	163	92.7	96.4
	Matabi	156	147	89.7	94.9
Thiclopride ($120 cm^3$)	Agromondo	122	187	93.9	97
	Matabi	144	155	90.6	95.3
Thiamethoxam (80 gm)	Agromondo	117	180	91.3	95.7
	Matabi	140	162	88.2	94.1
Profenofos ($720 cm^3$)	Agromondo	126	161	100	100
	Matabi	143	150	100	100
Flupyradifurone ($200 cm^3$)	Agromondo	127	163	96.5	98.3
	Matabi	137	154	95	97.6

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

3.2 Bioresidual activity of Thiacloprid against *B. tabaci*, *E. discipiens, C. undecimpunctata* and *C. carnea* on Cotton

Efficiency of Thiacloprid represented as mortality percentages after 24 hours of spraying as presented in Tables (2 and 3). The highest reduction in population of *B. tabaci* nymphs was occurred by Motorized Knapsack sprayer (Agromondo) (20 L/fed.) the droplet sizes were 122 & 144 and N/cm^2 were 187&155. The mean mortality percentages after one day of the two seasons (2018 and 2019) were 96 & 92.3% for initial for recommended dose sprayed with Motorized Knapsack sprayer (Agromondo) and Hydraulic sprayer (Matabi),and the general mean reduction percentages of two seasons 98&96.2% for residual sprayed with Motorized Knapsack sprayer (Agromondo) and Hydraulic sprayer (Matabi), respectively. The highest reduction in population of *E. discipiens* nymphs were occurred by Motorized Knapsack sprayer (Agromondo). The mean mortality percentages of *E. discipiens* nymphs of the two seasons (2018 and 2019) after one day of treatment were 93.9 & 90.6 % for initial and the general mean reduction percentages of two seasons were 97 & 95.3 % for residual for recommended dose sprayed with Motorized Knapsack sprayer (Agromondo) and Hydraulic sprayer (Matabi), respectively. The mean mortality percentages of *C. undecimpunctata* larvae of the two seasons (2018 and 2019) after one day of treatment by using Thiacloprid formulation were 69.7 & 66% for initial and the general mean reduction percentages of two seasons were 66 & 62% for residual for recommended dose sprayed with Motorized Knapsack sprayer (Agromondo) and Hydraulic sprayer (Matabi), respectively. The mean mortality percentages of *C. carnea* larvae of the two seasons (2018 and 2019) after one day of treatment by using Thiacloprid formulation were 74.3 & 68.6 % for initial and the general mean reduction percentages of two seasons were 63.7 & 55.6 % for residual for recommended dose sprayed with Motorized Knapsack sprayer (Agromondo) and Hydraulic sprayer (Matabi), respectively.

3.3 Bioresidual activity of Thiamethoxam against *B. tabaci, E. discipiens, C. undecimpunctata* and *C. carnea* on Cotton

Efficiency of Thiamethoxam represented as mortality percentages after 24 hours of spraying as presented in Tables (2 and 3). The highest reduction in population of *B. tabaci* nymphs was occurred by Motorized Knapsack sprayer (Agromondo) (20 L/fed.) the droplet sizes were 117&140 and N/cm^2 were 180 &162. The mean mortality percentages after one day of the two seasons (2018 and 2019) were 92 & 88.8% for initial for recommended dose sprayed with Motorized Knapsack sprayer (Agromondo) and Hydraulic sprayer (Matabi),and the general mean reduction percentages of two seasons 96 & 94.45% for residual sprayed with Motorized Knapsack sprayer (Agromondo) and Hydraulic sprayer (Matabi), respectively. The highest reduction in population of *E. discipiens* nymphs were occurred by Motorized Knapsack sprayer (Agromondo). The mean mortality percentages of *E. discipiens* nymphs of the two seasons (2018, 2019) after one day of treatment were 91.3 &88.2 % for initial and the general mean reduction percentages of two seasons were 95.7&94.1% for residual for recommended dose sprayed with Motorized Knapsack sprayer (Agromondo) and Hydraulic sprayer (Matabi),respectively. The mean mortality percentages of *C. undecimpunctata* larvae of the two seasons (2018, 2019) after one day of treatment by using Thiamethoxam formulation were 56&50% for initial and the general mean reduction percentages of two seasons were 46.3&38% for residual for recommended dose sprayed with Motorized Knapsack sprayer (Agromondo) and Hydraulic sprayer (Matabi), respectively. The mean mortality percentages of *C. carnea* larvae of the two seasons (2018, 2019) after one day of treatment by using Thiamethoxam formulation were 44.4&40.4% for initial and the general mean reduction percentages of two seasons were 35.7&30.8 % for residual for recommended dose sprayed with Motorized Knapsack sprayer (Agromondo) and Hydraulic sprayer (Matabi), respectively.

3.4 Bioresidual activity of profenofos against *B. tabaci, E. discipiens, C. undecimpunctata* and *C. carnea* on Cotton

Efficiency of profenofos represented as mortality percentages after 24 hours of spraying as presented in Tables (2, 3). The highest reduction in population of *B. tabaci*, *E. discipiens* nymphs and *E.discipiens*, *C. undecimpunctata* and *C. carnea* larvae was occurred by Motorized Knapsack sprayer (Agromondo) (20 L/fed.) the droplet sizes were 126&150 and N/cm^2 were 161&130. The mean mortality percentages after one day of the two seasons (2018, 2019) were100 % for initial for recommended dose sprayed with Motorized Knapsack sprayer (Agromondo) and Hydraulic sprayer (Matabi),and the general mean reduction percentages of two seasons 100% for residual sprayed with Motorized Knapsack sprayer (Agromondo) and Hydraulic sprayer (Matabi).

3.5 Bioresidual activity of Flupyradifurone against *B. tabaci, E. discipiens C. undecimpunctata* and *C. carnea*on Cotton

Efficiency of Flupyradifuronere presented as mortality percentages after 24 hours of spraying as presented in Tables (2, 3). The highest reduction in population of *B. tabaci* nymphs was occurred by Motorized Knapsack sprayer (Agromondo) (20 L/fed.) the droplet sizes were 127&137 and N/cm^2 were 163 &154.The mean mortality percentages after one day of the two seasons (2018, 2019) were 97.7&96% for initial for recommended dose sprayed with Motorized Knapsack sprayer (Agromondo) sprayer and Hydraulic sprayer (Matabi) sprayer,and the general mean reduction percentages of two seasons 98.9&98% for residual sprayed with Motorized Knapsack sprayer (Agromondo) and Hydraulic sprayer (Matabi), respectively. The highest reduction in population of *E. discipiens* nymphs were occurred by Motorized Knapsack sprayer (Agromondo). The mean mortality percentages of *E. discipiens* nymphs of the two seasons (2018, 2019) after one day of treatment were 96.5 &95 % for initial and the general mean reduction percentages of two seasons were 98.3&97.6% for residual for recommended dose sprayed with Motorized Knapsack sprayer (Agromondo) and Hydraulic sprayer (Matabi), respectively. The mean mortality percentages of *C. undecimpunctata* larvae of the two seasons (2018, 2019) after one day of treatment by using Flupyradifurone formulation were 100 % for initial and the general mean reduction % of two seasons were 100 % for residual for recommended dose sprayed with Motorized Knapsack sprayer (Agromondo) and Hydraulic sprayer (Matabi). The mean mortality percentages of *C. carnea* larvae of the two seasons (2018, 2019) after one day of treatment by using Flupyradifurone formulation were 84.8 &81.7% for initial and the general mean reduction percentages of two seasons were 77.8&73.4% for residual for recommended dose sprayed with Motorized Knapsack sprayer (Agromondo) and Hydraulic sprayer(Matabi), respectively.

Table 4: Lost spray on ground, as produced by low volume ground spraying equipment, against *B. tabaci* nymphs during seasons (2018-2019).

Insecticide & dose rate / fed.	Tested sprayer & spray volume (L / fed.)	*N / cm^2 of total spray droplets	N / cm^2 droplets lost (on ground)	Volume mean diameter VMD (on ground)	% N/cm^2 (ground) ----------x 100 N/Cm^2 (Plants+ground)	% Mortality	
						Intial mean *	Residual mean *
Acetamiprid (50 gm)	Agromondo(20)	181	18	142	9.9	94	97
	Matabi(56)	172	25	173	14.5	89.8	94.9
Thiclopride (120 cm^3)	Agromondo(20)	207	20	126	9.7	96	98
	Matabi (56)	182	27	179	14.8	92.3	96.2
Thiamethoxam (80 gm)	Agromondo(20)	199	19	129	9.5	92	96
	Matabi (56)	192	30	147	15.6	88.8	94.4
Profenofos (720 cm^3)	Agromondo(20)	177	16	130	9	100	100
	Matabi (56)	179	29	144	16.2	100	100
Flupyradifurone (200 cm^3)	Agromondo(20)	180	17	141	9.4	97.7	98.8
	Matabi (56)	182	28	121	15.4	96	98

N /cm^2 = Number of droplets per square centimeter. * On Cotton and lost spray on ground. *Average of two seasons.

3.6 Relationship between lost spray on ground and the bioresidual activity of insecticides used

Data in Tables (4 &5) showed that there were a negative correlation between lost spray on ground equipment and the bioresidual activity of insecticides used.The mean lost spray produced from Motorized Knapsack sprayer (Agromondo) spray volume (20L\fed.) was 9% and the mean spray lost produced from Hydraulic sprayer (Matabi) spray volume (56L\fed.) was 15%, we extracted that the smaller spray volume the lesser spray lost.

Table 5: Lost spray on ground, as produced by low volume ground spraying equipment, against *E.dicipiens* nymphs during seasons (2018-2019).

Insecticide & dose rate / fed.	Tested sprayer & spray volume (L / fed.)	*N / cm^2 of total spray droplets	N / cm^2 droplets lost (on ground)	Volume mean diameter VMD(on ground)	% N/cm^2 (ground) ----------x 100 N/Cm^2 (Plants+ground)	% Mortality	
						Intial mean *	Residual mean *
Acetamiprid (50 gm)	Agromondo(20)	181	18	142	9.9	92.7	96.4
	Matabi (56)	172	25	173	14.5	89.7	94.9
Thiclopride (120 cm^3)	Agromondo(20)	207	20	126	9.7	93.9	97
	Matabi (56)	182	27	179	14.8	90.6	95.3
Thiamethoxam (80 gm)	Agromondo(20)	199	19	129	9.5	91.3	95.7
	Matabi (56)	192	30	147	15.6	88.2	94.1
Profenofos (720 cm^3)	Agromondo(20)	177	16	130	9	100	100
	Matabi (56)	179	29	144	16.2	100	100
Flupyradifurone (200 cm^3)	Agromondo(20)	180	17	141	9.4	96.5	98.3
	Matabi (56)	182	28	121	15.4	95	97.6

N /cm^2 = Number of droplets per square centimeter. * On Cotton and lost spray on ground. *Average of two seasons.

3.6.1 Lost spray of Motorized Knapsack sprayer (Agromondo)

Data in Tables (4 &5) showed that the lost spray percentages were 9.9, 9.7, 9.5,9& 9.4 % from the total spray volumes in the case of Acetamiprid, Thiaclopride, Thiamethoxam, Profenofos, Flupyradifurone, respectively, and, the general mean reduction percentages of two seasons (2018-2019) were 97,98,96,100 & 98.9 % *B. tabaci* nymphs, were 96.4,97,95.7,100&98.3% *E. discipiens* nymphs at total recommended doses, respectively, in the case of the same insecticides, and the general mean reduction percentages of two seasons of *C.undecimpunctata* larvae were 57.8,66,26.2,100&100%,were 50, 63.7, 35.7, 100 & 77.8% *C. carnea* larvae for the same insecticides, successively.

3.6.2 Lost spray of Hydraulic sprayer (Matabi)

Data in Tables (4 &5) showed that the lost spray percentages were 14.5, 14.8,15.6,16.2&15.4 % from the total spray volumes in the case of Acetamiprid, Thiaclopride, Thiamethoxam, Profenofos, Flupyradifurone, respectively, and, the general mean reduction percentages of two seasons (2018-2019) were 94.9,96.2,94.4, 100 &98% *B. tabaci* nymphs, were 94.9, 95.3,94.1,100&97.6%,were% *E. discipiens* nymphs at total recommended doses, respectively, in the case of the same insecticides, and the general mean reduction percentages of two seasons of *C. undecimpunctata* larvae were 47.6,62,38, 100 &100%, were 45.9, 55.6, 30.8,100 & 73.4% *C. carnea* larvae for the same insecticides,successively. The mean lost spray produced from Motorized Knapsack sprayer (Agromondo) spray volume (20L\fed.) was 9% and the mean spray lost produced from Hydraulic sprayer (Matabi) spray volume (56L\fed.) was 15%, we extracted that the smaller spray volume the lesser spray lost.

3.7 Bioassay evaluation of the relationship between the tested chemicals, techniques, rate of performance fed.\day and the mortality percentages of *B.tabaci and E. discipiensC. undecimpunctata*, and *C. carnea* on Cotton

To study the influence of various compounds and spraying equipment before and after application Hendresson & Tilton's formula (1955) [7] was adopted to calculate the reduction percentages in the population. Tables (6,7,8,9,10,11,12&13) showed that, the percentages of reduction of *B.tabaci*, *E. discipiens* nymphs, *C. undecimpunctata* and *C. carnea* larvae on Cotton affected by certain insecticides sprayed with certain ground application techniques during the seasons of (2018-2019) using total recommended dose rate. The performance rate of Motorized Knapsack sprayer (Agromondo) was 12 Fed./day. It was the best equipment, but the lowest performance rate was Hydraulic sprayer (Matabi) since it could spray only 3.4 Fed. /day.

The following remarks and results were obtained

- There was no Phytotoxic effect on Cotton leaves after treatments, no change in the leaves color, no leaf curling or flaming up phenomena occured.
- Insecticides treated plants revealed the lowest Cotton yield loss in comparison with untreated plots; their application reduced the incidence of whitefly and jassid infestation on Cotton and decreased the percent loss of Cotton yield in all treatments and with all sprayers.
- The natural enemies like lady eleven spots beetel and aphid lion increased again after one weak of treatment till they reach their normal population.
- There was a significant differences between both the distribution percentages of droplets numbers/cm^2 on plants (LSD=3.2 for Acetamiprid, 3. 58 for Thiaclopride and 2.27 for Thiamethoxam, 2.27 for Profenofosand 3.58 for Flupyradifurone) & on land (LSD=2.27 for Acetamiprid, Thiaclopride, Thiamethoxam, Profenofos and Flupyradifurone), There was a significant differences between droplet sizes on plants (LSD=3.58 for Acetamiprid, 2.27 for Thiaclopride and 2.27 for Thiamethoxam, 4.53 for Profenofos and 1.6 for Flupyradifurone) & on land (LSD=2.92for Acetamiprid, 3.58 for Thiaclopride and 1.6 for Thiamethoxam, 3.58 for Profenofos and 2.27 for Flupyradifurone), and There was a significant differences between reduction percentages (LSD=2.05 for Acetamiprid, 3.58 for Thiaclopride and 3.58 for

Table 6: Reduction Percentages in *B.tabaci* nymphs affected by certain insecticides sprayed with certain ground equipment during the season (2018), data were averages of five replicates.

Equipment	Counted nymphs before treatment		% Reduction at the day indicated											
			2nd				5th				General mean			
Ttreatments	Agromondo	Matabi	Agromondo (20 L/fed.)		Matabi (56 L/fed.)		Agromondo (20 L/fed.)		Matabi (56 L/fed.)		Agromondo (20 L/fed.)		Matabi (56 L/fed.)	
			C	%R	C	%R	C	%R	C	%R	C	%R	C	%R
Acetamiprid (50 gm\fed.)	105	100	6	94.3	10	90	0	100	0	100	3	97.2	5	95
Thiclopride (120 cm^3)	111	107	4	96.4	8	92.5	0	100	0	100	2	98.2	4	96.3
Thiamethoxam (80 gm)	103	109	8	92.2	12	89	0	100	0	100	4	96.1	6	94.5
Profenofos (720 cm^3)	102	115	0	100	0	100	-	-	-	-	0	100	0	100
Flupyradifurone (200 cm^3)	106	108	2	98.1	4	96.3	0	100	0	100	1	99	2	98.2
Untreated	104	112	104	-	112	-	103	-	110	-	103.5	-	111	-

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

Table 7: Reduction Percentages in *B. tabaci* nymphs affected by certain insecticides sprayed with certain ground equipment during the season (2019), data were averages of five replicates.

Equipment	Counted nymphs before treatment		% Reduction at the day indicated											
			2nd				5th				General mean			
Ttreatments	Agromondo	Matabi	Agromondo (20 L/fed.)		Matabi (56 L/fed.)		Agromondo (20 L/fed.)		Matabi (56 L/fed.)		Agromondo (20 L/fed.)		Matabi (56 L/fed.)	
			C	%R	C	%R	C	%R	C	%R	C	%R	C	%R
Acetamiprid (50 gm\fed.)	110	105	7	93.6	11	89.5	0	100	0	100	3.5	96.8	5.5	94.8
Thiclopride (120 cm^3)	116	112	5	95.7	9	92	0	100	0	100	2.5	97.9	4.5	96
Thiamethoxam (80 gm)	108	114	9	91.7	13	88.6	0	100	0	100	4.5	95.9	6.5	94.3
Profenofos (720 cm^3)	107	120	0	100	0	100	-	-	-	-	0	100	0	100
Flupyradifurone (200 cm^3)	111	113	3	97.3	5	95.6	0	100	0	100	1.5	98.7	2.5	97.8
Untreated	109	117	109	-	112	-	107	-	115	-	108	-	116	-

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

Table 8: Reduction Percentages in *E.disipiens* nymphs affected by certain insecticides sprayed with certain ground equipment during the season (2018), data were averages of five replicates.

Equipment	Counted nymphs before treatment		% Reduction at the day indicated											
			2nd				5th				General mean			
Ttreatments	Agromondo	Matabi	Agromondo (20 L/fed.)		Matabi (56 L/fed.)		Agromondo (20 L/fed.)		Matabi (56 L/fed.)		Agromondo (20 L/fed.)		Matabi (56 L/fed.)	
			C	%R	C	%R	C	%R	C	%R	C	%R	C	%R
Acetamiprid (50 gm\fed.)	127	119	9	92.9	12	89.9	0	100	0	100	4.5	96.5	6	95
Thiclopride (120 cm^3)	120	130	7	94.2	12	90.8	0	100	0	100	3.5	97.1	6	95.4
Thiamethoxam (80 gm)	118	128	10	91.5	15	88.3	0	100	0	100	5	95.8	7.5	94.2
Profenofos (720 cm^3)	122	125	0	100	0	100	-	-	-	-	0	100	0	100
Flupyradifurone (200 cm^3)	126	129	4	96.8	6	95.3	0	100	0	100	2	98.4	3	97.7
Untreated	130	125	130	-	125	-	128	-	123	-	129	-	124	-

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

Table 9: Reduction Percentages in *E.disipiens* nymphs affected by certain insecticides sprayed with certain ground equipment during the season (2019), data were averages of five replicates.

Equipment	Counted nymphs before treatment		% Reduction at the day indicated											
			2nd				5th				General mean			
Ttreatments	Agromondo	Matabi	Agromondo (20 L/fed.)		Matabi (56 L/fed.)		Agromondo (20 L/fed.)		Matabi (56 L/fed.)		Agromondo (20 L/fed.)		Matabi (56 L/fed.)	
			C	%R	C	%R	C	%R	C	%R	C	%R	C	%R
Acetamiprid (50 gm\fed.)	132	124	10	92.4	13	89.5	0	100	0	100	5	96.2	6.5	94.8
Thiclopride (120 cm^3)	125	135	8	93.6	13	90.4	0	100	0	100	4	96.8	6.5	95.2
Thiamethoxam (80 gm)	123	133	11	91	16	88	0	100	0	100	5.5	95.5	8	94
Profenofos (720 cm^3)	127	130	0	100	0	100	-	-	-	-	0	100	0	100
Flupyradifurone (200 cm^3)	131	134	5	96.2	7	94.8	0	100	0	100	2.5	89.1	3.5	97.4
Un treated	135	130	135	-	130	-	133	-	128	-	134	-	129	-

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

Table 10: Reduction Percentages in *C.undecimpunctata* larvae affected by certain insecticides sprayed with certain ground equipment during the season (2018), data were averages of five replicates.

Equipment	Counted larvae before treatment		% Reduction at the day indicated											
			2nd				5th				General mean			
Ttreatments	Agromondo	Matabi	Agromondo (20 L/fed.)		Matabi (56 L/fed.)		Agromondo (20 L/fed.)		Matabi (56 L/fed.)		Agromondo (20 L/fed.)		Matabi (56 L/fed.)	
			C	%R	C	%R	C	%R	C	%R	C	%R	C	%R
Acetamiprid (50 gm\fed.)	25	20	9	64	9	55	12	32	12	40	10.5	58	10.5	47.5
Thiclopride (120 cm^3)	27	25	8	70.4	8	68	10	63	10	60	9	66.6	9	64
Thiamethoxam (80 gm)	22	20	10	54.5	10	50	15	32	15	25	12.5	44.5	12.5	37.5
Profenofos (720 cm^3)	26	21	0	100	0	100	0	100	0	100	0	100	0	100
Flupyradifurone (200 cm^3)	30	28	0	100	0	100	0	100	0	100	0	100	0	100
Un treated	29	26	29	-	26	-	31	-	28	-	30	-	27	-

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

Table 11: Reduction Percentages in *C. undecimpunctata* larvae affected by certain insecticides sprayed with certain ground equipment during the season (2019), data were averages of five replicates.

Equipment	Counted larvae before treatment			% Reduction at the day indicated										
				2nd				5th			General mean			
Ttreatments	Agromondo	Matabi		Agromondo (20 L/fed.)		Matabi (56 L/fed.)		Agromondo (20 L/fed.)		Matabi (56 L/fed.)		Agromondo (20 L/fed.)		Matabi (56 L/fed.)	
			C	%R		C	%R	C	%R	C	%R	C	%R	C	%R
Acetamiprid (50 gm\fed.)	27	22	10	63		10	54.5	13	52	13	41	11.5	57.5	11.5	47.7
Thiclopride (120 cm^3)	29	25	9	69		9	64	11	62	11	56	10	65.5	10	60
Thiamethoxam (80 gm)	26	22	11	57.7		11	50	16	38.5	16	27.3	13.5	48.1	13.5	38.6
Profenofos (720 cm^3)	23	20	0	100		0	100	0	100	0	100	0	100	0	100
Flupyradifurone (200 cm^3)	32	30	0	100		0	100	0	100	0	100	0	100	0	100
Un treated	31	28	31	-		28	-	33	-	30	-	32	-	29	-

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

Table 12: Reduction Percentages in *C. carena* larvae affected by certain insecticides sprayed with certain ground equipment during the season (2018), data were averages of five replicates.

Equipment	Counted larvae before treatment		% Reduction at the day indicated											
			2nd				5th				General mean			
Ttreatments	Agromondo	Matabi	Agromondo (20 L/fed.)		Matabi (56 L/fed.)		Agromondo (20 L/fed.)		Matabi (56 L/fed.)		Agromondo (20 L/fed.)		Matabi (56 L/fed.)	
			C	%R	C	%R	C	%R	C	%R	C	%R	C	%R
Acetamiprid (50 gm\fed.)	25	24	10	60	10	58.4	15	40	15	37.5	12.5	50	12.5	48
Thiclopride (120 cm^3)	32	26	8	75	8	69.2	15	53.1	15	42.3	11.5	64	11.5	55.8
Thiamethoxam (80 gm)	27	25	15	44	15	40	20	26	20	20	17.5	35.2	17.5	30
Profenofos (720 cm^3)	26	27	0	100	0	100	0	100	0	100	0	100	0	100
Flupyradifurone (200 cm^3)	35	29	5	85.8	5	82.8	10	71.4	10	65.5	7.5	78.6	7.5	74.1
Un treated	34	31	34	-	31	-	36	-	33	-	35	-	32	-

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

Table 13: Reduction Percentages in *C. carena* larvae affected by certain insecticides sprayed with certain ground equipment during the season (2019), data were averages of five replicates.

Equipment	Counted larvae before treatment		% Reduction at the day indicated											
			2nd				5th				General mean			
Ttreatments	Agromondo	Matabi	Agromondo (20 L/fed.)		Matabi (56 L/fed.)		Agromondo (20 L/fed.)		Matabi (56 L/fed.)		Agromondo (20 L/fed.)		Matabi (56 L/fed.)	
			C	%R	C	%R	C	%R	C	%R	C	%R	C	%R
Acetamiprid (50 gm\fed.)	27	24	11	59.3	11	54.2	16	40.7	16	33.3	13.5	50	13.5	43.7
Thiclopride (120 cm^3)	34	28	9	73.5	9	68	16	53	16	43	12.5	63.3	12.5	55.4
Thiamethoxam (80 gm)	29	27	16	44.8	16	40.7	21	27.6	21	22.3	18.5	36.2	18.5	31.5
Profenofos (720 cm^3)	28	26	0	100	0	100	0	100	0	100	0	100	0	100
Flupyradifurone (200 cm^3)	37	31	6	83.8	6	80.6	11	70.3	11	64.5	8.5	77	8.5	72.6
Un treated	36	33	36	-	33	-	38	-	35	-	37	-	34	-

C = Count of life larvae after treatment., R = % Reduction of larvae.

Thiamethoxam, 0 for Profenofos and 3.58 for Flupyradifurone), for white fly and (LSD=1.12 for Acetamiprid, 3.4 for Thiaclopride and 3.4 for Thiamethoxam, 0 for Profenofos and 2.89 for Flupyradifurone) for jassid. and (LSD=3.45 for Acetamiprid, 2.26 for Thiaclopride and 2.26 for Thiamethoxam, 0 for Profenofos and Flupyradifurone), for lady eleven spots beetle and (LSD=4.02 for Acetamiprid, 3.02 for Thiaclopride and 2.92 for Thiamethoxam, 0 for Profenofos and 1.7 for Flupyradifurone),for aphid lion.

4. Discussion and Conclusion

Field experiment was carried out on infested area with whitefly, *B. tabaci*, jassid *E. discipiens* nymphs, and their natural enemies existed; lady eleven spots *C. undecimpunctata* and aphid lion *C.carnea* larvae at early season on Cotton seedling. For evaluation the field performance of Low-Volume spraying machines; Motorized Knapsack sprayer (Agromondo) (20 L/fed.) and Hydraulic sprayer (Matabi) (56 L./fed.); to spray Acetamiprid, Thiaclopride, Thiamethoxam, Profenofos, Flupyradifurone, with full recommended dose. A satisfactory coverage was obtained on Cotton, the droplets spectrum was obtained in field experiment was agreed with the optimum droplet sizes which mentioned by Himel (1969) [8]. The best obtained result was 20 L/fed. as spray volume, and droplet spectrum were 135µm and 163 droplets/$cm^{2,}$ these results agreed with (Himel *et. al.,* 1969) [9] in the optimum droplet size to control cotton leafworm in cotton fields by ground equipment. Profenofos and Flupyradifiurone revealed the best bioefficiacy results with the two equipment followed by the other compounds, and these results agreed with Hindy *et al.* (2004) [12], Genidy *et al.* (2005) [6] which 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) [3] recommendation by using Profenofos followed by Pyriproxyfen and Spinosad with Agromondo motorized knapsack sprayer(20L/fed.) and Morsy *et al.* (2015) [1] whom recommended using Carbosolvan, Acetamiprid and Deltamethrin with low volume machines not less than (15 L/fed.), also Dar (2016) [15] recommendation 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 *B.tabaci, E. discipiens nymphs*.Also, Thiamethoxam and Acetamiprid have lower toxicity and more safe on both *Coccinella undecimpunctata* and *Chrysoprla carnea* Larvae,the natural enemies sexisted,this results were in agreement with Tabozada (2013) [19] who reviewed that Thiamethoxam has more indirect toxicity than Thiaclopride on *Chrysoperla carnea* Larvae and affected the predation capacity on *Tutaabsoluta* larvae. Also, Dar (2016) [15] who reported that, Profenofos was more toxic to *Chrysoprla carnea* Larvae than other insecticides.

Finnally, it could be recommended that using those compounds with LV spraying equipment with not less than (20L/Fed.).The data showed that Motorized Knapsack sprayer (Agromondo) (20 L.Fed.) was the best equipment to control both *Bemisia tabaci* and *Empoasca discipiens* on Cotton. The rate of performance of Motorized Knapsack sprayer (Agromondo) was 12 Fed./day. It was the best equipment, Also, the lowest spray volume and the lowest percentages of lost spraying between plants about 9%, but the lowest rate of performance was Hydraulic sprayer (Matabi) since it could spraying only 3.4 Fed./day,and spray lost about 15%, this results were agreed with Hindy *et al.* (1997) [11], who mentioned that, there was a positive correlation relationship between rate of application and lost spray on ground.

It could be concluded that, using Thiamethoxam and Acetamiprid followed by other compounds with low volume (LV) ground spraying equipment with not less than (20L./fed.) by using recommended doses which revealed successful management against piercing and sucking insects on Cotton under our local conditions and make a lesser harm to natural enemies to protect the natural equilibrium of environment.We hope that, in farther work we may use 3\4 or 1\2 recommended dose in order to keep the natural enemies in their natural counts.

There was a negative complete correlation between droplet sizes and the mean residual of mortality of *B. tabaci, E. discipiens* nymphs, *C. undecimpunctata* larvae, and while there was a positive complete correlate between N/cm^2 and the mean residual of mortality of *B. tabaci, E. discipiens* nymphs, *C. undecimpunctata, C. carnea* larvae in all treatments.

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