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Evaluation of three different spraying volumes produced from two variables technique against tomato whitefly *Bemisia tabaci* (Hemiptera: Aleyrodidae) and cotton aphid *Aphis gossypii* (Hemiptera: Aphididae) infesting marrows plants

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Abstract:

Current experiment was carried out at the New Salheia, El-Sharkyia Governorate, during agricultural seasons 2017/2018. The work aims to evaluate the effect of technique type (Air atomization and hydraulic atomization) on four insecticides (Buprofezin, imidacloprid, mineral oil and MTI-446) efficiency against tomato whitefly *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) and cotton aphid *Aphis gossypii* (Glover) (Hemiptera: Aphididae) on marrows plants. Besides, evaluate the loss of land. Three equipment were tested; Knapsack motor sprayer (Oleo Mac) with spray volume 42.7L., Electric battery sprayer fitted with hollow cone nozzle Tx-6 with spray volume 55.13L. and Conventional sprayer with spray volume 200L. The result obtained showed that inverse fit between spray with high volume and the efficiency of spraying. So, the conventional sprayer recorded a low reduction of pests while, the Knapsack motor gave a high reduction compared with conventional sprayer, but Electric battery with Tx-6 nozzle give the highly reduction.

Introduction

Marrows are one of the most important vegetables cultivated under all conditions in Egypt. Fruits are consumed as vegetables or dessert (pie) and seeds as nuts and to a lesser extent as cooking oil (Lazos, 1986 and 1992). Because of their resistance to drought and the high protein (23-35%) and oil (25-55%) contents of their seeds. Marrows have attracted the attention of many growers and plant breeders within the past 50 years (Curtis, 1946; Bemis *et al*., 1978 and Scheerens *et al.*, 1991). According to FAO (2012), the Egyptian production for marrows was 658.234 metric tons. The cultivated area with this crop increased during the last two decades, especially in new reclaimed regions in both open and protected plantation. Throughout the growing season, cucurbit plants are suffering from a severe infestation with different phytophagous insect pests such as cotton aphid *Aphis gossypii* (Glover) (Hemiptera: Aphididae) and the tomato whitefly *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) which considered the most common and dangerous insect pests of cucurbit plants. In case of heavy infestation, these pests cause serious damage

to plants, leading to greater reduction in the final yield (Hanafy, 2004).

In Egypt, pest control through chemical spraying is highly needed to reduce the annual losses in crops caused particularly by pests. Four types of insecticides have been recommended to control piercing-sucking insects, aphids and whiteflies. Insecticides efficiency depends on the spray spectrum (Number and size of droplets) (Palti and Ausher , 1986), which in turn depends on suitable techniques used. So, this study compared the efficiency of three equipment , air atomization technique (Knapsack motor sprayer (Oleo Mac) with 42.7L/fed., pressure or pneumatic atomization, Electric battery sprayer fitted with flat fan nozzle Tx-6) with 55.13 L/fed. and pressure or hydraulic atomization and (Conventional sprayer) with 200L/fed).

Therefore, this study aimed to evaluate the above mentioned application techniques on spraying efficiency, volume median diameter, number of droplets/cm² and loss of land.

Materials and methods

Marrows hybrids, variety new iskandarani (H1) was used in this study for manual planting were planted in ridges the distance between each ridge was 80cm. and row spacing between the plants was 50cm., this variety is recommended in Egypt. The experiment was carried out in a rectangular shape area about 52 kerates. Marrows area is planted by hand in ridges. The experiment area divided into thirteen plots area of plot 700m². (58.3x12m.) and left 6m.between each plot (Treatment) and the other for measure the drift spray. Twelve plots for treatment and one for control, 4 kerates for each treatment. Four recommended insecticides were tested. Buprofezin (Applaud 25% SC with recommended rate 600cm/fed.), imidacloprid (Avenue 70%WG with recommended rate 120gm./fed.), mineral oil (Chemisol with recommended rate 1.5 liter/100liter water) and MTI-446 20% W.P. with recommended rate 100gm/100-liter water.

1. Equipment spraying machinery:

Equipment spraying machinery used (Table 1) in this investigation and specification of equipment as follow:

Table (1): Technical data of three spraying equipment's.

Items	Knapsack motor sprayer (Oleo mac), Tip 3	Electric battery sprayer fitted with hollow cone nozzle (Tx-6)	Conventional Sprayer
Type of sprayer	**Pneumatic**	**Hydraulic**	**Hydraulic**
Spray tank (L).	14	20	20
Flow rate, (l/min.)	2.033	0.525	1.905
Rate of application,(L/fed.)	42.7	55.13	200
Spray height, (m)	0.50	0.50	0.50
Swath width, (m)	5	1.0	1.0
Working speed, (Km/h.)	3	2.4	2.4
Type of spray used	Target	Target	Target
Productivity, (fed/h.)	2.86	0.57	0.57
Rate of performance (fed/day.)	11.44	2.28	2.28

Productivity, (fed/h.)= $\frac{60*speed*swath\ wides}{4200}$

Rate of performance/day= Productivity, (fed/h.)* (6) * $\frac{2}{3}$**).**

1.1. Knapsack Motor Sprayer (Oleo Mac): This equipment has a 14 liter tank capacity, with spray volume 42.7, the air outlet velocity about 120 m/s, with cool air. While, the rate of air discharge is about 16 m^3/min., the flow rate is 2.033 liters /min. and the swath width are 5 m.

1.2. Electric battery sprayer fitted with hollow cone nozzle (Tx-6): It has a 20 liter liquid tank capacity, and diaphragm pump motor operated without air chamber. The power consumption for 4.5 hrs continuous operation is batter 12 volts, the spray volume is 55.13 L., flow rate is 0.525 L./min. and swath width is 0.75m.

1.3. Conventional Sprayer: Fitted with one hydraulic nozzle of conical spray pattern. It has a 20 liter liquid tank capacity, the spray volume is 200 L., flow rate is 1.905 L./min. and swath width is 1m.

2. Description of sampling line: Six plots were sprayed, and one was left for control. The sampling line consisted of 5 wires holders fix at one (m.). In diagonal line inside each treatment to collected sprayer chemicals. Sensitive paper cards double with the wire holder were fixed in "L" shape on the top of wire holders to measure the distribution ratio on the upper and lower surface of the sensitive paper. Three sensitive paper cards double were distribution on some plants (Right, middle, and left) at distance of one meter to measure the distributed on the upper and lower surface at five plants.In addition to one sensitive paper card was placed under each plant to measure loss of land. All cards were numbered, collected and transferred carefully to the laboratory for measurement the volume and number of deposited droplets per cm^2 by the above mentioned Strubin lens. Therefore, calculate the VMD of droplets.

Results were recorded, in ten successive classes with a range of 50microns. Volume median diameter (VMD) value was calculated according to the following equation Gabir (1978).

V.M.D= $[\sum_i^n = 1(nixi3)/\sum_i^n = 1ni]\frac{1}{3}$

Where:

Xi= droplet diameter for a given size class (1) µm

$\sum^{n} i$

$=$ total number of droplet, in all droplets categories

3. Laboratory coverage for used equipment (Table 2) :

Table (2): Spray coverage on artificial targets as produced by electric battery sprayer and knapsack motor sprayer Oleo Mac (AM 180).

Equipment				Electricbattery sprayer			Knapsack motor Sprayer (Oleo mac)		
Nozzle				Hollow cone Tx-6			Tip3		
Spray Volume (L/fed)				55.13			42.7		
Droplets spectrum Spray parameter				VMD µm	N/cm²	%N	VMD µm	N/cm²	%N
Working speed (2.4 km/h)	Spray height	(0.30m.)	Upper	150	104	67%	146	91	75.2%
			Lower	101	51	33%	107	30	24.8%
		(0.50m.)	Upper	115	102	63.8%	153	92	68.7%
			Lower	101	58	36.2%	99	42	31.3%
Working speed (3km/h)		(0.30m.)	Upper	138	76	69.7%	155	93	72%
			Lower	79	33	30.3%	116	36	28%
		(0.50m.)	Upper	12	72	72%	148	85	72%
			Lower	87	28	28%	106	33	28%

The air temperature in the field at 3.6.2017 and 10.5.2018 were 31°C and 34°C respectively, while relative humidity was 68% and 73%. Measurements used described by Barry (1978). A simple anemometer has a pith ball which moves up at vertical tube according to the strength of the wind "Dwyer's anemometer".The wind velocity: Face the wind hold meter in front of you in vertical position and with scale side toward. Do not block bottom holes. Height of ball indicates wind velocity for high scale, cover hole at extreme top with finger.

4. Determination of spray deposit:

Number and size spots (Droplets) on Ciba-Geigy sensitive cards will be measured with a special scaled monocular lens (Struben) with a magnification of X 15. This is a hand lens which gives a direct measurement because it magnifies both the spot and scale at the same rate, scales 6 mm in 60 parts, and diameter 7 mm.The area of its field =0.432 cm². Obtained data was corrected (By knowledge of the spread factor) and is calculated to obtain the Volumemedian diameter of droplets (VMD) and the number of these droplets in one square centimeter (N/cm²), according to Gabir (1995).

5. Bioassay of whitefly and aphids:

Samples of 25 plants were chosen randomly from each replicate before treatment and at 1, 3, 7 and 15 days after pesticides application. The number of target insects was counted. Percentage of the insect population was calculated according to Henderson and Tilton (1955). Comparing differences mean, the main effect and independent factors interaction were analyzed throughout Spss,program version 19.

Results and discussions

Data in Table (2) showed that the best coverage of each equipment at laboratory, electric battery sprayer with hollow cone Tx-6 nozzles gave the best coverage at working speed 2.4km/h and spray height 0.5m. while, Knapsack motor sprayer (Oleo Mac) tip 3 gave the best coverage at working speed 3km/h and spray height 0.5m. So, these parameters were used at field work.

1. Qualitative assessment of techniques:

The evaluation of techniques was based on volume median diameter (VMD) (µm) and number of droplets (N/cm²), and the effect of them on reduction percentage. this well be on both a horizontal card on leaves for the plant right, middle and left,it was calculated as follows upper and lower of surfaces the card while, on the land loss was calculated on upper surface the card.

1.1. Knapsack motor sprayer (Oleo Mac), (Air atomization technique):

Data of effect of different equipment used on spray spectrum (Volume and size) at spray volumes of equipment, with pesticides used. Volume median diameter and number of droplets with four different pesticides and loss of land are given in Table (3). The obtained results showed that the volume median diameter and number of droplets decreased on lower surface and increased on upper surface for plants while, increases the volume median diameter and decreased the number of droplets on the land loss with two types of pesticides.

Table (3): The effect of equipment used on volume median diameter and number of droplets with the pesticides used.

Pesticides	Spray spectrum	Knapsack motor sprayer (Oleo Mac) (42.7L.)			Electric battery sprayer, with Tx-6 (55.13L.)			Conventional sprayer (200 L.)		
		Plant level		Loss of land	Plant level		Loss of land	Plant level		Loss of land
		Upper	Lower		Upper	Lower		Upper	Lower	
Buprofezin	VMDµm	118	**84**	**149**	**103.7**	**87.7**	**142**	**482**	**168.7**	519
	N/cm²	63	35	27	75	38	36	24	21	18
	% N	50.4%	28%	21.6%	50.3%	25.5%	24.2%	38.1%	33.3%	28.6%
Imidacloprid	VMDµm	108	89	158	133	84.7	133	467.3	146.3	518
	N/cm²	62	36	20	68	39	38	27	19	19
	% N	52.5%	30.5%	17%	46.9%	26.9%	26.2%	41.5%	29.2%	29.3%
Mineral oil	VMDµm	139	105	102	150	130	126	630	0	602
	N/cm²	135	36	18	64	22	8	8	0	4
	% N	71.4%	19%	9.6%	68.1%	23.4%	8.5%	66.7%	0%	33.3%
MTI-446	VMDµm	163	126	130	172	140	136	615	0	610
	N/cm²	170	37	22	67	29	11	11	0	6
	% N	74.2%	16.2%	9.6%	62.6%	27.1%	10.3%	64.7%	0%	35.3%

VMD: volume median diameter, N/cm^2: number of droplets / cm^2,
N%: percentage number of droplets

Effect of Knapsack motor sprayer (Oleo Mac) at 42.7 L/fed on volume median diameter and number of droplets:

The results which obtained in Table (3) obvious that Applaud 25% SC (Buprofezin), the volume median diameter and number of droplets on upper and lower surface of plant leaves was (118 and 84µm), (63and 35N/cm²), respectively. Meanwhile, the droplet loosed of land was 149µm, 27N/cm^2. With Avenue 70% WG (Imidacloprid), the volume median diameter and number of droplets on upper and lower surface of plant leaves was (108 and 89µm), (62and 36N/cm²), respectively. Meanwhile, the droplet loosed of land was 158µm, 20N/cm2.With Chemisol (mineral oil),the volume median diameter and number of droplets on upper and lower surface of plant leaves was (139 and 105µm), (135and 36N/cm²), respectively. Meanwhile, the droplet loosed of land was 102µm, 18N/cm^2.With (MTI-446), the volume median diameter and number of droplets on upper and lower surface of plant leaves was (163 and 126µm), (170and 37N/cm²), respectively. Meanwhile, the droplets loosed of land was 130µm, 22N/cm^2.

1.2. Electric battery sprayer fitted with hollow cone nozzle (Tx-6) (Hydraulic atomization technique) at 55.13 L/fed:

Also, in Table (3) Applaud 25% SC (Buprofezin), the volume median diameter and number of droplets on upper and lower surface of plant leaves was (103.7 and 87.7µm), (75and 38N/cm²), respectively. Meanwhile, the droplet loosed of land was142µm, 36N/cm^2. With Avenue 70% WG (Imidacloprid), the volume median diameter and number of droplets on upper and lower surface of plant leaves was (133 and 84.7µm), (68and 39N/cm²), respectively. Meanwhile, the droplet loosed of land was 133µm, 38N/cm2.With Chemisol (mineral oil), the volume median diameter and number of droplets on upper and lower surface of plant leaves was (150 and 130µm), (64and 22N/cm²), respectively. Meanwhile, the droplet loosed of land was 126µm, 8N/cm^2. With (MTI-446), the volume median diameter and number of droplets on upper and lower surface of plant leaves was (172

and 140µm), (67and 29N/cm²), respectively. Meanwhile, the droplet loosed of land was 136µm, 11N/cm^2.

1.3. Conventional Sprayer (Hydraulic atomization technique) at spray rate 200L/fed:

Also, in Table (3) Applaud 25% SC (Buprofezin), the volume median diameter and number of droplets on upper and lower surface of plant leaves was (482 and 168.7µm), (24and 21N/cm²), respectively. Meanwhile, the droplets loosed of land was 519µm, 18N/cm^2. With Avenue 70% WG (Imidacloprid), the volume median diameter and number of droplets on upper and lower surface of plant leaves was (467.3 and 146.3µm), (27and 19N/cm²), respectively. Meanwhile, the droplet loosed of land was 518µm, 19N/cm2. With Chemisol (mineral oil) ,the volume median diameter and number of droplets on upper and lower surface of plant leaves was (630 and 0µm), (8and 0N/cm²), respectively. Meanwhile, the droplet loosed of land was 602µm, 4N/cm^2. With (MTI-446), the volume median diameter and number of droplets on upper and lower surface of plant leaves was (615 and 0µm), (11 and 0N/cm²), respectively. Meanwhile, the droplet loosed of land was 610µm, 6N/cm^2.

From these results it could be stated that inverse fit between spray with high volume and the efficiency of spraying. So, the conventional sprayer recorded low reduction of pests while, the Knapsack motor gave high reduction compared with conventional sprayer, but Electric battery with Tx-6 nozzle give the highly reduction. These results are closely related with those obtained by Ammar *et al.* (2018) they used two equipment for control wheat aphid, *Rhopalosiphum padi*, the first equipment, knapsack sprayer (3WDB) with battery charge and fitted with flat fan nozzle. The second equipment, Knapsack motor sprayer (IE34F) with hydraulic pump and spray gun, to determine the effect of application methods on initial and late biological efficacy of Imidacloprid and Dinotefuran against wheat aphid.Results indicated that, Knapsack motor sprayer showed less initial efficacy compared with knapsack sprayer. Although the Imidacloprid pesticide gives high efficacy compared with Dinotefuran pesticide. The author noticed that the main obtained differences were Imidacloprid with knapsack sprayer gave the highest efficacy with a significant difference compared with Dinotefuran with Knapsack motor sprayer.

2. Biological assessment of techniques:

Efficiency of the applied insecticides against aphids and whitefly infesting marrows plants: Data in Tables (4 and 5) and graphically illustrated in Figures (1 and 2) showed the initial effect (after 24 hrs.) and average % reduction (7, 15 and 30 days after application). Buprofezin showed slight increase in reduction percent compared to Imidacloprid. While, the greatest effect was obtained after 7 days of application, followed by 15 day and 30 day, respectively. Similar trend was observed with *B. tabaci* the tested insecticides showed similar reduction percent profile. With the least reduction percent initial and greatest reduction percent after 7 days.

Table (4): Effect of pesticides used against cotton aphid *Aphis gossypii* infesting marrows plants with various ground application techniques during seasons (2017/ 2018)

Pesticide	Date	Knapsack motor sprayer (Oleo Mac)	Electric Battery sprayer fitted with hollow cone nozzle (Tx-6)	Conventional sprayer
(Buprofezin) Applaud 25% SC	Pre-count	34.15	26.00	60.50
	Initial effect	66.07 **d**	81.84 **b**	96.24 **a**
	Mean residual effect	75.91 **b**	88.89 **ab**	80.83 **a**
	Average % reduction	**73.94 b**	**87.41 a**	**83.92 a**
(Imidacloprid) Avenue 70% WG	Pre-count	55.50	38.30	34.60
	Initial effect	72.81 **c**	80.59 **b**	69.54 **d**
	Mean residual effect	71.60 **ac**	87.55 **bc**	80.68 **b**
	Average % reduction	**71.68 bc**	**86.16 d**	**78.45 c**
(Mineral oil) Chemisol	Pre-count	34.00	39.40	35.70
	Initial effect	48.72 **c**	80.26 **b**	71.02 **d**
	Mean residual effect	74.52 **b**	86.62 **cd**	80.33 **b**
	Average % reduction	**69.36 c**	**84.86 c**	**78.47 c**
MTI-446 (20%) WP	Pre-count	45.00	38.20	26.20
	Initial effect	75.72 **b**	87.84 **a**	79.34 **c**
	Mean residual effect	78.49 **a**	90.51 **a**	80.31 **b**
	Average % reduction	**77.93 a**	**89.97 c**	**80.12 b**

N.B: Initial effect: after application with 24 hours. Mean residual effect: after application with (1, 3, 7 and 15 days).

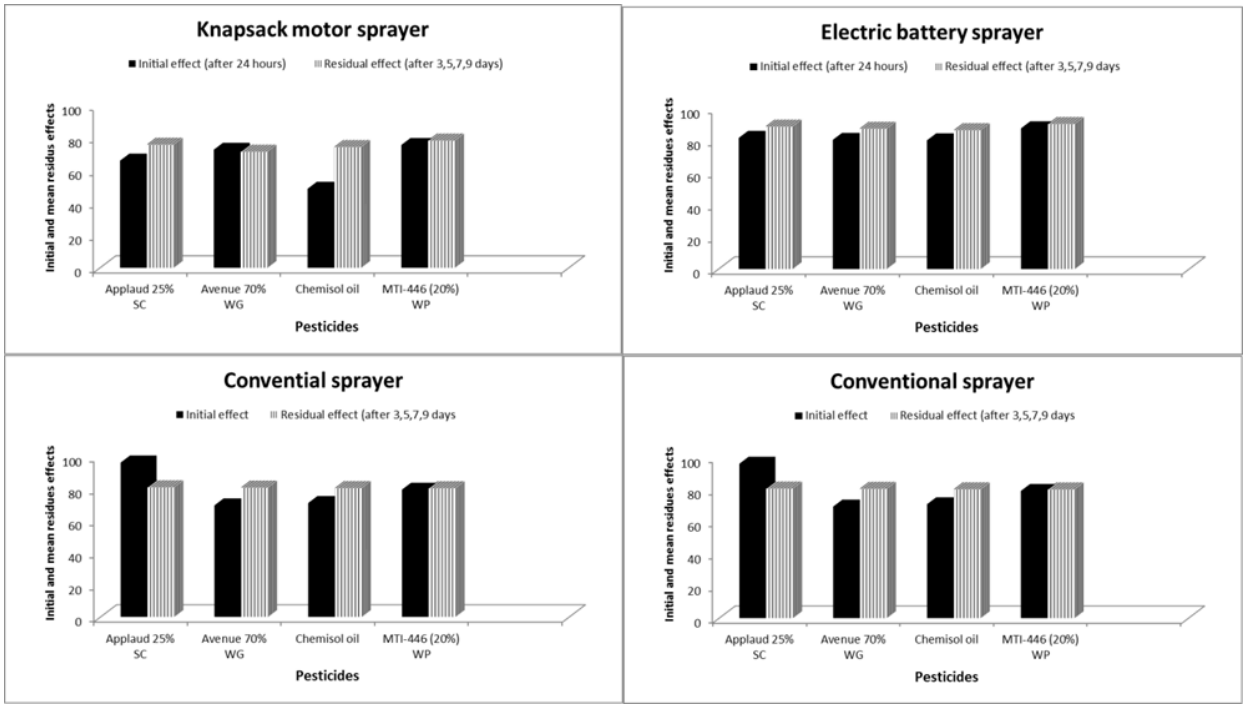

Figure (1): Effect of four different insecticides against *Aphis gossypii* infesting marrows plants with various ground application techniques during season 2017/2018.

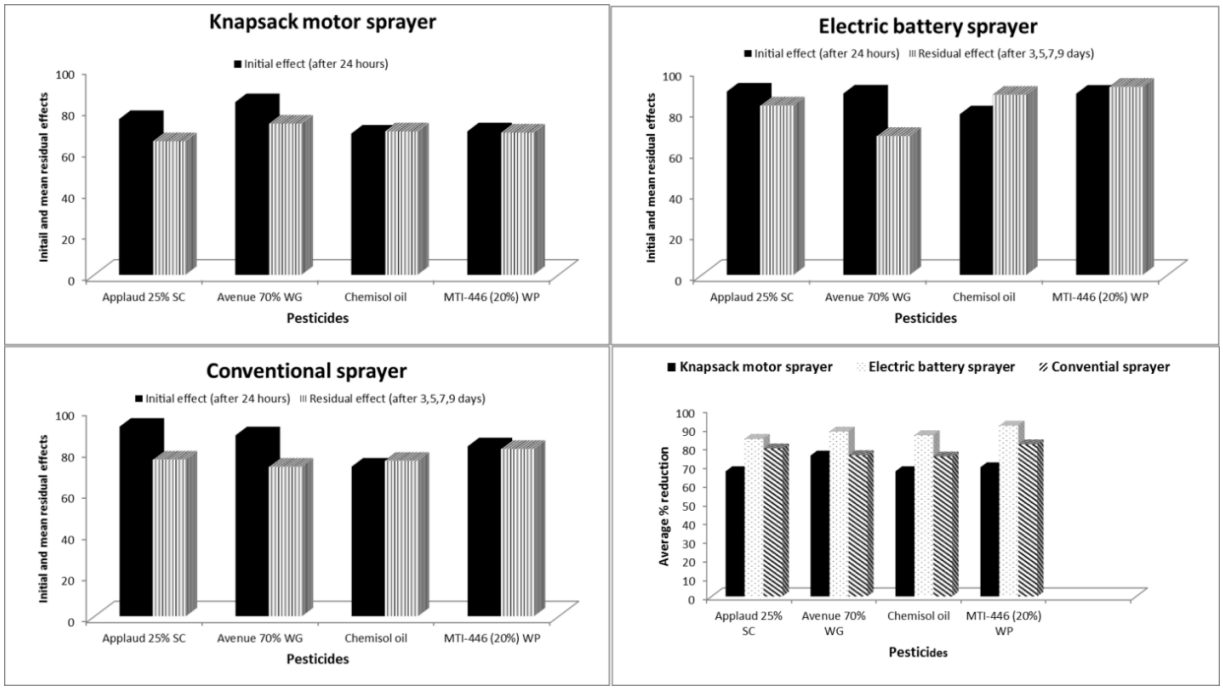

Figure (2): Effect of four different insecticides against *Bemisia tabaci* infesting marrows plants with various ground application techniques during season 2017/2018.

Table (5): Effect of pesticides used against tomato whitefly *Bemisia tabaci* infesting marrows plants with various ground application techniques during seasons (2017/ 2018).

Pesticide	Date	Knapsack motor sprayer (Oleo Mac)	Electric Battery sprayer fitted with hollow cone nozzle (Tx-6)	Conventional sprayer
(Buprofezin) Applaud 25% SC	Pre-count	10.80	14.40	9.00
	Initial effect	83.48 **a**	88.40 **a**	87.45 **b**
	Mean residual effect	73.08 **a**	67.78 b	72.30 **cd**
	Average % reduction	**75.16 a**	**87.9 b**	**75.33 b**
(Imidacloprid) Avenue 70% WG	Pre-count	9.20	13.50	11.20
	Initial effect	75.29 **b**	89.4 **a**	91.59 **a**
	Mean residual effect	64.62 **c**	82.64 **c**	75.77 **b**
	Average % reduction	**66.75 c**	**83.99 a**	**78.93 a**
(Mineral oil) Chemisol	Pre-count	8.40	13.20	10.20
	Initial effect	68.29 **c**	78.37 **c**	72.30 **d**
	Mean residual effect	69.41 **bc**	87.86 **b**	75.18 **bc**
	Average % reduction	**66.78 c**	**85.96 b**	**74.6 b**
MTI-446 (20%)WP	Pre-count	8.50	13.90	12.20
	Initial effect	69.34 **c**	88.35 **a**	82.11 **c**
	Mean residual effect	68.78 **b**	91.76 **a**	80.92 **a**
	Average % reduction	**68.89 bc**	**91.07 a**	**81.15 a**

N.B: Initial effect: after application with 24 hours. Mean residual effect: after application with (1, 3, 7 and 15 days).

Results as shown in Table (4), and graphically illustrated in Figure (1), all tested pesticides reduced the population of the aphids with varies percentage according to the spraying application techniques used. Based on the obtained results in general mean of percentage reduction, Imidacloprid and Buprofezin were the most effect pesticides which caused 89.97 and 87.41% of reduction, respectively. Followed by MTI-446 and Chemisol, with percentage of reduction 86.16 and 84.86% respectively in case of Electric Battery Sprayer, with Tx-6 technique. While Knapsack sprayer technique exhibited the

lowest effect which caused 77.93, 73.94, 71.68 and 69.36% of reduction in aphids population with Imidacloprid, Buprofezin, MTI-446 and Chemisol, respectively.

As well as data in Table (5) and graphically illustrated in Figure (2), revealed that, the efficacy of the tested pesticides in this study could be arranged according to the general mean of reduction percentages of whitefly population in a descending order as follows: Imidacloprid, MTI-446, Chemisol, and Buprofezin they were 91.07, 87.9, 85.96 and 83.99 % of reduction, respectively.

From the above results in Tables (4 and 5), Electric battery sprayer, with Tx-6 technique exhibited the highest effects with all pesticides used followed by Knapsack motor sprayer (Oleo Mac) and Knapsack sprayer technique, respectively.

From the afore mentioned results, it could be stated that, all pesticides used in this study reached the highest efficacy after 7 days of application, followed by 15 day, respectively against aphids and whitefly population with similar trend as shown in Tables (4 and 5). These results in harmony with those carried out on different equipment technique by many authors. Ramadan and Laila (1995) found that they tested the efficacies of seven insecticides sprayed with knapsack sprayer at the spray volume 200 l/fed. against aphids on potato plants. Data showed that Profenofos, Methomyl and Etofenprox showed the highest efficacy insecticides against the aphids while Prothiophos was the least one. Ammar (1997) evaluated four spraying techniques on cotton plantation against aphids by means of various doses. Deltanet and Prempet insecticides. The tested machines were Tapa, Semco, CP-3 and Conventional sprayer. Generally using the recommended dose of Prempet insecticide gave higher reduction piercing sucking insects (85%) than Deltanet insecticide (75%).

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