

## Toxicological evaluation and residual analysis of some acaricides against two-spotted spider mite *Tetranychus urticae* by using certain ground spraying equipment on cotton and its intercrops in Egypt

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### Abstract

Field experiments were carried on cotton during season 2020 at Al-Dakahlia and Al-Fayoum governorates, Egypt. Abamectin, Fenpyroximate, Buprofezin, were compared to a natural pesticidal product (Anti-insect) against all movable stages (immature and adults) of *Tetranychus urticae* by using two sprayers, a Motorized Knapsack motor (Cifarilli) (20 L. /Fed.) and a Hydraulic sprayer (Matabi) (56 L. /Fed.). The residual behavior of the tested acaricides was evaluated in cotton seeds, and the intercrops, cucumber, and tomato fruits loaded under early cotton stages in the field. All tested compounds induced a significant negative efficacy on *T. urticae* survival. Abamectin and Fenpyroximate exhibited the highest acaricidal activity, followed by Buprofezin and Anti-insect. Cifarilli sprayer was more effective to control *T. urticae* on cotton according to the homogeneity of the droplet spectrum. The Cifarilli' rate of performance (Fed. /day) was 4 times that Matabi sprayer. The lost spray-on ground for the Cifarilli motor was lower than Matabi sprayer with 40%. All cotton seed samples were free from residues of the pesticides. The recovery rate of Abamectin, Fenpyroximate, and Buprofezin from the fortified samples of cucumber, and tomatoes fruits ranged from 83.07% to 92%. The pre-harvest interval period was (10 and 4 days), (10 and 10 days) and (6-7 and 6 days) for tomatoes and cucumbers with Abamectin, Fenpyroximate, and Buprofezin, respectively. There were no significant differences between the effects of using the two sprayers on the safety period for the pesticides investigated, due to similarity in the pesticide degradation for sprayers and governorate.

**Keywords:** cotton, *Tetranychus urticae*, acaricides, lv ground equipment, residue analysis, MRL, and phi

### Introduction

The cotton plant (*Gossypium hirsutum* L.) is listed in the top ten crops commercialized daily. Cotton is sown in more than 100 countries, it takes about 2.5 percent of the world's arable land (OECD/ FAO, 2016). As normal to crops, pests could be a major concern for cotton affecting their yields by almost 40% if not adequately managed. In Egypt, cotton is infested by several pests during its different growth stages (Alves *et al.*, 2020) [4].

The two-spotted spider mite, *Tetranychus urticae* Koch belongs to phylum Arthropoda, class Arachnida, subclass Acari, order Acariformes, family Tetranychidae, is one of the most damaging agricultural pests. It is responsible for significant yield losses in many horticultural, ornamental, and crops worldwide. (Ilias *et al.*, 2014; Rauch and Nauen 2003) [21, 34, 39]. *T. urticae* is mainly active on the underside of leaves. It pierces the leaf cells with its cheliceral stylets and suckles the leaking cell contents, causing leaf chlorosis and even plant death (Riga *et al.*, 2014; Alakhdar *et al.*, 2015; Wang *et al.*, 2015) [34, 2, 37]. The spider mite is a serious pest on cotton and difficult to prevent and control, this may be due to its high fecundity, short generation time, limited territory, high ratio of inbreeding, and high possibility of pesticide exposure (Lin *et al.*, 2009) [25].

Pesticides have great hazards on man, animal, plant, and environment, besides, the development of pest' resistance which prompting the scientists to search on new alternatives

insecticides like biotic agents which achieved great success in controlling many pests such as mites with safe, cheap and Effective methods. Also, suitable ground equipment for spraying in the field has great importance in controlling pests by a definite amount of insecticide & water and minimum lost spray-on ground to avoid environmental contamination (Jepson, 2009) [22]. The world's attention was directed to alternate low volume sprayers instead of high volumes and reducing control costs by using ground spraying technique with low application costs per feddan. The ground sprayers differ in their spray coverage due to the arrangement of the nozzles, spraying volume, and application rate, (Dar 2020) [11, 12].

A great agriculture problem that occurred in Egyptian cotton fields is intercropping. It is an agricultural technique associated with growing the main crop along with one or more crops on the same plot of land that can be added to increase the yield from the available cultivation area. Biodiversity in monoculture is less than crops grown with the technique of intercropping, as biodiversity provides growing crops with a variety of benefits in addition to predatory insects. It can be mixed cultivation, by collectively growing a variety of well-suited plants; Alleys or rows, where different crops are planted with each other in rows; or intercropping, which depends on the speed of crop growth. There is a fast-growing crop with a slow-growing crop. (Atique-ur-Rehman *et al.*, 2020) [7].

Rising concern about food safety and environmental impact has led to an increasing number of studies on the impact of pesticide residues in agricultural products consumed by humans. The intensive, indiscriminate, and injudicious use of pesticides has resulted in widespread contamination of food and feed. This is due to poor insecticide handling practices and the usage of more toxic insecticides by agriculturalists (APHA, 2005) [6]. Therefore, international organizations and governments have established maximum residue limits (MRLs) (Regulation (EC), No. 396/2005) and pre-harvest intervals (PHI) for crops, vegetables, and fruits. It is well known that such pre-harvest intervals defined as the time required to decrease the residue levels below the MRL, can be estimated from the residue dissipation curve (Abd-Alrahman, *et al.*, 2015).

This work aimed to evaluate the efficiency of Abamectin, Fenpyroximate, Buprofezin, and Anti-insect against

*Tetranychus urticae* on the cotton field with Motorized Knapsack motor (Cifarilli) and Hand-held Hydraulic (Matabi), sprayers, to determine the relationship between spray quality, *T. urticae* survival, determine the dissipation rate, half-life values (RL<sub>50</sub>) and pre-harvest interval (PHI) of Abamectin, Fenpyroximate, and Buprofezin produced by the previous spraying equipment in the cotton field.

### Material and Methods

The present study was performed to manage the two-spotted spider mite *Tetranychus urticae* using three acaricides and a natural product as well as the impact of two spraying equipment and determination of the pesticide residues in cotton seeds and the fruits of cucumber and tomato intercropped with cotton.

### The Tested Compounds

**Table 1:** List of Pesticides and Their Rates of Application.

Trade name	Compounds		Recommended Rate	Source
	Common name	Formulation type		
Vertemic® 1.8% E.C	Abamectin	E.C (Emulsifiable Concentrate)	160 cm <sup>3</sup> /fed	Syngenta Co
Ortus super® 5 % E.C	Fenpyroximate	E.C (Emulsifiable Concentrate)	200 cm <sup>3</sup> /fed	Shoura Chemicals Co
Buprolord® 25 % S.C	Buprofezin	S.C (Suspension concentrate)	400 cm <sup>3</sup> /fed	UPL CO
Antinsect® formulation of some natural oils	Anti-insect	S.C (Suspension concentrate)	2.7 L /fed	Central Laboratory of Organic Agriculture/Agricultural Research Center.

Pesticide Manual (1994)

### Execution of field experiments

#### Arrangements of the experiments

Field experiments were carried out during the early cotton season on the med of May in private fields during the season 2020, at Aga district, Al-Dakahlia governorates, and Sannores district, Al-Fayoum governorate. The cotton variety (Giza 86) was cultivated in Al-Dakahlia, and (Giza 95) in Al-Fayoum in the first half of March, intercrops tomatoes (GS 12 variety) and cucumber (Beta alpha variety) were planted during an early cotton season, where cotton plants were small and large distances between them. The experiments occurred under local meteorological conditions of 32 °C average temperature, 55% average RH, and 2 m/sec. as an average wind velocity during spraying operations at Al-Dakahlia governorate, 36 °C average temperature, 60% average RH, and 1.7 m/sec. as an average wind velocity during spraying operations at the Al-Fayoum governorate. The selected area of one feddan (4200 m<sup>2</sup>) was split into 8 plots and a control plot. The area of each plot was 466.7 m<sup>2</sup>, three rows of cotton plants between treatments were not sprayed as barrier zones to prevent drift spray between treatments, spraying operations have not been done with compounds before the execution of the field experiment (Dar and Al-Akhdar, 2020) [3, 12]. Abamectin, Fenpyroximate, Buprofezin, Anti-insect were sprayed with the recommended dose rate, for *T. urticae*. All treatments were sprayed as target spraying technique with two mentioned sprayers, except one left without treatment as a control.

Our work end on 30<sup>th</sup> May and all intercrops were picked and yielded before cotton spraying with other insecticides to avoid fruit contamination.

### Bioassay Procedure

The design of the experiment was a randomized complete block (RCBD) with three replicates, when the infestation was proved with *T. urticae*, ten leaves were collected from each replicate and the number of all movable stages of *T. urticae* were counted before treatment and after three, seven, and 14 days post-treatment by the aid of a stereomicroscope at Acarology lab., Plant Protection Research Institute, Agricultural Research Center, as the protocol of the Ministry of Agriculture (Alakhdar 2020) [3, 12].

### Spraying equipment tested on cotton

Two ground application equipment was selected to perform the scope of this work as follows:

1. Motorized Knapsack motor sprayer (Cifarilli), Spraying volume (20 L. /fed.), made in Italy.
2. Hand-held Hydraulic sprayer (Matabi), Spraying volume (56 L. /fed.), made in Spain.

The tested equipment was calibrated with water and represented according to the technical categorization mentioned in table (1). Calculations of productivity and rate of performance were recorded as described by (Hindy, 1992) [18].

**Table 2:** Techno-Operational data of certain ground sprayers applied to the cotton field during the season (2020).

Equipment	Motorized Knapsack sprayer (Cifarilli)	Hydraulic sprayer (Matabi)
Type of atomization	Mechanical Pneumatic	Manual Hydraulic
Nozzle type	Air shear nozzle	Hollow cone nozzle 80°
Pump type	Centrifugal fan	Piston 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=8 hours daily. \*Number of workers=2

\*Calculations of productivity and rate of performance after (Hindy, 1992) [18].

## Calibration and performance adjustment of the tested equipment

### a. Collection of spray coverage of droplets on cotton plants

A sampling line was constructed of five-wire holders fixed in a diagonal line at each treatment before spraying each cotton treatment in the field to evaluate the lost spray between cotton plants; each wire holder top has a fixed water-sensitive paper (Novartis Cards ®) on it. Also, for each cotton plant, of about 70 cm length, to collect the droplets deposit on cotton leaves, the water-sensitive paper cards were put at upper and lower levels of plants in each treatment, according to the method described by (Hindy, 1989) [17]. After treatment, all cards were collected and transferred carefully to the laboratory for measuring and calculating the average number of droplets/cm<sup>2</sup> and its average droplet sizes (VMD) µm in all treatments.

### b. Determination of spray droplets distribution and its sizes

Number and size of blue spots (deposited droplets) on each water sensitive cards (Novartis cards) measured with a scaled special monocular Japanese lens (Strüben) ® (15X). According to (Hindy, 1992) [18], the volume means diameter (VMD) µm and the average number of droplets in one square centimeter (N/cm<sup>2</sup>) were estimated, the spread factor of water-sensitive paper was 2.2.

### c. Phytotoxic effect

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

## Determination of acaricide residues in cotton seeds, cucumber, and tomato fruits during the growing season, 2020

The residues of the pesticides (Vertemic® 1.8% E.C, Ortus super® 5%E.C and Bupro lord®25% S.C) were determined at the Central Agriculture Pesticides Laboratory (CAPL), Agricultural Research Center, Ministry of Agriculture.

### a. Chemical and reagents

The organic solvents were of HPLC grade and supplied by Merck, USA. Primary and secondary amines (PSA, 40 ml Bondesil) were purchased from Supelco (Supelco, Bellefonte, USA). Anhydrous magnesium sulphate was of analytical grade, purchased from Merck, USA, and was activated by heating at 250 °C for 4 hr. in an oven previous to the using and kept in desiccators.

### b. Sampling

Samples of cucumber and tomato fruits with similar ripening stage, size, and shape were located and tagged. Samples about 1.0 kg were taken 1 hr. after the pesticide application. Subsequent samples were taken after 2, 5, 7, and 10 days of treatment.

During the experiment, a control sample was taken at each sampling time. While cotton seeds are taken in harvest time. Directly after the samples were collected, samples were packed in polyethylene bags and transferred to the lab. in iceboxes. The obtained samples were homogenized using a food processor (Thermomix Vorwerk). Each sample was homogenate where three representative samples of 15 g were taken. Then, samples were placed into a polyethylene 50-ml centrifuge tube and frozen at -20 °C until the time of analysis.

### c. Extraction and Clean-up of Pesticides Residues

Samples were extracted and cleaned up directly after collected using QuEChERS methodology (Lehotay *et al.*, 2010) [24]. About 15 gm. of the homogenized samples were weighted in a 50-mL centrifuge tube and 10 ml of acetonitrile (1% acetic acid) were added, then the screw cap was closed and the tube vigorously was shaken for 1 min. using a vortex mixer at the highest speed. Next 1 gm. NaCl and 4 gm. anhydrous magnesium sulfate were added. The sample was vortexed for 30 s. The extracts were centrifuged for 5 min at 3800 rpm and 40°C. An aliquot of 4 ml was transmitted from the supernatant to a new clean 15 ml centrifuge tube and cleaned up by dispersive solid-phase extraction with 100 mg PSA, 20 mg GCB, and 600 mg MgSo<sub>4</sub>. The sample was again vortexed for 1 min and then centrifugation was carried out as mention above. Then, 1ml of the supernatant was taken, mixed with 2ml toluene, and evaporated to dryness. The residues were re-dissolved in 1ml of toluene, filtered through a 0.22 µm PTFE filter (Millipore, USA), and transmitted into a 1.5 ml glass vial for HPLC analysis.

### d. Instrumental determination

The residual of all pesticides was revealed by employing High-Performance Liquid Chromatography (HPLC). HPLC analysis was made with an Agilent 1100 HPLC system (USA), with a diode array detector (DAD). The chromatographic column was C18 Zorbax SB (250 X 4.6 mm X 5 µm film thickness). HPLC grade solvents used as mobile phases were purchased from Fisher Scientific. All solvents were properly degassed using a sonicator and filtered through a 0.45 µm nylon filter medium before use. Twenty ML., of the filtered sample, was injected. The HPLC conditions like the mobile phase, flow rate, and detection wavelength are presented in Table 2. Recovery studies were carried out by spiking 3 replicates of untreated date samples (control) with 50, 100, and 50 mg/kg of pesticides. Samples were analyzed by the use of their prescribed procedure and mean values of the three replicates were calculated. Recovery percentages were satisfactory for pesticides and ranged from 83.07% to 93.31%. The minimum detection limit of pesticides was 0.005mg/kg.

**Table 3:** HPLC conditions and % Recovers for Pesticides Residues Determination.

Common name	Mobile Phase	Flow Rate (ml/min)	Detectors Wavelength (nm)	mean Recovery% ± SD
Vertimec® 1.8% E.C	(acetonitrile/Methanol/water = 45/40/15 v/v/v)	1.5	245 DAD	92 ± 2.83
Ortus super® 5 % E.C	methanol/water, 80:20, v/v)	0.8	210 DAD	91.69 ± 2.16
Buprolord®25 % S.C	acetonitrile /water, 70:30, v/v)	1	250 DAD	83.07 ± 1.62

DAD =Diode-Array Detection

**Residue half-life estimation (t0.5)**

The half-life time (t0.5) for each investigated pesticide was calculated using the following equation (Moye *et al.*, 1987)

[27].

Whereas:

$$t_{0.5} = \ln 2 / K = 0.6932 / K.$$

$$k' = 1 / T_x \times \ln (a/bx).$$

k' = rate of decomposition Tx = time in days.

A = initial residue Bx = residue at x time.

**Calculation and data analysis**

- The reduction percentages in the average populations of all movable stages of *T. urticae* were calculated according to Henderson and Tilton (1955) [14].
- Obtained data were analyzed using Proc. ANOVA in SAS (Anonymous, 2003) [5]. Means separation was conducted using LSD in the same statistical program.

**Results**

**Efficacy of some acaricides against spider mite *T. urticae* and their relation to spraying types of equipment on cotton**

Reduction percentages of four pesticides by using two ground spraying equipment, Motorized Knapsack motor

sprayer (Cifarilli) (20L./fed.) and Hydraulic sprayer (Matabi) (56 L/fed.) were presented in Table (4).

The general mean reduction in *T. urticae* population was detected in the Al-Fayoum governorate. Abamectin was highly toxic to *T. urticae* with 92 & 88.6 and 93.9 & 90.8 % mortality percentage regardless of treatment by Cifarilli and Matabi at Al-Dakahlia and Al-Fayoum governorate, respectively. For Fenpyroximate, the mortality percentage was (75.3&67.9), (83.8& 76.5), and (93&86) after three, seven, and 14 days of treatment for Cifarilli and Matabi at Al-Dakahlia.

In Al-Fayoum, mean numbers of individuals after three days of treatment were 40 and 48 with mean reduction percentages of 62.6 and 54.1% for Buprofezin, after one-week treatment, mean numbers of individuals were 34 and 44 with mean reduction percentages of 69.9 and 60.1%, for two-week exposure indicated that means the number of *T. urticae* were 21 and 26 with reduced rates of 83.1 and 78.7%, by using Cifarilli and Matabi, respectively.

By applying the natural oil product Anti-insect in Al-Dakahlia, the general mean reduction percentages of the population of *T. urticae* was 53 and 45.5% by using Cifarilli and Matabi, respectively whereas, it was 58 and 48.8 in Al-Fayoum by the same sprayers.

**Table 4:** Reduction Percentages of all movable stages of *T. urticae* affected by certain compounds sprayed with two ground equipment during the season (2020) at Al-Dakahlia and Al-Fayoum governorates, after three, seven, and 14 days of treatments.

Equipment	% Reduction after spraying															
	Al-Dakahlia governorate															
	3rd				7th				14th				General mean			
	Motorized Knapsack Cifarilli		Matabi sprayer		Motorized Knapsack Cifarilli		Matabi sprayer		Motorized Knapsack Cifarilli		Matabi sprayer		Motorized Knapsack Cifarilli		Matabi sprayer	
Treatments	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %
Abamectin (160 gm./ fed.)	18	84.5	23	80.8	8	93.5	11	91.3	3	97.9	9	93.8	9.7	92	14.4	88.6
Fenpyroximate (200cm <sup>3</sup> / fed.)	29	75.3	36	67.9	20	83.8	28	76.2	10	93	19	86	19.7	84	27.7	76.7
Buprofezin (400cm <sup>3</sup> / fed.)	50	56.7	54	50.9	45	62.9	52	54.9	30	78.5	34	74.4	41.7	66	46.6	60
Anti-insect (2.7 L./ fed.)	59	42.9	69	34.6	52	52	60	45.8	45	64	56	52	53	61.6	45.5	
Untreated control	100	-	100	-	105	-	105	-	121	-	121	-	109	-	109	-
	Al-Fayoum governorate															
	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %
Abamectin (160 gm./ fed.)	12	88.7	18	83.9	6	94.6	8	93.2	2	98.4	6	95.4	6.7	93.9	10.7	90.8
Fenpyroximate (200cm <sup>3</sup> / fed.)	20	81.5	28	74	15	86.8	22	80.7	8	93.6	13	89.7	14.3	87.3	21	81.5
Buprofezin (400cm <sup>3</sup> / fed.)	40	62.6	48	54.1	34	69.9	44	60.1	21	83.1	26	78.7	31.7	71.8	39.4	64.3
Anti-insect (2.7 L./ fed.)	49	48.1	60	41.4	42	57.8	51	42.7	35	68.2	45	62.3	42	58	52	48.8
Untreated control	91	-	91	-	96	-	96	-	106	-	106	-	98	-	98	-

C= Count of all movable stages after treatments. R= % Reduction of *T. urticae* population.

As shown in (Table 5), the highest reduction percentages of *T. urticae* occurred by Motorized Knapsack motor sprayer (Cifarilli) (56 L/fed.). For Abamectin, the droplet sizes were 139 & 138 and 146 & 145 while the N/cm<sup>2</sup> were 174 & 163 and 165 & 155 for Cifarilli and Matabi, in Al-Dakahlia and Al-Fayoum governorates, respectively during the same

season. Based on Fenpyroximate, the droplet sizes were 135 & 156 and N/cm<sup>2</sup> were 157 and 147 with the general mean reduction 87.3 and 81.5% for Cifarilli and Matabi, in Al-Dakahlia and Al-Fayoum, respectively. The droplet sizes of Fenpyroximate were 136 & 149 and N/cm<sup>2</sup> were 166 and 155 with general mean reduction percentages 84 and 76.7%

for Cifarilli and Matabi, respectively in Al-Dakahlia. While in Al-Fayoum, the droplet sizes of Buprofezin were 145 & 153 and N/cm<sup>2</sup> were 150 & 138 for Cifarilli and Matabi, respectively with general mean reduction percentages of Al-Fayoum governorate 71.8 and 64.3% for Cifarilli and Matabi. For Anti-insect, the droplet sizes were 138 & 159 and N/cm<sup>2</sup> were 150 and 136 with a general mean of reduction 53 and 45.5% in Al-Dakahlia while it was 145 & 166 and N/cm<sup>2</sup> were 142 and 130 with a general mean of reduction 58 and 48.8% in Al-Fayoum governorate for Cifarilli and Matabi, respectively during the same season.

**Table 5:** The relation between droplet distributions obtained by the tested ground spraying equipment and the corresponding mortality of all movable stages of *T. urticae* on cotton plants during the season (2020) at Al-Dakahlia and Al-Fayoum governorates.

Insecticide and dose rate	Tested sprayer	Upper level		Lower level		% Mortality General mean
		N /cm <sup>2</sup>	VMDµm	N /cm <sup>2</sup>	VMDµm	
Al-Al-Dakahlia governorate						
Abamectin (160 cm <sup>3</sup> /fed.)	Cifarilli	170	138	177	140	92
	Matabi	165	136	160	140	88.6
Fenpyroximate (200cm <sup>3</sup> /fed.)	Cifarilli	165	138	166	133	84
	Matabi	159	145	150	152	76.7
Buprofezin (400cm <sup>3</sup> /fed.)	Cifarilli	160	138	156	138	66
	Matabi	150	150	141	155	60
Anti-insect (2.7L./ fed.)	Cifarilli	150	136	150	140	53
	Matabi	142	157	130	160	45.5
Al-Fayoum governorate						
Abamectin (160 cm <sup>3</sup> /fed.)	Cifarilli	161	145	168	147	93.9
	Matabi	157	143	152	147	90.8
Fenpyroximate (200cm <sup>3</sup> /fed.)	Cifarilli	157	145	158	140	87.3
	Matabi	151	152	143	160	81.5
Buprofezin (400cm <sup>3</sup> /fed.)	Cifarilli	152	145	148	145	71.8
	Matabi	142	158	134	163	64.3
Anti-insect (2.7L./ fed.)	Cifarilli	142	143	143	147	58
	Matabi	135	165	124	168	48.8

**VMD = Volume Mean Diameter. N / cm<sup>2</sup> = Number of droplets per square centimeter.**

The previous data indicated the presence of significant differences between both the distribution percentages of droplet numbers/cm<sup>2</sup>; for Al-Dakahlia (LSD=5.4916 between levels and 4.4839 between tools, and 6.3412 between compounds), for Al-Fayoum (LSD=5.22 between levels and 4.26 between tools, and 6.02 between

compounds). Differences between droplet size VMD for Al-Dakahlia (LSD=2.79 between levels, 2.8 between tools, and 3.22 between compounds), for Al-Fayoum. Between reduction percentages for *T. urticae* (LSD= 1.909 for tools, 3.6269 for compounds) for Al-Dakahlia, (LSD= 1.8734 for tools and 3.5594 for compounds) for Al-Fayoum.

**Relationship between the lost spray-on ground and the bioresidual activity of compounds used**

Data in Table (6) showed that there was a negative correlation between the lost spray-on ground and the efficacy of compounds used. The mean lost spray produced from Motorized Knapsack motor sprayer (Cifarilli) (20 L./Fed.) was 8.93% and the mean spray lost produced from Hydraulic sprayer (Matabi) spray volume (56L\ fed.) was 14.85 % for Al-Dakahlia governorate, while it was 10.2% and 16.2% for Hydraulic sprayer (Matabi) spray volume (56L\ fed.) was 16.2% for Al-Fayoum governorate, we recommended that the smaller spray volume the lesser spray lost.

**a. Lost spray of Motorized Knapsack motor sprayer (Cifarilli)**

Data in Table (6) showed that the lost spray percentages were 8.1, 8.6,9 and 10% from the total spray volumes, while the general mean in reduction percentages of Al-Dakahlia governorate were 92, 84, 66, and 53% for *T. urticae*, for Abamectin, Fenpyroximate, Buprofezin, and Anti insect, respectively during the season 2020. The lost spray percentages were 9.3, 9.8, 10.2, and 11.5% from the total spray volumes, while the general mean in reduction percentages of Al-Fayoum governorate was 93.9, 87.3, 71.8 and 58% for *T. urticae*, for Abamectin, Fenpyroximate, Buprofezin, and Anti insect, respectively during the same season.

**b. Lost spray of Hydraulic sprayer (Matabi):**

Data in Table (4) showed that the lost spray percentages were 14, 14.4,15, and 16% from the total spray volumes, while the general mean in reduction percentages of Al-Dakahlia governorate were 88.6, 76.7, 60, and 55.5% for *T. urticae*, for Abamectin, Fenpyroximate, Buprofezin, and Anti insect, respectively during the season 2020. The lost spray percentages were 15.3, 15.8, 15.9, and 17.6% from the total spray volumes, while the general mean in reduction percentages of Al-Fayoum governorate were 90.8, 81.5, 64.3, and 48.8% for *T. urticae*, for Abamectin, Fenpyroximate, Buprofezin, and Anti insect, respectively during the same season.

**Table 6:** Lost spray-on ground, as produced by low volume ground spraying equipment, against all movable stages of *T. urticae* during the season (2020) at Al-Dakahlia governorate.

Insecticide and dose rate	Tested sprayer and spray volume (L / fed.)	*N / cm <sup>2</sup> of total spray droplets	N / cm <sup>2</sup> droplets lost (on the ground)	Volume mean diameter VMD (on the ground)	% N/cm <sup>2</sup> (ground) — 100 N/Cm <sup>2</sup> (Plants+ground)
Al-Al-Dakahlia governorate					
Abamectin (160 gm./ fed.)	Cifarilli (20)	347	32	139	8.1
	Matabi(56)	325	53	145	14
Fenpyroximate (200 cm <sup>3</sup> / fed.)	Cifarilli (20)	331	32	138	8.6
	Matabi (56)	309	52	157	14.4
Buprofezin (400cm <sup>3</sup> / fed.)	Cifarilli (20)	316	32	141	9
	Matabi (56)	300	51	160	15
Anti-insect (2.7 L./ fed.)	Cifarilli (20)	300	35	145	10
	Matabi (56)	272	52	165	16
Al-Fayoum governorate					
Abamectin (160 gm./ fed.)	Matabi(56)	309	56		
Fenpyroximate	Cifarilli (20)	314	34	145	9.8

(200 cm <sup>3</sup> / fed.)	Matabi (56)	293	55	165	15.8
Buprofezin (400cm <sup>3</sup> / fed.)	Cifarilli (20)	300	34	148	10.2
	Matabi (56)	285	54	168	15.9
Anti-insect (2.7 L./ fed.)	Cifarilli (20)	285	37	152	11.5
	Matabi (56)	258	55	173	17.6
Anti-insect (2.7 L./ fed.)	Cifarilli (20)	285	37	152	11.5
	Matabi (56)	258	55	173	17.6

N /cm<sup>2</sup> = Number of droplets per square centimeter. \* On cotton and lost spray-on ground.

The rate of performance of Hand-held Hydraulic sprayer (Matabi) (56 L./Fed.) and Motorized Knapsack motor sprayer (Cifarilli) (20 L. /Fed.) was 3.4 Fed./day and 12 Fed./day, respectively.

**Relations between spray quality and the general reduction percentages of certain insecticides**

Data in Table (7) indicated that all the tested spraying

Equipment gave satisfactory coverage on cotton i.e. more than 50 droplets/ cm<sup>2</sup>, and droplet sizes ranged from 133 to 168 μm (VMD). The difference in the mortality percentage was due to the different modes of action of the compounds insecticides and the degree of homogeneity of droplets spectrum in the case of Motorized Knapsack motor sprayer (Cifarilli) is higher than hand-held Hydraulic (Matabi) sprayer.

**Table 7:** Relationship between field spray qualities (homogeneity) of certain equipment during the season (2020) at Al-Dakahlia governorate against all movable stages of *T. urticae*.

Equipment	Motorized Knapsack Cifarilli (20L./Fed.)				Hand-held hydraulic Matabi (56L./Fed.)			
	Abamectin	Fenpyroximate	Buprofezin	Anti-insect	Abamectin	Fenpyroximate	Buprofezin	Anti-insect
Al-Al-Dakahlia governorate								
Level	S.Q	S.Q	S.Q	S.Q	S.Q	S.Q	S.Q	S.Q
Upper Level	0.81	0.84	0.86	0.85	0.82	0.9	1	1.1
Lower Level	0.8	0.8	0.88	0.93	0.8	1	1.1	1.2
Al-Fayoum governorate								
Upper Level	0.9	0.92	0.95	1	0.9	1	1.1	1.3
Lower Level	0.88	0.89	0.98	1.03	0.97	1.1	1.2	1.35

S.Q = spray quality. = VMD/N/cm<sup>2</sup>= Spray quality (degree of homogeneity). The spray height is constant ~ 0.5 meters in all treatments. VMD= Volume mean diameter, N/cm<sup>2</sup>= Number of droplets/cm<sup>2</sup>.

**Determination of the tested acaricides residues in cotton seeds and intercropping during the growing season2020**

the effects of using the different sprayers in two governorates on the initial deposit of the pesticides understudy, Knapsack motor sprayer (Cifarilli) (20 L. /Fed.) was less than the Hydraulic sprayer (Matabi) (56 L/Fed.) according to the more homogeneity of the droplet spectrum and the lower spray volume of (Cifarilli) (20 L. /Fed.), Al-Fayoum governorate was more than Al-Dakahlia governorate, according to the high temperature and low humidity in Al-Fayoum governorate. While no significant differences between the effects of using the two sprayers and governorates on the number of days of the safety period for the pesticides understudy, due to similarity in the pesticide degradation for sprayers and governorates.

**a. Determination of the residual effect of different treatments in cotton seeds**

All samples of cotton seeds collected from the two governorates and treated with two tested equipment Cifarilli and Matabi, under field conditions, were free from any detectable amounts of test acaricides (Abamectin, Fenpyroximate, Buprofezin) residues.

**b. Determination of tested acaricides residues in tomatoes fruits**

As mentioned in Table (7) the residual effect of the tested acaricides (Abamectin, Fenpyroximate, Buprofezin) with two tested equipment (Motorized Knapsack motor sprayer (Cifarilli), Spraying volume (20 L./fed.) and Hand-held Hydraulic sprayer (Matabi), Spraying volume (56 L./fed.), under field conditions, in two governorates. Tomatoes samples collected from Al-Dakahlia and Al-Fayoum governorates, which treatments with two types of equipment (Cifarilli and Matabi) in zero time (after one hr of treatment after the applications are (3.4 and 4.6) and (3.9 and 5.1),

(1.1 and 2.61) and (1.24 and 2.9), (0.61 and 0.77) and (0.88 and 1.1) mg/kg) for Abamectin, Fenpyroximate, Buprofezin, respectively. After 24 hrs the residue level is decreased to ((2.3 and 2.91) and (2.6 and 3.2), (1 and 2.25) and (1.12 and 2.5), (0.38 and 0.45) and (0.55 and 0.65) mg/kg), respectively. After ten days of treatment the residue level is decreased to ((0.07 and 0.08) and (0.08 and 0.08), (0.1 and 1.17) and (0.18 and 0.19) mg/kg), respectively. In Abamectin and Fenpyroximate, while in Buprofezin decreased to blow LOD. While in the case of both of Abamectin, Fenpyroximate were reached undetectable amounts after 14 days.

The half-life of Abamectin, Fenpyroximate, Buprofezin, which use by two tested equipment (Cifarilli) and (Matabi) under field conditions, in two governorates Al-Dakahlia and El Fayoum, respectively. Calculated in tomato fruit treated at recommended dose was ((1.45 and 1.75), (1.82 and 1.8) and (4 and 2.4), (05.4 and 2.65) and (1.5 and 1.8), (1.86 and 1.9) and (095 and 1.1), (1.25 and 1.2)) days, respectively.

According to the EU Pesticides database the maximum residue level (MRL) of the tested acaricides are 0.09, 0.2, and 0.01 mg/kg for Abamectin, Fenpyroximate, Buprofezin, which use by two tested equipment (Cifarilli) and (Matabi) under field conditions, in two Governorates Al-Dakahlia and Al-Fayoum, respectively. The obtained results showed that the preharvest interval for acaricides was (1.45, 1.75 and 1.82, 1.8), (10, 10 and 10, 10), and (6, 6 and 7, 7), days, respectively. This means that the lowest preharvest interval was Buprofezin followed by Abamectin, Fenpyroximate.

**c. Determination of tested acaricides residues in cucumber fruits**

Data in Table (6) the residual effect of the tested acaricides (Abamectin, Fenpyroximate, Buprofezin) with two tested equipment (Motorized Knapsack motor sprayer (Cifarilli),

Spraying volume (20 L./fed.) and Hand-held Hydraulic sprayer (Matabi), Spraying volume (56 L./fed.) under field conditions, in two governorates. Cucumber samples collected from Al-Dakahlia and Al-Fayoum governorates, which treatments with two types of equipment (Cifarilli and Matabi) in zero time (after one hr. of treatment after the applications are ((3.02 and 4) and (3.32 and 4.4), (0.89 and 1.5) and (10.99 and 1.93), (0.49 and 0.54) and (0.7 and 0.78) mg/kg) for Abamectin, Fenpyroximate, Buprofezin, respectively. After 24 hrs the residue level is decreased to ((2.1 and 2.37) and (2.3 and 3.63), (0.58 and 1.2) and (0.65 and 1.5), (0.26 and 0.28) and (0.38 and 0.40) mg/kg), respectively. After ten days of treatment the residue level is decreased to ((0.02 and 0.03) and (0.02 and 0.03), (0.06 and

0.06) and (0.075 and 0.078) mg/kg), in Abamectin and Fenpyroximate, respectively. While in Buprofezin decreased to blow LOD. While in the case of both of Abamectin, Fenpyroximate were reached undetectable amounts after 14 days. According to the EU Pesticides database the maximum residue level (MRL) of the tested acaricides are 0.4, 0.08, and 0.01 mg/kg for Abamectin, Fenpyroximate, Buprofezin, which use by two tested equipment (Cifarilli) and (Matabi) under field conditions, in two governorates Al-Dakahlia and Al-Fayoum, respectively. The obtained results showed that the preharvest interval for these acaricides was (4 -5), (10, 10), and (6- 7), days, respectively. This means that the lowest preharvest interval was Abamectin followed by, Buprofezin and Fenpyroximate.

**Table 8:** Residues of Abamectin, Fenpyroximate, and Buprofezin (mg/kg) in /on tomatoes and cucumber fruits by different spraying techniques under field conditions in Al-Dakahlia and Al-Fayoum governorates.

Governorates	Pesticides times	Abamectin				Fenpyroximate				Buprofezin			
		tomatoes		cucumber		tomatoes		cucumber		tomatoes		cucumber	
Al-Dakahlia	spraying machines types	Q <sub>1</sub>	Q <sub>2</sub>	Q <sub>1</sub>	Q <sub>2</sub>	Q <sub>1</sub>	Q <sub>2</sub>	Q <sub>1</sub>	Q <sub>2</sub>	Q <sub>1</sub>	Q <sub>2</sub>	Q <sub>1</sub>	Q <sub>2</sub>
	0	3.4	4.6	3.02	4	1.1	2.61	0.89	1.5	0.61	0.77	0.49	0.54
	1-day	2.3	2.91	2.1	2.37	1.00	2.25	0.58	1.2	0.38	0.45	0.26	0.28
	3-days	0.7	0.93	0.56	0.76	0.6	1.25	0.47	0.55	0.14	0.29	0.12	0.09
	7-days	0.4	0.7	0.188	0.2	0.45	0.72	0.25	0.16	0.03	0.02	0.02	0.02
	10-days	0.07	0.08	0.02	0.03	0.1	0.17	0.06	0.06	n.d	n.d	n.d	n.d
	14-days	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d
	T0.5	1.45	1.75	1.8	1.35	4	2.4	3.5	2.3	1.5	1.8	0.95	1.1
	MRL	0.09		0.4		0.2		0.08		0.01		0.01	
	PHI	10	10	4	5	10	10	10	10	6	6	6	6
Al-Fayoum	0	3.9	5.1	3.32	4.4	1.24	2.9	0.99	1.93	0.88	1.1	0.7	0.78
	1-day	2.6	3.2	2.30	2.63	1.12	2.5	0.65	1.5	0.55	0.65	0.38	0.40
	3-days	0.8	1.8	0.62	0.84	0.74	1.39	0.53	0.69	0.21	0.42	0.18	0.13
	7-days	0.4	0.7	0.2	0.2	0.5	0.8	0.28	0.2	0.05	0.04	0.03	0.04
	10-days	0.08	0.08	0.02	0.03	0.18	0.19	0.075	0.078	n.d	n.d	n.d	n.d
	14-days	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d	n.d
	T0.5	1.82	1.8	1.5	1.37	5.4	2.65	3.6	2.4	1.6	1.9	1.25	1.2
	MRL	0.09		0.4		0.2		0.08		0.01		0.01	
	PHI	10	10	4	5	10	10	10	10	7	7	7	7

Q<sub>1</sub>: Motorized Knapsack motor sprayer (Cifarilli), Spraying volume (20 L./fed.).

Q<sub>2</sub>: Hand-held Hydraulic sprayer (Matabi), Spraying volume (56 L./fed.).

### The following remarks and results were obtained

There was no phytotoxic effect on cotton leaves after treatments with three compounds, no change in the leaves color, no leaf curling, or flaming up phenomena occurred.

Insecticides treated plants revealed the lowest cotton yield loss in comparison with untreated plots; their application reduced the incidence of all movable stages of two-spotted spider mite *T. urticae* infestation on cotton and decreased the percent loss of cotton yield in all treatments and with the two sprayers.

### Discussion

The obtained data indicated that Abamectin and Fenpyroximate have more efficacy against *Tetranychus urticae* than Buprofezin and anti-insect in the two governorates, Al-Dakahlia and Al-Fayoum, this was in agreement with authors who found that *T. urticae* mortality was significantly greater than the control (3, 7, and 14 days) after application by Abamectin due to its bio-origin. Abamectin was the most effective for mite population reduction, it was most toxic to the nymphs followed by Fenpyroximate (Kenneth *et al.*, 2002; Singh and Choudhary, 2008 and Ismail *et al.*, 2007) [23, 36, 20].

In other studies, Abamectin was the best in effect with

63.34% reduction, Fenpyroximate (48.56%), and Buprofezin (43.75%) (Patil *et al.*, 2014) [29]. Also, Abamectin and Fenpyroximate showed excellent control of *T. urticae* on chrysanthemum grown under Polyhouse conditions (Reddy *et al.*, 2014) [33]. Fenpyroximate showed an effective acaricidal activity to the mites. *T. urticae* sprayed with 0.5 µg/ml Fenpyroximate indicated distortions in mitochondria, in peripheral nerve cells such as swelling, irregular cristae arrangement, and lower matrix electron density caused by the compound when observed by transmission electron microscopy (Motoba *et al.*, 1992; Sato *et al.*, 2004) [26, 35].

Consequently, all components, in particular Abamectin and Fenpyroximate, can be used as acaricides with effectiveness against *T. urticae*.

Aside from selection by acaricides, the used sprayer equipment may play a role in the influence of acaricides efficacy against spider mite. A satisfactory coverage was achieved on cotton plants, the droplet spectrum was obtained in field experiment was agreed with the optimum droplet sizes mentioned by (Himel, 1969) [15, 16], (Himel *et al.*, 1969) [15, 16] in the optimum droplet size to control cotton leafworm in cotton fields by ground equipment. Abamectin and Fenpyroximate revealed the best bio-efficacy results

with the two equipment followed by Buprofezin, and Anti insect. These results harmonized with Hindy *et al.* (2004)<sup>[19]</sup>, who recommended the use of low volume spraying to reduce the time lost in the process of 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)<sup>[9]</sup> suggestion by using Profenofos followed by Pyriproxyfen and Spinosad with Agromondo motorized knapsack sprayer (20L/fed.) and using Carbosolvan, Acetamiprid and Deltamethrin with low volume machines not less than (15 L/fed.), also Dar (2016)<sup>[10]</sup> recommendation whenever using Lufenuron followed by Spinosad in controlling cotton leafworm on Clover with low volume machines. The previous data indicated that the high temperature and low humidity at Al-Fayoum explain the increase in droplet sizes, and decreasing droplet numbers per cm.

Also, Motorized Knapsack motor sprayer (Cifarilli) revealed the lowest spray volume and the lowest percentages of lost spraying between plants about 8.93% at Dakahlia governorate, 10.2 at Al-Fayoum governorate and Hydraulic sprayer (Matabi), spray lost about 14.85% at Al-Dakahlia governorate, 16.2 at Al-Fayoum governorate, these results were agreed with (Dar 2020)<sup>[11, 12]</sup>, who mentioned that there was a positive correlation relationship between the rate of application and lost spray-on ground. The data showed that Cifarilli sprayer was the best equipment to control *T. urticae* on cotton plants according to the homogeneity of droplet spectrum, this agreed with (Dobson, 2001)<sup>[13]</sup> who explained the typical values for spray quality (homogeneity)=more than 2.5 (very poor distribution) for hydraulic nozzle whereas = 2 for an air-shear nozzle, respectively.

There were significant differences between the effects of using the two sprayers and the two governorates on the initial deposit of the pesticides understudy Cifarilli was less than Matabi according to the more homogeneity of the droplet spectrum and the lower spray volume of Cifarilli, Al-Fayoum governorate was more than Al-Dakahlia governorate, according to the high temperature and low humidity in Al-Fayoum governorate. While no significant differences between the effects of using the different sprayers and the different governorates on the number of days of the safety period for the pesticides understudy, due to similarity in the pesticide degradation for sprayers and governorate.

The dissipation/degradation of various pesticide compounds after their application depends on various factors, including plant species, chemical formulation, and mode of application (Womac *et al.*, 1994), climate disorders, physical phenomena (essentially volatilization), and photo-degradation, in which sunlight performs a prominent role (Papadopoulos and Kotopoulou, 1995). Therefore, dissipation findings for a given crop under the open field conditions of each growing area are needed to test if the pesticide residue levels soon after the pre-harvest interval (PHI) are below the maximum residue limit (MRL). PHI, which is defined as the period between the last pesticide application and harvesting the crop, after which the pesticide residue level is expected to be below the established maximum residue level (MRL), is one of the important pesticide registration requirements in Egypt. Our results were in harmony with (Abd-Alrahman *et al.*, 2015) revealed that the dissipation of the pre-harvest interval

(PHI) of Profenofos residues in cotton seeds was safe in the harvest. Economy Micron ULVA sprayer (15L/Fed.) indicated the best reduction in larval infestation and best spray quality with less amount of Profenofos residue.

## Conclusion

It could be concluded that using Abamectin, Fenpyroximate, followed by Buprofezin and Anti-insect, respectively, with low volume (LV) ground spraying equipment with not less than (20 L./fed.) by using recommended doses which revealed successful management against *T. urticae* on cotton under our local conditions.

There was a negative complete correlation between droplet sizes and the mean mortality of *T. urticae*, while there was a positive complete correlation between N/cm<sup>2</sup> and the mean mortality of *T. urticae* in all movable stages, in all treatments. There were significant differences between the effects of using the different sprayers and the different governorates on the initial deposit of the pesticides understudy, Knapsack motor sprayer (Cifarilli) (20 L./Fed.) was less than the Hydraulic sprayer (Matabi) (56 L/Fed.), El-Fayoum governorate was more than Dakahlia governorate.

No significant differences were found between the effects of using spray machines and the two governorates on the number of days of the safety period.

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