Academic Journal of Entomology 15 (2): 18-26, 2022
ISSN 1995-8994

DOI: 10.5829/idosi.aje.2022.18.26

Evaluation of Two Photosensitizers Against White Fly *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) in Tomato Fields

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Abstract: The aim of this study was to evaluate the efficiency of two photosensitizers; Copper chlorophylline and Magnesium chlorophylline as photoinsecticide to reduce the population of polyphagous plant pest *Bemisia tabaci* in tomato fields during two successive seasons 2019/2020 and 2020/2021. Two tomato varieties commonly planted in Egypt were chosen for field evaluation, one of them was Adora which was planted in winter season and another was Elisa which was planted in summer season. The doses of the two photosensitizers ranged between 10^{-2} to 10^{-5} ml/l. Methomyl was sprayed as reference insecticide with the recommended dose (1cm/l) as well as water was sprayed as a control. The numbers of alive *B. tabaci* were counted in the treatments and control intervals days from 1 to 15 days post spray. Reduction percentages in the population corresponding to each treatment were calculated. Results showed the calculated reduction percentages in population of *B. tabaci* on sprayed tomato var. Addora in the winter 2019 revealed that all Photosensitizers exhibited reduction (47.1 - 73.3%) higher than that of methomyl insecticide (42.3%) at 24 h post spraying. The calculated reduction percentages of *B. tabaci* on sprayed tomato var. Elisa in the summer 2020 revealed that the highest concentration of either Copper chlorophylline or Magnesium chlorophylline recorded high reduction, 77.27 and 80.68%, respectively. The calculated reduction percentages of *B. tabaci* on sprayed tomato var. Addora at winter 2020 revealed that all tested concentrations of Magnesium chlorophylline recorded (85 - 94.5%) higher reductions than copper chlorophylline and the insecticide (76 - 90.3%). The calculated reduction percentages of *B. tabaci* on sprayed tomato var. Elisa at summer 2021 revealed that the concentration 10^{-3} ml/l of either Copper chlorophylline or Magnesium chlorophylline recorded the highest reductions (71.75% & 62.08%) and (46.48 & 49.57%) on the 1st and 7th day post first spray, respectively. On the second spray, the two photsynthetizers induced weak reductions ranged from 0 -35.98% and 13.20 - 28.78% on the 1st and 7th day post spray. It could be concluded that the highest dose of the two photosensitizeres (10^{-2} ml/L) can be recommended in controlling the white fly *B. tabaci* in tomato fields.

Key words: Control · Field Evaluation · Photoinsecticide · Population · Mortality

INTRODUCTION

The white fly, *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae) is considered as one of the most devastating insect pests for different crops. The fly sucks the plant sap that reduces the quality and quantity of the sap. The direct damages of *B. tabaci* are feeding on the plant phloem, injection of toxins and secretion of honeydew which serves as a substrate for sooty molds that reduce quality, promotes Capnodium sooty mold that, in turn, causes cosmetic injury and impairs photosynthesis and causing crop disorders, such as irregular ripening of tomato. Moreover, *B. tabaci* is known as vector of more than 100 different plant viral diseases

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from different genera including Begomovirus, Crinivirus, Carlavirus and others. White fly transmitted viruses have emerged during the past twenty years as major plant pathogens inducing serious diseases of economically important crops. Weeds may enhance *B. tabaci* problems by serving as hosts near crops and between cropping seasons. In addition, weeds may serve as alternate hosts for whitefly-transmitted viruses [1-7]. A large number of different chemical insecticide are used for controlling *B. tabaci* in tomato fields. Conventional insecticide often show undesirable side effects such as significant toxicity to non-target organisms, human health and contamination for the environment. These drawbacks and insect resistance to pesticides have led to search for alternative plant protection products. The application of environmental friendly tools instead of chemical applications is necessary for integrated pest management. A promising alternative to reduce the harmful effects caused by synthetic insecticide is the use of photosensitizers [8, 9].

Photosensitization involves activation of light-sensitive compounds, producing chemical reactions that damage or destroy cells; in some cases the excited photosensitizer is converted into a toxic photoproduct [10]. Several photosensitizing agents, which are activated by illumination with sunlight or artificial light sources [11], have been shown to be accumulated in significant amounts by a variety of insects when they are administered in association with suitable baits. El-Tayeb *et al*. [12] found that the myiasis producing flesh fly, *Parasarcophaga argyrostoma* exposed to the photosensitizer (Hematoporphyrin IX) and sunlight in sugar bait traps exhibited high mortality in adult flies reached to 96%. Berni *et al.* [13] tested Xanthene dyes as photoinsecticide on different dipteran species. They found that Phloxine B ingested by *Ceratitis capitata* larvae showed low toxicity under dark conditions and acute light-dependent toxicity when the insects were exposed to light during the dispersion stage before pupariation. Lukšiene *et al.* [8] stated that the polyphagous plant pest *Liriomyza bryoniae* (Kaltenbach, 1858) (Diptera, Agromyzidae) which feed bait containing photosensitizer (hematoporphyrin dimethyl ether) and expose to visible light resulted fast death. Moreover, photosensitizers exhibited lethal effects against fourth instar larvae and adults of mosquitoes in the laboratory and field conditions [14, 15].

The aim of this study was to evaluate the efficiency of several photosensitizers as photoinsecticide to control the population of polyphagous plant pest *B. tabaci* in tomato fields during two successive seasons.

MATERIALS AND METHODS

Photosensitizers: Both magnesium chlorophyllin (Mg-Chl) and copper chlorophyllin (Cu-Chl) were used as photosensitizers. *Stevia rebaudiana* leaves extract was used to form Cu-Chl and fresh spinach leaves extract to create Mg-Chl using acetone solvent as described by Abbas *et al.* [16].

The White Fly *Bemisia tabaci*: To reduce the population of *B. tabaci* in the field, different concentrations of the above mentioned two photosensitizers were sprayed on tomatoes. The nymphs and adults of *B. tabaci* were counted together indicating the population of *B. tabaci* before spraying and throughout the days after treatment (1, 3, 5, 7, 10 and 15 day).

Tomato Varities: Two tomato varities commonly planted in Egypt were chosen for field evaluation. One of them is Adora (planted in winter) and another is Elisa (planted in summer). One-old-month seedlings of the two varaties were purshased from privat company and sown on a sutible time. Adora seedlins were planted twice, one on 25 October in winter of 2019 and another on 1 November in winter 2020. Elisa seedlings were planted also twice, one on 22 April in summer of 2020 and another on 1 May in summer of 2021.

Study Area: This study was conducted at the Experimental Station of the Faculty of Agricultural, Cairo University, Giza, Egypt (30°01'32.5"N & 31°11'33.0"E) during 2019/2020 and 2020/2021 seasons.

Expeimental Design

Spraying the Field of Tomato Var Addora in Winter of 2019 and 2020: Two photosensitizers with two concentrations (10^{-3} and 10^{-4}) for each were applied against *B. tabaci* in the field of tomato var Addora during the winter season of 2019. At the same time Methomyl was sprayed as a reference insecticide with recommended dose (1 cm/l) as well as water was sprayed as a control group. The numbers of alive *B. tabaci* insects including adults and nymphs in the treatments and control groups were counted on the 1^{st}, 7^{th}, 10^{th} and 15^{th} day post sparying. These procedures were repeated in winter 2020 on the same tomato variety with additional low dose (10^{-5} ml/l). In this spray, the numbers of alive *B. tabaci* insects were counted on the 1^{st}, 5^{th} and 10^{th} days post spraying.

Spraying the Field of Tomato Var Elisa in Summer of 2020 and 2021: Two photosensitizers with four concentrations (10^{-2}, 10^{-3}, 10^{-4} and 10^{-5}) for each were applied against *B. tabaci* in the field of tomato var Elisa during summer of 2020. At the same time Methomyl was sprayed as a reference insecticide with recommended dose (1 cm/l) as well as water was sprayed as a control group. The numbers of alive *B. tabaci* insects including adults and nymphs in the treatments and control groups were counted on the 1st, 3th, 5th and 10th day post sparying. These procedures were repeated in summer 2021 on the same tomato variety with two concentrations (10^{-3} and 10^{-4} ml/l). In this spray, the numbers of alive *B. tabaci* insects were counted on the 1st and 7th days post spraying.

The treatments were performed two-month-day post planting of tomato seedlings. The experiments were carried out with a randomized complete block design with four replicates. Plant samples were investigated before treatment and post treatment on the 1st, 3rd, 5th, 7th, 10th and 15th day post spraying according to variety and season. The sample that included 20 plants were randomly selected from each plot and investigated for alive insects. The third leave of each seedling was carefully investigated. All adults and nymphs of *B. tabaci* were counted together and recorded.

Data Analysis: Data were statistically analysed using an analysis of varience (ANOVA), with the means separated using Duncan's Multiple Range criterion (P<0.05) between all treatments through investigated days and also between days for each treatment. Reduction percentages corresponding to each treatment were calculated using means of alive insects for each treatment comparing with those alive in untreated control group by the equation of Handreson and Telton [17].

RESULTS

Population of *B. tabaci* on Sprayed Tomato Var. Addora at Winter 2019: The two tested concentrations of either Copper chlorophylline or Magnesium chlorophylline revealed high declining in the population of *B. tabaci* on the first day post spraying. After 7 and 10 days, the number of alive insects was not declined significantly in all treatments. However, this number was significantly declined on the 15th day post spraying comparing with that on the 7th or 10th day. In contrary, the reference insecticide gave an extending effect on the population of *B. tabaci*. Moreover, all treatments significantly reduced the population of insects comparing with untreated control in the all days (Table 1). The calculated reduction percentages revealed that both photosensitizers exhibited reduction (47.1 - 73.3%) higher than that of methomyl insecticide (42.3%) at 24 h post spraying. Magnesium chlorophylline had higher reduction than Copper chlorophylline until 7 day post spraying. Both photosensitizers revealed low reductions on the 10th day post spraying, whereas the reduction increased again on the 15th day even it was more than the insecticide (Fig. 1).

Population of *B. tabaci* on Sprayed Tomato Var. Elisa at Summer 2020: Twenty Four hours after treatment, copper chlorophylline seemed to be weak in its efficacy against *B. tabaci*, while Magnesium chlorophylline achieved significant decline in the population of *B. tabaci* excepting the lowest concentration of this compound (10^{-5} ml/l). Significant decline in alive number of *B. tabaci* was recorded at 3 days post spray with the two photosensitizers. The number of white fly in various treatments exceeded on the 5th day post spray and reached to a population more than that recorded before spray. The highest concentration of the two photosensitizers recorded the lowest significant number of *B. tabaci*, 1.5 and 1.7 insects with Copper chlorophylline and Magnesium chlorophylline, respectively. Three days post spray, all photosensitizers treatments exhibited the same significant level of insect number that range from 0.2 - 0.9 insects comparing with 6.2 insects in untreated control plots. Five to ten days, the highest concentration of the two photosensitizers recorded the same significant level of insect number of *B. tabaci*. The insecticide was more effective than photosensitizers on the 10th day post spray (Table 2). The calculated reduction percentages revealed that the highest concentration of either Copper chlorophylline or Magnesium chlorophylline recorded high reduction, 77.27 and 80.68%, respectively. These reduction values were lower than that recorded with insecticide (85.15%) after one day of spraying. While at 3 days post spray, the highest concentration of Magnesium chlorophylline recorded high reduction (95.16%) comparing with other treatments. In general, all treatments achieved high reductions on the 3rd day post spray. On the 5th day post spray, the highest concentration of the two photosensitizers continued recording high reductions (89.29 - 92.86 %) comparing with the insecticide (79.59 %) (Fig. 2).

Table 1: Efficiency of photosensitizers Copper clorophline and Magnesium clorophline against the population of white fly *Bemisia tabaci* infesting tomato var. Adora in the field at winter season of 2019

		Mean of alive adults and nymphs ± SE						
		Day post spray						
Formulation	Rate ml/l	Before spray	1	7	10	15	F value	P value
Copper chlorophlline	10^{-3}	21.2±1.4 Ab	11± 2.5 Bc	9.73±0.8 Bc	9.17± 0.6 Bb	4.1± 0.8 Cb	19.928	0.000
	10^{-4}	25.9±4.1Aab	15.3± 2.5 Bbc	13.1± 0.8 Bb	9.6± 1.8 BCb	4.3± 0.5 Cb	11.805	0.001
Magnesium chlorophlline	10^{-3}	27.7±1.8Aab	9.8± 1.3 Bc	7.1± 0.9 Bc	6.9± 1.2 Bb	3.1± 0.3 Cb	64.607	0.000
	10^{-4}	33.5±2.0Aa	10± 1.1 Bc	8.2± 0.9 Bc	8.8± 0.9 Bb	3.4± 0.3 Cb	99.229	0.000
Methomyl	1 cm/l	27.5±3.9Aab	17.7± 2.1 Bb	7.37± 1.2 Cc	8.0± 0.6 Cb	5.3± 1.9 Cb	17.379	0.000
Control	0	34.2±1.3Aa	38.2± 1.3 Aa	38.3± 1.5 Aa	16.7± 0.7 Ba	15.5± 1.8 Ba	71.438	0.000
F value	-	3.323	32.935	133.161	10.328	17.537		
P value	-	0.041	0.000	0.000	0.001	0.000		

Means within a column or row followed by the same letter are not significantly different using Duncan's Multiple Range Test. Small letters indicate to the significant differences between treatments while capital letters indicate to significant differences between days.

Table 2: Efficiency of photosensitizers Copper clorophline and Magnesium clorophline against the population of white fly *Bemisia tabaci* infesting tomato var. Elesa in the field at summer season of 2020

		Mean of alive adults and nymphs ± SE						
		Days post spray						
Formulation	Rate ml/l	Before spray	1	3	5	10	F value	P value
Copper chlorophlline	10^{-2}	1.8±0.3Ab	1.5±0.2Ae	0.8±0.2BCb	0.3±0.1Ce	1.3±0.2ABfg	8.520	0.000
	10^{-3}	1.6±0.2Bb	4.1±0.4Ab	0.6±0.7Cb	0.8±0.2Ccde	1.9±0.2Bdef	29.185	0.000
	10^{-4}	1.9±0.3Bb	4.2±0.6Ab	0.3±0.1Cb	1.3±0.3Bbcd	2.3±0.3Bcde	16.712	0.000
	10^{-5}	2.5±0.3ABab	2.8±0.5ABcd	0.2±0.1Cb	1.9±0.4Bb	3.4±0.2Ab	13.179	0.000
Magnesium chlorophlline	10^{-2}	2.4±0.3Aab	1.7±0.2Bde	0.4±0.1Cb	0.6±0.2Cde	0.9±0.2Cg	16.391	0.000
	10^{-3}	2.3±0.3Aab	1.7±0.3ABde	0.6±0.2Cb	1.0±0.3BCbcde	1.6±0.3ABefg	6.017	0.000
	10^{-4}	3.1±0.5Aa	2.4±0.4Acde	0.7±0.2Bb	1.1±0.3Bbcde	2.6±0.4Abcd	8.015	0.000
	10^{-5}	1.9±0.3Bb	3.0±0.4Abc	0.9±0.3Cb	1.5±0.3BCbc	3.0±0.2Abc	10.540	0.000
Methomyl	1 cm/l	2.1±0.3Ab	1.1±0.2Be	0.5±0.2Cb	1.0±0.2BCbcde	0.8±0.2BCg	8.505	0.000
Control	0	1.8±0.3Cb	6.6±0.7Aa	6.2±0.5ABa	4.8±0.5Ba	5.0±0.6Ba	13.364	0.000
F value		2.115	15.804	51.591	18.239	20.404		
P value		0.023	0.000	0.000	0.000	0.000		

Means within a column or row followed by the same letter are not significantly different using Duncan's Multiple Range Test. Small letters indicate to the significant differences between treatments while capital letters indicate to significant differences between days

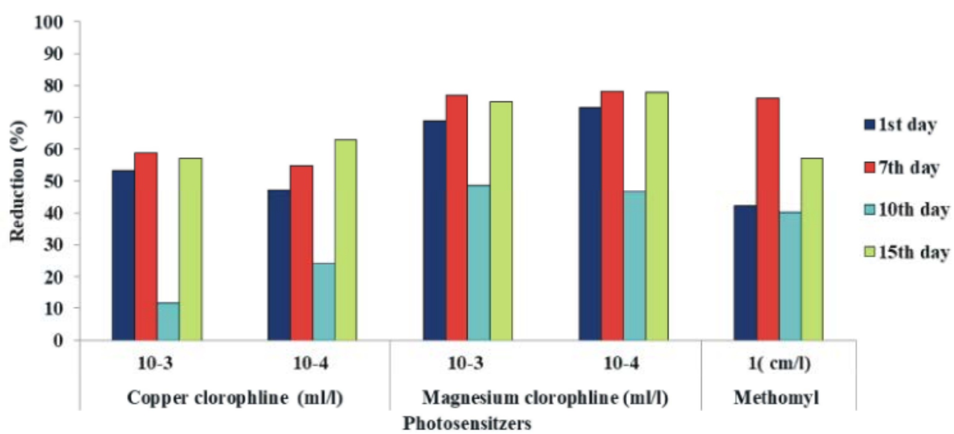

Fig 1: Reduction percentages in the population of white fly *Bemisia tabaci* treated with photosensitizers Copper clorophline and Magnesium clorophline in the field of tomato var. Adora at winter season of 2019

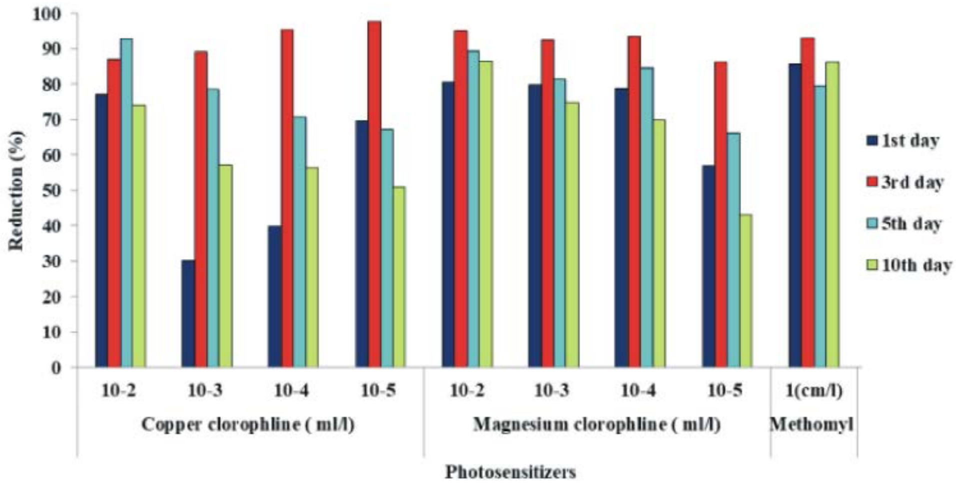

Fig. 2: Reduction percentages in the population of white fly *Bemisia tabaci* treated with photosensitizers Copper clorophline and Magnesium clorophline in the field of tomato var. Elesa in the field at summer season of 2020

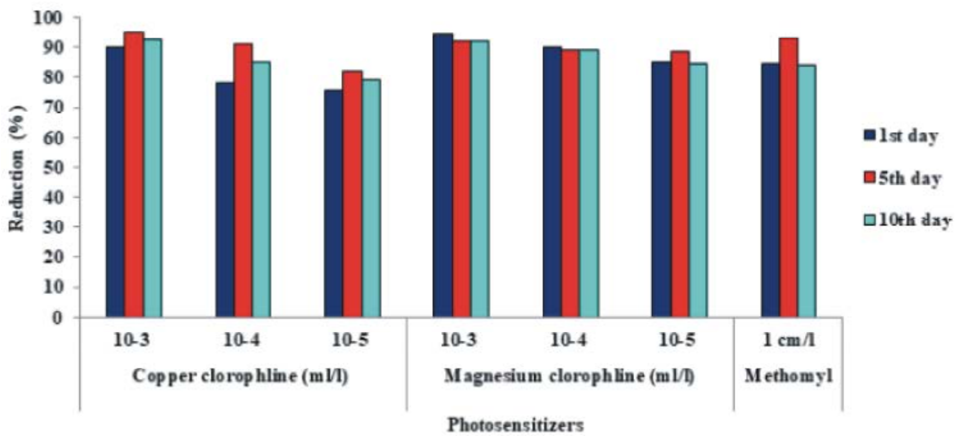

Fig. 3: Reduction percentages in the population of white fly *Bemisia tabaci* treated with photosensitizers Copper clorophline and Magnesium clorophline in the field of tomato var. Addora at winter season of 2020

Table 3: Efficiency of photosynthesizers Copper clorophline and Magnesium clorophline against the population of white fly *Bemisia tabaci* infesting tomatoes var. Addora in the field at winter season of 2020

		Mean of alive adults and nymphs ± SE					
		Day post spray					
Formulation	Rate ml/l	Before spray	1	5	10	F value	P value
Copper chlorophlline	10^{-3}	3.6±0.5Aab	1.4±0.2Bcd	1.1±0.1Bc	1.3±0.2Bd	15.550	0.000
	10^{-4}	2.4±0.4 cde	2.1±0.3bc	1.3±0.2cd	1.7±0.4bcd	2.311	IN
	10^{-5}	2.5±0.4bcd	2.4±0.3b	2.7±0.3b	2.5±0.4bc	0.101	IN
Magnesium chlorophlline	10^{-3}	4.1±0.5Aa	0.9±0.1Cd	2.0±0.3Bbc	1.6±0.2BCcd	18.495	0.000
	10^{-4}	3.4±0.4Aabc	1.3±0.2Bcd	2.2±0.2Bb	1.8±0.3Bbcd	9.387	0.000
	10^{-5}	3.6±0.5Aab	2.1±0.3Bbc	2.5±0.3Bb	2.7±0.2ABb	4.009	0.009
Methomyl	1 cm/l	2.1±0.4Ade	1.3±0.2ABcd	0.9±0.2Bd	1.6±0.3ABcd	3.150	0.027
Control	0	1.2±0.2Ce	4.8±0.5Ba	7.3±0.6Aa	5.8±0.5Ba	34.569	0.000
F value	-	5.948	18.023	39.299	18.390		
P value	-	0.000	0.000	0.000	0.000		

Means within a column or row followed by the same letter are not significantly different using Duncan's Multiple Range Test. Capital letters indicate to the significant differences between days while small letters indicate to significant differences between treatments. IN: insignificant

Table 4: Efficiency of photosynthesizers Copper clorophline and Magnesium against the population of white fly *Bemisia tabaci* infesting tomatoes var. Elisa in the field in summer season of 2021

		Mean of alive adults and nymphs ± SE				
		Day post spray				
Formulation	Rate ml/l	Before spray	1	7	F value	P value
			1st spray			
Copper chlorophlline	10^{-3}	6.70±0.94A	1.10±0.30B	2.35±0.35B	23.648	0.000
	10^{-4}	5.30±0.70A	1.45±0.20C	2.90±0.29B	18.502	0.000
Magnesium chlorophlline	10^{-3}	5.90±0.85A	1.30±0.30B	1.95±1.07B	8.433	0.000
	10^{-4}	5.20±0.94A	1.85±0.19B	2.50±0.30B	9.399	0.000
Methomyl	1 cm/l	6.25±1.00A	1.50±0.17B	1.50±0.25B	22.386	0.000
Control	0	7.40±0.81A	4.30±0.54B	4.85±0.75B	5.438	0.007
F value	-	0.921	14.990	4.476		
P value	-	IN	0.000	0.001		
		2nd spray				
Copper chlorophlline	10^{-3}	2.35±0.35	1.80±0.20	1.65±0.24	1.837	IN
	10^{-4}	2.90±0.29A	2.25±0.18AB	2.05±0.23B	3.491	0.037
Magnesium chlorophlline	10^{-3}	1.15±0.21	1.30±0.19	0.70±0.18	2.588	IN
	10^{-4}	2.50±0.30A	1.65±0.3B	1.45±0.22B	5.857	0.005
Methomyl	1 cm/l	1.15±0.25	0.95±0.14	0.50±0.15	3.120	IN
Control	0	4.85±0.75	5.00±0.68	3.95±0.44	0.793	IN
F value	-	11.615	21.089	22.105		
P value	-	0.000	0.000	0.000		

Means within a column or row followed by the same letter are not significantly different using Duncan's Multiple Range Test. Capital letters indicate to the significant differences between days while small letters indicate to significant differences between treatments. IN: insignificant

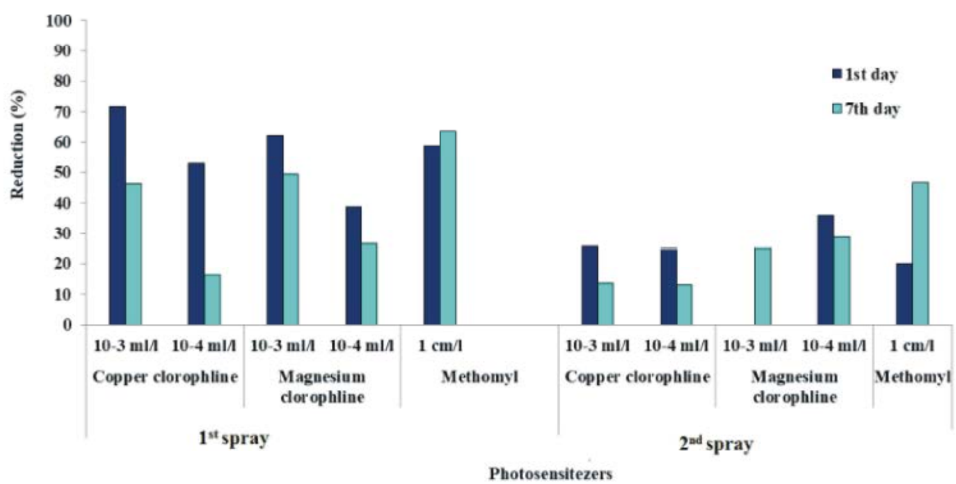

Fig. 4: Reduction percentages in the population of white fly *Bemisia tabaci* treated with photosensitizers Copper clorophline and Magnesium clorophline in the field of tomato var. Elisa in summer season of 2021

Population of *B. tabaci* on Sprayed Tomato Var. Addora at Winter 2020: The alive number of *B. tabaci* was significantly lower on the 1st, 5th and 10th day post spraying with 10^{-3} ml/l of Copper chlorophylline. However, the two concentrations 10^{-4} and 10^{-5} ml/l of Copper chlorophylline did not reveal any significant effect on the population of *B. tabaci* throughout the days post spraying. All tested concentrations of Magnesium chlorophylline exhibited significant decline in alive number of *B. tabaci*. On the 1st day post spray, 10^{-3} m/l of Magnesium chlorophylline induced the lowest significant number of *B. tabaci*. On the 5th day post spray, 10^{-3} m/l of Copper chlorophylline recorded the lowest alive number of *B. tabaci* (1.1 insects) but it was lower that recorded with methomyl (0.9 insect). On 10 day post spray, the concentration 10^{-3} ml/l of either copper chlorophylline or Magnesium chlorophylline recorded the lowest value of insect number (Table 3). The calculated reduction percentages revealed that all tested concentrations of Magnesium chlorophylline recorded (85 - 94.5%) higher reductions than copper chlorophylline and the insecticide (76 - 90.3%). On the 5th day post spray, 10^{-3} and 10^{-4} ml/l of Copper chlorophylline recorded higher reductions (95 and 91.1%) than those of Magnesium chlorophylline (92 and 89.4%). On the 10th day post spray, it is clear that 10^{-3} ml/l of the two photosensitizers had the highest reductions even from insecticide.

Population of *B. tabaci* on Sprayed Tomato Var. Elisa at Summer 2021: All treatments recorded significant decline in the alive number of *B. tabaci* during the 1st and 7th day post the first spray. In the second spray, a slight decrease in alive insect numbers was recorded. The number of insects was significantly lower than control in all treatments in the first and second spray (Table 4). The calculated reduction percentages revealed that the concentration 10^{-3} ml/l of either Copper chlorophylline or Magnesium chlorophylline recorded the highest reductions (71.75% & 62.08%) and (46.48 & 49.57%) on the 1st and 7th day post first spray, respectively. On the second spray, the two photsynthetizers induced low reductions ranged from 0 -35.98% and 13.20 - 28.78% on the 1st and 7th day post spray (Fig. 4).

DISCUSSION

The white fly *B. tabaci* is a key pest on tomato crops and causes huge losses in tomato production by its feeding or transmission of viruses. Chemical insecticide could be used in controlling this pest until arose problems due to repeated uses of these chemicals such as insect resistance, toxic effects on mammals and humans, pollution of the environment. Hence, the development of new and environmentally safe techniques to control insect pest populations is of great importance. Photoactive compounds usually used for photosensitization might be effective as pesticide agents, with low impact on the environment, being non-toxic and not mutagenic. Photosensitizer accumulates within the insect body and, following exposure to visible light, induces lethal photochemical reactions and death [8]. In this study two novel photosensitizers namely Copper chlorophylline or Magnesium chlorophylline were firstly evaluated as photoinsecticide to reduce the population of *B. tabaci* in tomato fields. The two tomato varieties, Adora and Elisa commonly planed in Egypt were chosen for field evaluation. Adora was planted in winters of 2019 and 2020 while Elisa was planted in summers of 2020 and 2021.

In the present study, Copper chlorophylline and Magnesium chlorophylline revealed high declining in the population of *B. tabaci* on the first day post spraying on tomato var. Addora at winter 2019. Following 7 and 10 days, the number of alive insects was not declined significantly in all treatments. However, this number was significantly declined on the 15th day post spraying comparing with that in 7th or 10 days. This finding indicated to the effect of photosensitizers is rabidly and not extend more than 24 hours and the reduction in population on the 15th day post spray may be attribute to the reverse environmental conditions especially the population was also reduced in control plots at the same time (15 day post spray). This finding was agreed with that recorded by Lukšiene *et al*. [8] who evaluated several photosensitizers (acridine orange, aminolevulinic acid, hematoporphyrin dimethyl ether [HPde], methylene blue) as photopesticides to control population of polyphagous plant pest *Liriomyza bryoniae* (Kaltenbach, 1858) (Diptera, Agromyzidae). They found that insect feeding with bait containing hematoporphyrin dimethyl and sugar induced remarkable accumulation of this compound in the body of insect. They also detected the highest HPde amount in the body of insect at 16 h after feeding, whereas no significant photosensitizer amount was detected in the same insect following 48 h. Moreover, the alive number of *B. tabaci* was significantly lower on the 1st, 5th and 10th day post spraying with 10^{-3} ml/l of Copper chlorophylline in tomato var Adora at winter 2020. However, the two concentrations 10^{-4} and 10^{-5} ml/l of Copper chlorophyllin did not reveal any significant effect on the population of *B. tabaci* throughout the days post spraying. This finding may attribute to the low number of insects before spraying comparing with the highest number that recorded in the winter of 2019 on the same tomato variety (Addora). All tested concentrations of Magnesium chlorophylline exhibited significant decline in alive number of *B. tabaci*. This result is in agreement with that recorded by El-Tayeb *et al*. [12] who found that the photosensitizer (Hematoporphyrin IX) caused a decrease in *Parasarcophaga argyrostoma* population. Therefore, it is recommended to use a high concentration (10^{-3} ml/L) of two photosensitizers in the control of *B. tabasi* in tomato var Addora fields.

In the current study, 24 h post spray tomato var Elisa at summer 2013, Magnesium chlorophylline achieved significant decline in the population of *B. tabaci* than copper chlorophylline. While after 3 days of spraying, both photosensitizers significantly reduced the number of alive *B. tabaci*.

The number of insects in different treatments exceeded on the 5th day post spray and reached more than that recorded before spraying. The significant effect or reduction recorded lower than that recorded with Addora in winter season may attribute to the population with low in summer season on tomato Elisa. The highest concentration of Copper chlorophylline and Magnesium chlorophylline recorded the lowest number of *B. tabaci* (1.5 and 1.7 insects). All treatments recorded significant decline in the alive number of *B. tabaci* during the 1st and 7th day post spray in tomato var Elisa at summer 2021. In the second spray, a slight decrease in alive insect numbers was recorded. This finding indicated to the second spray has not significant effects on the population of *B. tabaci* because the population was already low after one week from the first spray. Therefore, it is preferable spraying photsensitizers when the population of the pest is high.

This study is considered the first to apply novel two photosensitizers in field against phytophagous pest (*B. tabaci*). Dondji *et al*. [15] studied the effectiveness of light-induced killing of mosquito larvae in the presence of photosensitizers (xanthene, chlorin and porphyrin derivatives) with fourth instar larvae of medical insect pest *Culex quinquefasciatus* grown under field conditions. In agreement with the findings in the present study Huang *et al*. [18] investigated the photolarvicidal activities of 10 thienyl 1, 3, 4-thia (oxa) diazoles as novel photosensitizers. They found that these compounds showed strong larvicidal activities against *Pseudaletia separata* only under irradiated conditions. They added that the degree of mortality was increased with increasing accessibility period of the insects to photosensitizer-loaded leaves during exposure to light. Helleck and Hartberg [14] found that *Eretmapodites quinquevittatus* larvae fed Photofrin® porfimer sodium (3.75 μg/ml) showed significantly reduced survival compared to untreated larvae also the fertility of adults was significantly lower than control. The insect mortality after treatment with phtosinestizer may be due to their accumulated within the insect body and induces damage of cuticle, malpighian tubes, midgut wall and feeding inhibition [19].

CONCLUSION

The two new photosensitizers copper chlorophyllin and magnesium chlorophyllin were first applied against the whitefly *B. tabaci* in tomato fields. The magnesium chlorophyllin especially at high concentrations (10^{-2} and 10^{-3} ml/l) gave the highest reduction in *B. tabaci*. So, photosensitizer compounds can be used in PIM program to control *B. tabaci* in tomato fields.

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