Middle East Journal of Applied Sciences
Volume: 12 | Issue: 04| Oct. – Dec. | 2022

EISSN: 2706 -7947 ISSN: 2077- 4613
DOI: 10.36632/mejas/2022.12.4.47
Journal homepage: www.curresweb.com
Pages: 660-670

Acaricidal Activity of Some Natural Products on the Two-Spotted Spider Mite, *Tetranychus urticae* in Laboratory

Essam A. Ali[1], Ayman Y. Zaki[2] and Hamdi S. Abd El-Karim[2]

[1]Plant Protection Dept., Pesticides Unit, Desert Research Center, Mataria, Cairo, Egypt.
[2]Vegetable, Medicinal & Aromatic Plant Mite Dept., Plant Protection Research Institute, Agricultural Research Center, Giza, Egypt.

Received: 25 Oct. 2022 **Accepted:** 15 Dec. 2022 **Published:** 30 Dec. 2022

ABSTRACT
Two-spotted spider mite *Tetranychus urticae* Koch (Acari: Tetranychidae) is a great economic importance in Egypt that causing considerable damage to many crops. Some silicon formulations as kaolin, bentonite, aglev Si 300 & diatom as powder formulations, different forms of liquid formulation for potassium silicate and palmito formulation (plant extracts) as standard, were examined against *Tetranychus urticae* under laboratory conditions. The toxicity effect on adult females was determined. Also, acaricidal effects on some biological aspects of *Tetranychus urticae* were studied. The results demonstrated that the percentage of mortality increased as the concentration increase. palmito, diatom and kaolin gave the highest mortality rates followed by aglev Si 300, while the least effect found in bentonite on *T. urticae* adult females. The obtained results revealed that the best treatment for the rate of laying eggs at 100 % concentration was potassium salt for liquid formulations, diatom and aglev Si 300 for powder formulations. In general, liquid formulations were more effective on the oviposition rate for treated females than powder formulations. In egg incubation treatment, kaolin (100% conc.) gave the longest incubation period with an average (4.8 days), while the lowest average (3.4 days) was recorded with bentonite (75% conc.), which is the same rate as was found in the control. The best treatment for the egg hatch rate was bentonite (100% conc.), while the least effect was recorded with Kaolin (50% conc. Accordingly to the results of egg period, the best treatments were si El-Ghanem (100% conc.), bentonite (100% conc.), bentonite (75% conc.) and aglev Si 300 (100% conc.). The best treatments of larva period were bentonite (100% conc.), aglev Si 300 (100% conc.), diatom (100% conc.) and diatom (75% conc.). The present study revealed that some silicon formulations, such as diatom, kaolin, aglev Si 300, si El-Ghanem, kaolinated potassium silicate and potassium salt can be used alternatively as acaricides for potential mite management in integrated crop management.

Keywords: Silicon formulations, kaolin, potassium silicat, *Tetranychus urticae*, toxicity, acaricidal effects.

1. Introduction
It is common fact that family Tetranychidae, has 1,200 mite species. Two-spotted spider mite is consider the most significant species (Alzoubi and Cobanoglu 2008). It investigates more than 300 hosts (Le Goff *et al*., 2009). *Tetranychus urticae* mite caused a major harmful mite in agricultural crops and was economic pest causing high level of damages (Reddy and Dolma 2018; Hassan *et al*., 2021). Yellowing, drying and defoliation could be occurred since in direct feeding or indirect feeding damage that cause decreases in photosynthesis, transpiration to change in leaf colour from green to yellow and white, significantly causing reduce of the yield quantity and quality (Park and Lee 2002). Synthetic acaricides are main application method to control *T. urticae*, resulting many serious problems incuding environmental pollution and harm to human and animal health, in addition to the negative effects on the natural enemies of pests. (Hassan *et al*., 2021). One of the recommendations to be used the development of processed particle film technology, it is a new technique to control insects (Glenn *et*

Corresponding Author: Essam A. Ali, 1Plant Protection Dept., Pesticides Unit, Desert Research Center, Mataria, Cairo, Egypt.

al., 1999). In this technology, the mineral particle as kaolin, benronite, diatom and Aglive are really important to the farmers to transform from traditional to organic techniques. The particle films method support some good practices as decreasing insect populations and pathogen harmphul, good at photosynthesis and the yield, by physical characterizations (Glenn and Puterka 2005).

Silicon has several benefits in increasing plant resistance to control pests. Therefore, it must be important to increase alternative plant protection materials. Naturally, there are a lot of silica sources as diatomaceous earth, kaolin bentonite and potassium silicate have already been as potential insecticide to control plant (Athanassiou *et al.,* 2003; Stathers *et al.,* 2004; Ali *et al.,* 2021). Films could be created by particle film technology that make a physical barrier to repel insects with no toxic selection pressure. Film technology based insect control programs to reduce the using of synthetic pesticide, reduce the water irrigation by increasing the water efficiency reducing sunburn and heat stress in crops system. (Laing *et al*, 2006). Silica showed to mortality of adult mosquitoes; flesh flies, secondary screwworm flies, *Cochliomyia macellaria* (F.); and house flies through direct contact (Chen *et al*., 2021). Plant extracts have been caused the broad action on different types of pests as well as biodegradability, low toxicity to mammals and low negative effects on environment (Isman 2020). Under laboratory conditions, two synthesis agents (silica bulk-abamectin, silica NPs-abamectin), silica nanoparticles and silica bulk had potential effects compared to abamectin on the immature stages of *T. urticae*. The effects of sublethal concentrations of the examined compounds on egg deposition and hatchability were investigated over 5 days at 22 & 28°C, respectively (Zayed 2022).

The aims of our research were to study the potential of some silicon formulations to control the phytophagous mite *Tetranychus urticae* and evaluate how they would affect the reproductive rates, under laboratory conditions.

2. Materials and Methods

2.1. Silicon Sources

In this study, we used different silicon sources in two groups. The first one was powder group that were kaolin, bentonite, attapulgite (Agliv Si 300) and Diatomaceous Earth (Diatom) that were naturel soil sources. The second was liquid group, potassium silicate that had three sources of liquid silicon. While, the source of the first was from sand, the second was from kaolin mineral and the third was from chemical manufacture. The previous materials were compared with the standard of natural insecticide as Palmito and untraditional material as (potassium salt) (Ali *et al*., 2021). The material sources are listed in Table 1 as follows:

Table 1: Different silicon formulations

	Name	Case	Source	Structure
1	**Kaolin**	Powder clay	Investment Petroleum Group IPG inc	Aluminum Silicate
2	**Bentonite**	Powder clay	Green Way Company	Aluminum Silicate (Calcium)
3	**Aglev Si 300**	Powder clay	Geohellas Company	Magnesium Aluminum Silicate
4	**Diatom**	Powder	Green Way Company	Diatom
5	**Si El-Ghanem**	Liquid	Abo Ghanema Company	Potassium silicate
6	**Silica Ke**	Liquid	Techno Green	Potassium silicate
7	**Kaolinated Potassium silicate**	Liquid	Investment Petroleum Group IPG inc	Potassium silicate + kaolin
8	**Poassuim salt**	Solid	Green Way Co.	Untraditional material
9	**Palmito**	Liquid	El-Masria for fertlizers	Some Plant extracts

2.2. Mass rearing of *Tetranychus urticae*

The colony of *T. urticae* was taken from the laboratory of acarology in Plant Protection Research Institute, Giza, Egypt. A culture of spider mite was reared on leaves of acalypha (*Acalypha wilkesiana marginata*, Müll., Family: Euphorbiaceae) under laboratory conditions of 27±2°C, 60%±5 R.H and (16 h L/8 h D) photoperiod until hatching (Ismail 2017). The leaves were placed on a piece of wet cotton pad maintained permanently wet in phil dishes (25 cm×15 cm) as a source of mites.

2.3. Bioassay of some silicon formulations against *T. urticae* in the laboratory

2.3.1. Toxic effects on adult females

Leaf discs of acalypha (3 cm diameter) were put separately upside-down on moist cotton pads in phil dishes. Ten adults of two-spotted spider mite were placed on each disc then treated by sprayed with different concentrations of silicon formulations, potassium salt and palmito. The concentrations were determined after initial experiments. Five replicates for each concentration were treated. All treated discs were under laboratory condition (at 27 ± 2°C and 65 ± 5% RH). Mortality was estimated daily for 7 days. Adult corrected mortality and the corrected mortality percentages were calculated (Abbott 1925). Individuals were considered dead when they did not move after prodded using soft brush bristles and carefully examined under the light stereomicroscope (Choi *et al*., 2003 and Peschiutta *et al*., 2017).

2.3.2. The ovicidal effect on eggs

Ten adult females of *T. urticae* were reared on disc of acalypha leaf on moist cotton pads in phill dishes for oviposition. Dishes were incubated for 24h at 27 ± 2°C and 65 ± 5% RH. After that the individuals were removed from the discs. Each concentration included five replicates. Twenty eggs of *T. urticae* were left on each disc (replicate). Discs containing eggs were sprayed by using glass atomizer with the same aforementioned formulations and concentrations were tested (Ghaderi *et al*., 2013). Effect on egg hatching and development period of larvae also were evaluated.

Statistical analysis

Corrected mortality percentage of adult females and eggs were calculated according to Abbot's formula (1925). Values of LC_{50}, LC_{90} and slant were estimated according to Finney (1971) using Ldp line software as determined by Bakr (2000).

Data were analyzed using the InfoStat computer software package (version, 2012). The differences among treatments were compared by LSD as a post hoc test at ≤ 5% level of significance (Gomez and Gomez 1984).

3. Results

3.1. Toxic effect of silicon formulations on adult females of *Tetranychus urticae* mite

The data given in table (2&3) show the toxicity of some silicon formulations against adult females of *T. urticae* which were tested with the leaf disc technique. A level of mortality was found for the most silicon formulations through 7 days exposure period under laboratory conditions. The toxicity of *T. urticae* on adult females increased as exposure time after treatment increased.

3.1.1. Toxic effect of silicon powder formulations on adult females of *T. urticae*

As shown in table (2), Silicon powder formulations, palmito, diatom and kaolin formulations showed the highest acaricidal effect against adult female stage, they gave 100% mortalities after seven days exposure. aglev Si 300 showed corrected mortality percentage 78.3 %. While, bentonite gave the lowest percentage mortality 54.4%.

More details study must be done for the most toxic materials as palmito, potasuim salt, diatom, Kaolin and aglev Si 300 against adult females of *T. urticae* mite to calculate LC_{50} .

Table 2: Effect of silicon powder formulations on mortality percentage of adult females of *Tetranychus urticae* mite.

Treatments	Exposure time (Days) % Corrected Mortality						
	1	2	3	4	5	6	7
Diatom	12.0	44.0	100.0	100.0	100.0	100.0	100.0
Kaolin	48.0	62.0	74.0	78.0	88.0	97.9	100.0
Bentonite	12.0	14.0	24.0	36.0	46.0	46.5	54.4
Aglev Si 300	32.0	42.0	62.0	64.0	70.0	72.3	78.3
Palmito	88.0	90.0	100.0	100.0	100.0	100.0	100.0

Middle East J. Appl. Sci., 12(4): 660-670, 2022
EISSN: 2706 -7947 ISSN: 2077- 4613 DOI: 10.36632/mejas/2022.12.4.47

3.1.2. Toxicity lines and LC_{50} values for some powder silicon formulations against adult females of *T. urticae*

Data in table (3) demonstrated that palmito, diatom, kaolin and aglev Si 300 were the highest toxicity against adult female of the two-spotted spider mite, so more details must be studied to calculate the lethal concentrations (LC_{50}). The lethal concentrations (LC_{50}) along is presented in table 3. Based on the toxic activity, palmito formulation showed the most toxic (LC_{50}= 31.9 mg/ml to the adults followed by diatom and kaolin with LC_{50} 139.9 mg/ml but agliv Si 300 was the least toxic (LC_{50}= 149.0 mg/ml).

Table 3: Cumulative LC_{50} values (mg/ml) of some powder silicon formulations against female adult of the two-spotted spider mite, *Tetranychus urticae*.

Exposure time (Days)	Treatments							
	Diatom		Kaolin		Agliv 300 Si		Palmito	
	LC_{50}	P	LC_{50}	P	LC_{50}	P	LC_{50}	P
1 Day	391.2	1.8	366.6	2.9	1128.7	1.8	49.6	2.8
2 Days	309.8	2.0	366.6	2.9	205.8	4.1	43.0	3.4
3 Days	309.8	2.0	366.6	2.9	191.3	4.4	35.4	5.7
4 Days	163.6	3.0	268.8	2.1	163.4	5.0	31.9	5.2
5 Days	162.8	3.1	222.3	2.5	161.3	4.5	31.9	5.2
6 Days	156.6	3.1	199.1	2.8	149.0	4.9	31.9	5.2
7 Days	139.9	3.3	139.6	3.8	149.0	4.9	31.9	5.2

LC_{50} = Lethal concentration that kill 50% of populations P = slope

3.1.3. Toxic effect of silicon liquid formulations on adult females of *T. urticae*:

Bioassay was conducted to estimate the potential activity of silicon liquid formulations towards adult female stage of *T. urticae* mite. The results are given in table (4) showed that palmito formulation and potassium salt were the most toxicity on adult females with (100.0 & 80.4%) percentages mortalities after seven days exposure. Si El-Ghanem and kaolineted potassium silicate showed maximum toxicity with >70 % percent mortality (76.1 & 73.9%) after 7 days exposure time towards the adult females. Silica ke formulation achieved activity less than 30 % mortality (28.0%).

More details study must be done for the most toxic materials as palmito, potassium salt, si El-Ghanem and kaolineted potassium silicate against adult females of *T. urticae* mite to calculate LC_{50}

Table 4: Effect of silicon liquid formulations on mortality percentage of adult females of *Tetranychus urticae* mite.

Treatments	Exposure time (Days) % Mortality						
	1	2	3	4	5	6	7
Si El-Ghanem	18.0	38.0	46.0	56.0	60.0	68.1	76.1
Silica ke	6.0	14.0	19.2	21.0	22.0	25.0	28.0
Kaolineted Potassium Silicate	28.0	48.0	58.0	64.0	70.0	68.1	73.9
Potassium salt	52.0	66.0	70.0	76.0	82.0	74.5	80.4
Palmito	88.0	90.0	100.0	100.0	100.0	100.0	100.0

3.1.4. Toxicity lines and LC_{50} values for some liquid silicon formulations against adult females of *T. urticae*:

In addition to activities of silicon liquid formulations, toxicities of five formulations on adult females of mite are listed in table (5). Palmito formulation was the most toxic (LC_{50} = 31.9 mg/ml) to the adults, followed by potasuim salt (LC_{50} = 96.3 mg/ml), kaolineted potassium silicate (LC_{50} = 106.0 mg/ml) and si El-Ghanem (LC_{50} = 114.3 mg/ml).

Table 5: Cumulative LC_{50} values (mg/ml) of some liquid silicon formulations against adult females of *Tetranychus urticae.*

Exposure time (Days)	Treatments							
	Potassium salt		Kaolinated potassium silicate		Si El-Ghanem		Palmito	
	LC_{50}	P	LC_{50}	P	LC_{50}	P	LC_{50}	P
1 Day	1128.7	1.8	0.0	0.0	31626.7	0.8	49.6	2.8
2 Days	283.4	3.1	230.1	3.7	4008.5	1.1	43.0	3.4
3 Days	189.9	3.5	238.9	3.0	238.9	3.0	35.4	5.7
4 Days	129.0	4.0	145.4	3.8	220.2	2.4	31.9	5.2
5 Days	117.5	3.8	132.2	3.2	145.9	3.0	31.9	5.2
6 Days	103.0	4.0	107.7	3.1	126.3	3.6	31.9	5.2
7 Days	96.3	4.3	106.0	3.2	114.3	4.0	31.9	5.2

LC_{50} = Lethal concentration that kill 50% of populations P = slope

3.2. Effect of some silicon formulations on some biological aspects of *Tetranychus urticae* mite:

3.2.1 Effects on treated females

3. 2.1.1 Oviposition (female fecundity)

From table (6) it is clear that treatment with liquid formulations, potassium salt with (100% conc.) gave the highest effect in reducing the mean number of egg laid by treated females with an average of 43.0 eggs, followed by si El-Ghanem with (100% conc.) which gave (45.0) and potassium salt with (75% conc.) which recorded number of (55.2), while the least effect was recorded with kaolinated potassium silicate (50% conc.) with and recorded (101.4 eggs) compared to the control with an average number of (107.0).

As for the treatment of powder formulations, the highest scale effect with diatom (100% conc.) is at the lowest average laying of eggs (142.6 eggs), followed by Aglev Si 300 (100% conc.) with an average of (145.2). However, aglev Si 300 (75% & 50% conc.) have moderate effects (204.8 & 223.6 eggs), respectively. While the least effect was found with bentonite (50% conc.) and Kaolin (50% conc.) with an average of (301.4 & 320.20) respectively, compared to the control (358.0) (Table 6).

According to these results, it can be concluded that the best treatment for the rate of laying eggs was Potassium salt (100% conc.) for liquid formulations, and diatom (100% conc.) and aglev Si 300 (100% conc.) for powder formulations.

In general, liquid formulations were more effective on the oviposition rate for treated females than powder formulations.

3.2.1.2 Impact on the egg incubation period

It is also clear from table (6) that no clear differences between the treatments and the concentrations of the liquid formulations for egg incubation of eggs deposited by treated females, yet the longest period of the egg incubation was registered with potassium salt (100% conc.), si El-Ghanem (100% conc.) and potassium salt (50% conc.) with an average of (4.4) days each, while the lowest period recorded with the kaolinated potassium silicate (75% conc.) with an average of (3.6) compared to the control (3.8 days).

For the powder formulations, kaolin (100% conc.) gave the longest incubation period with average of (4.8 days), while the lowest average (3.4 days) was recorded with bentonite (75% conc.), which is the same rate which recorded with in the control (table 6).

From these results it can be concluded that the best result in all treatments and concentrations was kaolin (100% conc.), while the bentonite (75% conc.) recorded the least effect.

3.2.2 Effect on treated eggs

3.2.2.1 Impact on egg hatchability (fertility)

As shown in table (7), for the liquid formulations, the best result was observed with the lowest average egg hatch 14.4 with potassium salt (100% conc.), while kaolinated potassium silicate (50% conc.) gave the lowest effect on the hatching with an average of 18.2 compared to the control that recorded a hatching rate of 19.4.As for the powder formulations, bentonite (100% conc.) gave the highest effect on inhibiting egg hatch with an average of 8.0, followed by bentonite (75% conc.) with an average of 12.6, while the least scale effect recorded with the kaolin (50% conc.) with average of 19.8 compared to the control 19.6 (table 7).

So, the best treatment for the egg hatch rate was bentonite (100% conc.), while the least effect was recorded with kaolin (50% conc.).

Table 6: Effect of some different silica formulations on oviposition rate and egg incubation period of of *T. urticae* treated females.

Treatments	Conc. %	Biological aspects		
		Oviposition		Egg incubation
		Total	Mean±SE	
A) Liquid form.				
Potassium salt	100	215	43±4.09 a	4.4±0.25 a
	75	276	55.2±3.34 ab	4.2±0.37 a
	50	389	77.8±2.96 d	4.4±0.25 a
Si El-Ghanem	100	225	45±5.61 ab	4.4±0.25 a
	75	298	59.6±0.75 bc	4.2±0.2 a
	50	407	81.4±7.95 d	4±0.32 a
Kaolinated potassium silicate	100	298	59.6±6.24 bc	4.2±0.37 a
	75	374	74.8±8.4 cd	3.6±0.4 a
	50	507	101.4±6.73 e	3.8±0.2 a
Control		535	107±4.21 e	3.8±0.37 a
LSD		16.21		0.8
B) Powder form.				
Kaolin	100	1198	239.6±31.81 bcde	4.8±0.37 a
	75	1430	286±16.75 defg	4.4±0.24 ab
	50	1601	320.2±36.95 fg	4.8±0.2 bc
Bentonite	100	871	174.2±23.89 ab	4.2±0.37 abc
	75	1208	241.6±26.95 bcde	3.4±0.24 c
	50	1507	301.4±34.14 efg	3.8±0.37 bc
Agliv 300 Si	100	726	145.2±24.44 a	4±0.32 abc
	75	1024	204.8±32.59 abc	4.4±0.24 ab
	50	1118	223.6±16.56 bcd	3.6±0.4 bc
Diatom	100	713	142.6±9.64 a	3.8±0.2 bc
	75	1402	281.4±29.03 def	3.6±0.24 bc
	50	1295	259±16.56 cdef	3.6±0.24 bc
Control		1790	358±18.63 g	3.4±0.24 c
LSD		73.97		0.85

Means with a common letter are not significantly different ($p > 0.05$)

3.2.2.2. Egg Incubation period

Data in table (7) showed that, in liquid treatments, the longest period recorded with Si El-Ghanem (100% conc.) with an average of 4.4 days, followed by Si El-Ghanem (75% conc.) with an average of 4.2 days, while the least record effect with kaolinated potassium silicate (50% conc.) at the lowest average 3.2 days compared to the 3.4 days control.

For the powder formulations, the longest period was found with bentonite (100% conc.), bentonite (75% conc.), aglev Si 300 (100% conc.) with the same average 4.4, while the lowest record with aglev Si 300 (50% conc.) was the same average control 3.2 days, table (7).

Accordingly, the best treatments were si El-Ghanem (100% conc.), bentonite (100% conc.), bentonite (75% conc.) and aglev Si 300 (100% conc.).

3.2.2.3 Larva period

As indicated in table (7) no considerable difference in all concentrations of liquid formulations estimated, but the highest average recorded 2.8 days with potassium salt (100% conc.), while the result of the control was 2.4 days.

Likewise, no explicit differences between treatments and concentrations in powder formulations, the highest average were recorded 3.0 with each of bentonite (100% conc.), aglev Si 300 (100% conc.), diatom (100% conc.) and diatom (75% conc.), while the lesser average 2.4 recorded with aglev Si 300 (50% conc.) compared to control which recorded 2.6 days, table (7).

Consequently, the best treatments were bentonite (100% conc.), aglev Si 300 (100% conc.), diatom (100% conc.) and diatom (75% conc.).

No significant differences were observed between all tested formulations for immature development period of *T. urticae.*

Table 7: Effect of some different silica formulations on hatchability, egg and larva development period of treated eggs of *T. urticae*.

Treatments	Conc. %	Biological aspects			
		Hatchability%		Immature development period	
				Eggs	Larvae
		Total	Mean±SE	Mean±SE	
A) Liquid form.					
Potassium salt	100	72	14.4±0.6 a	4.2±0.2 abc	2.8±0.2 a
	75	80	16±0.32 bcd	3.8±0.24 abc	2.6±0.98 a
	50	88	17.6±0.51 de	3.8±0.2 abc	2.6±0.24 a
Si El-Ghanem	100	75	15±0.63 abc	4.4±0.24 a	2.4±0.24 a
	75	84	16.8±0.58 cde	4.2±0.2 ab	2.6±0.24 a
	50	85	17±0.71 de	3.8±0.2 abc	2.4±0.24 a
Kaolinated potassium silicate	100	74	14.8±0.66 ab	3.6±0.24 bc	2.4±0.24 a
	75	89	17.8±0.92 de	3.6±0.24 bc	2.6±0.24 a
	50	91	18.2±0.58 ef	3.2±0.2 c	2.40.24 a
Control		97	19.4±0.4 f	3.4±0.24 c	2.4±0.24 a
LSD		1.75		0.69	0.65
B) Powder form.					
Kaolin	100	96	19.2±0.37 bc	4.2±0.2 ab	2.8±0.2 a
	75	93	18.6±0.98 bc	4±0.32 abc	2.8±0.2 a
	50	99	19.8±0.2 c	3.6±0.24 abc	2.6±0.24 a
Bentonite	100	40	8±1.38 a	4.4±0.24 a	3±0.00 a
	75	63	12.6±0.81 a	4.4±0.24 a	2.6±0.24 a
	50	94	18.8±0.73 bc	4±0.00 abc	2.8±0.2 a
Agliv 300 Si	100	79	15.8±1.02 bc	4.4±0.24 a	3±0.00 a
	75	96	19.2±0.8 bc	3.8±0.2 abc	2.8±0.2 a
	50	97	19.4±0.4 bc	3.2±0.2 c	2.4±0.24 a
Diatom	100	76	15.2±1.2 b	4.2±0.37 ab	3±0.00 a
	75	96	19.2±0.8 bc	4±0.00 abc	3±0.32 a
	50	96	19.2±0.58 c	3.6±0.24 bc	2.6±0.24 a
Control		98	19.6±0.4 c	3.2±0.2 c	2.6±0.24 a
LSD		3.63		0.74	0.62

Means with a common letter are not significantly different ($p > 0.05$)

4. Discussion

Two-spotted spider mite is an important polyphagous mite species in agricultural crops (Van Leeuwen *et al*., 2007; Reddy and Dolma 2018). Unfortunately, the mites have a resistant to chemicals due to rapidly development, short life cycle, high fecundity and produce several generations throughout the year. Natural products are very good alternative to chemical pesticides to reduce negative impacts to human health and the environment (Isman and Machial 2006). The minerals as particle film technology which are particularly formulated for coating over the agricultural has emerged as a new method for a protective area to control plant pests (Glenn *et al*., 1999; Stanley 1998; Glenn and Puterka 2004; Daniel *et al*., 2005). The particle film is based on kaolin, bentonite, diatom and aglve Si 300. In this study, It is reasonable to conclude that, The data show the effect of some silicon formulations as kaolin, bentonite, aglev Si 300 and diatom as powder formulations, different forms of liquid formulation for potassium silicate and palmito formulation (plant extract) as standard against toxic effects of adult female, oviposition (female fecundity), egg incubation period, egg hatchability (fertility), egg period and larva period of the two-spotted spider mite, which tested with the leaf discs technique. The toxicity against adult females of *T. urticae* increased as exposure time after treatment increased. Our results explained that, the toxic influence of palmito, diatom and kaolin gave highest mortality rates followed by aglev Si 300, while the least effect found in bentonite on *T. urticae* adult females. These data agree the data which obtained by Ali *et al*., (2021) who concluded that aglev Si 300, diatoms, palmito and glister were considered as the most active materials gave 100 % mortalities against preadult stage of mango shield scale insect, followed by kaolin, kaolineted potassium silicate, potassium silicate, (boiled lime & sulfur) and malathion gave potential activity more than 90% mortalities while Bentonite and potassium silicate (Silica Ke) considered active against preadults with moderate percentage corrected mortality. palmito and glister formulations were the best one with 100% corrected mortality against adult stage of mango shield scale insect. In the field study, Ali (2016) showed that the same effect of some minerals as kaolin, diatom and bentonite was achieved in suppressing the infestation of the olive fruit fly. His results confirmed that the treatment with a concentration of 5% gave the best result in affecting this pest, while the concentrations 3% and 4% were economically less cost. Also suggested that it is possible to include these materials as a modern technique within integrated pest management programs when controlling the olive fruit fly. Direct applications of silica on insects are medically important, such as bed bug control. CimeXa, a finely divided silica aerogel powder, rapidly adsorbs the tick’s wax layer, and it can also increase plant tolerance to pest infestation when applied to amend and improve soil texture and properties, which results in strengthening plant cell walls. (Keeping and Meyer 2002, 2003; Laing *et al*., 2006; Donahue *et al*., 2015; Showler and Harlien 2018). Ali (2016) reported that Particle film technology is a new technique to control for insects and diseases. The mode of action of minerals particle film by shells of minerals has negative effects on cuticle layer of integument of insects, and physical properties because the shells absorb the lipids which could the epicuticular waxy layer and abrade the exoskeleton, especially in its thinnest zones (Korunic 1997; Glenn *et al*., 1999; Puterka *et al*., 2000). Rouini (2008) supposed that minerals may prevent insects from identifying a host plant and could not feed on or lay eggs on the plant, where the layer of minerals covering the leaves or fruits can be unpalatable and repellent to these insects that feed on the plant. Our results agreed with Soubeih *et al*., (2017) who investigated that the diatoms and kaolin were the best potential at concentration 5% on aphid, leafminer infestations and early blight disease incidence and severity. Also, Pangihutan *et al*., (2022) cleared that talc and calcium oxide decrease the numbers of fruit flies and have negative effects on female fecundity under the laboratory bioassay. The biological activity of silicon formulations (minerals or potassium silicate) is by silicon which can be promoting mechanical strength, light interception and resistance to biotic and abiotic stresses, give highly production in both quantity and quality. It may cause acaricidal and ovicidal effect on *T. urticae*. Data of this study may develop acaricidal effect from silicon. It can be concluded that the best treatment for the rate of laying eggs at 100 % concentration was Potassium salt for liquid formulations, Diatom and Aglev Si 300 for powder formulations. In general, liquid formulations were more effective on the oviposition rate for treated females than powder formulations. In egg incubation treatment, Kaolin (100% conc.) gave the longest incubation period with average (4.8), while the lowest average (3.4 days) was recorded with bentonite (75% conc.), which is the same rate as was found in the control. The best treatment for the egg hatch rate was bentonite (100% conc.), while the least effect was recorded with Kaolin (50% conc.). Accordingly the results of egg larva period, the best treatments were Si El-Ghanem (100% conc.), Bentonite (100% conc.), bentonite (75% conc.) and aglev Si 300 (100% conc.). The best treatments of larva to nymphs period were bentonite (100% conc.), Aglev Si 300 (100% conc.), diatom (100% conc.) and Diatom (75% conc.). The present study proved that some silicon formulations as diatom, kaolin, aglev Si 300, si El-Ghanem, kaolinated potassium silicate and potassium salt can be used as an effective alternative to acaricides in mite control within the integrated crop management. Our results were a similar pattern of Sheibani *et al*., (2016) in the effect of kaolin, which indicated that the oviposition rate decreased 91% to 100% at ≥ 5% concentrations and no eggs were recorded at a concentration of 7.5% on the leaflets of treated pistachio trees. Ali (2016) demonstrated that particle film technique is not directly toxic to insects but it has repellent and anti-ovipositional with its highly reflective white coating. Application of substances in biological and mineral origin gave directly positive effects of pest control in some cases (Zehnder *et al*., 2007; Iannotta *et al*., 2007).

5. Conclusion

Based on the results, it can be revealed that potassium salt, kaolin, diatom agliv S300, potassuim silicate (kaolinated potassium silicate and si El-Ghanem) is a good potential as effective alternative to acaricides in integrated pest management strategies for control the phytophagous mite *Tetranychus urticae* after evaluate the safety of these formulations before practical application.

References

Abbott, W.S., 1925. A method of computing the effectiveness of an insecticide. Journal of Economic Entomology, 18: 265-267.

Ali, E. A. 2016. Effectiveness of Particle Film Technology and Copper Products in the Control of Olive Fruit Fly. J. Plant Prot. and Path., Mansoura Univ., 7(7): 439-444.

Ali, E.A., M.I. Abd El Razzik, S.A. Attia, and A.S. Fatma, 2021. Bioassay of Some Silicon Formulations against Mango Shield Scale Insect (*Milviscutulus Mangiferae* (Green) (Hemipetra: Coccidae) Under Laboratory Conditions. Middle East Journal of Agriculture Research, 10(04): Oct.-Dec. 1477-1487

Alzoubi, S. and S. Cobanoglu, 2008. Toxicity of some pesticides against *Tetranychus urticae* Koch and its predatory mites under laboratory conditions. American-Eurasian J. Agric. & Environ. Sci., 3(1): 18-25.

Athanassiou, C.G. N.G., Kavallieratos, F.C. Tsaganou, B.J. Vayias, C.B. Dimizas, and C.T. Buchelos, 2003. Effect of grain type on the insecticidal efficacy of SilicoSec against *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae). *Crop Prot*. 22:1141-1147.

Bakr, M., 2000. Towards a methodology for investigating the style of literary translator. Target, 12: 241-266. doi:10.1075/target.12.2.04bak.

Chen, K., J.M. Deguenon, G. Cave, S.S. Denning, M.H. Reiskind, D.W. Watson, D.A. Stewart, D. Gittins, Y. Zheng, X. Liu, *et al*., 2021. New thinking for filth fly control: residual, non-chemical wall spray from volcanic glass. Med. Vet. Entomol., 35(3): 451-461. doi: 10.1111/mve.12521.

Choi, W.I., E.H. Lee, B.R. Choi, H.M. Park, and Y.J. Ahn, 2003. Toxicity of plant essential oils to *Trialeurodes vaporariorum* (Homoptera: Aleyrodidae). *J. Econ. Entomol*., 96: 1479-1484.

Daniel, C., W. Pfammatter, P. Kehrli, and E. Wyss, 2005. Processed kaolin as an alternative insecticide against the European pear sucker, *Cacopsylla pyri* (L.). Journal of Applied Entomology, 129(7):363-367.

Donahue, W.A., A.T. Showler, M.W. Donahue, B.E. Vinson, L. Hui, and W.L.A. Osbrink, 2015. Knockdown and lethal effects of eight commercial nonconventional and two pyrethroid insecticides against moderately permethrin-resistant adult bed bugs, *Cimex lectularius* (L.) (Hemiptera: Cimicidae). *Biopestic. Int.*, 11: 108-117.

Finney, D.J., 1971. Propit analysis combridge University Press, Cambridge London, 333 pp.

Ghaderi, S., K. Minaei, V. Rowshan, and M. Ghamadyari, 2013. Toxicity and ovicidal activity of different plant extracts on two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae). Archives of Phytopathology and Plant Protection, 46(1): 120-126. doi:10.1080/03235408.2012.734721

Glenn, D.M. and G.J. Puterka, 2004. Particle film technology: an overview of history, concepts and impact in horticulture. Acta Hort., 636: 509-511.

Glenn, D.M. and G.J. Puterka, 2005. Particle films: a new technology for agriculture. Horticultural Reviews, 31: 1-44

Glenn, D.M., Puterka, G.J., T. Vanderzwet, R.E. Byers, and C. Feldhake, 1999. Hydrophobic particle films: a new paradigm for suppression of arthropod pests and plant diseases. J. Econ. Entomol., 92(4): 759-771.

Gomez, K.A. and A.A. Gomez, 1984. Statistical procedures for agricultural research (2 ed.). John wiley and sons, NewYork, 680.

Hassan, M.F., S.S. El-Badawy, M.G. Draz, and E.S. Ibrahim, 2021. New acaricidal activities and chemical compositions of orange oil and extracts of (wild mint and henna) against *Tetranychus urticae* Koch (Acari.:Tetranychidae). Archives of Phytopathology and Plant Protection, 54(19-20):1-16. DOI: 10.1080/03235408.2021.1950508

Iannotta, N., T. Belfiore, P. Brandmaya, M.E. Noce, and S. Scalercio, 2007. Evaluation of the impact on entomocoenosis of active agents allowed in organic olive farming against *Bactrocera oleae*. J. Environ. Sci. Health, 42: 783-788.

Ismail, M.S.M., 2017. Extract of the Plant *Costus speciosusas* a New Acaricide for Control of the Two-Spotted Spider Mite *Tetranychus urticae* Koch (Acari: Tetranychidae). African Entomology, 25(1): 148-155. doi:10.4001/003.025.0148

Isman, M.B., 2020. Botanical insecticides in the twenty-first century-fulfilling their promise? Annu. Rev. Entomol., 65: 233-249. doi:10.1146/annurev- ento- 011019- 025010.

Isman, M.B. and C.M. Machial, 2006. Pesticides based on plant essential oils: from traditional practice to commercialization. In M. Rai and M.C. Carpinella (eds.), Naturally Occurring Bioactive Compounds, Elsevier, BV, 29-44.

Keeping, M.G., and J.H. Meyer 2002. Calcium silicate enhances resistance of sugarcane to the Africa stalkborer, *E. saccharina* Walker (Lepidoptera: Pyralidae). Agric. For. Entomol., 4: 265-274.

Keeping, M. G., and J.H. Meyer, 2003. Effect of four sources of silicon on resistance of sugarcane varieties to *Eldana saccharina* Walker (Lepidoptera: Pyralidae). Proc. S. Afr. Sug. Technol. Assoc., 77: 99-103.

Korunic, Z., 1997. Rapid assessment of the insecticidal value of diatomaceous earth without conducting bioassays. Journal of Stored Products Research, 33: 291-229.

Laing, M.D., M.C. Gatarayiha, and A. Adandonon, 2006. Silicon use for pest control in agriculture: A review. Proc. S Agr. Sug. Technol. Ass., 80: 278-286.

Le Goff, G., A.C. Mailleux, C. Detrain, J.L. Deneubourg, G. Clotuche, and T. Hance, 2009. Spatial distribution and inbreeding in *Tetranychus urticae*. Biologies, 332: 927-933.

Pangihutan, J.C., D. Dono, and Y. Hidayat, 2022. The potency of minerals to reduce oriental fruit fly infestation in chili fruits. *Peer J.,* 10:e13198 https://doi.org/10.7717/peerj.13198

Park, Y.L. and J.H. Lee, 2002. Leaf cell and tissue damage of cucumber caused by two spotted spider mite (Acari: Tetranychidae). Journal of Economic Entomology, 95(5): 952-957. https://doi.org/10.1093/jee/95.5.952

Peschiutta, M.L., R.P. Pizzolitto, M.A. Ordano, Y.P. Zaio, and J.A. Zygadlo, 2017. Laboratory evaluation of insecticidal activity of plant essential oils against the vine mealybug, *Planococcus ficus*. Vitis., 56: 79-83.

Puterkalenn, D.M., D.G. Sekutowski, T.R. Unruh, and S.K. Jones, 2000. Progress toward liquid Environ. Entomol., 29(2): 329-339.

Reddy, S.G.E. and S.K. Dolma, 2018. Acaricidal activities of essential oils against two spotted spider mite, *Tetranychus urticae* Koch. Toxin Rev., 37(1):62-66.

Rouini, I., 2008. Olive fly management with allowed formulations in organic agriculture. Thesis requise pour submitted Master of Science in “Mediterranean Organic Agriculture”

Sheibani, Z., M. Shojaii, M. Shojaaddini, S. Imani, and M.R. Hassani, 2016. Repellency of kaolin particle film to common pistachio psyllid, *Agonoscena pistaciae* under field conditions. Bulletin of Insectology, 69: 7-12.

Showler, A.T. and J.L. Harlien, 2018. Effects of the botanical compound p-anisaldehyde on horn fly (Diptera: Muscidae) repellency, mortality, and reproduction. J. Med. Entomol., 55:183–192.

Soubeih, K.A., E.A. Ali, and A.E. El- Hadidy, 2017. Effect of kaolin and diatoms on growth, productivity and pests of potato under North Sinai conditions. Egyptian J. Desert Res., 67(1): 83-115.

Stanley, D., 1998. Particle film: a new kind of plant protectant. Agric. Res., 46(11): 16-19.

Stathers, T.E., M. Denniff, and P. Golob, 2004. The efficacy and persistence of diatomaceous earths admixed with commodity against four tropical stored product beetle pests. *J. Stored Prod. Res*., 40:113–123.

Van Leeuwen, T., S. Van Pottelberge, R. Nauen, and L. Tirry, 2007. Organophosphate inseceticides and acaricides antagonise bifenazate toxicity through esterase inhibition in *Tetranychus urticae*. Pest Manag Sci., 63(12):1172-1177.

Zayed, M.S., 2022. Silica Nanoparticles Boosted Abamectin's Acaricidal Bioactivity Against *Tetranychus urticae* Koch's Two Spotted Spider Mite Developmental Stages. J. of Plant Protection and Pathology, 13(5):93-100.

Zehnder, G., G.M. Gurr, S. Kuhne, M.R. Wade, S.D. Wratten, and E. Wyss, 2007. Arthropod pest management in organic crops. Annu. Rev. Entomol., 52: 57-80.