Middle East Journal of Agriculture Research
Volume: 10 | Issue: 04| Oct. – Dec.| 2021

EISSN: 2706-7955 ISSN: 2077-4605
DOI: 10.36632/mejar/2021.10.4.101
Journal homepage: www.curresweb.com
Pages: 1477-1487

Bioassay of Some Silicon Formulations against Mango Shield Scale Insect (*Milviscutulus Mangiferae* (Green) (Hemipetra: Coccidae) Under Laboratory Conditions

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Received: 07 Nov. 2021 **Accepted:** 20 Dec. 2021 **Published:** 30 Dec. 2021

ABSTRACT

The entomotoxic effects of silica structures were explored against mango shield scale insect (*Milviscutulus mangiferae* (green) (Hemipetra: coccidae) by utilizing the leaf dipping technique bioassay protocols. Mango shield scale insect damages mangos by direct feeding on the plant juices and by the reduction of photosynthetic capacity as a result of its production of 'honeydew' and the subsequent growth of sooty mold on the leaves. A high level of corrected mortality was found for the most silicon formulations through exposure period of three days under laboratory conditions. The toxicity against preadult and adults of mango shield scale insect increased as exposure time and concentrations increasing. The results showed 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. It is known that adult stage of mango shield scale insect were more resistance than preadult therefore, Palmito and Glister formulations were the best one with 100% corrected mortality against adult stage of mango shield scale insect. Malathion, kaolinated potassium silicate, potassium silicate (Si El-Ghanem) and kaolin gave more than 90% corrected mortalities against adult stage of mango shield scale insect. While (boiled lime & sulfur), and Potassium Silicate (Silica Ke) considered moderate effect with more than 80% mortalities. When two factors (time and concentration) were considered separately, all treatment effects were effective. The corrected mortality rate increased with the increase in exposure time and concentration. it can concluded that all these silicon sources extractives provide promising result that supports the presence of some bioactive compounds that are much effective against preadults and adults stages of mango shield scale insect.

Keywords: Silicon formulations, potassium silicate, kaolin, bentonite, attpulgite, Malathion, Kz oil, Palmito, Glister

1. Introduction

Biotic stress is including, insects caused damage to other living organisms, (Newton *et al.,* 2011). Besides the global agricultural potency. However, pests and pathogens have become tolerant to the use of conventional methods to improve agricultural production. This has resulted in low yields of crops worldwide (Divya and Geeta, 2018).

Arthropod pests are biotic aggressors, attacking plants above and below ground and eventually reducing yield quantity and quality (Kogan and Lattin, 1999). Insect pests are one of the major biological constraints that limit crop production throughout the world (Laing *et al.,* 2006). Plants counteract insect attacks both directly and indirectly. Many of these defenses are regulated by signaling pathways in which

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phytohormones have central roles. Direct defenses associated with host morphological traits such as trichomes, wax and cell wall lignification affect insect feeding behaviour and performance (Alhousari and Greger, 2018). Soft scale insects (Hemiptera: Coccidae) constitute one of the most important group of pest in agriculture, many species are destructive especially to fruit trees and ornamental plants, (Attia *et al.,* 2018, Abd-Rabou, 2011).The mango shield scale *Milviscutulus mangiferae* is polyphagous soft scale insect attacking plants belonging to over 65 genera placed in 40 families including Anacardiaceae, Euphorbiaceae, Moraceae, Myrtaceae and Rutaceae among of them *Mangifera indica* (mango) (Ben-Dov *et al.,* 2001).This soft scale insect is a serious pest of mango trees in various parts of the world (Garcia Morales *et al.,* 2016) and has a great potential to invade other countries of the world due to its small size, wide host range, and association with plants that are often imported from areas where it occurs (Abd-Rabou and Evans, 2018), (Grimshaw and Donaldson, 2007). This species damages mangos by direct feeding on the plant juices and by the reduction of photosynthetic capacity as a result of its production of 'honeydew' and the subsequent growth of sooty mold on the leaves. Heavy infestations may result in reduced tree vigor and leaf size, causing yellowing of the leaves, leaf drop and death of branches (Pena and Mohyuddin, 1997). *Coccus mangiferae* [*M. mangiferae*] had three generations per year on mango and recorded on spring, summer and autumn (Avidov and Zaitzov, 1960).

Many experiments have been conducted since 1942 on the potential agronomic benefits of silicon in agriculture. The use of silicon with its high natural abundance and non-toxic nature, has received most attention. (Sieburth *et al.,* 1990). Silicon (Si) is a relatively inert element that rarely occurs freely in nature (Datnoff *et al.,* 2007). Although these forms of silicon are both chemically and biologically inert, they are reported to significantly influence the physical properties of soils including soil texture, water holding capacity and fertility (Conley, 2002). Silicon content in soils ranges between 20-35% for clay or silt to 40-44% for sandy soils (Essington, 2003).

The higher silicon content in the soil and growth medium reduced the incidence of several crop pests (Laing *et al.,* 2006). It was reported that the application of silicon sources for pest management can save the cost of expensive fungicides and insecticides (Datnoff *et al.,* 1997). Si-application tends to reduce pest infestations and may provide a sustainable environment friendly integrated strategy as an alternative to extensive pesticide use (Bakhata *et al.,* 2018). The application of silicon in crops provides a viable component of integrated management of insect pests and diseases because it leaves no pesticide residues in food or the environment, and it can be easily integrated with other pest management practices, including biological control (Laing, 2006). Soluble silicon reduces reproduction capacity of phloem feeding aphids *Myzus persicae* in potato and wheat and white fly (*Bemisia tabaci*) in cucumber plants. The hardness of cane of sugarcane plants is due to a higher silica content which reduces the shoot borer attack (Rao, 1967). The attack of stem maggot, plant hopper, green leaf hopper and leaf folder on rice plants were reduced with silicon nutrition. Low silicon concentration in rice tissues is associated with increased susceptibility to insect pest and fungal diseases (Sawant *et al.,* 1994). The current recommendations in management of the disease are through eco-friendly methods such as balanced application of nutrients, use of organic amendments and use of biocontrol agents (Divya and Geeta, 2018).The application of silicon in crops provides a viable component of integrated management of insect pests and diseases because it leaves no pesticides residues in food or the environment, it can be easily integrated with other pest management practices, including biological control (Laing *et al.,* 2006).

Therefore, the aim of this work is to study the toxicity of some silicon formulations against adult and preadult stages of *Milviscutulus mangiferae* (green) (Hemipetra: coccidae)) under laboratory conditions.

2. Materials and Methods

2.1. Silicon Sources

In this study, we used different silicon sources that were divided into two groups. The first one was powder group was 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 insecticides as (Glister, Malathion and KZ oil) and untraditional material as (boiled lime & sulfur). The materials sources were 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	Green Way Co.	potassium silicate + kaolin
8	**KZ oil**	Liquid	Kafr El-Zayat Co.	Petroluim oil 95%
9	**Palmito**	Liquid	El-Masria for fertlizers	Some Plant extracts
10	**Malathion 57%**	Liquid	Kafr El-Zayat Co.	Malathion
11	**Glister**	Liquid	Watania Co.	Glister
12	**Boiled lime & sulfur**	Liquid	Green Way Co.	Untraditional material

2.2. Insecticidal activity of some silicon formulations against mango shield scale insects

2.2.1. Test insect

The selected insects for this study were mango shield scale insect (*Milviscutulus mangiferae* (green) (Hemipetra: coccidae)) that were obtained from mango trees (*Mangifera indica*) growing in the mango field of Ismailia Governorate. The insects were identified by taxonomy specialists at the department of scale Insects and mealy bugs, Plant Protection Research Institute, Giza, Egypt. Adults and immature stages of mango shield scale insects were selected to study the insecticidal activities of some silicon formulations.

2.2.2. Bioassay technique

The leaf dipping technique (Ali, 1999 and Ali., *et al.,* 2017) was used as toxicity test some silicon formulations against mango shield scale insect (*Milviscutulus mangiferae)*. Plant leaves were selected from mango trees and were dipped in each silicon formulation for 10 seconds. After drying at ambient temperature a single leaf was placed in polyethylene bag. Five replicates were conducted for each treatment. A control leaf was dipped in sterilized uninoculated media. Tested silicon formulations were compared with some natural products as plant extract formulation (Palmito) and mineral oil (KZ oil). Glister, Malathion (chemical pesticides) and (boiled lime & sulfur) as Untraditional material to control mango shield scale insect which were prepared in water. This procedure repeated with whole silicon formulations. After application, polyethylene bags placed in laboratory conditions and examined for mango shield scale corrected mortality after 1, 2, and 3 days. With serial concentrations; 100, 75 & 50% of the most effective silicon formulations. These concentrations were selected after preliminary tests. Insect corrected mortality was recorded and the corrected mortality percentages (Abbott, 1925) was calculated. Insects were considered to be dead if appendages did not move when prodded with a fine hair brush, when observed under the light stereomicroscope (Choi *et al.,* 2003 and Peschiutta *et al.,* 2017).

3. Results

3.1. Toxic effect of silicon formulation against mango shield scale insects.

Table (2) show the toxicity of some silicon formulations against adult and preadult of mango shield scale insect (*Milviscutulus mangiferae)* which tested with the leaf dip technique. A high level of corrected mortality were found for the most silicon formulations through 3 days exposure period under laboratory conditions. The toxicity against preadult and adults of mango shield scale insect increased as exposure time after treatment increased.

3.1.1. Silicon powder formulations

3.1.1.1. Effects on adults

As shown in table (2), silicon powder formulations, kaolin showed the highest insecticidal effect against adult stage of mango shield scale insect since, it gave more than 90% corrected mortalities after three days exposure followed by diatom, which gave percentage corrected mortality more than 70 %. Aglev Si 300 and bentonite showed percentage corrected mortality more than 60 %.

3.1.1.2. Effects on preadult

Silicon powder formulations, Aglev Si 300 and diatom showed the highest toxic effect against preadult of mango shield scale insect since they gave 100 % mortalities after 3 days exposure. Kaolin and bentonite depicted mortality: 88.2 and 80 % after 3 days exposure.

Table 2: Effect of silicon powder formulations on corrected mortality percentage of mango shield scale insect preadult and adults.

Treatments	Exposure time (Days) % Corrected Mortality					
	Preadult			Adults		
	1 day	2 days	3 days	1 day	2 days	3 days
Aglev Si 300	46.1	60.7	100.0	31.9	49.5	67.7
Bentonite	48.2	72.5	80.0	54.2	56.4	63.4
Diatom	51.4	81.4	100	51.0	68.6	72.2
Kaolin	45.8	64.1	88.2	43.1	45.8	92.4

3.2. Silicon liquid formulations

3.2.1. Effects on adults

The data presented in table (3) show that kaolineted potassium silicate and Si El-Ghanem (potassium silicate) gave percentage mortalities reached 96.0 & 90.8% on the mango shield scale adult and potassium silicate (Silica ke) gave the percentage mortalities by 81.5% corrected mortality after 3 days exposure times.

3.2.2. Effects on preadult

The bioassay was conducted to estimate the potential activity of silicon liquid formulations towards the mango shield scale preadults. The results are given in table 3 show that kaolin, Kaolinated Potassium Silicate, and Si El-Ghanem showed maximum toxicity with > 90 % percent corrected mortality (98.5 & 90.7%) after 3 days exposure time towards the mango shield scale preadults. Silica ke formulation achieved activity less than 90 % corrected mortality (78.4%).

Table 3: Effect of silicon liquid formulations on corrected mortality percentage of mango shield scale insect preadult and adults.

Treatments	Exposure time (Days) %Corrected Mortality					
	Preadult			Adults		
	1 day	2 days	3 days	1 day	2 days	3 days
Kaolineted Potassium Silicate	51.7	79.3	98.5	60.9	81.3	96.0
Si El-Ghanem	62.6	88.3	90.7	68.4	68.5	90.8
Silica Ke	63.4	77.8	78.4	55.0	74.6	81.5

3.3. Toxic effect of standard pesticides against mango shield scale.

3.3.1. Effects on adults

The data showed in table (4) that Palmito formulation was the most effective with 100 % percentage corrected mortality against mango shield scale insect after 3 days exposure time. Glister and Malathion formulations were the second potential activity against mango shield scale insect after 3 days exposure time, however their corrected mortality percentage were 99.0 & 97.0%. Boiled lime & sulfur gave moderate effect against mango shield scale insect after 3 days exposure time with their corrected mortality percentage 88.7%. KZ oil formulation was the least effective treatment with 71.9 % corrected mortality percentage against mango shield scale insect after 3 days exposure time.

3.3.2. Effects on preadults

As shown in table (4), Palmito and Glister showed the highest insecticidal effect against preadult stage of mango shield scale insect since it gave 100 % mortalities after three days exposure followed by Malathion, (boiled lime & sulfur) and Kz oil, which gave percentage corrected mortality 98.0, 94.1 and 74.7%.

Table 4: Effect of standard formulations on corrected mortality percentage of mango shield scale insect preadults and adults.

Treatments	Exposure time (Days) %Corrected Mortality					
	Preadults			Adults		
	1 day	2 days	3 days	1 day	2 days	3 days
Palmito	100	100	100	100	100	100
KZ oil	52.9	71.4	74.6	31.8	60.6	71.9
Glister	92.0	98.0	100.0	91.0	96.0	99.0
Malathion	90.0	95.0	98.0	90.0	94.0	97.0
Boiled lime & Sulfur	79.2	82.4	94.1	56.4	82.4	88.7

Generally, it could be concluded that aglev Si 300, diatoms, Palmito and Glister were considered as the most active materials since they gave 100 % mortalities against preadult stage of mango shield scale insect. While Kaolineted Potassium Silicate 4, Malathion, (boiled lime & sulfur) and Si El-Ghanem gave potential activity more than 90% mortalities (98.5, 95.0, 94.1 & 90.7%). Kaolin and Silica ke considered active against preadults with moderate percentage corrected Mortality 88.2 & 78.4, respectively. It is known that adult stage of mango shield scale insect were more resistance than preadult, so Palmito formulation was the best one with 100% corrected mortality against adult stage of mango shield scale insect. Glister, Malathion, potassium kaolineted potassium Silicate, kaolin and Si El-Ghanem gave more than 90% corrected mortalities (99.0,97.0,96.0, 92.0 & 90.8%) against adult stage of mango shield scale insect while boiled lime & sulfur 6, Silica ke, considered very good effect with more than 80% mortalities (88.7 & 81.5%). Diatom, KZ oil Aglev Si 300 and bentonite showed moderate effect with from 60 to 75% mortalities (72.2, 71.9, 67.7 and 63.4 %).

3.4. Toxic effect of some serial of silicon formulations against mango shield scaleinsects.

When two factors (time and concentration) were considered separately, all treatment effects were high. The corrected mortality rate increased with the increase in exposure time and concentration.

3.4.1. Toxic effect of some serial of powder silicon formulations against mango shield scale insects.

Results in Table (5) indicated of leaf deep technique of silicon powder formulations after 24, 48 and 72 that all different concentrations (100, 75 & 50%) caused different corrected mortality percentages against preadult and adults of the mango shield scale insect.

3.4.1.1. Effects on preadults

Results showed that all concentrations of silicon powder formulations caused toxicity against preadult of the mango shield scale insect. The highest corrected mortality was observed in diatom, (100, 94.7 & 90.5%) and aglif 300 (100, 88.5 & 70.6) at 100, 75 and 50% concentrations after three days exposure times compared to other treatments. Kaolin and bentonite were the second formulations in the toxicity and gave corrected mortality (90.9, 73.0 & 60.0%) and (82.5, 61.2 &43.1%) at 100, 75 and 50% concentrations after three days as exposure times.

In general, there is the highest increase in toxicity of silicon formulations was observed with increasing of concentrations and the time of applications against the mango shield scale insect and the percent corrected mortality ranged between 43.0 to 100 % with preadult.

Overall results indicated that diatom, aglev 300 and kaolin caused the highest mortalities in 24, 48 and 72 hrs of duration against preadult of mango shield scale but the bentonite was the least mortality.Thereafter, mango shield scale caused the highest mortalities and the efficiency of those materials increased when their concentrations and time exposure increased.

3.4.1.2. Effects on adults

Kaolin formulation showed the highest toxic effect against adult of mango shield scale insect since they gave > 90 % mortalities (93.2%) at 100% concentration, followed by 70.1 & 57.3% corrected Mortality at 75 & 50% concentrations after 3 days exposure. The potential activity of diatom, Agliv Si 300 and bentonite against adult of mango shield scale insect were from 78.9 to 50.0% as follow (78.9, 70.0 & 63.9), (68.0, 63.8 & 51.8%) and (65.0, 58.6 & 50.1%), respectively at concentrations 100, 75 & 50% after 3 days.

Table 5: Effect of some serial of concentrations of silicon powder formulations on corrected mortality percentage of mango shield scale insect preadult and adults.

Concentrations	Exposure time (Days) % Corrected Mortality					
	Preadults			Adults		
	1 day	2 days	3 days	1 day	2 days	3 days
Diatom 100%	59.4	87.2	100.0	30.0	71.4	78.9
75%	49.6	85.2	94.7	21.4	65.3	70.0
50%	31.1	7.52	90.5	16.3	58.3	63.9
Aglev Si 300 100%	45.0	63.2	100.0	35.0	56.4	68.0
75%	40.0	58.1	88.5	31.4	48.0	63.8
50%	33.0	48.2	70.6	28.2	41.2	51.3
Kaolin 100%	50.1	78.3	90.9	40.1	49.3	93.2
75%	43.1	60.1	73.0	30.2	45.0	70.1
50%	34.1	45.2	60.2	28.1	40.0	57.3
Bentonite 100%	50.3	70.4	82.5	52.0	71.6	65.0
75%	38.0	50.3	61.2	38.2	45.3	58.6
50%	26.1	31.3	43.1	24.7	40.2	50.1

3.5. Toxic effect of some serial of liquid silicon formulations against mango shield scale insects

The data showed in table (6) that the liquid silicon formulations had a toxic action against preadult and adult of mango shield scale insects at all concentrations (100, 75 & 50%) through the three days as exposure times.

3.5.1. Effects on preadult and adults

Kaolinated potassium silicate was the best material at all concentrations (100, 75 & 50%), with (97.0, 90.3 & 75.3%) & (95.0, 91.3 & 72.5%) corrected mortality against preadult and adult of mango shield scale insects, respectively. The results also showed toxic effect to Si El-Ghanem with (93.5, 80.2 & 68.0 %) and (91.2, 80.0 & 55.0%) corrected mortality at concentration 100, 75 & 50% after three exposure time for preadult and adult of the tested pest. The data indicated that Silica ke showed the least potential from 60.0 to 83.0 % for preadult and from 39.0 to 80.0 % percentage mortalities at 100, 75% & 50% concentration.

Thereafter, mango shield scale caused the highest mortalities and the efficiency of those materials increased when their concentrations and time exposure increased.

Table 6: Effect of some serial of silicon liquid formulations on corrected mortality percentage of mango shield scale insect preadult and adults.

Concentrations	Exposure time (Days) % Corrected Mortality					
	Preadults			Adults		
	1 day	2 days	3 days	1 day	2 days	3 days
Silica ke 100%	50.0	78.4	83.0	48.2	76.0	80.0
75%	39.3	60.5	75.2	30.3	65.0	70.1
50%	22.1	35.5	61.2	18.2	35.1	39.3
Kaolineted Potassium Silicate 100%	50.0	75.8	97.0	55.4	82.5	95.0
75%	40.8	65.1	90.3	48.3	65.5	91.3
50%	33.3	50.2	75.3	39.1	53.2	72.5
Si El-Ghanem 100%	55.5	85.3	93.5	65.3	70.1	91.2
75%	50.0	66.1	80.2	49.6	62.3	80.0
50%	40.5	58.1	68.0	30.1	34.8	55.1

3.6. Toxic effect of some serial of concentrations of some standard pesticide formulations against mango shield scale insects preadult and adults.

Data in Table (7) revealed that all concentrations of standard pesticide formulations showed significant toxic effects against mango shield scale insects in the three exposure time. The toxicity rate was positively correlated with the concentration of standard pesticides formulations. The palmito and Glister formulations were more effective than Malathion, KZ oil and Boiled lime & sulfur against preadult and adult of mango shield scale insects at all concentrations (100, 75 & 50%) tested.

The highest toxicity rates were recorded for palmito and Glister 100% corrected Mortality with preadult and adult stages of mango shield scale insects at 100% and 75% concentrations after three days exposure time, while their potential activity decreased to 90 – 97% mortalities when the concentration decreased to 50%.Malathion was the second material at all concentrations (100, 75 & 50%), with (97.0, 89.1 & 60.1%) & (98.5, 81.6 & 49.6 %) percentage corrected mortality against preadult and adult of mango shield scale insects, respectively. The data indicated that boiled lime & sulfur showed more than 90% percentage mortalities at 100 & 75% concentration with preadult of mango shield scale insects but the lowest concentration dose level of 50% gave less than 90% corrected mortality against adult of mango shield scale insects. The boiled lime & sulfur 6 solution gave less than 80% corrected mortality at the lowest concentration at 50% against preadult and adult of mango shield scale. In case of the toxic action of KZ oil against preadult and adult of mango shield scale insects was less than 80% percentage corrected mortality after three days exposure time and three days of exposure times.

Table 7: Effect of some serial standard pesticide formulations against mango shield scale insects.

Treatments	Exposure time (Days) %Corrected Mortality					
	Preadults			Adults		
	1 day	2 days	3 days	1 day	2 days	3 days
Palmito 100%	100.0	100.0	100.0	100.0	100.0	100.0
75%	98.0	100.0	100.0	95.0	98.0	100.0
50%	90.0	94.0	97.0	88.0	89.0	91.0
KZ oil 100%	53.0	70.9	77.3	30.8	62.0	70.8
75%	45.2	55.7	66.7	28.4	55.6	62.1
50%	35.0	40.9	49.2	31.0	35.0	40.0
Glister 100%	92.0	98.0	100.0	91.0	96.0	100.0
75%	90.0	95.0	100.0	88.2	90.0	100.0
50%	85.2	90.0	93.5	83.5	88.5	90.1
Malathion 100%	91.0	95.0	97.5	90.0	93.0	98.5
75%	80.1	84.0	89.1	75.0	80.5	81.6
50%	45.1	50.5	60.5	30.5	39.7	49.6
Boiled lime & sulfur 100%	78.0	85.0	95.0	58.0	84.0	89.0
75%	75.0	88.5	92.0	50.0	80.2	85.1
50%	65.2	70.5	78.9	42.2	50.0	64.2

4. Discussions

The use of higher dosage and repeated applications of conventional pesticides have led to the rapid development of insect resistance to pesticide and adverse effects on human health and environment. Accordingly, researchers are prompted to identify an alternative entomotoxic agent for crop protection (Shoaib *et al.,* 2018). Silicon is helpful in promoting mechanical strength, light interception and resistance to various biotic and abiotic stresses, improving both quantity and quality of production. In this study, we evaluated the entomotoxic effects of silica on preadult and adult of mango shield scale insects, in a laboratory using leaf dipping method. The bioassay of some silicon products gave from medium to high potential effects against preadult and adult of mango shield scale insects under laboratory conditions. Preadult was more susceptible to silicon products than adult of mango shield scale insects The data indicated that all products were more toxic to preadult than adult of mango shield scale insects. Overall results indicated in case of powder products that diatom, Aglev 300 and Kaolin caused the highest mortalities after 72 hrs of duration against preadult and adults of mango shield scale insect but bentonite lower corrected mortality. Thereafter, mango shield scale caused the highest mortalities and the efficiency of those materials increased when their concentrations and time exposure increased. These results could be agreed with Gomaa *et al*., 2021 when Cabbage plants treated as foliar spraying with atabouglite, kaolin formulations exhibited high decrease of aphid population compared with bentonite application which gave the least potential towards adult of aphid insects. Also, atabouglite had a superior effect on average cumulative cotton leaf worm *Spodoptera littoralis* (Boisd) infestations of leaves and larvae followed by Kaolin. Bentonite had the lowest effect.Also these data were agreed with Valizadeh *et al.,* 2013 that kaolin plus diatom suppresses the vine cicada egg laying activity (50% reduction in comparison to untreated control). Kaolin and diatom particles successfully suppressed *P. althageos* oviposition and provided season-long insect control. Kaolin particles proved to be a promising alternative method to synthetic insecticides and could be used to control *P. althageos* in vine groves. The previous results could be explored by Silicon may provide a mechanical barrier against insect pests (Laing *et al.,* 2006). Besides, (Salim and Saxena, 1992) noticed that sucking pests and leaf eating caterpillars have a low preference for the silicified tissues than low silica containing succulent parts. Silicon decreases the food intake, growth longevity, fecundity and population growth of xylem feeding by White Backed Plant Hopper, *Sogatella frucifera* and Soluble silicon reduces reproduction capacity of phloem feeding aphids *Myzus persicae*in potato and wheat and white fly (*Bemisia tabaci*) in cucumber plants. The hardness of cane of sugarcane plants is due to a higher silica content which reduces the shoot borer attack (Rao, 1967). Debnath *et al.,* 2012 confirmed that superior entomotoxicity of silica products is caused by powder of silicon formulations of water from the preadult and adult cuticles. The insect begin to lose water through desiccation as the water barrier is damaged and finally die owing to desiccation, leaving their hard corpses behind. Silica also induced abrasion on insect cuticle which enhanced the preadult and adult corrected mortality. The attack of stem maggot, plant hopper, green leaf hopper and leaf folder on rice plants were reduced with silicon nutrition. Low silicon concentration in rice tissues is associated with increased susceptibility to insect pest and fungal diseases (Sawant *et al.,* 1994).White fly (*Bemisia tabaci*) is important pest of cotton, wheat, cucumber and sugarcane which reduces their yield but soil or foliar application of silicon as calcium silicate increases the corrected Mortality of the nymphs of whitefly (Correa *et al.,* 2005). Several earlier researchers (Debnath *et al.,* 2011, 2012; Rouhani *et al.,* 2012, Vani and Brindhaa, 2013; Arumugam *et al.,* 2016) reported that after treatment of silicon, the water on silicon surface was reduced, and abrasion owing to silicon was enhanced as the exposure time increased. As a consequence, the number of preadult and adult death increased. This finding is supported our result,. that may be one of the possible reasons for the age-old tradition of using silica dust as a protective agent for stored seed by different ethnic races all over the world (Ebeling and Wagner, 1959; Ebeling, 1971). Mahmoud., *et al.,* 2010 found that the effect of kaolin powder film was clearly effective in the first month of storage period of the treated seeds resulted a 100% protection of treated seeds at high concentrations from 1.0 to 0.2 w/w for both tested insects. After three months of storage of the treated seeds only the highest two concentrations 1.0 and 0.8 w/w gave a 100% protection for both tested insects. After six months of storage of the treated seeds, kaolin powder still could protect the broad bean seeds against *C. maculatus* and *C. chinensis* attacks although the efficacy of kaolin powder decreased with aging. Thus, residual effect of Kaolin powder film was reduced by prolongation of the storage period.

In case of liquid silica products, it showed that potassium silicate in all the three forms were effective to preadult and adult of mango shield scale insects at the three concentrations but they were more effective at 100 & 75% concentrations. Kaolinated potassium silicate and Si El-Ghanem gave 100% mortalities at 100 & 75% conc. After 3 days exposure time. These data were accepted with Laane, 2018 that said that Foliar sprays with silicates are effective as pesticides, while (stabilized) sallcylic acid sprays increase growth and yield and decrease biotic and abiotic stresses. The limited data on foliar silica-nano sprays show a tendency to decrease biotic stress and to stimulate a limited increase in growth and yield.The previous results were confirmed by (Prakash *et al.,* 2008 & 2011) when using silicon compounds on the rice plants that reduced the pesticides rates by 50% compared to the control plants. Ratnakumar, *et al.,* (2016) found that positive effects on growth, development, quality and the reduction of infections and mite infestations have been reported for plants grown in alkaline, neutral and more acidic soils, especially when stress factors such as salinity and acidity are involved and drought stress.

These results agreed with El-Helaly *et al.,* (2016) who reported the efficacy of two nano-Si sprays (with different concentrations of 200, 300, 400 and 500 ppm Si) were compared with (a) silicate sprays; (b) Diazinon (standard recommended insecticide); and (c) water (control) on newly hatched *Spodoptera littoralis* larvae on squash plants in a greenhouse. The neonate larvae corrected mortality rate was 68% for the nano-Si spray at 500 ppm; 6.8% for silicates, and 51.6% for Diazinon and no corrected mortality with distilled water. The lifespan of the PEG-sSA treated plants was longer compared to all other treatments. Nikpay and Laane, 2017 found that the effects were studied of one to four PEG-sSA sprays with concentrations of 1, 2, 3 and 4 mL/L (7, 15, 22 and 30 ppm Si) on yellow mite *Oligo nychussacchari* McGregor, on two sugarcane varieties, over a two-year period. All treatments significantly decreased the mite populationand leaf dryness compared to the control. Four 4 mL/L PEG-sSA sprays appeared to be themost effective. These results suggested that silica can be an alternative to conventional pesticides.

The data obtained from this study warrant further research to explore the potential of silicon to control pests under field conditions.

5. Conclusion

After evaluating the results of insecticidal activity of mineral and potassium silicate against mango shield scale insect preadults and adults, it can concluded that all these silicon sources extractives provide promising result that supports the presence of some bioactive compounds that are much effective against preadults and adults stages of mango shield scale insect. Therefore, these all could be used in strategic control of horticultural pests in a ecofriendly way that is highly recommended in the present context of integrated pest management. It can be also suggested that further investigation is needed to detect the specific compound which is responsible for showing this sort of bioefficacy.

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