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THE ROLE OF SOME DIFFERENT SILICON FORMULATIONS AND WINDBREAKS TO CONTROL MANGO SHIELD SCALE INSECT (*MILVISCUTULUS MANGIFERAE* (GREEN) (HEMIPETRA: COCCIDAE) ON MANGO TREES AFFECTED BY AEOLIAN DEPOSITS

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The current study was carried out during the two successive seasons of 2021 and 2022 on Ewais mango cultivar affected by the movement of sand dunes and grown in a private orchard in El-Mostakbal City, Ismailia Governorate, Egypt, to evaluate the effect of silicon formulations spraying and casuarina windbreak to control mango shield scale insect *Milviscutulus mangiferae* (green) (Hemipetra: Coccidae), and its effect on vegetative growth, leaf characteristics and yield. It can be concluded that the successful control of the mango shield scale insect can be achieved by diatom and Aglev Si 300 with a reduction percentage of more than 80%, followed by kaolin (60-87%) and bentonite (50-70%), respectively in different stages of mango shield scale insect (immature, adult and ovipositing adult stages). The efficacy of kaolineted potassium silicate and Si El-Ghanem compounds on the infestation percentage decreased with different stages with a reduction percentage of 79-91%, respectively against different stages of *M. mangiferae.* Extra power, triple power, boiled lime and sulfur against different stages had more than 90% reduction, compared to the control treatment. The results revealed that spraying silicon formulations with casuarina windbreak led to an increase in shoot diameter and length, leaf area, leaf total chlorophyll content, leaf water content, and yield. While, it decreased hard leaf character and leaf succulence grade, which led to an increase in the effectiveness of spraying silicon formulations in reducing infection. In addition, the casuarina windbreak significantly reduced sand drift.

Keywords: *Milviscutulus mangiferae*, mango, minerals, potassium silicate, casuarina windbreak, sand drift, vegetative growth, yield

INTRODUCTION

The mango (*Mangifera indica* L.) is a significant fruit in tropical and subtropical regions and is an evergreen fruit tree in the Anacardiaceae family. Various factors such as unfavorable environmental conditions and malnutrition can reduce its yield. Biotic and abiotic stresses have a clear impact on fruiting in mango cv. Scale insects (Coccidae: Hemiptera) are destructive pests of mango and other horticultural crops (Attaia et al., 2018). The mango shield scale *Milviscutulus mangiferae* is a polyphagous soft scale insect that attacks plants from over 65 genera in 40 families, including Anacardiaceae, Euphorbiaceae, Moraceae, Myrtaceae and Rutaceae, with *Mangifera indica* (mango) being one of them (BenDov et al., 2001). They severely reduce the yield by sucking the cell sap from leaves, twigs, and fruits. Due to its small size and broad host range, this soft scale insect poses a severe threat to mango trees throughout the world (Garcia et al., 2016 and Abd-Rabou and Evans, 2018).

Higher dosages and more frequent applications of conventional pesticides have accelerated the development of pesticide resistance in insects and had detrimental impacts on the environment and public health. As a result, scientists are challenged to find a different entomotoxic substance to safeguard crops (Shoaiba et al., 2018 and Ali et al., 2021). Silicon (Si) has been found to mitigate a wide range of biotic and abiotic stresses in crop plants and protecting crops from pets. Silicon creates a physical barrier on the leaf, regulates the deposition of callose in the sieve tube elements, and could boost the effectiveness of other chemical defenses produced in response to herbivore attacks (Debona et al., 2017 and Alhousari and Greger, 2018). While silica accumulation can have indirect effects that postpone herbivore establishment, it can also work directly to reduce insect performance and plant damage (Reynolds et al., 2009). The use of silicon in coproduction is a practical aspect of integrated pest management because it does not leave any pesticide residues in food or the environment and can be easily combined with other pest control methods, such as biological control (Amine et al., 2022). Several studies have indicated that silicon has the potential to alleviate the adverse impacts of water stress on plant growth, pest resistance, nutritional status, and fruit production (Abd El-Rahman, 2015). El-Khawaga and Mansour (2014) have reported that the utilization of silicon in any form is linked to increased growth and fruit production in fruit crops. Silicon has long been thought to play a significant role in plant resistance to insect pests by creating a physical barrier through silicon deposition beneath leaf cuticles. This silicon deposition enhances the rigidity and abrasiveness of plant tissues, forming a mechanical barrier that makes them less palatable and digestible to both vertebrate and invertebrate herbivores. The increased abrasiveness of leaves due to silicon deposition reduces the quality of food for herbivores and can cause wear of herbivore mouthparts, leading to reduced feeding efficiency and growth rates (Massey and Hartley, 2006; 2009 and Rahman et al., 2015).

Application of potassium silicate and other silicon compounds appears the concealment of creepy crawly bothers such as sap suckers, borers, folivores, and non-creepy crawly bugs like vermin and creepy crawly (Keeping and Kvederas, 2008). The utilization of potassium silicate as a supplement may be a plausibility to extend the sugars and amino acids concentrations in plants. In this way, the plants are safe to creepy crawlies and illnesses, too expanded diverse quality characteristics as taste, estimate and color (Kikuchi, 1999). Utilizing of potassium silicate may be move forward its properties, because it can present distinctive organic exercises with variable chemical-physical properties such as surface zone, volume, positive nature, etc. Nanoparticles display diverse properties from bulk materials (Gad et al., 2021). Furthermore, in several plant species maintained at high sun radiation levels, a reflective Kaolin spray was found to reduce transpiration rate more than photosynthesis and to lower leaf temperature by enhancing leaf reflectance (Nakano and Uehara, 1996). Anti-transpirants (folicote and vapor-guard) increased growth parameters of Egyptian Sulani fig tree (*Ficus carica*) grown under rainfall conditions of the western coastal zone Matrouh Governorate (Al-Desouki et al., 2009).

Windbreak is one of the key components for making successful agriculture systems through reduced wind erosion, improved microclimate, expanded biodiversity, and generation possibility of timber and agrarian crops. Indeed, although windbreak involves as it were a little portion of rural scene, its advantages on the ecological and economical perspective are quite high (Vacek et al., 2018).

Depending on the windbreak's intended purpose, there are many advantages to windbreaks. These systems, when engineered for wind reduction, can improve field and orchard crop productivity (Osorio et al., 2018 and Mume and Workalemah, 2021). Better plant growth results from these improved conditions, and this can be a useful agricultural practice for integrated pest management (El-Gamal et al., 2023).

The capacity to at the same time give financial, biological and open benefits is one of the reasons why windbreaks are progressively seen as a technique for maintainable escalated and enhancement of agroecosystems. Moreover, as discussions increase almost how to more successfully sequester carbon, decrease nursery gas emanations (i.e. extend drawdown and trillion trees activity) and adjust to changes as of now happening, agroforestry frameworks, counting windbreaks, are being recognized as a compelling and key approach. This is due to agroforestry's co-benefits; whereas it upgrades climate alter resiliency and moderation, it too increments rural generation and broadening (Schoeneberger et al., 2017 and Frischmann et al., 2020).

The goal of this study was to examine the effect of various silicon formulations and windbreaks to control mango shield scale insect (*M.*

mangiferae (green) (Hemipetra: Coccidae) on mango trees under field conditions in addition to the effect of casuarina windbreak on reducing the sand movement.

MATERIALS AND METHODS

This study was conducted during the two successive seasons of 2021 and 2022 on Ewais mango cultivar affected by the movement of sand dunes and grown in a private orchard in El-Mostakbal City, Ismailia Governorate, and Egypt. Twenty years old trees were grown in sandy soil under a drip irrigation system, planted 6 x 6 meters away. Twenty-one trees of similar strength and size were selected to assess the effect of silicon formulation spraying and casuarina windbreak to control mango shield scale insect (*M. mangiferae* (green) (Hemipetra: coccidae), vegetative growth, leaf characteristics, and yield of the Ewais mango cultivar. All the selected trees received the common horticultural practices that already applied in the orchard. The tested mango trees were protected with 3.5-meters-high and 237-meters-long *Casuarina prisea* as windbreak planted perpendicular to the wind direction extended from NNE to SSW. The N direction crosses with it in an angle of 68˚ to study it effect on reducing the sand movement in addition to growth and yield as well as control mango shield scale insect of Ewais mango trees under Ismailia conditions.

Soil samples at depths of 0:30 cm, 30:60 cm and 60: 90 cm were taken for determining physical and chemical properties as shown in Tables (1, 2 and 3). Soil pH in a 1:2.5 (soil: water) suspension was determined using Jennway pH meter according to Mckeague (1978). Electrical conductivity was determined using YS1 Model 35 conductivity meter according to the procedure of Richards (1954). Organic matter was determined according to Walkely (1947).

1. Control of Mango Shield Scale Insect (*Milviscutulus mangiferae)*

1.1. Silicon sources

In this study, different silicon sources were used and were divided into two groups. The first one was the powder group that was kaolin, bentonite, attapulgite (Agliv Si 300) and diatomaceous earth (diatom) that were natural soil sources. The second was a 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 triple power and chemical insecticide as extra power and untraditional material as boiled lime and sulfur (Ali et al., 2021). The materials sources are represented in Table (4).

1.2. Sampling techniques

The test compounds were evaluated during the experimental period of growth, from February to December. The effect of pretreatment was examined by evaluating the effect of pretreatment on the following parameters. In this study, five replications of the control and nine treatments were used. Each sample consisted of three trees. Fifteen leaf samples were randomly collected from each tree (replicate) representing different levels and orientations of the tree to study mango shield scale insects that damage leaves (Ali, 2016).

Table (1). The basic elements of climate of this region.

Months	Wind speed (m/s)	Temperature (˚C)			Air humidity %	Total rainfall (mm)
		Min	Average	Max		
Season 2021						
January	2.66	4.76	13.94	26.93	63.38	22.37
February	2.56	4.47	14.23	27.57	65.88	26.37
March	2.98	6.66	15.85	33.34	60.69	21.09
April	3.24	6.80	19.75	40.40	52.12	0.65
May	2.90	15.07	25.61	41.63	45.81	0.19
June	3.03	15.98	26.46	39.32	51.06	0.00
July	2.83	20.23	29.68	42.34	48.69	0.00
August	2.57	21.48	30.23	42.92	49.81	0.00
September	3.05	18.41	27.12	39.90	56.62	0.46
October	2.91	16.28	23.50	34.57	61.25	1.39
November	2.34	12.45	20.73	32.97	62.38	11.54
December	2.76	6.65	14.39	25.40	64.81	18.94
Season 2022						
January	3.16	4.76	13.94	26.93	68.25	26.37
February	2.49	4.47	14.23	27.57	66.94	73.83
March	3.23	6.66	15.85	33.34	61.31	44.92
April	2.98	6.8	19.75	40.40	61.12	1.05
May	3.00	15.07	25.61	41.63	55.12	0.00
June	3.03	15.98	26.46	39.32	52.47	0.00
July	2.83	20.23	29.68	42.34	44.71	0.00
August	2.57	21.13	30.01	43.72	45.86	0.00
September	3.05	18.41	27.12	39.94	58.24	0.23
October	2.98	16.28	23.57	34.01	63.94	4.02
November	2.93	12.64	20.73	32.97	64.11	18.17
December	3.38	7.05	14.39	25.40	66.28	18.94

Table (2). Physical properties of soil site in Ismailia Governorate.

Soil sample depth (cm)	Clay (%)	Silt (%)	Sand (%)		Texture class
			Coarse	Fine	
0:30	11.27	22.32	23.78	42.65	Sandy loam
30:60	7.14	17.56	27.38	48.83	Loamy sand
60:90	5.45	16.84	29.84	50.14	Loamy sand

Table (3). Chemical analysis of soil site.

Chemical analysis	0:30 cm	30:60 cm	Soil mix (0:60 cm)
$CaCO_3$%	-------------	-------------	-------------
O.M.%	0.99	0.61	0.80
EC (dS m^{-1}) Soil paste	2.95	2.91	5.13
pH in (1:2.5 extract)	7.90	8.40	7.50
Soluble anions			
HCO_3^{-} (meq.l^{-1})	1.53	2.37	1.75
SO_4^{--} (meq.l^{-1})	9.81	13.45	19.20
Cl^{-} (meq.l^{-1})	18.10	14.70	37.50
Soluble cations			
Ca^{++} (meq.l^{-1})	7.80	7.10	22.60
Mg^{++} (meq.l^{-1})	6.44	7.34	7.70
Na^{+} (meq.l^{-1})	14.50	14.40	26.20
K^{+} (meq.l^{-1})	0.66	0.67	2.80
SAR (%)	2.30	2.30	3.50

*OM: Organic Matter; EC: Electrical Conductivity; SAR: Sodium Adsorption Ratio; Not Detected.

Table (4). Different silicon products

No	Name	Case	Source	Structure	Using rate
1	Kaolin	Powder clay	Investment Petroleum Group IPG Inc	Aluminum silicate	3 kg/100 L of water
2	Bentonite	Powder clay	Green Way Company	Aluminum silicate (Calcium)	3 kg/100 L of water
3	Aglev Si 300	Powder clay	Geohellas company	Magnesium Aluminum silicate	1 kg/100 L of water
4	Diatom	Powder	Green Way Company	Diatom	350 g/100 L of water
5	Si El-Ghanem	Liquid	Abo Ghanema company	Potassium silicate	500 ml/100 L of water
6	Kaolinated Potassium silicate	Liquid	Green Way Co.	Potassium silicate + kaolin	500 ml/100 L of water
7	Triple Power	Liquid	Green Way Company	Some plant extracts	250 ml/100 L of water
8	Extra Power	Liquid	Green Way Company	chloroprimiphos	100 ml/100 L of water
9	Boiled lime and sulfur	Liquid	Liquid Green Way Co. Untraditional material	Untraditional material	7 L/100 L of water

1.3. Insect observations

Samples were gathered and analyzed in the laboratory utilizing a stereoscopic microscope. The samples were preserved in paper bags within a refrigerator. The reduction percentage in infestation was determined using the formula established by Topps and Wain (2008) as follows:

$$R\,\% = \frac{C - T}{C} \times 100$$

Where:
C: Number of insects recorded in the control samples.
T: Number of insects recorded in treatment samples

Control trees were left without treatment. All trees were covered completely with treatment solutions. Foliar applications of different treatments were applied with 25 L/tree. Twenty two sprayings were used starting from the first February on growth, while interval times between spraying were two weeks. A six-horsepower motor sprayer, known as "Beem," equipped with a 600-liters tank, was utilized for spraying at a rate of 25 liters per tree.

2. Aeolian Sand Deposits

2.1.1 Sand grain distribution and texture

Six sand collectors were arranged in the windward and the leeward sides; three in each side for casuarina windbreak, while there were three sand collectors in the open area of mango orchard and were in the same line of the casuarina windbreak.

Sand samples, which trapped in the sand collectors, were weighted and mechanically analyzed using laboratory test sieve, Model (Retsch, Germany), the sieve apertures were arranged beginning the one having the largest apertures, sand samples is passed successively through the sieves and the separated material is weighed. Finally each weight is divided by the total weight of the sample in order to turn it into a percentage. Then the sand grain texture was computed by plotting grain size distribution in phi (Φ) units on probability paper with cumulative weight of sand samples, then sorting, skewness, mean size and kurtosis were calculated according to Folk and Ward (1957) according to following:

$$\text{Mean size} = \frac{\Phi 16 + \Phi 84 - 2\,\Phi 50}{2\,(\Phi 84 - \Phi 16)} + \frac{\Phi 5 + \Phi 95 + 2\,\Phi 50}{2\,(\Phi 95 - \Phi 5)}$$

$$\text{Skewness} = \frac{\Phi 16 - \Phi 50 + \Phi 84}{3}$$

$$\text{Sorting} = \frac{\Phi 84 - \Phi 16}{4} + \frac{\Phi 95 - \Phi 5}{6.6}$$

$$\text{Kurtosis} = \frac{\Phi 95 - \Phi 5}{2.44\,(\Phi 75 - \Phi 25)}$$

Where, $\Phi = -\log_2$ grain size

2.1.2. Sand drift potential

Sand drift potential was measured in the windward and leeward fences sides using sand collectors according to Bagnold (1941) as follows: one in windward side and three in leeward side with 15-meter distance among them, while there were four sand collectors in the open area of mango orchard and were in the same line of the casuarina windbreak.

Sand samples, which trapped in the sand collectors, were weighed monthly to calculate the seasonal sand accumulation in each season.

2.1.3. Windbreak efficiency

It was calculated based on the sand weight trapped in sand collectors in the windward and leeward sides of windbreak according to Bagnold (1941) as following:

Windbreak efficiency =
((sand weight trapped in the windward side - sand trapped in the leeward side) /sand trapped in the windward side)* 100

2.2. Vegetative parameters

2.2.1. Shoot characteristics

a) Shoot length (cm²): Five labeled shoots per tree were selected to determine the average shoot length (cm) at the end of June.

b) Shoot thickness (cm): The same five labeled shoots were utilized to obtain the average shoot thickness (cm), 3 cm above the main shoot.

2.2.2. Leaves characteristics

Three monthly samples (for spring, summer and autumn growth cycles) each of 30 fully developed leaves located at the third node from shoot tip (3 reps.) were taken, from each treatment to determine the following parameters:

a) Leaf surface area (cm²) using leaf area apparatus (Cl-203 Area Meter CID, Imc) as average of 10 leaves.

b) Leaf fresh and dry weights (g) before and after drying leaf samples (10 leaves) at 70°C until constant weight=

c) Water content (hydration ratio) was calculated according to the following equation according to Clausen and Kozlowski (1965):

$$\text{Water content} = \frac{\text{Leaf fresh weight} - \text{Leaf dry weight}}{\text{Leaf fresh weight}} \times 100$$

d) Hard leaf character and succulence grade were estimated in 5 leaves for each replicate according to Bourquin (1969) as following:

$$\text{Hard leaf character} = \frac{\text{Leaf dry weight in (mg)}}{\text{Leaf area in (cm}^2\text{)}}$$

$$\text{Succulence grade} = \frac{\text{Leaf water content in (mg)}}{\text{Leaf area in (cm}^2\text{)}}$$

e) Chlorophyll content (SPAD): using MINOLTA chlorophyll meter SPAD-502

2.3. Yield

At harvesting, the yield of each individual mango tree was weighed in kg/tree and counted as number of fruits for each replicate.

2.4. Experimental design and data statistical analysis

Aeolian sand deposits, vegetative parameters and yield were arranged in split plot design with three replicates for each treatment. Least significant differences between means (LSD) were computed by Statistix 9 Program for various treatments by using Duncan's multiple range tests at 5% (Duncan, 1955).

RESULTS AND DISCUSSION

1. Control of Mango Shield Scale Insect by Some Silicon Products Under Casuarina Windbreak.

To determine the effect of some powder and liquid of silicon formulations (kaolin, bentonite, Agliv Si 300, diatom, kaolineted potassium silicate and Si El-Ghanem) and untraditional natural sources (triple power and boiled lime and sulfur) in addition to a chemical insecticide (extra power) on mango shield scale insect (*M. mangiferae*) infestation, two criteria were used, the total number of infested fruits and the occurrence of immature, adult and ovipositing adult stages of mango shield scale insect on mango leaves. All the experiments were conducted for two years through 2021 and 2022. Tables (5–7) show the reduction of the infestation and average of infestation of mango shield scale insect with the average of the two seasons 2021 and 2022, El-Mostakbal City, Ismailia Governorate, Egypt.

1.1. Effects of some silicon powder formulations on mango shield scale insect.

Data presented in Table (5) show that four types of minerals were selected as particle film technology (Aglev Si 300, diatom, kaolin and bentonite) to decrease total infestation, immature, adult and ovipositing adult stages of mango shield scale insect in mango fields.

1.1.1. Effects on total infested leaves

Data in Table (5) show the differences in the total number of mango leaves infestation by mango shield scale insect as affected by the treatments. The obtained data indicated that infestation was significantly lower in the treated mango leaves than untreated ones. In average of 2021 and 2022 seasons showed that the highest number of total infestation of leaves by mango shield scale insect (30.2) was obtained with bentonite treatment as a source of silica, with 64.4% of insect reduction, while the lowest number (14.1, 15.2, and 20.2) and highest reduction (83.4, 82.0 and 76.1%) was obtained with diatom, Aglev Si 300 and kaolin compared with the control treatment (84.7).

Table (5). Cumulative infestation of mango shield scale insect (*Milviscutulus mangiferae)* in mango groves treated with powder silicon as particle film technology, throughout seasons 2021 and 2022.

Treatments	Infested leaves *							
	Total no.		Immature stages		Adults		Ovipositing Adults	
	Mean*	**R%**	**Mean***	**R%**	**Mean***	**R%**	**Mean***	**%R**
Aglev Si 300	15.2 d	82.0	10.2 d	87.3	17.3 d	75.8	11.2 d	87.6
Diatom	14.1 e	83.4	9.8 d	87.8	16.3 e	77.2	10.0 e	88.9
Kaolin	20.2 c	76.1	12.8 c	84.1	27.2 c	62.0	12.0 c	86.6
Bentonite	30.2 b	64.3	28.3 b	64.8	33.1 b	53.8	25.2 b	72.0
Control	84.7 a		80.4 a		71.6 a		90.0 a	

R% = Reduction Percentage
*Cumulative number of infested fruits all over the growing season (12 dating samples)

1.1.2. Effects on immature stages

The results indicated that infestation was significantly lower in the treated mango than untreated ones. Diatom, Aglev Si 300 and kaolin were the superiority in controlling mango shield scale insect over bentonite and the untreated control treatments. The average number of immature stages as affected by diatom, Aglev Si 300 and kaolin complete coverage spray was 9.8, 10.2 and 12.8, respectively as compared with 80.4 in the control treatment. These results represented 87.8, 87.3, 84.1 and 64.8% reduction in leaves infestation after treatments with diatom, Aglev Si 300, kaolin and bentonite.

1.1.3. Effects on adult stages

Data in Table (5) clearly indicate the high effect of diatom, Aglev Si 300 and kaolin followed by bentonite to control *M. mangiferae*. The results indicated significant differences between untreated and treated trees. The results indicated significant differences between treatments in their effectiveness against adult of mango shield scale insect infestation. They reduced adult population by 77.2, 75.8, 62.0 and 53.8% reduction, respectively. Their cumulative adult numbers were 16.3, 17.3, 27.2 and 33.1 respectively as compared with 71.6 in the untreated control.

1.1.4. Effects on ovipositing adult stages

The results of the average of the two seasons 2021 and 2022 indicated great significant differences between the average of ovipositing adult numbers found in examined control samples and treated samples. The lowest infestation percent of ovipositing adult on mango shield scale insect was recorded on leaves sprayed by diatom (10.0) and the highest infestation of ovipositing adult in treated samples occurred in those sprayed with bentonite (25.2). The infestation average number of ovipositing adult were 10.0, 11.2, 12.0 and 25.2 for diatom, Aglev Si 300, kaolin and bentonite, respectively while it was 90.0 in the untreated trees. The ovipositing adult was quite susceptible to all tested compounds. Diatom caused the highest reduction percent in eggs of red scale insect (88.9%) followed by Aglev Si 300, kaolin and bentonite which caused 87.6, 86.6 and 72.0 469% reductions, respectively.

From the previous results, it can be concluded that the successful control of the mango shield scale insect can be achieved by diatom and Aglev Si 300 with reduction percentage more than 80.0% followed by kaolin (from 60.0 to 87.0%) and bentonite (from 50.0 to 70.0%), respectively in different stages of mango shield scale insect (immature, adult and ovipositing adult stages). Thus we recommended using the particle film technology (diatom, Aglev Si 300, kaolin and bentonite) for their advantages in minimizing the environmental pollution.

Specifically, applying silicon to plants can greatly improve their resilience to diseases, pests, and insects, increasing yields. When silicon is applied to reduce insect populations, sensitive types typically show responses more visibly than resistant ones. Monocots that have silicon deposits on them could offer a mechanical defense against insect infestations. However, an active role for silicon has been demonstrated in the physiological resistance of crops to diseases, challenging the idea that silicon only plays a passive role (Laing et al., 2006). These results agree with those obtained by Ali et al. (2021), who concluded that Aglev Si 300 and diatoms are considered as the most active materials gave 100% mortalities against preadult stage of mango shield scale insect, followed by kaolin, gave potential activity more than 90% mortalities while bentonite considered active against preadults with moderate percentage corrected mortality under laboratory conditions. Ali (2016) demonstrated that kaolin clay is unequivocally non-toxic to the environment.

The white coating produced by kaolin sprays allows growers to easily identify the need for additional treatments while monitoring the fruits in the field. Furthermore, both kaolin and bentonite have proven effective in significantly reducing infestations of the olive fruit fly. Additionally, the use of kaolin and bentonite for managing olive fruit fly populations presents a valuable opportunity for organic farms, particularly in the production of table olives. Ali and El-Mahdy (2024) observed the toxicity study against adult and pupa stages of peach fruit fly *Bactrocera zonata.* The results indicated that a potent effect of diatom, kaolin, aglive Si 300 and bentonite in powder form of silicon with corrected mortality from 40 to 100%, respectively. Also, Ali et al. (2022) cleared that some silicon formulations such as kaolin, bentonite, Aglev Si 300 and diatom as powder formulations had a toxic effect against two-spotted spider mite, *Tetranychus urticae* in the laboratory. Adding silicon to plants can boost yields by significantly enhancing their resistance to pests, diseases, and insects. Sensitive insects react more readily than resistant ones when silicon is used to lower insect populations. Silicon-coated monocots may provide a mechanical barrier against insect infestations. Contrary to the belief that silicon exclusively has a passive role, silicon has been shown to play an active role in crops' physiological resistance to diseases (Laing et al., 2006). Additionally, the outcomes may be comparable to those of Soubeih et al. (2017), who found that foliar spraying with kaolin had a superior effect at a concentration of 5% on cumulative leaf miner, aphid infestations, and the incidence and severity of early blight disease. Furthermore, compared to bentonite application, which offered the least possibility for aphid insect adult development, cabbage plants treated with foliar spraying with atabouglite and kaolin formulations showed a significant drop in the population of *Aphis crassivora*. Additionally, atabouglite outperformed kaolin in terms of average cumulative cotton leaf worm infestations of leaves and larvae caused by *Spodoptera littoralis*. The least effective material was bentonite (Gomaa et al., 2021). 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 et al., 2006).

1.2. Effect of some silicon liquid formulations (potassium silicate) on mango shield scale insect

1.2.1. Effects on total infested leaves

In Table (6), data report that the efficiency of two formulations of potassium silicate in different mode of actions on the infestation percentage decrease with mango shield scale insect in both years of 2021 and 2022 at the mango orchard of Ismallia Governorate. The obtained data cleared that, kaolineted potassium silicate and Si El-Ghanem formulations under field condition showed significantly decreases in reduction percentage in 91.7 and 83.5%, respectively against mango shield scale insect. The average number of leaves infestation was 7 and 14 that were compared with the control treatment (84.7), respectively.

Table (6). Cumulative infestation of mango shield scale insect (*Milviscutulus mangiferae)* in mango groves treated with some liquid silicon as potassium silicate, throughout seasons 2021 and 2022.

Treatments	**Infested leaves***							
	Total no.		**Immature stages**		**Adults**		**Ovipositing adults**	
	Mean	**R %**	**Mean**	**R %**	**Mean**	**R %**	**Mean**	**R %**
Kaolineted potassium silicate	7.0 c	91.7	8.0 c	90.0	9.0 c	87.4	8.9 c	90.1
Si El-Ghanem	14.0 b	83.5	13.3 b	83.4	14.4 b	79.9	12.4 b	86.2
Control	84.7 a		80.4 a		71.6 a		90.0 a	

R %= Reduction Percentage
*Cumulative number of infested fruits all over the growing season (12 dating samples)

1.2.2. Effects on ovipositing adult stage

Data in Table (6) indicate that kaolineted potassium silicate and Si El-Ghanem formulations gave the highest reduction percentage in infestation against ovipositing adult stage numbers of mango shield scale insect. Kaolineted potassium silicate compound recorded a high value of 90.1%

reduction, which was significantly higher than that investigated with Si El-Ghanem (86.2%).

1.2.3. Effects on immature stages

Data in Table (6) clear that kaolineted potassium silicate and Si El-Ghanem compounds gave low mean numbers of immature stages of mango shield scale insect compared with the control treatment. Their mean numbers of infestation were 8 and 13.3, respectively. The reduction percentage of kaolineted potassium silicate and Si El-Ghanem formulations were 90 and 83.4%, respectively. The previous data presented that kaolineted potassium silicate gave more potential than Si El-Ghanem formulation and the two formulations can be used to reduce mango shield scale insect.

1.2.4. Effects on adults

Results assured that the efficacy of kaolineted potassium silicate and Si El-Ghanem compounds on the infestation percentage decrease with adult of *M. mangiferae*, in the two tested years. The reduction percentage of kaolineted potassium silicate and Si El-Ghanem were 87.4 and 79.9%, respectively against adults of *M. mangiferae.*

The above results are more combatable with Ali et al. (2021), who showed that potassium silicate in all the three forms (kaolinated potassium silicate, Si El-Ghanem and silica ke) are effective to preadult and adult of mango shield scale insects at the three concentrations but they were more effective at 100 and 75% concentrations. Kaolinated potassium silicate and Si El-Ghanem gave 100% mortalities at 100 and 75% concentration after 3 days exposure time. The results in the present study agree with Ali et al. (2022), who said that liquid silicon formulations were more effective on the oviposition rate of the two spotted mites for treated females than powder silicon formulations. 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. The previous results agree with Ali and El-Mahdy (2024), who said that potassium silicate formulations had a toxic effect in different corrected mortality percentage from 55.7 to 100% against peach fruit fly.

1.3. Effect of untraditional materials on mango shield scale insect

1.3.1. Effects on total infested leaves

Data in Table (7) illustrate that three untraditional compounds (triple power, boiled lime and sulfur and extra power) showed significant reduction of total number of infested leaves of mango shield scale insect as compared with control treatment. Data showed that the three untraditional compounds gave the highest reduction with more than 90% against *M. mangiferae.* Extra power treatment had a 98% reduction percentage followed by triple power with 95%, and then boiled lime and sulfur with 93.8%, respectively against mango shield scale insect during both seasons. The average numbers of infested leaves of mango shield scale insect were 1.7, 4.2 and 5.2 compared with the control treatment 84.7.

Table (7). Cumulative infestation of mango shield scale insect (*Milviscutulus mangiferae)* in mango groves treated with some untraditional materials, throughout seasons 2021 and 2022.

Treatments	Infested leaves*							
	Total no.		Immature stages		Adults		Ovipositing adults	
	Mean	R %	Mean	R %	Mean	R %	Mean	R %
Triple power	4.2 c	95.0	4.3 c	94.7	6.4 c	91.1	6.3 b	93.0
Boiled lime and sulfur	5.2 b	93.8	5.5 b	93.2	7.0 b	90.2	6.1 b	93.2
Extra power	1.7 d	98.0	3.8 c	95.3	4.0 d	94.4	2.5 c	97.2
Control	84.7 a		80.4 a		71.6 a		90.0 a	

R %= Reduction Percentage

*Cumulative number of infested fruits all over the growing season (12 dating samples)

1.3.2. Effects on immature stages

These results are cleared in Table (7). The total average numbers of immature stages of mango shield scale insect recorded were 3.8, 4.3, and 5.5 by spraying triple power, boiled lime and sulfur and extra power, respectively comparing with the control treatment (80.4). The reduction percentages of the three compounds were 95.3, 94.7 and 93.2, respectively.

1.3.3. Effects on adults stage

Data obtained from this experiment are shown in Table (7). The results indicated that infestation was significantly lower in the treated mango trees than untreated ones. After the foliar spraying by extra power, triple power and boiled lime and sulfur against the cumulative mango shield scale insect of adult infestation through the two seasons in treated trees were 4.0, 6.4 and 7.0 for extra power, triple power and (boiled lime and sulfur), respectively as compared with 71.6 in the untreated trees. These treatments reduced adult infestation by 94.4, 91.1 and 90.2%, respectively.

1.3.4. Effects on ovipositing adult stage

Data presented in Table (7) show the effects of triple power, boiled lime and sulfur and extra power on the population of mango shield scale insect infestation on mango trees. The data provided for this study indicated that the application of triple power, boiled lime and sulfur, and extra power significantly enhanced the health characteristics of the plants to a considerable extent when compared to the control treatment. The most substantial decrease in the ovipositing adult stage count of the mango shield scale insect was observed in plants treated with extra power, achieving a reduction of 97.2%.

This was followed by boiled lime and sulfur, which resulted in a 93.2% reduction, and triple power, also achieving a 93.2% reduction, in comparison to untreated plants.

It is evident from the data in Table (7) that after the foliar spraying by extra power, triple power and boiled lime and sulfur against the cumulative mango shield scale insect of total invested leaves, eggs, immature stages and adult infestation through the average of two seasons in treated mango trees had more than 90% of percentage reduction, compared to the control treatment.

These data agree with Ali et al. (2021), who found that boiled lime and sulfur had very good effect with more than 80.7% mortality against adult preadult of mango shield scale insect. Palmito formulation (plant extract) was the best one with 100% corrected mortality against adult stage of mango shield scale insect. Glister and malathion gave more than 90% corrected mortalities against adult stage under laboratory conditions. Siam and Othman (2020) conducted an evaluation of the insecticidal properties of extracts from aloe, ginger, garlic, and hot pepper. These extracts were tested either as individual sprays, in combinations of two plant sources, or as a mixture of all extracts, and were compared to the insecticide Lambda against the mango scale insect, *Aulacaspis tubercularis* (Newstead) (Hemiptera: Diaspididae). The findings indicated that Lambda insecticide effectively reduced the population of *A. tubercularis*, achieving total reduction rates of 62.0 and 72.52% in the years 2017 and 2018, respectively. In contrast, the botanical mixture resulted in reductions of 83.60 and 72.52% in the same seasons. Notably, the combination of garlic and aloe proved to be the most effective, yielding reductions of 58.71 and 59.93% in the two consecutive years. Conversely, hot pepper exhibited the least efficacy, with reduction rates of 19.48% in 2017 and 21.51% in 2018.

2. Effect of Casuarina Windbreak on Sand Grain Particle and Sand Drift

2.1. Sand grain size and texture

Results obtained in Table (8) on grain size distribution as affected by windbreak indicated that sand fractions of grain size of 0.125-> 0.063 mm represent the most grain size percentage of El-Mostakbal City, Ismailia Governorate, Egypt. Moreover, the grain size distribution in wind and leeward sides of windbreak showed that, the percentage of sand grain size of 0.125-> 0.063 mm in the windward recorded 61.7%. In the leeward side it recorded 70.05% for casuarina windbreak. While it recorded 62.05% in the same extended line of the unsheltered area.

The obtained data in Table (9) indicate the statistical and textural size parameters which revealed that grains were fine sand in the windward side. While very fine sand grains represent the leeward sides of casuarina windbreak.

Table (8). Sand grain size percentage as affected by windbreak

Windbreak	Side of windbreak	Grain size (mm) 2->1.0	1->0.5	0.5->0.225	0.225->0.125	0.125->0.063	0.063	<0.063
Casuarina	Windward	0	0.353	0.783	6.389	61.704	26.077	4.694
	Leeward	0	0.000	0.047	9.219	70.05	20.427	0.257
Unsheltered area	________	0	0.000	0.267	7.159	62.05	28.37	2.154

Table (9). Sand grain textures as affected by windbreak.

Windbreak	Fence side	Sorting	Mean size	Kurtosis*	Skewness*
Casuarina	Wind ward	0.633**	2.629**	1.127	0.967
	Leeward	0.462*	3.736***	0.82	0.867
Unsheltered area	-------------	0.513**	3.029***	1.416	0.967

Sorting: Well sorted* - Moderately well sorted**
Mean size: Fine sand** - Very fine sand***
Kurtosis: Extremely leptokurtic
Skewness*: Strongly fine skewed.

2.2. Sand drift potential

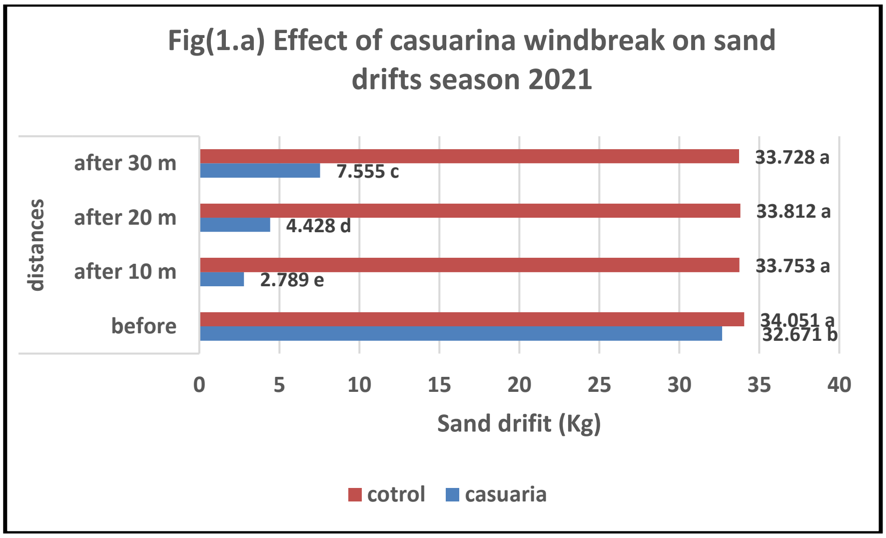
It is clear from Fig. (1 a and b) that the results on sand drift potential derived using sand collectors indicated that protected areas were significantly lower than unprotected areas in total seasonally sand drift. However, the lower amount of sand accumulated in sand collectors were obtained after 10 m distance from windbreak in the leeward side (2.789 and 5.46 kg/sand collector /year) in the first and second seasons, respectively with significant differences between them and the amount of sand accumulated in sand collectors at 20 m and 30 m in the leeward side. While the higher amount of sand accumulated in sand collectors (ranged among 33.942 and 35.859 kg) were recorded in unprotected areas.

These results agree with those obtained from Miri and Arnott (2021), who found that a single *Tamarix* tree as windbreak reducing wind speed and sediment flux, and thus its suitability as a potential control on erosion and sediment transport. Shelterbelts reduced windward wind speed and the less porous, is more effective in reducing wind-ward wind speed and wind erosive forces, and in depositing sand while wind erosiveness was reduced for a range of 45-67% (Dafa-Alla and Al-Amin, 2016).

2. 3. Windbreak efficiency

Fig. (2 a and b) shows the efficiency of casuarina windbreak during the two studied seasons, in the first season, the effectiveness was clearer than the results obtained in the second season, and during the two seasons, the effectiveness was obvious till 10 m in the leeward side and then, it gradually decreases as the distance from the windbreak increases. In the first season, the effectiveness of the casuarina windbreak was 91.46, 86.45 and 76.88% at the distances of 10, 20, and 30 meters in the leeward side, respectively, with significant differences between them. While, in the second season, it was

84.21, 81.82 and 71.86% at the same distances, with insignificant difference between the distance of 10 and 20 meters, but there was a significant difference between them and a distance of 30 meters.



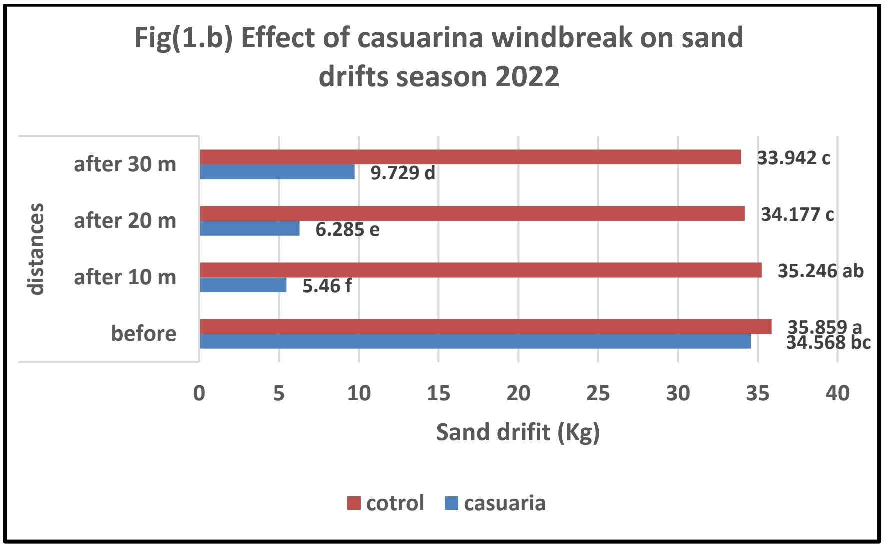


Fig. (1). Effect of casuarina windbreak on sand drifts for **a.** season 2021 and **b.** season 2022.

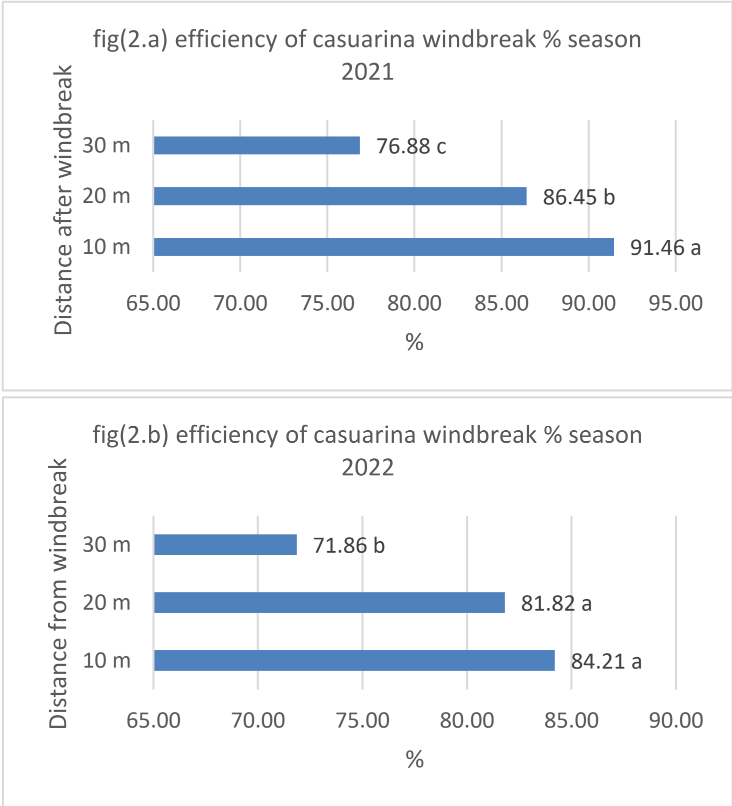


Fig. (2). Efficiency of casuarina windbreak on sand drifts for **a.** season 2021 and **b.** season 2022.

Similar results were obtained by Zaghloul (2006), who considered the impact of single and twofold lines of date fronds mate and theran wall and found that their viability extended from 27 to 50% in catching sand since of the lessening in wind speed. Windbreaks altogether contribute to a diminished wind speed, in this manner securing soil against wind disintegration, expanding arrive efficiency, ensuring rural crops, expanding recreational values of the scene (Vacek et al., 2018).

3. Vegetative Growth

3.1. Effect of casuarina windbreak on shoot characteristics

Casuarina windbreak was significantly affected shoot characteristics (Table 10). Mango trees protected by casuarina windbreak showed the highest values for shoot length (41.0 and 37.76 cm) and shoot diameter (0.9524 and 0.998 cm) in 2020 and 2021, respectively, while the lowest values of shoot length (37.01 and 35.29 cm) and shoot diameter (0.8561 and 0.8808 cm) was obtained from unprotected trees in both seasons. The results agree with those obtained by Hegazi et al. (2001) on grapevines, Elkarbotly (2006) on olive and El-Gamal (2007) on peach.

Windbreaks increased shoot growth during active shoot growth flushes in spring and early summer and reduce damaged fruit-bearing branches will increase the number of bearing positions for the following season (Basile et al., 2012 and Zanamwe, 2018).

3.2. Effect of foliar spraying on shoot characteristics

Results in Table (10) indicate that, the highest values of shoot length (43.68 cm) was obtained with bentonite foliar spry, followed by kaolineted potassium silicate (43.35 cm) and extra power (43.22 cm) without significant different between them in the first season, but the highest values in the second season was achieved with kaolineted potassium silicate (43.22 cm). However, the lowest values of shoot length (27.72 and 26.50 cm) were obtained with non-sprayed mango trees in the first and second seasons, respectively. It is clear from Table (10) that there was no significant differences for the effect of spraying treatments on shoot diameter, but they all differed significantly from the non-sprayed trees.

Generally, it could be summarized that foliar application of anti-transpirants gained superiority in shoot growth characters over the control. This result agrees with Abd El-Rahman (2022), who studied the effect of foliar applications to anti-stressors on vegetative growth parameters of Balady mandarin trees and found that all applications of anti-stressors foliar significantly increased of all studied growth traits (shoot length, number of leaves and leaf area). Foliar applications with potassium silicate and amino acids, single or mixed treatments increased shoot length and shoot thickness as compared with control for Keitte mango trees (Aly et. al., 2019).

Moreover, significant differences were noticed at the interaction of casuarina windbreak with spraying treatments concerning shoot length and shoot diameter of mango trees, the highest values of shoot length (45.68 and 45.22 cm) were obtained from the protected trees with casuarina windbreak sprayed with kaolineted potassium silicate in the first and second seasons, respectively.

As for the shoot diameter of treated mango trees with all foliar spraying and protected with casuarina windbreak, there was no significant difference between them, but it differed significantly with unprotected trees.

This trend is similar to that reported by Abd El-Rahman (2015), who found that spraying Keitte mango trees once, twice or thrice with potassium silicate at 0.05 to 0.2% significantly accompanied with enhancing shoot length, number of leaves/shoot and leaf area over the check treatment. There was gradual stimulation on these growth characters with increasing concentrations and frequencies of application. Significant differences in these growth traits were observed among all concentrations and frequencies except between 0.1 and 0.2% as well as between using silicon twice or thrice. Therefore, the recommended treatment from an economical point of view was using potassium silicate twice at 0.1%. The untreated trees produced the minimum values.

Table (10). Effect of windbreak and spraying of anti-transpirants on shoot length and shoot diameter of Ewais mango trees.

Treatment	Shoot Length			Shoot diameter		
	2021		Mean	2021		Mean
	Casuarina windbreak			Casuarina windbreak		
	with	without		with	Without	
Diatom	35.84 g-i	31.86 ij	33.85 E	0.9930 a	0.9063 a-c	0.9497 A
Kaolin	37.98 d-h	34.32 hi	36.15 DF	0.9603 ab	0.8503 cd	0.9053 A
Aglif Si 300	40.25 b-f	36.69 f-h	38.47 CD	0.9963 a	0.9097 a-c	0.9530 A
Bentonite	45.50 a	41.83 a-e	43.68 A	0.9677 ab	0.8707 b-d	0.9192 A
Kaolineted potassium silicate	45.68 a	41.01 b-f	43.35 A	0.9627 ab	0.8627 b-d	0.9127 A
Triple power	42.08 a-d	37.71 e-h	39.90 BC	0.9447 a-c	0.8447 cd	0.8947 A
Si El-Ghanem	43.25 a-c	39.58 c-g	41.42 A-C	1.0037 a	0.9263 a-c	0.9650 A
Boiled lime and sulfur	44.14 ab	40.48 b-f	42.31 AB	0.9673 ab	0.8647 b-d	0.9160 A
Extra Power	45.55 a	40.89 b-f	43.22 A	0.9447 a-c	0.8413 cb	0.8930 A
Control	29.72 jk	25.71 k	27.72 F	0.7840 de	0.6840 e	0.7340 B
Mean	41.00 A	37.01 B		0.9524 A	0.8561 B	

Treatment	2022		Mean	2022		Mean
	Casuarina windbreak			Casuarina windbreak		
	with	without		with	without	
Diatom	41.42 ab	38.08 bc	39.75 AB	1.0573 a	0.9207 b-d	0.9890 A
Kaolin	33.02 c-f	30.68 e-g	31.85 C	1.0000 ab	0.8743 de	0.9372 A
Aglif Si 300	33.24 c-f	31.91 d-f	32.85 C	1.0130 ab	0.9253 b-d	0.9692 A
Bentonite	41.22 ab	37.89 b-d	39.56 AB	1.0640 a	0.9177 b-d	0.9908 A
Kaolineted potassium silicate	45.22 a	41.22 ab	43.22 A	1.0077 ab	0.8960 c-e	0.9518 A
Triple power	38.84 bc	35.84 b-e	37.34 B	0.9903 a-c	0.8780 de	0.9342 A
Si El-Ghanem	38.92 bc	36.25 b-e	37.58 B	1.0450 a	0.9397 b-d	0.9923 A
Boiled lime and sulfur	38.48 bc	35.81 b-e	37.14 B	1.0067 ab	0.8813 de	0.9440 A
Extra power	40.89 ab	39.55 ab	40.22 AB	0.9897 a-c	0.8680 de	0.9288 A
Control	27.33 fg	25.67 g	26.50 D	0.8063 e	0.7073 f	0.7568 B
Mean	37.86 A	35.29 B		0.9980 A	0.8808 B	

*Kaolineted Potassium Silicate
**Si El-Ghanem

4. Leaf Characteristics

4.1. Effect of Casuarina windbreak on Leaf area and total chlorophyll content

It is clear from Table (11) that leaf area and total chlorophyll content of the protected mango trees by casuarina windbreak was increased significantly in the two seasons. So, protected trees gave biggest leaf area (88.62 and 96.206 cm^2) than unprotected trees which recorded the smallest leaf area (86.06 and 90.202 cm^2) in the first and second seasons, respectively. In addition, protected trees recorded the highest leaf total chlorophyll content (41.913 and 44.31) while, unprotected trees gained the lowest content (40.05 and 41.759) in the first and second seasons, respectively.

These results agree with those obtained by Hegazi et al., (2001) on grapevines, Elkarbotly (2006) on olive, El-Gamal (2007) on peach and Abd El-Rahman (2022) on Balady mandarin.

4.2. Effect of foliar spry on Lleaf area and total chlorophyll content

Data in Table (11) clarify significant effects of all foliar spray treatments on leaf area and total chlorophyll content in the first and second seasons. However, kaolineted potassium silicate sprayed trees recorded the highest leaf area (99.02 and 105.82 cm^2) while, unsprayed trees gained the lowest values (71.32 and 77.05 cm^2) in the first and second seasons, respectively. Moreover, the unsprayed trees achieved the lowest total leaf chlorophyll content (30.767 and 33.617) while, the highest contents (45.25 and 47.183) were reported with diatom foliar spry in the first and second seasons, respectively.

Many investigators confirm these results, such as, Abd El-Kader et al. (2006) on banana plants, Al-Desouki et al. (2009) on Egyptian Sultani fig tree, Zaen El-deen et al. (2015) on young mango trees, Gooda et al. (2018) and Aly et al. (2019) on Keitte mango.

Leaf area and total chlorophylls of Keitte mango trees were significantly increased because of using potassium silicate once, twice or thrice at 0.05 to 0.5% comparing to the control treatment (Abd El-Rahman, 2015). Also, Abd El-Rahman (2022) studied the effect of foliar applications to anti-stressors on vegetative growth parameters of Balady mandarin trees and found that they significantly increased the number of leaves and leaf area.

In relation to the interaction effect of casuarina windbreak with spraying treatments concerning leaf area and total chlorophyll content of mango leaves, data in Table (11) show that the interaction of casuarina windbreak with kaolineted potassium silicate surpassed significantly the other interactions and gave the highest values of leaf area (100.18 and 107.16 cm^2) in the two seasons, respectively. Whereas the highest values of total chlorophyll content (45.467 and 47.733) were due to the interaction between casuarina windbreak and diatom in the first and second seasons, respectively.

Table (11). Effect of windbreak and spraying of anti-transpirants on leaf area and total chorophyll content of Ewais mango trees.

Treatment	Leaf area 2021 Casuarina windbreak With	Leaf area 2021 Casuarina windbreak Without	Leaf area Average	Total chlorophyll content 2021 Casuarina windbreak With	Total chlorophyll content 2021 Casuarina windbreak Without	Total chlorophyll content Average
Diatom	83.89 e-h	77.50 hi	80.70 E	45.467 a	45.033 ab	45.250 A
Kaoline	86.37 d-g	82.27 f-h	84.32 DE	42.500 b-d	41.967 cd	42.233 BC
Aglif 300	88.49 c-f	84.49 e-h	86.50 C-E	43.333 a-c	42.533 b-d	42.933 B
Bentonite	90.69 b-e	85.32 d-h	88.01 B-D	43.600 a-c	42.233 cd	42.917 B
Kaolineted potassium silicate	100.18 a	97.85 ab	99.02 A	41.200 c-e	40.233 de	40.717 CD
Triple power	95.93 a-c	91.36 b-e	93.65 AB	43.833 a-c	41.767 cd	42.800 B
Si El-Ghanem	93.06 a-d	88.39 c-f	90.73 BC	42.733 b-d	40.533 de	41.633 B-D
Boiled lime and sulfur	90.21 b-f	86.21 d-g	88.21 B-D	41.533 cd	38.600 e	40.067 D
Extra power	83.72 e-h	78.39 g-i	81.05 E	42.400 b-d	38.600 e	40.500 CD
Control	73.63 ij	68.82 j	71.23 F	32.533 f	29.000 g	30.767 E
Average	88.62 A	84.06 B		41.913 A	40.050 B	
Treatment	**2022 Casuarina windbreak With**	**2022 Casuarina windbreak Without**	**Average**	**2022 Casuarina windbreak With**	**2022 Casuarina windbreak Without**	**Average**
Diatom	91.06 e-g	85.28 gh	88.17 E	47.733 a	46.633 ab	47.183 A
Kaoline	91.22 e-g	91.77 d-g	91.50 DE	46.000 a-c	43.600 d-f	44.800 BC
Aglif 300	97.83 b-e	90.03 fg	93.93 CD	46.400 ab	44.133 c-f	45.267 B
Bentonite	100.19 bc	95.26 c-f	97.72 BC	44.300 c-e	43.383 d-f	43.842 CD
Kaolineted potassium silicate	107.16 a	104.49 ab	105.82 A	42.533 e-g	41.197 gh	41.865 E
Triple power	104.53 ab	98.17 b-d	101.35 AB	44.933 b-d	43.333 d-f	44.133 B-D
Si El-Ghanem	99.85 bc	89.98 fg	94.91 CD	45.867 a-c	42.173 f-h	44.020 B-D
Boiled lime and sulfur	95.62 cdef	86.02 g	90.82 DE	44.300 c-e	40.367 h	42.333 E
Extra power	95.77 cdef	85.77 g	90.77 DE	46.067 a-c	40.500 h	43.283 DE
Control	78.85 hi	75.25 i	77.05 F	34.967 i	32.267 j	33.617 F
Average	96.206 A	90.202 B		44.310 A	41.759 B	

*Kaolineted Potassium Silicate
**Si El-Ghanem

4.3. Effect of Casuarina windbreak on leaf fresh, dry weights and water content

As shown in Table (12), the casuarina windbreak significantly affected the leaf fresh, dry weights and water content in the first and second seasons. However, the highest significant values of leaf fresh, dry weights and leaf water content were obtained in the protected trees with casuarina windbreak (3.24 and 3.39 g), (1.682 and 1.505 g) and (55.309 and 58.571%) compared with the unprotected trees (3.12 and 3.23 g)), (1.503 and 1.396 g) and (45.656 and 53.126%) in the first and second seasons, respectively.

These findings are in line with those found by Elkarbotly (2000) and El-Gamal (2007). They worked on olive and peach and indicated that there are many factors that distinctly affect leaf water content; high temperature, dry winds, lack of soil moisture, relative magnitude of transpiration and water supply. However, sheltered trees were higher than unsheltered in leaf water content.

4.4. Effect of foliar spry on leaf fresh, dry weights and water content

Regarding leaf fresh weight results (Table 12), they indicate that the highest values of leaf fresh weight (3.63 and 3.63 g) in 2021 and 2022 seasons, respectively, was due to triple power spraying, while the lowest one (2.89 and 2.96 g) was at control. Concerning leaf dry weight, all spraying treatments had similar effect, but they were significantly higher than the control.

Data in Table (12) reveal the significant effect of foliar spray materials on leaf water content in the tested mango trees. The sprayed trees with kaolineted potassium silicate achieved the uppermost percentage (57.369 and 62.832%) while, the lowermost percentage (42.247 and 45.106%) was recorded by the unprotected trees in the first and second seasons, respectively.

The past discoveries coincided with those gotten by Abd El-Kader et al. (2006) on Banana plants, Al-Desouki et al. (2009) on Egyptian Sultani fig tree and Zaen El-deen et al. (2015) on young mango trees.

4.5. Effect of casuarina windbreak on hard leaf character and leaf succulence grade

It appears from Table (13) that the casuarina windbreak affected hard leaf character of the protected trees significantly in the two seasons. However, the highest hard leaf character was recorded with protected trees (0.2098 and 0.1690) and the lowest hard leaf character was gained with the unprotected trees (0.1719 and 0.1469) in the first and second seasons, respectively.

Data in Table (5) present the significant effect of casuarina windbreak on leaf succulence grade of protected mango trees in the two seasons. The protected trees gained the lowest values (0.5578 and 0.5905) while, the highest values (0.6029 and 0.5905) were achieved with the unprotected trees in the first and second seasons, respectively.

These results are similar to what was achieved by El-Gamal (2007), who worked on peach trees and found that protected trees with artificial fences gained the highest hard leaf character and lowest leaf succulence grade.

Table (12). Effect of windbreak and spraying of anti-transpirants on leaf fresh weight, leaf dry weight and leaf water content of Ewais mango trees.

Treatment	Leaf fresh weight 2021 Casuarina windbreak With	Without	Average	Leaf dry weight 2021 Casuarina windbreak With	Without	Average	Leaf water content 2021 Casuarina windbreak With	Without	Average
Diatom	3.27 c-e	3.19 c-f	3.23 BC	1.597 a-e	1.544 b-e	1.570 AB	52.756 c	49.883 c-e	51.320 B
Kaolin	3.13 d-f	3.00 fg	3.07 C-E	1.618 a-d	1.501 b-f	1.559 AB	52.105 cd	46.165 ef	49.135 BC
Aglif 300	3.17 c-f	3.01 e-g	3.09 CD	1.770 a	1.607 a-e	1.683 A	49.403 c-e	40.938 fg	45.170 CD
Bentonite	3.32 b-d	3.19 c-f	3.26 BC	1.698 a-c	1.491 c-f	1.594 A	55.146 a-c	46.538 d-f	50.842 B
Kaolineted potassium Silicate	3.40 bc	3.31 cd	3.35 B	1.634 a-d	1.698 a-c	1.666 A	60.903 a	53.890 bc	57.396 A
Triple power	3.68 a	3.59 ab	3.63 A	1.638 a-d	1.484 d-f	1.561 AB	59.713 ab	54.276 bc	56.994 A
Si El-Ghanem	3.00 fg	2.83 g	2.91 DE	1.708 ab	1.397 ef	1.553 AB	53.338 c	39.403 g	46.370 CD
Boiled lime and sulfur	3.19 c-f	3.16 c-f	3.18 BC	1.798 a	1.527 b-f	1.663 A	52.136 cd	43.143 ef	47.639 BC
Extra power	3.22 c-f	3.10 d-f	3.16 C	1.771 a	1.524 b-f	1.647 A	52.586 c	42.839 ef	47.713 BC
Control	2.97 fg	2.80 g	2.89 E	1.331 f	1.524 b-f	1.427 B	45.009 e-g	39.486 g	42.247 D
Average	3.24 A	3.12 B		1.682 A	1.503 B		53.309 A	45.656 B	

Treatment	Leaf fresh weight 2022 Casuarina windbreak With	Without	Average	Leaf dry weight 2022 Casuarina windbreak With	Without	Average	Leaf water content 2022 Casuarina windbreak With	Without	Average
Diatom	3.47 bc	3.26 def	3.37 BC	1.544 a-d	1.400 e-g	1.472 B	59.673 c-e	52.626 gh	56.149 D
Kaolin	3.35 cde	3.14 fg	3.25 D	1.501 b-f	1.411 e-g	1.456 BC	57.834 c-f	52.190 gh	55.012 DE
Aglif 300	3.39 cd	3.11 gh	3.25 D	1.607 a-c	1.447 d-g	1.527 B	57.254 d-f	48.321 ij	52.787 E
Bentonite	3.49 bc	3.36 c-e	3.42 B	1.492 b-f	1.222 i	1.357 DE	64.953 ab	55.535 f-h	60.244 AB
Kaolineted potassium silicate	3.55 b	3.36 c-e	3.45 B	1.614 ab	1.637 a	1.626 A	65.330 a	60.334 cd	62.832 A
Triple power	3.72 a	3.54 b	3.63 A	1.484 c-f	1.440 d-g	1.462 BC	61.221 bc	58.064 c-f	59.642 BC
Si ElGhanem	3.25 ef	3.17 fg	3.21 D	1.397 fg	1.351 gh	1.374 CD	58.383 c-f	55.872 e-g	57.127 CD
Boiled lime and sulfur	3.33 de	3.23 e-g	3.28 CD	1.527 a-e	1.401 e-g	1.464 B	57.893 c-f	52.716 gh	55.305 DE
Extra power	3.37 c-e	3.17 fg	3.27 CD	1.524 a-f	1.450 d-g	1.487 B	56.948 def	51.964 hi	54.456 DE
Control	3.00 hi	2.92 i	2.96 E	1.229 hi	1.331 g-i	1.280 E	46.217 jk	43.995 k	45.106 F
Average	3.39 A	3.23 B		1.505 A	1.396 B		58.571 A	53.162 B	

*Kaolineted Potassium Silicate
**Si El-Ghanem

4.6. Effect of foliar spry on hard leaf character and leaf succulence grade

Data in Table (13) present the significant effect of all foliar spry materials on hard leaf character and leaf succulence grade of sprayed mango trees in the two seasons. However, the highest hard leaf character (0.2552 and

0.2111) and leaf succulence grade (0.6414 and 0.6364) were achieved by unsprayed trees in the first and second seasons, respectively.

On the contrary, the lowest hard leaf character (0.1445 and 0.1210) was gained by kaolineted potassium silicate but Aglif 300 Si gave the lowest leaf succulence grade (0.5614 and 0.5614) in the first and second seasons, respectively.

The outcomes of foliar application were upheld by the discoveries of Massey and Hartley (2006 and 2009), they found that silicon deposition contributes to expanded unbending nature and abrasiveness of plant tissues. Silicon gives quality and inflexibility to the cell wall, makes strides development, health and efficiency (Divya and Sharma, 2018).

4.7. Effect of casuarina windbreak on yield attributes

Data in Table (7) show that the casuarina windbreak affected mango fruit number / tree significantly in both seasons, but its effect on the yield was significant in the first season only. Nevertheless, the highest numbers of fruit / tree (242.3 and 257.7) were recorded with protected trees compared with unprotected ones which gained the lowest numbers of fruit / tree in the first and second seasons, respectively.

These results generally are in line with those reported by Elkarbotly (2000) and Hegazi et al. (2001) on Thompson seedless grapevine, Elkarbotly (2006) on olive and El-Gamal (2007) on peach. They reported that the impacts of the windbreaks and barriers relative to open-field environments expanded yields of different examined fruit species. Tree shield has appeared to increase the growth and yield of different agricultural and field crops by 6–56%. The review recommends a positive relationship between tree shelterbelts and crop growth and improvement ascribed to adjusting microclimate conditions (Suratman and Brandle, 2024).

4.8. Effect of foliar spray on yield attributes

The data obtained in Table (14) clarify the significant effect of spray treatments on fruit number / tree and yield/tree. However, the highest fruit number / tree was recorded by sulfur and lime boiling (272.8) followed by kaolin (268.0) in the first season but in the second season kaolin achieved the highest number (282.5) followed by sulfur and lime boiling (281.7). Moreover, the lowest fruit number / tree was gained by Aglif 300 Si (189.1 and 211.1) in the first and second seasons, respectively.

In addition, Table (14) shows that, sulfur and lime boiling spry gave the highest yield / tree (24.5 and 19.36 kg) while, the lowest yield / tree (7.2 and 5.26 kg) was recorded by unsprayed trees in the first and second seasons, respectively.

Table (13). Effect of windbreak and spraying of anti-transpirants on hard leaf character and leaf succulence grade of Ewais mango trees.

Treatment	Hard leaf character 2021 Casuarina windbreak With	Without	Average	Leaf succulence grade 2021 Casuarina windbreak With	Without	Average
Diatom	0.1842 d-h	0.2067 b-e	0.1955 BC	0.6306 ab	0.5970 b-d	0.6138 AB
Kaoline	0.1742 e-h	0.2039 b-f	0.1891 BC	0.6048 a-d	0.5883 b-d	0.5965 AB
Aglif 300	0.1815 d-h	0.2098 b-d	0.1957 BC	0.5587 cd	0.4834 e	0.5210 C
Bentonite	0.1644 g-i	0.2071 b-e	0.1858 BC	0.6093 a-d	0.5736 b-d	0.5893 B
Kaolineted potassium silicate	0.1331 i	0.1558 g-i	0.1445 D	0.6091 a-d	0.5534 d	0.5812 B
Triple power	0.1574 g-i	0.1880 c-g	0.1727 C	0.6244 a-c	0.6030 a-d	0.6137AB
Si El-Ghanem	0.1500 hi	0.2101b-d	0.1800 BC	0.5736 b-d	0.4831 e	0.5279 C
Boiled lime and sulfur	0.1695 f-h	0.2014 b-f	0.1854 BC	0.5779 b-d	0.4822 e	0.5305 C
Extra power	0.1827 d-h	0.2268 b	0.2048 B	0.6294 ab	0.5467 de	0.5880 B
Control	0.2219 bc	0.2885 a	0.2552 A	0.6244 a-c	0.6715 a	0.6414 A
Average	0.1719 B	0.2098 A		0.6029 A	0.5578 B	

Treatment	2022 Casuarina windbreak With	Without	Average	2022 Casuarina windbreak With	Without	Average
Diatom	0.1538 c-e	0.1812 b	0.1675 B	0.5863 de	0.5846 d-f	0.5855 BC
Kaoline	0.1549 cd	0.1638 bc	0.1594 BC	0.6350 a-c	0.5705 ef	0.6028 AB
Aglif Si 300	0.1481 c-e	0.1784 b	0.1633 B	0.5859 de	0.5369 f	0.5614 C
Bentonite	0.1219 gh	0.1573 c	0.1396 D	0.6485 ab	0.5837 d-f	0.6161 AB
Kaolineted potassium silicate	0.1147 h	0.1273 f-h	0.1210 E	0.6100 a-e	0.5778 d-f	0.5939 BC
Triple power	0.1379 d-g	0.1535 c-e	0.1457 CD	0.5864 de	0.5937 c-e	0.5901 BC
Si El-Ghanem	0.1354 e-g	0.1552 cd	0.1453 D	0.5845 d-f	0.6214 a-d	0.6030 AB
Boiled lime and sulfur	0.1465 c-f	0.1779 b	0.1622 B	0.6063 b-e	0.6129 a-e	0.6096 AB
Extra Power	0.1515 c-e	0.1779 b	0.1647 B	0.5950 c-e	0.6061 b-e	0.6006 B
Control	0.2047 a	0.2176 a	0.2111 A	0.6553 a	0.6174 a-e	0.6364 A
Average	0.1469 B	0.1690 A		0.6093 A	0.5905 B	

*Kaolineted Potassium Silicate ** Si El-Ghanem

Table (14). Effect of windbreak and spraying of anti-transpirants on yield attributes of Ewais mango trees.

Treatment	Fruits no. / tree 2021 Casuarina windbreak With	Without	Average	Yield / tree kg 2021 Casuarina windbreak With	Without	Average
Diatom	233.3 c-g	223.9 e-h	228.6 CD	11.2 e-h	8.4 gh	9.8 DE
Kaolin	272.0 ab	264.0 a-c	268.0 AB	13.0 d-g	10.6 f-h	11.8 DE
Aglif 300	197.8 hi	180.9 i	189.3 F	13.8 d-g	11.0 f-h	12.4 D
Bentonite	227.9 e-h	205.5 g-i	215.7 DE	23.3 ab	18.7 b-d	21.0 A-C
Kaolineted potassium silicate	247.2 b-f	219. 7 f-h	233.4 CD	21.5 a-c	16.9 b-f	19.2 BC
Triple power	245.0 b-f	232.8 c-g	238.88 C	18.0 b-e	17.4 b-f	17.7 C
Si El-Ghanem	227.9 e-h	205.0 g-i	216.5 DE	27.2 a	21.0 a-c	24.1 AB
Boiled lime and sulfur	291.2 a	254.3 b-e	272.8 A	26.7 a	22.2 a-c	24.5 A
Extra power	223.0 e-h	186.6 i	204.8 EF	16.2 c-f	9.7 gh	12.7 D
Control	259.7 a-c	232.8 d-g	246.0 BC	8.29 gh	6.00 h	7.2 E
Average	242.3 A	220.5 B		17.9 A	14.1 B	

Treatment	2022 Casuarina windbreak With	Without	Average	2022 Casuarina windbreak With	Without	Average
Diatom	250.6 d-f	233.8 fg	242.2 BC	9.54 ef	7.79 efg	8.67 C
Kaolin	283.9 ab	281.1 a-c	282.5 A	9.83 ef	10.62 ef	10.22 C
Aglif 300	210.3 g	211.3 g	211.1 D	7.58 fg	11.19 def	10.22 C
Bentonite	244.9 d-f	224.7 fg	234.8 C	16.33 c	14.76 cd	15.54 B
Kaolineted potassium silicate	264.5 b-e	232.2 fg	248.3 BC	18.49 abc	15.60 c	17.05 AB
Triple power	264.1 b-e	252.9 c-f	258.5 B	15.90 c	18.29 abc	17.09 AB
Si El-Ghanem	247.4 d-f	238.4 e-g	242.9 BC	20.53 ab	17.23 bc	18.88 A
Boiled lime and sulfur	300.1 a	263.2 b-e	281.7 A	21.46 a	17.27 bc	19.36 A
Extra power	238.5 e-g	225.9 fg	232.2 C	11.52 de	10.16 ef	10.84 C
Control	270.6 b-d	233.0 fg	251.8 BC	5.77 g	4.74 g	5.26 D
Average	257.5 A	239.6 B		13.694 A	12.764	

*Kaolineted Potassium Silicate **Si El-Ghanem

These results, generally are in line with those reported by Abd El-Kader et al. (2006) on Williams banana plants, Al-Desouki et al. (2009) on Egyptian Sultani fig trees and Abd El-Rahman (2015), Gooda et al. (2018) and Aly et al., 2019) on Keitte mango tree , who found that the effects of spraying different anti-transpiration agents cause an increase in the yield of trees. Moreover, foliar showering with nano-chitosan and nano-potassium silica moved forward blooming, efficiency and fruit quality of the Ewais mango cultivar and spraying nano-potassium silicate at 0.6 and 0.8 g/L were more successful in expanding panicle length and diminishing botanical mutation in expansion to accomplishing the most noteworthy surrender and the best natural product characteristics as compared with un-treated trees (Gad et al., 2021).

The great impact of foliar spraying with nano-chitosan and nano-potassium silicate compared to the control on blossoming, mutation, yield and fruits quality characteristics of the Ewais mango cultivar have been clarified by several researchers (Anusuya and Sathiyabama, 2016; Zagzog et al., 2017; Laane, 2018 and Zahedi et al., 2020).

Where Zahedi et al. (2020) showed that, application of nanofertilizers such chitosan on several fruit trees such as almond, grapes, pomegranate and mangoes had a positive coordinate impact on the growth, the final items and the quality of these fruits. The expansion of nano-chitosan at 5 ml/L to mango trees progressed number of fruits per tree by 35.28% more than the untreated trees and expanded resistance to mutation by 38–40% more than the non-nanofertilizers treatment expansion to upgraded fruits physical and chemical properties (Zagzog et al., 2017).

It is worthy to mention that the use of anti-transpirants, which are biodegradable organic film, defined to ensure plants from damage caused by intemperate transpiration or water misfortune through leaves, stems and branches may help in keeping healthy plant during the developing season. So, it is in this manner recognized that the increases happened in vegetative growth of mango (shoot length, leaf total chlorophyll content, leaf area, number of leaves per shoot and leaf fresh and dry weights) treated with anti-transpirants such as kaolin was conceivably due to two viewpoints. First, was the protection of tissues from climatic conditions, and second was the increment of water potential at a time when the growth plant was more dependent on water status than on photosynthesis (Abou-Hadid, 1984).

CONCLUSION

From the results obtained here it could be concluded that, the use of silicon formulations spraying and casuarina windbreak in the study area decreased the infestation of mango shield scale insect and exposure to sand drift led to an increase in shoot diameter, length, leaf area, leaf total chlorophyll content, leaf water content, and yield. While, decreased hard leaf character and leaf succulence grade. In addition, the casuarina windbreak significantly reduced sand drift. Thus, it is recommended using the particle film technology, potassium silicate, triple power, (boiled lime and sulfur) and some plant extracts for their advantages in minimizing the environmental pollution.

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دور بعض مستحضرات السيلكون ومصدات الرياح في مكافحة حشرة المانجو القشرية الرخوة الغازية (green) *Milviscutulus mangiferae*) (Hemipetra: coccidae) في أشجار المانجو المتأثرة بحركة الرواسب الهوائية

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أجريت الدراسة الحالية خلال الموسمين المتتاليين ٢٠٢١-٢٠٢٢ على صنف مانجو عويس المتأثر بحركة الكثبان الرملية والمزروع في حقل خاص بمدينة المستقبل بمحافظة الإسماعيلية بمصر. وذلك لتقييم تأثير الرش ببعض بمركبات السيليكون ومصدات الرياح (الكازوارينا) على مكافحة الحشرة القشرية الرخوة الغازية (*Milviscutulus mangiferae* Hemipetra: Coccidae) والتأثير على النمو الخضري وصفات الأوراق والمحصول. يمكن الاستنتاج أن المكافحة الناجحة لحشرة المانجو القشرية يمكن تحقيقها بواسطة الدياتوم و Aglev Si 300 بنسبة خفض أكثر من ٨٠٪ يليها الكاولين (من ٦٠ إلى ٨٧٪) والبنتونيت (من ٥٠ إلى ٧٠٪) على التوالي في أطوار مختلفة من الحشرة (الأطوار الغير كاملة والحشرة الكاملة والحشرة الكاملة واضعة البيض). إن فعالية مركبات سيليكات البوتاسيوم المكولنة والسي الغانم تؤدي إلي خفض في نسبة الإصابة في الأطوار المختلفة للحشرة حيث بلغت نسبة التخفيض من ٧٩ إلى ٩١٪ على التوالي ضد الأطوار المختلفة من *M. mangiferae*. حيث حققت المركبات الاكسترا بور والتربل بور ومغلي الجير والكبريت في الأطوار المختلفة إنخفاضًا بنسبة ٩٠٪ مقارنة بمعاملة الكنترول. أوضحت النتائج أن رش مركبات السيليكون مع وجود مصدات الرياح الكازوارينا أدى إلى زيادة في قطر وطول المجموع الخضري ومساحة الورقة ومحتوى الكلوروفيل الكلي للورقة ومحتوى الماء في الورقة والمحصول بينما أدى ذلك إلى إنخفاض في خصائص الورقة الصلبة ودرجة عصارة الورقة مما أدى إلى زيادة فعالية رش مركبات السيليكون في تقليل الإصابة. بالإضافة إلى ذلك، أدت مصدات الرياح الكازوارينا إلى تقليل إنجراف الرمال بشكل كبير.