



Article

Efficacy of Various Silica-Based Compounds in Managing Corn Pests and their Influence on Agronomic Traits

Esmat S. A. Zaghlol^{1,*}, Asmaa, A. Tharwat² and Marwa E.S. Amer²



¹Field Crop Pests Research Dept., Plant Protection Research Institute Agricultural Research Center, Egypt

²Scale Insects and Mealybugs Department. Plant Protection Research Institute, Agricultural Research Center, Egypt

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*Corresponding author: esmatsalem123@gmail.com

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Abstract: In Moshtohor district of the Qalubia Governorate, field experiments were carried out in 2024 and 2025. The corn leaf aphid, *Rhopalosiphum maidis* (Fitch), and the cotton leaf worm, *Spodoptera littoralis* Boisid, and Silica sources were used for control. The plants were sprayed with potassium, sodium, and magnesium silicate as well as their Nano image. The highest percentage decrease (76.84 and 77.84) and (70.27 and 71.21) in controlling the maize leaf aphid and the cotton leaf worm in the 2024 and 2025 seasons, respectively, was found when the spray was applied at a rate of 4g/l from Nano potassium silicate. In both seasons, magnesium silicate at a rate of 6g/l produced the lowest percentage reduction on maize leaf aphids (45.43 and 45.90) and cotton leaf worms (40.79 and 41.02), respectively. The yield characteristics of maize plants increased the most when treated with potassium silicate NPs, and there was no discernible difference between the two seasons.

Key words: Silica-Based Compounds, Corn, *Rhopalosiphum maidis*, *Spodoptera littoralis*.

1. Introduction

In light of its application in numerous industries, corn is one of the most strategic crops in Egypt and one of the most significant agricultural crops in the Middle East. Its distinctive qualities also make it a significant commercial commodity for the region. It is the third-largest cereal crop, behind wheat and rice. Maize serves as a food source for both humans and animals in addition to being a nutrient-rich forage crop. Paints, textiles, plastics, and pharmaceuticals are among the industries that employ corn. It is also utilized in the manufacture of biofuel and energy, as well as animal feed, particularly for cattle and poultry. (AL-Eryan *et al.* 2019 and El-Rasoul *et al.*, 2020).

In Egypt, maize cultivated area reached about 3 million feddan which produced about 3-4.5 tons of grains with an average yield of 25-30 ardab/feddan (Anonymous, 2024).

The greatest losses in maize occur between the seedling stage and harvesting due to a number of insect pests that target the crop at different stages of plant growth. The two pests that are most dangerous to the economy are the corn leaf aphid, *Rhopalosiphum maidis* (Fitch) the cotton leaf worm, *Spodoptera littoralis* Boisid., (Mahmoud *et al.*, 2021, Naroz *et al.*, 2021). The corn leaf aphid (*R. maidis* (Fitch)), one of the most serious cereal pests, feeds on more than thirty Gramineae genera. A severe aphid infestation can cause substantial losses in grain yield because of feeding damage, tassels covered with honeydew, and viral infections (Kuo *et al.*, 2006). The cotton leafworm *Spodoptera littoralis*, was and continues to be considered one of the most dangerous and harmful pests. In Egypt, *S. littoralis* attacks over 112 host plants, seriously harming many crops. When it consumes leaves, flower buds, fruiting buds, and bolls, it causes significant damage. In Egypt and other Middle Eastern nations, this pest is widespread. The purpose of this study is to identify how various silicate compounds affect crop output by reducing the number of insects attached to corn. According to (Massey *et al.*, 2006), silicon accumulates and polymerizes in cell walls, which strengthens plant defenses against insect attack and stops insects from penetrating and chewing once the cells harden. By strengthening plant tissues, enhancing natural defenses, enhancing plant design, decreasing plant lodging and boosting photosynthetic rate, and possibly altering insect behavior and reproduction, silicate can help control some pests that impact maize harvests. Therefore, some crops may profit from its adoption by becoming more resistant to pests and illnesses. It may specifically lessen pest damage by fortifying plants' defenses against insect invasion and attack. Furthermore, it might shield against fungal and viral infections (González *et al.*, 2015). SiNPs can penetrate plants and regulate their metabolic functions. Disease management, better nutrition supply, pesticide delivery, and higher photosynthetic efficiency and germination rate are all associated to the deposition of SiNPs on plant tissue surfaces. Because SiNPs have been shown to be non-toxic, they can be used in agriculture (Laing *et al.*, 2006 and Goswami *et al.*, 2022).

2. Materials and Methods

Experiments were conducted in Moshtohor, region of the Qalubia Governorate during two successive maize growing seasons in 2024 and 2025 to evaluate the effectiveness of applying various silica compounds in decreasing the populations of cotton leaf worms and corn leaf aphids in corn crop infestation. The experimental area was 126 m² prepared and sown with Treble cross, (T.C 324 hybrid) on July 15th in both seasons. Throughout the growing seasons, all suggested cultural activities were implemented without the use of insecticides. For each treatment, the experimental area was split into four 31.5 m² replicates. Each plot was three meters long and seventy-five centimeters wide, with five rows. At a distance of 25 cm between the pits, two maize seeds were seeded each hill. Ten randomly selected plant samples were taken from each plot, and the percentage of afflicted maize plants with two insect pests was recorded by counting the number of *R. maidis* per square inch and *S. littoralis* larvae. The control group consisted of untreated maize plants. Randomized complete blocks (RCB) were used to arrange the treatments.

Treatments using silica foliar spray

Following 60 days of planting, the following silica compounds were sprayed:

- T1. K₂ SiO₃ (potassium silicate): 6 g/L
 - T2. Na₂ SiO₃ (sodium silicate): 6 g/L
 - T3. Mg₂ SiO₃ (magnesium silicate): 6 g/L
 - T4. K₂ SiO₃- NPs: 4 g/L
 - T5. Na₂ SiO₃-NPs: 4 g/L
 - T6. Mg₂ SiO₃ -NPs: 4 g/L
- As a control, use tap water.

The silica was sourced from Emdad for trading agencies and factory Services Company, in Egypt. It was 99.99% pure and had a dimension of 20 nm. The Nanotechnology Unit of the National Research Center produced the nanoparticles. The investigated substances were sprayed in the morning using a 20-liter dorsal motor with a single nozzle. Samples were collected 1, 3, 7, and 10 days after spraying in addition to right before. The **Henderson-Tilton formula (1955)** was used to determine the percentage reduction following spraying.

$$\text{Reduction \%} = 1 - (T_a \times C_b) / (T_b \times C_a) \times 100$$

Various treatments' effects on maize yield

The experiment was conducted in a natural environment. Maize ears were harvested from every plant in each treatment after 120 days of sowing, and they were then allowed to dry. The weight of 100 grains, the weight of 20 ears, and the feddan grain yield were all determined.

Statistical analysis

The gathered data were properly statistically analyzed using the F-test According to **Fisher (1954)**, to compare means L.S.D. at the 0.05 level of probability (**Waller and Duncan, 1969**).

3. Results and discussion

This study examined how various Si supplementation compounds affected corn leaf aphid and cotton leaf worm infestations in maize over the course of two consecutive seasons in the Qalubia governorate, 2024 and 2025.

1. Effect of some different silica compounds in controlling corn leaf aphid in corn during 2024 and 2025 seasons in Qalubia Governorate

Results have shown that applying silica to corn plants increases their resistance to aphids. When it came to boosting maize plants' resistance to these insects, potassium silicate—both in its elemental and Nano-forms—performed better than sodium and magnesium silicates. The data in Tables (1 and 2) showed significant differences between treatments during the first and second seasons. Ten days following the spraying operation, potassium Nano silicate caused the biggest percentage reduction in aphid infestation (76.84 and 77.84%), followed by sodium Nano silicate (61.64 and 63.74%) and magnesium Nano silicate (56.17 and 59.42%). Conversely, when compared to the control in both seasons, the plants treated with natural silica treatments had the lowest percentage reduction. According to data from **Maanju *et al.* (2025)**, potassium silicate increases corn plants' resistance to aphids on *Hordeum vulgare*, and concur with **Shameen *et al.* (2025)** found that utilizing Si greatly reduces the infestation of corn leaf aphids.

2. Effect of some different silica compounds in controlling cotton leaf worm in corn during 2024 and 2025 seasons in Qalubia Governorate

Significant differences between treatments with cotton leaf worm infestation in corn during the 2024 and 2025 seasons are indicated by the data in Tables (3 and 4). After 10 days of spraying, potassium silicate nanoparticles at a concentration of 4 g/L showed the greatest reduction in cotton leaf worms in corn (70.27 and 71.21%), followed by sodium silicate nanoparticles (59.73 and 60%), and magnesium nanoparticles (56.15 and 58.28%) in both seasons. Conversely, corn plants treated with natural magnesium silicate showed the least reduction in cotton leaf worm (40.79 and 41.02%) in both seasons. The current findings are generally consistent with those previously published by **Amine *et al.* (2022)**, who discovered that the greatest reduction of cotton leaf worm population in sugar beet plants was achieved by spraying silica nanoparticles at a rate of 4 g/L.

Table (1). Effect of some different silica compounds in controlling corn leaf aphid in corn during 2024 season in Qalubia Governorate

Treatment	Rate	Efficiency % after spray against aphids infestation									
		After spray									
		Pre-spray	One day	R%	3Days	R%	7Days	R%	10Days	R%	Total R %
T1	6 g/L	37.5	25.3	37.33 b	23.1	46.04 c	20.6	54.43 c	20.9	56.41 c	48.55 bc
T2		35.5	27.1	27.43 d	25.5	36.77 e	24.5	42.84 d	22.5	49.59 d	39.15 d
T3		40.8	30.2	31.59 c	28.6	38.31 e	27.4	44.41 d	28.1	45.43 d	39.91 d
T4	4 g/L	45.8	27.9	43.34 a	21.0	60.01 a	16.2	69.31 a	13.6	76.48 a	62.29 a
T5		29.4	20.3	35.86 b	17.0	49.02 b	14.6	58.98 b	14.3	61.64 b	51.38 b
T6		33.5	24.4	32.39 c	22.1	41.90 c	20.0	50.61 c	18.5	56.17 c	45.27 c
Control	-	30.6	32.8	-	34.7	-	36.7	-	38.5	-	
F. value				29.89		169.27		51.09		45.93	35.19
L.S.D.				3.023		1.977		4.155		4.832	4.350

LS.D test at $p < 0.05$.**Table (2). Effect of some different silica compounds in controlling corn leaf aphid in corn during 2025 season in Qalubia Governorate**

Treatment	Rate	Efficiency % after spray against aphids infestation									
		After spray									
		Pre-spray	One day	R%	3Days	R%	7Days	R%	10Days	R%	Total R%
T1	6 g/L	22.7	17.7	29.75 b	14.9	44.33 b	13.6	52.92 c	13.1	57.70 c	46.17
T2		18.6	15.3	24.19 cd	13.0	40.18 c	12.4	46.22 d	12.1	52.08 d	40.67
T3		15.8	13.0	23.84 d	12.0	34.47 d	11.4	40.97 e	11.6	45.90 e	36.30
T4	4 g/L	13.9	7.9	47.62 a	6.6	59.34 a	4.7	74.37 a	4.3	77.84a	64.79
T5		20.5	15.2	30.54 b	12.8	47.06 b	10.6	59.66 b	10.2	63.74 b	50.25
T6		20.0	15.6	28.50 bc	13.3	43.51 bc	12.2	51.72 c	11.1	59.42 c	45.79
Control	-	25.4	27.6	-	29.7	-	32.0	-	34.2	-	-
F. value				37.30		42.77		95.68		91.02	77.09
L.S.D.				4.311		3.836		3.601		3.454	3.376

LS.D test at $p < 0.05$.**Table (3). Effect of some different silica compounds in controlling cotton leaf worm in corn during 2024 season in Qalubia Governorate**

Treatment	Rate	Efficiency % after spray against cotton leaf worm infestation									
		After spray									
		Pre-spray	One day	R%	3Days	R%	7Days	R%	10Days	R%	Total R%
T1	6 g/L	16.6	13.4	29.33 bc	12.1	42.47 b	11.2	50.69 c	10.9	53.72 c	44.05c
T2		20.1	18.2	21.06 cd	17.3	32.73 c	16.8	39.81 d	16.4	42.86 d	34.12d
T3		23.3	21.9	18.45 d	20.8	30.20 c	20.0	37.90 d	19.7	40.79 d	31.84 d
T4	4 g/L	20.1	13.1	43.21 a	11.4	55.82 a	9.4	66.40 a	8.7	70.27 a	58.92 a
T5		15.6	12.4	30.81 b	10.9	45.57 b	9.4	56.59 b	9.0	59.73 b	48.17 b
T6		22.7	18.8	26.98 bcd	16.1	44.46 b	14.7	53.30 b c	14.3	56.15bc	45.22 c
Control	-	18.6	21.1	-	23.5	-	25.5	-	26.3	-	
F. value				8.41		25.11		39.78		49.15	148.22
L.S.D.				9.072		5.610		5.077		4.714	2.443

LS.D test at $p < 0.05$.

Table (4). Effect of some different silica compounds in controlling cotton leaf worm in corn during 2025 season in Qalubia Governorate

Treatment	Rate	Efficiency % after spray against cotton leaf worm infestation									
		After spray									
		Pre-spray	One day	R%	3Days	R%	7Days	R%	10Days	R%	Total R%
T1	6 g/L	13.1	10.7	25.18b c	9.5	41.34b	8.2	54.17 b	7.9	56.17 b	44.22 c
T2		14.7	12.8	19.54 c d	12.3	31.05 c	11.7	40.93 c	11.6	42.52 c	33.51 d
T3		19.1	17.8	15.04 d	16.9	28.20 c	16.0	38.80 c	15.7	41.02 c	30.76 e
T4	4 g/L	20.5	14.0	38.09 a	10.5	58.51 a	8.5	70.07 a	8.2	71.21 a	57.47 a
T5		12.8	9.5	30.58 a b	8.3	46.66b	7.3	57.55 b	6.9	60.00 b	48.70 b
T6		16.9	12.7	29.85ab	11.4	45.67 b	9.9	57.05 b	9.8	58.28 b	47.71 b
Control	-	16.1	17.6	-	19.8	-	21.8	-	22.2	-	-
F .value				8.81		21.45		34.55		37.17	138.30
L.S.D.				8.418		7.239		5.967		5.642	2.714

LS.D test at $p < 0.05$.

3. Correlation coefficients (r) between Aphid population and weather factors in 2024 and 2025 seasons

Table (5) and Fig. (1) Showed a significant seasonal shift in the statistical association between aphid populations and meteorological parameters between 2024 and 2025. Maximum and minimum temperatures throughout the 2024 season showed a significant negative connection ($r = -0.86$ and $r = -0.97$, respectively). This suggests that a population explosion was caused by a subsequent drop toward the ideal range after initial high thermal units (over 35°C) acted as a limiting factor. The 2025 season, on the other hand, exhibited a positive correlation ($r = +0.38$) because the ambient temperature stayed within the ideal range for aphid development. Remarkably, relative humidity continued to have a favorable impact throughout both seasons ($r = +0.67$ and $r = +0.46$), underscoring its critical function in aphid outbreak support and desiccation prevention. Data concur with **Wains *et al.* (2010)**, **Lalaoui *et al.* (2012)**, **Saleh (2018)** and **Abou-Zaid and El-Gantiry (2021)**.

Table (5). Correlation coefficients (r) between Aphid population and weather factors in 2024 and 2025 seasons.

2024 season					2025 season				
Aphid population		Max.Temp.	Mini.Temp.	RH%	Aphid population	Max.Temp.	Mini.Temp.	RH%	
Pre-spray	30.6	35.7	24.4	64	25.4	31.4	21.7	58.6	
3 day after	1	32.8	33	23	75	27.6	33.5	23.5	81.5
	3	34.7	33	23	75	29.7	33.3	23.3	80.3
	7	36.7	33	22.8	74.3	32	32.8	22.8	76.7
	10	38.5	32.7	22.6	72.7	34.2	32.5	22.5	74.2
Correl.		-0.86	-0.97	+0.67	Correl.	+0.38	+0.25	+0.46	

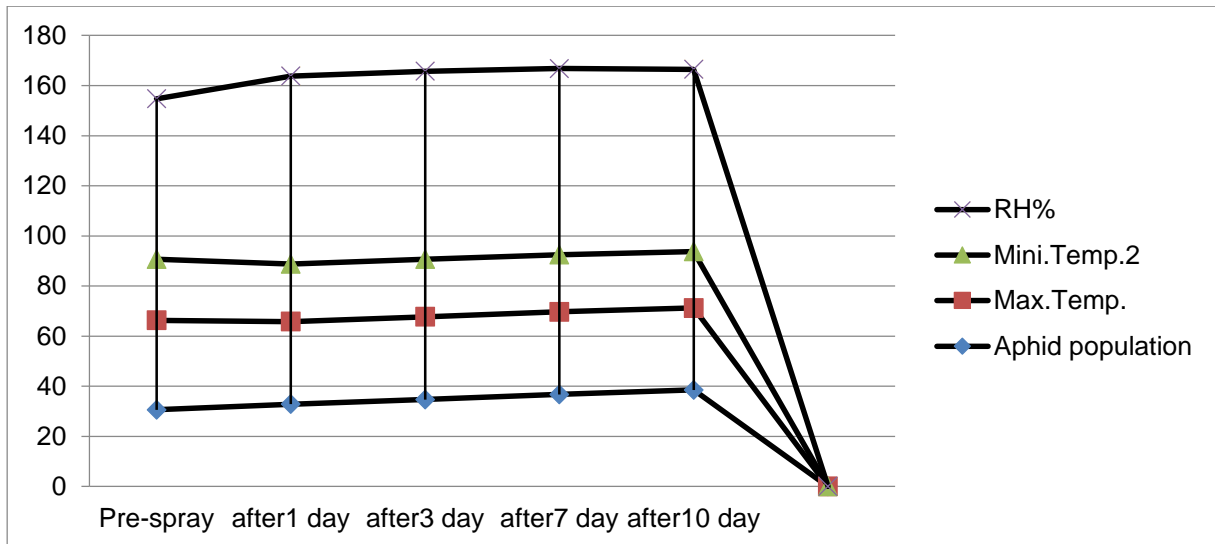


Fig. (1a)

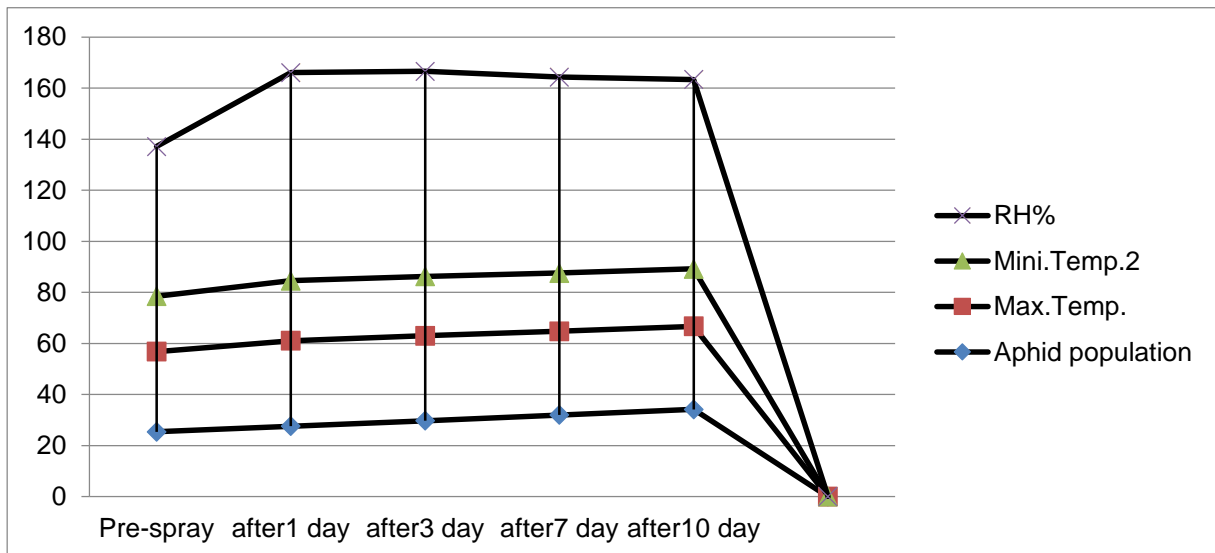


Fig. (1b)

Fig 1(a and b). Correlation coefficients (r) between Aphid population and weather factors in 2024 and 2025 seasons.

4. Correlation coefficients (r) between Cotton leaf worm population and weather factors in 2024 and 2025 seasons.

Table (6) and Fig. (2) Observed a dynamic relationship between *S. littoralis* populations and predominant weather variables during the two seasons. The population was severely limited by high thermal stress during the first season, as shown by the strong negative connection with maximum temperature ($r = -0.89$). In contrast, this association changed to an insignificant positive correlation ($r = +0.16$) in the second season, suggesting that temperatures stayed within the species' preferred biological range. Notably, the most dependable cause of larval outbreaks was Relative Humidity (RH %), which consistently and strongly positively influenced both seasons ($r = +0.82$ and $r = +0.65$). These results are consistent with those of **Dahi (2016)** and **Abou-Zaid (2021)** who highlighted that humidity maximizes egg hatching and larval survival, especially when the temperature varies near the upper thresholds of the species.

Table (6). Correlation coefficients (r) between Cotton leaf worm (C.L.Worm) population and weather factors in 2024 and 2025 seasons

2024 season					2025 season			
C.L.Worm population		Max.Temp.	Mini.Temp.	RH%	C.L.worm population	Max.Temp.	Mini.Temp.	RH%
Pre-spray	18.6	35.7	24.4	64	16.1	31.4	21.7	58.6
1 3 day after 7 10	21.1	33	23	75	17.6	33.5	23.5	81.5
	23.5	33	23	75	19.8	33.3	23.3	80.3
	25.5	33	22.8	74.3	21.8	32.8	22.8	76.7
	26.3	32.7	22.6	72.7	22.2	32.5	22.5	74.2
Correl.		-0.89	-0.81	+0.82	Correl.	+0.16	+0.04	+0.65

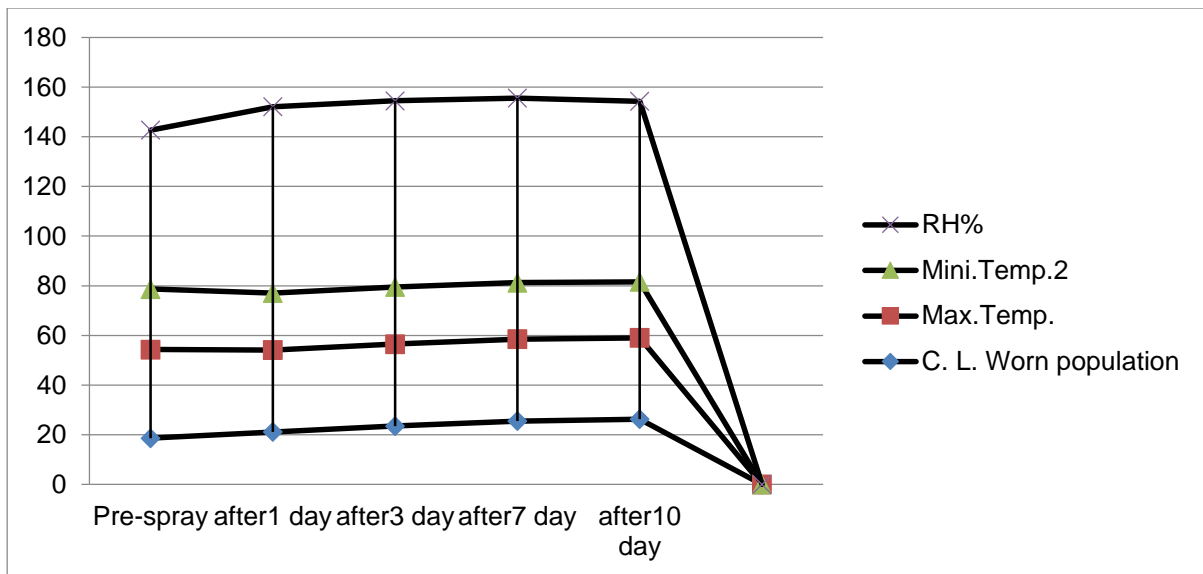


Fig. (2a)

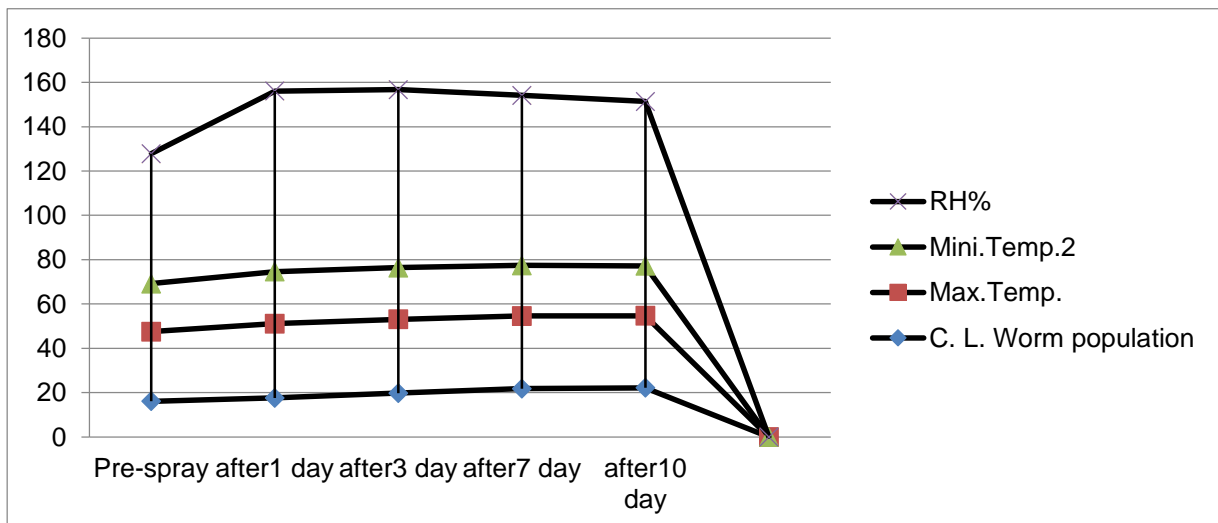


Fig. (2b)

Fig (2(a and b). Correlation coefficients (r) between Cotton leaf worm (C.L.Worm) population and weather factors in 2024 and 2025 seasons

5. Effect of some different silica compounds on yield characteristics of corn during 2024 and 2025 seasons in Qalubia Governorate

Table (7) and Fig. (3) found that there were significant differences in the weight of 100 grains (g), weight of 20 ears (kg), and yield grains fed/ton (yield characteristics) when silica treatment was applied to maize plants in both seasons. Corn plants treated with potassium silicate NPs showed the most gain in yield characteristics, in contrast, during the experimental seasons of 2024 and 2025. Plants treated with natural magnesium silicate produced the lowest values in (yield characteristics) when compared to the control. These findings agree with **Elmahdy *et al.* (2023)**.

Table (7). Effect of some different silica compounds on Yield characteristics of corn during 2024 and 2025 seasons in Qalubia Governorate

Treatment	Rate	Weight of 100 grains (g)		Weight of 20 eares (kg)		Yield grain fed/ton	
		2024	2025	2024	2025	2024	2025
T1	6 g/L	35.60 c	36.55 c	6.16 c	5.85 cd	3.34 bc	3.45 b
T2		33.19 d	34.06 d	5.74 d	5.83 cd	3.03 cd	3.37 b
T3		32.31 d	33.10 d	4.93 e	5.07 d	2.83 bd	2.88 c
T4	4 g/L	41.22 a	42.45 a	7.74 a	8.12 a	3.75 a	3.99 a
T5		38.86 b	39.38 b	6.93 b	7.01 b	3.45 ab	3.54 b
T6		36.2 c	37.02 c	6.29 c	6.56 bc	3.38 abc	3.49 b
Control	-	29.9 e	30.67 e	3.69 f	3.93 e	2.43 e	2.54 c
F. value		33.17	33.81	91.73	24.06	10.48	12.26
L.S.D.		2.01	2.043	0.409	0.820	0.406	0.401

LS.D test at $p < 0.05$.

4. Conclusion

The infection levels of corn leaf aphid (*Rhopalosiphum maidis*) the cotton leaf worm (*Spodoptera littoralis*) in maize crops were considerably decreased by foliar application of several silica compounds. Interestingly, Nano silica proved to be more effective than its natural or bulk form. The best results were obtained at a concentration of 4 g/L of Nano silica, which simultaneously improved crop yield characteristics and successfully suppressed insect populations. This study shows that weather-related elements have threshold-dependent effects on insect population dynamics. Temperatures above 35°C act as a limiting thermal stress, but temperatures between 31 and 33°C encourage optimal growth, according to the transition from a strong negative correlation in 2024 to a positive correlation in 2025. On the other hand, pest outbreaks were greatly increased by relative humidity, which continued to be a consistently beneficial driver throughout both seasons. These findings demonstrate that humidity is a more reliable indicator of population increases than temperature, which varies according to the physiological optimum of the species.

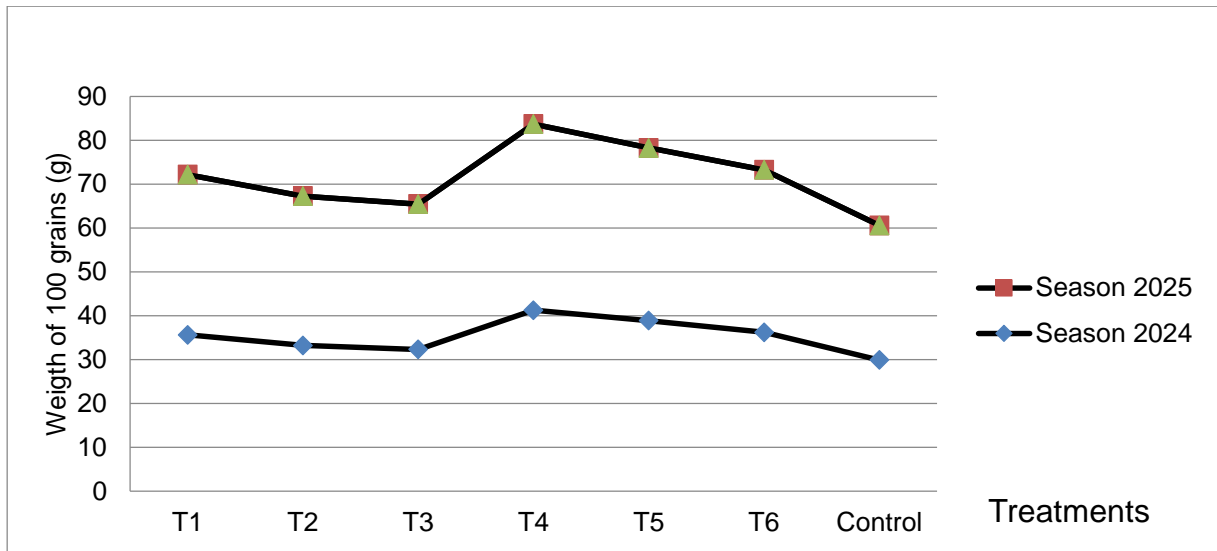


Fig. (3a)

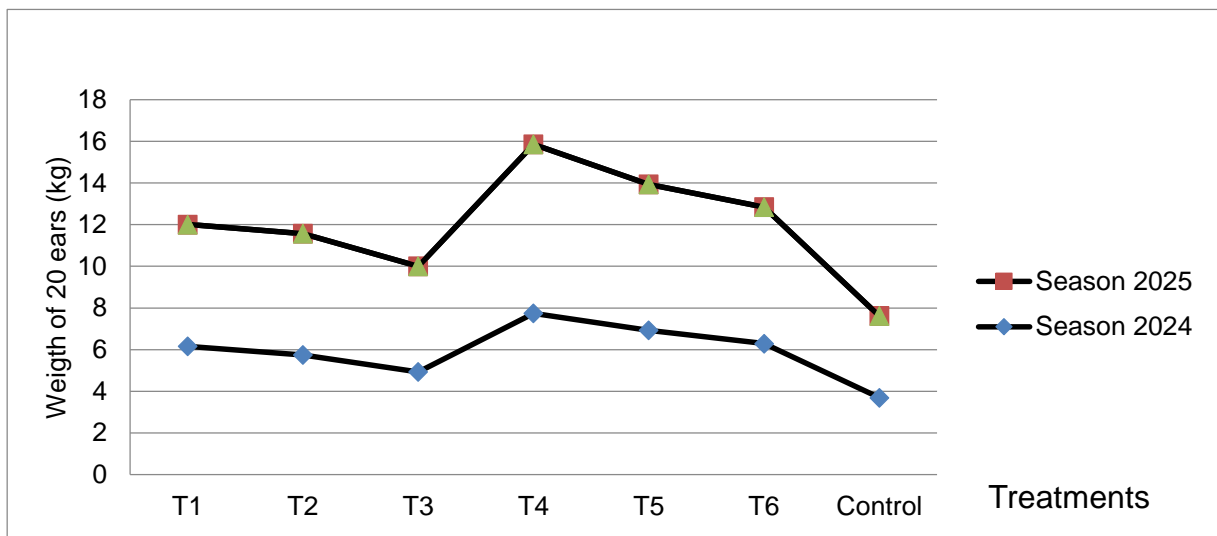


Fig. (3b)

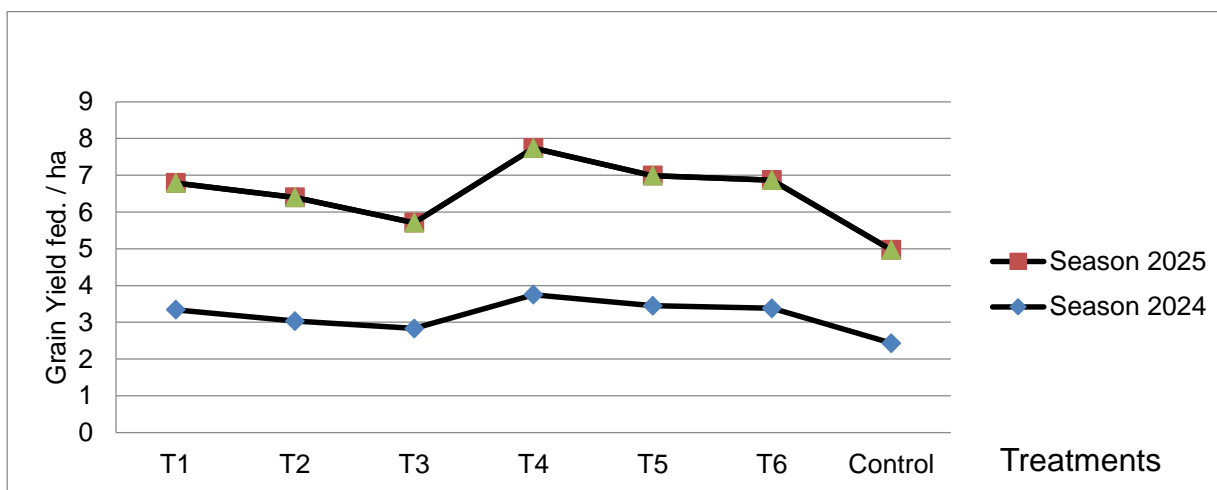


Fig. (3c)

Fig (3(a ,b and c). Effect of some different silica compounds on Yield characteristics of corn during 2024 and 2025 seasons in Qalubia Governorate

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