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Effect of different silica sources on cotton leafworm population in sugar beet plants, and their influence on sugar beet yield

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Abstract
Field and laboratory experiments were conducted at Taifaa region and Agricultural research station, Kafr El-Sheikh Governorate, during two successive seasons 2019/2020 and 2020/2021. To estimate the efficiency of alternative materials for controlling *Spodoptera littoralis,* some silica sources were incorporated to the soil such as (straw and husk) and sprayed on the plants, spray such as potassium, magnesium, sodium silicate and Si NPs.
Burnt husk added to the soil at the rate of 200 g/m^2 gave the highest reduction 50.48, 48.72%, highest root yield 25.16, 24.60 ton/fed, foliage yield 8.99, 8.60 ton/fed, sucrose percentage 16.71, 17.43%, T.S.S% 20.40, 20.60%, purity 81.91, 84.61% and white sugar 4.20, 4.29 ton/fed in the two seasons, respectively. Spray of silica NPs at the rate of 4g/L gave the highest reduction 68.46, 77.81%, root yield 26.03, 26.01 ton /fed, foliage yield 8.60, 8.36 ton/fed, sucrose percentage 18.80, 19.00%, TSS% 22.90, 22.60%, Purity 86.46, 84.07% and white sugar 4.89, 4.94 ton/fed in the two seasons, respectively.
In the laboratory, the toxic effect of each of silica NPs**,** potassium silicate, magnesium silicate and sodium silicate for 2nd larvae instar after 96 hr., was and found that Lc_{50}values were 0.079, 0.212, 0.239 and 0.261 g/L. While the corresponding values for 4th after 96 hr., were 0.120, 0.218, 0.261 and 0.594 g/L, respectively.

Keywords: Silica, sources, cotton, population, sugar, influence

Introduction
The Egyptian cotton leaf worm (*Spodoptera littoralis*) is one of the most dangerous insects that threatens sugar beet crop, especially the early (August) plantation which may need to be replanted or abolished [1] and [2]. This insect causes great losses in quantity and quality of the attacked crops [3] and [4]. The use of insecticides causes disturbance between beneficial insects and harmful ones [5], [6] and [7]. Due to several problems caused by insecticides for controlling insects such as pollution, resistance and harmful effect on human and animal health, it has become necessary to use alternative materials against some insects which attack plants [8].
Various studies have revealed the importance of silica application on increasing plant growth significantly [9]. Silicon has generally not been considered essential for plant growth, although it is well recognized that many plants, particularly family Poaceae, have high silica content [10, 11] concluded that spray of silica nanoparticles has reduced the cotton infestation by cotton bollworm, *Pectinophora gossypiella*.
The application of silicon in coproduction provides a viable component of integrated management of pests because it leaves no pesticide residues in food and environment, and can be easily integrated with other pest management practices, including biological control [12]. Rice husk has a chemical composition which typically corresponds to the following; cellulose (40 - 45%), lignin (25 -30%), ash (15 - 20%) and moisture (8 -15%). Straw utilization techniques are becoming more practical and economical, as an integral part of the bio-circular economy [13]. The field application of silicon to susceptible rice and wheat cultivars increased crop tolerance to pest infestation [14].
The objective of the current investigation was to study the effect of applications of different sources of silica on *S. littoralis* infestation to sugar beet. Also, it aimed to study the efficiency of the different types of silica such as rice residues, silica compounds and silica NPs against *Spodoptera littoralis* in early sugar beet plantation and in the laboratory.

Materials and Methods

At Taifa region, Kafr El- Sheikh Governorate, experiments were conducted during 2019/2020 and 2020/2021 seasons to find out the role of different silica sources in reducing *Spodoptera littoralis* infestation.

Field experiments

Silica soil treatments

The sources of silica were;
Rice straw at rates of 100, 200 g/m^2
Burnt straw at rates of 100, 200 g/m^2
Burnt husk at rates of 100, 200 g/m^2

Materials were added during soil preparation. The experimental area was divided into plots, each of 42 m^2 and the treatments were arranged in a randomized complete block design with 3 replicates. Baraca sugar beet variety was sown on 15 of August at 20 cm between hills and 50 cm between rows. The normal agricultural practices were followed with no pesticides. Normal cultural practices during the experimental period. When the plants reached 30 days old, 30 plants from each treatment were taken randomly (10 plants / replicate) to count the larvae of *S. littoralis* Sampling counted weekly till the crop reached 90 days old.
Data were collected and the loss ratios were calculated compared to control, according to Abbot (1925). At harvest, ten plants were randomly taken from each plot to estimated, root, foliage, sucrose percentage, TSS%, purity, white sugar.

Silica foliar spray treatments

Another equal area was prepared as previous and divided into 13 treatments each one measured 42 m^{2,} then the same variety was planted on the same date, and after one month of sowing, spraying was done with the silica compounds as follows:
Sodium silicate: At rates of (2, 4, 6) g/L
Magnesium silicate: At rates of (2, 4, 6) g/L
Potassium silicate: At rates of (2, 4, 6) g/L
Silica Nps: At rates of (2 ‘4) g/L

The experimental area was divided into plots each of 1/100 feddan, and the treatments were arranged in a randomized complete block design with 3 replicates. Dorsal motor (20 L) with one nozzle was used to spray the tested compounds.
At 10 days after spraying, reduction percentage in *S. littoralis* population was estimated for each treatment according to the formula of [15].

At harvest, ten plants were randomly taken from each plot to estimate, the following parameters

1. Root and foliage weight were determined on the basis of whole plot, then transferred to ton/fed.
2. Total soluble solids T.S.S% were measured by refract meter according to [16].
3. Sucrose percentage was measured by Sucrometer apparatus according to method described by [17].
4. Juice purity percentage was calculated according to the method described by [18].
5. Purity% = sucrose /TSS% × 100
6. White sugar yield (ton / fed) = root fresh weigh (ton/fed) × sugar%

Statistical analysis

The obtained data were subjected to ANOVA, and significantly different means were compared using [19].

[20]: in the field

$$\text{Reduction } \% = \frac{\text{control} - \text{treatment}}{\text{control}} \times 100$$

Abbot formula (1925): In the laboratory

$$\text{Mortality } \% = \frac{\text{Mortality \% of the treatment} - \text{Mortality \% of the control}}{100 - \text{Mortality \% of the control}} \times 100$$

Henderson and Tilton (1955)

$$\text{Reduction } \% = 1 - \left[\frac{\text{Treatment after} \times \text{controlbefor}}{\text{Treatment before} \times \text{control after}}\right] \times 100$$

1. Laboratory Experiments

The silica nanoparticles from Rice husk was synthesized following the procedure of [21] as follows**:**
Rice husk was washed with tap water to remove sand, dust, soluble substances, and other contaminants. It was then dried at 60ºC in forced air oven. The cleaned rice husk was burned in open environment to collect rice husk. 50 g of rice husk was stirred with 500 ml of HCl 1N at room temperature for 2 hours and allowed to stand overnight to separate the metal ions in rice husk. The acid treated rice husk was filtered and washed with distilled water and dried at 60ºC in forced air oven. Finally, the treated rice husk was transferred into porcelain cup and claimed at 700ºC for 2 hours in furnace, (muffle). The obtained product was SiO_2 NPs white powder.
That happened in a soil department laboratory of Faculty of Agriculture – Kafr el Sheikh University. The obtained product was Sio_2Nps white powder. The transmission Electronic Microscope (TEM) image of silica nanoparticles was did in Nanotechnology department, Faculty of Science, Kafr el Sheikh University, It is shown in Fig (1).

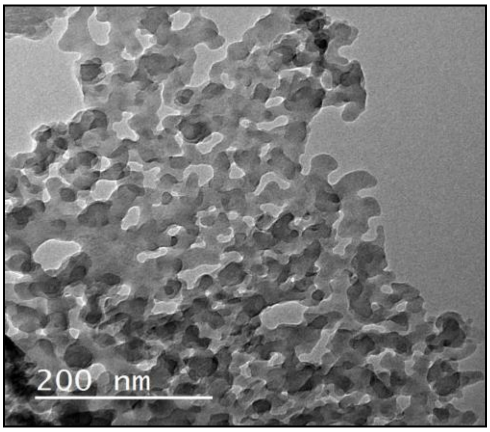

Fig 1: Shape and size of silica nanoparticles from rice husk

Laboratory strain2ndand 4th instar of cotton leaf worm *S. littoralis* was chosen for bioassay. This strain start as field strain reared under laboratory condition of 25 ± 2 c^o and 65 ± 5 R.H for several years in laboratory of Sakha Agricultural Research Station on Castor leaves according to [22].
Each castor leaf disc (2 cm^2) was dipped into the suspension of tested formulation for 10 sec., Tested concentrations were prepared in glass distilled water [23]. Discs were held vertically to allow excess solution to drip off and placed on a rack to dry for 2 hr. Treated discs were offered to starved *S. litoralis*larvae (one disc per cup) and left under constant conditions. Thereafter survivors were transferred with fresh

castor leaves to clean cups and kept under the same conditions. Control larvae were allowed to feed on castor leaf disc treated with distilled water. The container was covered with muslin cloth to allow aeriation. Each treatment was repeated three times. Mortality percentages were calculated for each concentration for 48 & 94 hrs and corrected according to [20], the LC_{25} &LC_{50} &LC_{90} & slope values of the tested compounds were calculated using the equation of [24] by LDP software program.

The concentrations in the laboratory

Na silicate : 0.25, 0.5, 1 g/L
Mg silicate : 0.25, 0.5, 1 g/L
K silicate : 0.25, 0.5, 1 g/L
SiO_2 Nps : 0.25, 0.5, 1 g/L

Results and Discussion

Data presented in Tables (1&2) show the differences in the number of *S.littoralis* larvae per 10 plants as affected by the treatments. In 2019/2020 season (Table 1) show that the highest number of *S. littoralis*, larvae (80.25/10 plants) was obtained with ground straw as a source of silica (100 g/m^2), with 20.46% of insect reduction, while the lowest number (51.25 larvae/10 plants) and highest reduction 50.48% was obtained with Burnt husk at a rate of 200 g/m^2 compared with the control 103.50 larvae/10 plants.

Applying burnt husk at the rate of 200 g/m^2, resulted in the highest values of root yield, foliage, sucrose, TSS%, purity% and white sugar with 25.16 ton/fed, 8.99 ton/fed, 16.71%, 20.40%, 81.91% and 4.20 ton, respectively. Due to the addition of different treatments from rice residues in soil,The root yield ranged between 20.50 and 25.16 ton/fed compared with the control (18.88 ton/fed), The purity ranged between 77.08 and 84.32% compared with the control 75.12% and sucrose percentage ranged from 12.99 to 16.71% compared with 12.32% in the control.

Table 1: Reduction in *Spodoptera littoralis* larvae, and sugar beet yield components, due to applications of different silica sources, to the soil before planning, 2019/2020

Treatment	Larvae/ 10plants	Reduction%	Yield and yield component					
			Root Yield ton/f	Foliage Ton/f	Sucrose%	TSS%	Purity%	White sugar Ton/f
Ground straw 100g/m^2	80.25 f	22.46	20.50	6.67	12.99	16.40	79.21	2.66
Ground straw 200g/m^2	73.25 d	29.23	23.20	8.67	14.27	17.80	80.17	3.31
Brunt straw 100g/ m^2	77.25 e	25.36	22.66	8.51	13.72	17.80	77.08	3.11
Brunt straw200g/m^2	56.50 b	45.41	23.36	8.82	15.38	18.80	81.81	3.59
Burnt husk100g/m^2	63.25 c	38.89	23.30	8.60	13.66	16.20	84.32	3.18
Burnt husk200g/m^2	51.25 a	50.48	25.16	8.99	16.71	20.40	81.91	4.20
Control	103.50 g	-	18.88	6.33	12.32	16.40	75.12	2.33

In 2020/2021 season, Data in Table (2) indicated that that the highest population density of cotton leaf worm, *S. littoralis* larvae was found in the treatment of Ground straw at a rate of 100 g/m^2 received 94.25 larvae/10 plants with reduction of 19.79%. As for Burnt treatment at a rate of 200 g/m^2 received 60.25 larvae/10 plants compared with untreated treatment 117.50 larvae/10 plants. At all treatments, the highest reduction 48.72% was recorded at Burnt husk 200 g/m^2.

As for yield and yield component, in all cases, burnt husk 200 g/m^2 was the most effective treatment for root yield, foliage, sucrose percentage, TSS%, purity% and white sugar, which achieved 24.60 ton/fed, 8.60 ton/fed, 17.43%, 20.60%, 84.61% and 4.29 ton/fed, respectively. Followed by Burnt straw 200g/m^2 which achieved 23.20 ton/fed, 7.50 ton/fed, 14.72%, 18.00%, 81.78% and 3.42 ton/fed, compared with 19.03 ton/fed, 6.00 ton/fed, 12.63%, 75.18% and 2.40 ton/fed in the control, respectively. These results are agree with [25] who used Burnt rice straw and Burnt rice husk to reduce *S.littoralis* larvae before planting sugar beet plants and found that lower larval populations values were 0.49 and 0.00 larvae/5 plants, respectively, moreover sucrose percentage and root yield were 16.70% and 5.50 kg/5 plants for Burnt rice straw treatment and 16.90%, 6.20 kg/5 plants for Burnt rice husk treatment.

Table 2: Reduction in *Spodoptera littoralis* larvae, and sugar beet yield components, due to applications of different silica sources, to the soil before planting, 2020/2021

Treatment	Larvae/ 10plants	Reduction%	Yield and yield component					
			Yield Ton/fed	Foliage Ton/fed	Sucrose%	TSS%	Purity%	White sugar Ton/fed
Ground straw 100g/m^2	94.25 f	19.79	19.42	6.30	12.71	15.80	80.44	2.47
Ground straw 200g/m^2	87.00 e	25.96	22.66	7.36	13.13	16.20	81.05	2.98
Brunt straw 100g/m^2	78.50 d	33.19	20.99	7.14	13.72	18.00	76.22	2.88
Brunt straw 200g/m^2	70.50 b	40.00	23.20	7.50	14.72	18.00	81.78	3.42
Burnt husk 100g/m^2	76.50 c	34.89	22.12	7.09	13.92	18.20	76.48	3.08
Burnt husk 200g/m^2	60.25 a	48.72	24.60	8.60	17.43	20.60	84.61	4.29
Control	117.50 g	-	19.03	6.00	12.63	16.80	75.18	2.40

In the first season, results in Table (3) show that the plants treated with silica NPs at a rate of 4 g/L induced the lowest number of larvae per 10 plants (78.33 larvae) after 10 days from spraying with a reduction of 68.46%. In addition, it produced the highest values of the yield and yield components and final product as follows; 26.03 ton/fed root yield, 8.60 ton/fed foliage yield, 18.80% sucrose percentage, 22.90% TSS%, 86.46% purity and 4.89 white sugar, followed by potassium silicate treatment at a rate of 6g/L resulted in 100.00 larvae/10 plants with 59.74% reduction which gave 25.43 ton/fed root yield, 8.47 ton/fed foliage yield, 18.38% sucrose percentage, TSS% was 22.80%, purity was 80.61% and white sugar was 4.67%, this was followed by Mg silicate 6 g/L, then sodium silicate 6g/L. Due to the spray of silica sources, root yield, foliage, sucrose percentage, TSS%, purity and white sugar ranged from (20.12 to 26.01 ton/fed), (6.76 to 8.78 ton/fed), (12.66 to 19.00%), (16.00 to 22.60%), (76.04 to 84.07%)and (2.55 to 4.94 ton/fed), respectively. The statistical analysis revealed significant differences among all treatments and concentrations. These results are like those find by [26] who mentioned that the purity of beet juice usually ranged between 85 to 88% in atypical washed beet (beet without tare).

Table 3: Reduction in *Spodoptera littoralis* larvae, and sugar beet yield components, due to foliar spray of different silica sources in 2019/2020

Treatment	Rate	Larvae/ 10plants	Reduction%	Yield and yield component					
				Root Ton/f	Foliage Ton/f	Sucrose%	TSS%	purity%	White sugar Ton/f
Na silicate	2g/L	135.67 g	45.37	19.96	6.76	13.17	17.00	77.47	2.63
	4g/L	124.00 ef	50.07	22.14	7.00	15.60	20.00	78.00	3.45
	6g/L	118.33 de	52.36	23.18	7.81	16.28	20.20	80.59	3.77
Mg silicate	2g/L	128.6 7f	48.19	20.00	6.60	13.40	16.40	81.71	2.68
	4g/L	119.00 de	52.08	22.19	7.31	14.00	17.60	79.55	3.11
	6g/L	105.67 bc	57.45	24.75	8.36	17.21	21.40	80.42	4.26
K silicate	2g/L	122.00 ef	50.88	21.00	6.96	13.35	17.20	77.61	2.80
	4g/L	112.00 cd	54.90	23.61	8.00	14.38	18.60	77.81	3.40
	6g/L	100.00 b	59.74	25.43	8.47	18.38	22.80	80.61	4.67
Si Nps	2g/l	99.33 b	60.01	24.00	8.32	17.21	21.80	78.94	4.13
	4g/l	78.33 a	68.46	26.03	8.60	18.80	22.90	86.46	4.89
Control		260.00 h	-	19.00	6.00	12.86	16.70	77,00	2.44

In the second season, 2020/2021, Table (4) show the use of some silica sources with different concentrations resulted in significant level of cotton leaf worm, *S. littoralis* on sugar beet field and increased the yield and yield components. The highest number of *S. littoralis* larvae was 176.67 larvae/10 plants due to foliar spray of sodium silicate2g/L after 10 days with 48.20% reduction. On the contrary, the number of larvae was 75.67 larvae/10 plants due to foliar spray of silica NPs of 4g/L after 10 days with 77.81% reduction.

Therefore, reduction percentage due to application of foliar spray with silica sources ranged from 48.20 to 77.81%.

With respect to yield and yield components and final product, at the treatment of silica NPs 4g/L, root yield, foliage, sucrose percentage, TSS%, purity% and white sugar reached to 26.01 ton/fed, 8.36 ton/fed, 19.00%, 22.60%, 84.07% and 4.94 ton/fed, respectively. Followed by potassium silicate 6g/L which gave 25.55 ton/fed, 8.63 ton/fed, 17.91%, 21.40%, 83.69% and 4.58 ton/fed, respectively. Followed by magnesium silicate 6g/L which gave 24.87 ton/fed, 8.78 ton/fed, 15.95%, 20.40%, 78.19% and 3.97 ton/fed, respectively. Followed by sodium silicate 6g/L which gave 23.82 ton/fed, 7.99 ton/fed, 15.03%, 19.20%, 78.28% and 3.58 ton/fed, respectively.

The obtained results agreement with the results obtained from [25] who found that Mg silicate with a rate of 6g/L which reduced the larval population to 10.83 larvae /5 plants and the root yield gave 5.53 kg/5 plants [27]. Treated sugar beet plants in the field with SiNPs at rates of of 60, 40 and 20 g/fed and recorded 40.14, 20.15 and 16.21% reduction in *S. littoralis*. And these results are like those found by [28, 29] were reported that the purity ranged from 65.483 to 73.030 and 78.59 to 82.45%, respectively at harvest. The statistical analysis indicated that there were significant differences among all treatments and concentrations for the number of *S. littoralis* larvae.

Table 4: Reduction in *Spodoptera littoralis* larvae, and sugar beet yield components, due to foliar spray of different silica sources in 2020/2021

Treatment	Rate	Larvae/ 10plants	Reduction%	Yield and yield component					
				Root Ton/f	Foliage Ton/f	Sucrose%	TSS%	purity%	White sugar Ton/f
Na silicate	2g/L	176.67 h	48.20	20.12	6.76	12.66	16.00	79.13	2.55
	4g/L	161.00 g	52.79	22.14	7.08	13.72	17.20	79.77	3.04
	6g/L	138.33 de	59.44	23.82	7.99	15.03	19.20	78.28	3.58
Mg silicate	2g/L	173.67 h	49.08	20.51	6.78	12.85	16.90	76.04	2.64
	4g/L	149.67 f	56.12	22.52	7.77	14.66	18.20	80.55	3.30
	6g/L	132.67 d	61.10	24.87	8.78	15.95	20.40	78.19	3.97
K silicate	2g/L	165.67 g	51.43	20.39	6.82	13.17	17.00	77.47	2.69
	4g/L	142.00 ef	58.37	23.81	7.89	14.88	19.40	76.70	3.54
	6g/L	120.67 c	64.53	25.55	8.63	17.91	21.40	83.69	4.58
SiNPs	2g/L	96.67 b	71.66	23.42	7.86	17.20	22.20	77.48	4.03
	4g/L	75.67 a	77.81	26.01	8.36	19.00	22.60	84.07	4.94
Control	-	338.00 i	-	17.38	6.03	12.40	16.40	75.61	2.16

Susceptibility of 2nd instar larvae of *S. littoralis* to four silica compounds such as silicate potassium, silicate magnesium, silicate potassium and silica nanoparticles with concentrations of 0.25, 0.50,1 g/L for each of them is presented in Table (5). On the basis of LC_{25}, LC_{50}, LC_{90} values after 48 hr., were effective which gave 0.127, 0.5, 6.810 g/L for silica NPs, respectively, followed by 0.477, 1.727, 19.916 g/L for potassium silicate, respectively, followed by 0.549, 1.846, 18.531 g/L for magnesium silicate, respectively, followed by 0.733, 2.573, 27.951 g/L for sodium silicate, respectively. On the other hand, the corresponding values of LC_{25}, LC_{50}, LC_{90} for the tested silica compounds after 96 hr., were 0.033, 0.079, 0.430 g/L for silica NPs, respectively. Followed by 0.076, 0.212, 1.498 g/L for potassium silicate, respectively. Followed by 0.081, 0.239, 1.881 g/L for magnesium silicate. Followed by 0.058, 0.261, 4.578 g/L for sodium silicate, respectively. As mention before, silica NPs was the most effective compound among all tests silica compounds at 48 and 96 hr., for 2nd instar larvae of *S. littoralis*. Moreover, the toxicity increased with increasing the exposure time and decreased by increasing the stage of larval instars.

These results are like those found by [30]. Used Si NPs as a concentrations of (0.1, 0.2, 0.3 g/L) which caused larval mortality 65.33, 76.00 and 82.00%, respectively, compared with the control 3.33%.And [8] who used six concentrations of silica NPs (75, 150, 225, 300, 375 and 425 ppm) in the laboratory to reduce *S. littoralis* and recorded that the two concentrations of silica nanoparticles 75 and 150 ppm showed larval mortality of 16.00 and 20.67%, respectively, the other concentrations 225, 300, 375 and 425 ppm recorded with significant differences 60.00, 73.67, 94.67 and 95.33%, respectively, compared with control which recorded 4.67% mortality percentage.

Table 5: Toxicity of Na, Mg, K silicat and silica Nps against 2nd instar larvae of cotton leaf worm after 48 and 96 hours of exposure

Treat	Hrs.	LC_{25} (g/L) Confidence limit	LC_{50} (g/L) Confidence limit	LC_{90} (g/L) Confidence limit	Slope
Na Silicate	48	0.733 (0.539 – 1.272)	2.573 (1.412 18.425)	27.951 (6.756 – 3857.47)	1.237 ± 0.351
	96	0.058 (0.003 – 0.131)	0.261 (0.097 – 0.373)	4.578 (1.929 -105.237)	1.030 ± 0.305
Mg Silicate	48	0.549 (0.393 – 0.764)	1.846 (1.149 – 7.062)	18.531 (5.494 – 775.75)	1.280 ± 0.335
	96	0.081 (0.020 – 0.143)	0.239 (0.131 – 0.321)	1.881 (1.178 – 5.743)	1.431 ± 0.317
K Silicate	48	0.477 (0.316 – 0.651)	1.727 (1.079 – 6.888)	19.916 (5.573 – 1213.98)	1.207 ± 0.327
	96	0.076 (0.020 – 0.134)	0.212 (0.112 – 0.288)	1.498 (1.001 – 3.743)	1.511 ± 0.325
Si Nps	48	0.127 (0.027 – 0.215)	0.50 (0.355 – 0.705)	6.810 (2.696 – 121.331)	1.130 ± 0.301
	96	0.033 (0.002 – 0.078)	0.079 (0.013 – 0.143)	0.430 (0.323 – 0.613)	1.747 ± 0.464

Results presented in Table (6) revealed that the toxicity of some sources of silica against the 4th larval instar of *S. littoralis* at 48 and 96 hr., of exposure. Among the tested compounds, silica NPs was the most effective compound followed by potassium silicate, followed by magnesium silicate, while sodium silicate was the least effective one. The LC_{25}, LC_{50}, LC_{90} values after 48 hr., were 0.286, 1.217, 19.108 g/L for silica NPs, respectively. 0.785, 2.650, 26.723 g/L for potassium silicate, respectively. 1.098, 3.682, 36.717 g/L for magnesium silicate, respectively, and 1.561, 4.845, 41.698 g/L for sodium silicate, respectively. Increasing the period of exposure from 72 to 06 hr., decreased the LC_{25}, LC_{50}, LC_{90} values to reach 0.048, 0.120, 0.681 g/L for silica NPs, respectively. 0.063, 0.218, 2.302 g/L for potassium silicate, respectively.0.058, 0.261, 4.578 g/L for magnesium silicate, respectively and 0.224, 0.594, 3.793 g/L for sodium silicate, respectively. Generally, 2nd larval instar was found to be more sensitive to the tested silica compounds than 4th instar.

These results are agree with [31] who tested silica products against the field pests *Epilachnavigin tioctopunctata* (F.) and *spodoptera litura* (F.), the results showed that 100% mortality rate was achieved two days after treatment of adult *E. vigintioctopunctata* and *S. litura* larvae, [25] who found that applying Mg silicate at concentrations of 1.0 up to 6.0 g/L resulted in 28.0-38.0% cotton leaf worm larval mortality with higher values in early larval instars as compared with late instars and [32] showed that one of the benefits of silica Nps is its ability to stop pest feeding almost immediately after feeding on treated parts of the soybean plant. Its unique mode of action ends the damage quickly, so crops are protected.

Table 6: Toxicity of Na, Mg, K Silicat and silica Nps against 4th instar larvae of cotton leaf worm after 48 and 96 hours of exposure

Treat	Hrs.	Lc_{25} (g/L) Confidence limit	Lc_{50} (g/L) Confidence limit	Lc_{90} (g/L) Confidence limit	Slope
Na Silicate	48	1.561 (0.990 – 8.379)	4.845 (2.084 – 166.722)	41.698 (7.994 – 52473.42)	1.371 ± 0.439
	96	0.224 (0.127 – 0.299)	0.594 (0.480 – 0.774)	3.793 (2.122 – 13.307)	1.592 ± 0.308
Mg Silicate	48	1.098 (0.765 – 3.117)	3.682 (1.770 – 55.309)	36.717 (7.709 – 14752.01)	1.283 ± 0.386
	96	0.058 (0.003 – 0.131)	0.261 (0.097 – 0.373)	4.578 (1.930 – 105.24)	1.030 ± 0.305
K Silicate	48	0.785 (0.580 – 1.413)	2.650 (1.453 – 18.344)	26.723 (6.665 – 2987.09)	1.277 ± 0.358
	96	0.063 (0.008 – 0.127)	0.218 (0.094 – 0.308)	2.302 (1.302 – 11.16)	1.253 ± 0.314
Si Nps	48	0.286 (0.114 – 0.405)	1.217 (0.812 – 4.059)	19.108 (5.070 – 2179.40)	1.072 ± 0.310
	96	0.048 (0.009 – 0.96)	0.120 (0.043 – 0.185)	0.681 (0.529 – 1.089)	1.696 ± 0.376

Conclusion

In conclusion, it could be concluded that foliar spray with silica NPs at rate of 4 g/L on sugar beet plants considered as the greatest treatments not only in reduction of *S. littoralis* larvae but also in increasing yield and yield components. In any case, application of foliar spray with all silica compounds was better than application of ground additions with some rice residues in pest control and also in increasing yield and yield components. So, silica compounds can be used in integrated pest management on sugar beet fields.

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