COMPARATIVE THE EFFICACY OF SODIUM METASILICATE WITH SILICA NANOPARTICLES AGAINST *SPODOPTERA LITTORALIS* (BOISD.) IN THE LABORATORY

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Abstract

The current experiment was conducted at the Plant Protection Research Institute (PPRI), Sakha Agriculture Research Station (SARS). In this study, the effects of sodium metasilicate and silica nanoparticles on the mortality of cotton leafworm, *Spodoptera littoralis* (Boisd.) larvae were studied in addition some biological aspects. The results showed that, the silica nanoparticle was more effective at all concentrations than sodium metasilicate. Increase the sodium metasilicate or silica nanoparticles concentrations showed adverse effects on the cotton leaf worm biological aspects especially at the high concentration. Silica nanoparticles showed easily absorption in soybean plants, so it highly effective on cotton leafworm survival and biological aspects. This study pointed to that, silica nanoparticles can be used as a safety agent for controlling *S. littoralis* through a I.P.M.

Key words: *Sodium metasilicate, Silica nanoparticles, Spodoptera littoralis, soybean plants, pest control*

INTRODUCTION

Soybean, *Glycine max* (L.) occupies a premier position among legume crops, being the most important source of both protein and oils. As a legume it is capable of utilizing atmospheric nitrogen through biological nitrogen fixation and is therefore much less dependant on synthetic nitrogenous fertilizer than other most crops (FAO, 1994). Soybean used in a wide range of foodstuffs derived for soybean.

Spodoptera littoralis (Boisduval) (Lepidoptera: Noctuidae) is one of the most destructive pests of several crops. Over the past 25 years, the intensive use of broad-spectrum insecticides against this pest has led the development of resistance to many registered pesticides for its control (Aydin and Gurkan, 2006).

Silicon is the second abundant element in the earth crust after oxygen (Epstein and Bloom, 2005). In soil solution, silicon is mainly present in the form of H_4SiO_4 with a range of 0.1 to 0.6 mM (Epstein, 1994). In plants, silicon accounts for

about 0.1 to 10% with a big variation between plant species (Epstein, 1999). Rice plant absorbs silicon actively through the root hairs (Ma and Yamaji, 2008) and accumulated mainly in husk and stem (Currie and Perry, 2007). Silicon also improves crop yield (Snyder *et al.*, 2007), and particularly improves the tolerance of plants to biotic and abiotic stress (Epstein and Bloom, 2005).

Nanotechnology has provided new solutions to problems in plants and offers new approaches to the rational selection of raw materials, or the processing of such materials to enhance the quality of plant products. Nanotechnology is emerging as a highly attractive tool for formulation and delivery of pesticide active ingredients as well as enhancing and offering new active ingredients. Such as nanocapsules based on polymers are being designed for controlled release of active ingredient as well as enhanced delivery through improved penetration through leaves (Borei *et al.*, 2014).

The current investigation was conducted to study effect of sodium metasilicate comparing with silica nanoparticles on soybean infestation with cotton leafworm, *S. littoralis* for using in clean agriculture.

MATERIALS AND METHODS

The current study was conducted at the Plant Protection Research Institute (PPRI), Sakha Agriculture Research Station (SARS).

1.Tested silica:

1.1. Silica nanoparticles:

The silica nanoparticles were obtained from Nanotech Egypt Company Limited, Cairo, Egypt. The nanosilica size was 20 nm with a purity of 99.99%. The image of the nanosilica is shown in **Fig. 1**. Three concentrations of this material, 0.1, 0.2 and 0.3 g/l were examined under laboratory conditions. A hand sprayer (2 L volume) was used in spraying.

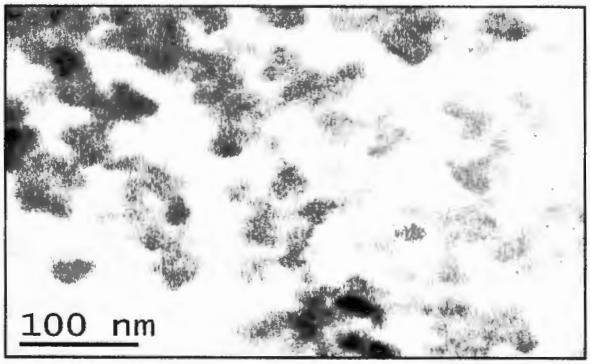

Fig. (1): Shape and size of silica nanoparticles.

1.2. Sodium metasilicate:

Sodium silicate is the common name for compounds with the formula $Na_2(SiO_2)_nO$ (Fig. 2). A well known member of this series is sodium metasilicate, Na_2SiO_3. Also known as waterglass or liquid glass, these materials are available in aqueous solution and in solid form. The pure compositions are colourless or white, but commercial samples are often greenish or blue owing to the presence of iron-containing impurities (Greenwood *et al.*, 1997). Three concentrations of sodium metasilicate (2, 4 and 6 g/l) were examined under laboratory conditions by the same previous way.

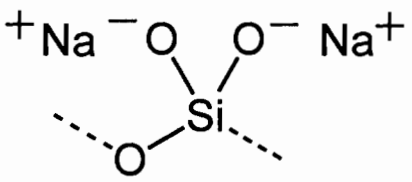

Fig. (2): Sodium metasilicate structure

2. Tested insect:

A laboratory strain of cotton leafworm, *S. littoralis*, was reared in the laboratory on castor-bean leaves under constant laboratory conditions of 25±2 °C and 65±5 % R.H. (El-Defrawi *et al.*, 1964).

3. Larval mortality:

Soybean plants (Crawford variety) when reached 60 days old were sprayed completely with each concentration with three replicates for each, 50 neonates of *S. littoralis* were released on four soybean plants in each replicate.

The cage was then covered with double muslin cloth. An evaluation was performed 15 days post *S. littoralis* release as number of alive.

4. Reproduction and development of the insect:

The survived larvae from all previous treatments were reared on soybean leaves and compared with larvae reared on untreated leaves (control) at 25±2°C and 65±5% RH. The following observations were performed: larval duration, pupal period, adult longevity, number of laid eggs per female and percent of hatching.

5. Statistical Analysis:

The obtained data were treated statistically according to Duncan Multiple Range Test **(Duncan, 1955)**.

RESULTS AND DISCUSSION

1. Mortality percentage:

Results in Fig. (3) showed mortality percentage of *S. littoralis* larvae treated with sodium metasilicate and silica nanoparticles. The results pointed to that, increase the concentrations of silica gradual increased in the mortality of larvae. According to sodium metasilicate, the highest concentration (6 g/l) showed high mortality percentage (31.33%). While the treatment of silica nanoparticles showed the highest mortalities ranged 69.33 – 88.00% compared with sodium metasilicate and control 5.33%.

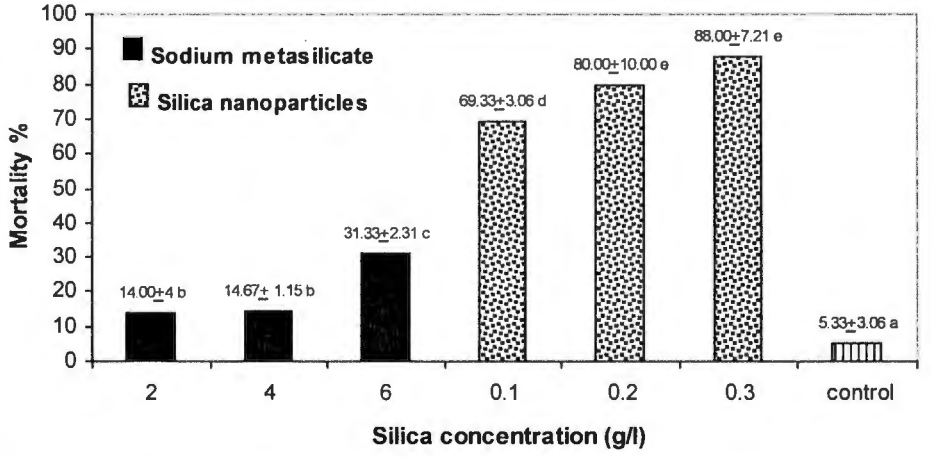

Fig. (3): Mortality percent of *Spodoptera littoralis*.

Means followed by the same letter are not significantly different at the 5% level according to DMRT

2. Reproduction and Development of the insect:

The presented data in Table (1) showed effects of sodium metasilicate and silica nanoparticles on certain biological aspects of *S. littoralis* under laboratory conditions. The larval stage of *S. littoralis* reared on soybean plants recorded gradually long periods in sodium metasilicate and silica nanoparticles, compared with control. It recorded 14.20, 14.00 and 19.60 days when treated with 2, 4 and 6 g/l sodium metasilicate, respectively. Using silica nanoparticles showed significant differences in the duration 20.00, 20.80 and 20.80 days with 0.1, 0.2 and 0.3 g/l,

respectively. As for the pupal stage, silica nanoparticles (14-15 days) showed significant differences in all concentrations when compared with sodium metasilicate (10-12 days) and control (10 days).

Adult longevity showed no significant differences between all treatments and control this period ranged between 12.4-13.8 days. The statistical analysis showed the total number of eggs laid per female affected significantly comparing with the control especially in using silica nanoparticles. The female laying eggs at all concentrations, the total number of eggs/female recorded high number 247.5 and 252.5 eggs/female with two sodium metasilicate concentrations 2 and 4 g/l, respectively. Using silica nanoparticles, decreased the numbers to 220.00, 222.50 and 168.75 eggs/female with 0.1, 0.2 and 0.3 g/l, respectively. The hatching percentage of eggs affected clearly by using sodium metasilicate or silica nanoparticles, low percents (52 – 69) were recorded comparing with the control (81).

Table 1. Biological aspects of *Spodoptera littoralis* reared on soybean leaves treated with silica nanoparticles at 25±2 °C and 65±5 RH%.

Silica Conc. (g/l)		Larval duration (day)	Pupal stage (day)	Adult longevity (day)	Egg No./female	Hatching %
Sodium metasilicate	2	14.2±1.5a	10.0±1.0a	12.6±0.6a	247.5±15.0c	69.3±8.3c
	4	14.0±0.7a	11.2±0.8a	12.8±0.8a	252.5±13.2c	65.0±5.8bc
	6	19.6±1.5b	12.4±1.1ab	12.4±0.6a	220.0±16.3b	63.8±6.3ab
Silica nanoparticles	0.1	20.0±2.5b	14.2±1.9c	13.0±0.7a	220.0±18.3b	60.8±6.5b
	0.2	20.8±1.8b	14.6±1.8c	13.2±0.8a	222.5±20.6b	55.8±4.4a
	0.3	20.8±0.8b	15.2±1.5c	13.0±0.7a	168.8±10.3a	52.0±3.6a
Control	-	14.40±1.14a	10.20±1.10a	13.80±0.84a	252.50±6.45d	80.75±4.35d

Means followed by the same letter are not significantly different at the 5% level according to DMRT

Recent researches have been focused on the beneficial effects of silicon in increasing crop resistance to pests and diseases (Keeping and Meyer, 2002 and El-Samahy *et al.,* 2014). Painter (1951), Epstein (1999) and El-Samahy (2002) suggested that silicon deposited in the epidermal tissue may have several functions including support and protection as a mechanical barrier against pathogen and herbivore invasions.

One of the main uses of silicon in plants for structural rigidity and strength in cell walls. Silicon has been documented to greatly enhance a plant's ability to fend off fungal diseases and insects. It is thought that this may be due to an epidermis that is more difficult to penetrate. Research has also shown that cells that accumulate greater silicon have a greater natural defense system by producing greater quantities of phenolic materials and chitinases when infected by an invader (Nissan *et al.,* 2011).

The polymerized silica is deposited into cell wall, cell lumen, intra-cellular spaces, and trichomes (Cooke and Leishman, 2011), and thus increases the tissue strength. Reinforcement of the cell wall by silica deposition impedes penetration of insect herbivores (Reynolds *et al.,* 2009). Borei *et al.*, (2014) showed that silica nanoparticles had adverse effects on the cotton leaf worm survival and some biological aspects.

Sodium metasilicate and silica nanoparticles sprays affect the feeding preference the *S. littoralis*, increasing the resistance of soybean. Concomitantly it affects biological parameters of the insect such as longevity and nymph production, thus reducing the reproductive potential of females on soybean and therefore reducing the insect population density, damages and yield losses to the crop. In conclusion, this study evidenced that silica nanoparticle is effective than sodium metasilicate against cotton leafworm, *S. littoralis* and would therefore be a useful component of an integrated pest management strategy and clean agriculture.

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مقارنة فعالية ميتا سيليكات الصوديوم بجزيئات النانو سيليكا على دودة ورق القطن "سبودوبترا لتولارس" معمليا

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أجريت هذه التجارب في فرع معهد بحوث وقاية النباتات (PPRI) بسخا، بهدف مقارنة فعالية ميتا سيليكات الصوديوم بفعالية النانو سيليكا على دودة ورق القطن *Spodoptera littoralis* (Boisd.) وكذلك على بعض الجوانب البيولوجية لها. ولقد أظهرت النتائج أن النانو سيليكا كانت أكثر فاعلية بجميع تركيزاتها المختبرة (0,1، 0,2 و0,3 جم/لتر) مقارنة بميتا سيليكات الصوديوم بتركيزات 2، 4 و6 جم/لتر. كذلك ظهر من الدراسة أن زيادة تركيز أى من المادتين يزيد من التأثيرات السلبية لهما على بيولوجى الحشرة. ولقد لوحظ أن جزيئات السيليكا النانومترية تمتصها نباتات فول الصويا بدرجة أكبر لذلك زادت من قوة دفاع وتحمل النباتات لدودة ورق القطن والذى أثر بالسلب على حياة الحشرة من نسبة موت عالية (69 – 88٪) وتدهور قياساتها البيولوجية. ولهذا تعتبر جزيئات السيليكا النانومترية من الطرق الآمنة التى يمكن أن تساهم فى مكافحة دودة ورق القطن على محصول فول الصويا وبالتالى تقليل الكميات المستخدمة من المبيدات.