J. Plant Prot. and Path., Mansoura Univ., Vol. 7 (1): 79 - 83, 2016

COMPARE SILICA NANOPARTICLES WITH TWO INSECT PATHOGENS IN CONTROLLING COTTON LEAFWORM, *Spodoptera littoralis* BOISD. IN EARLY SUGAR BEET PLANTATION AND THEIR EFFECTS ON SOME ASSOCIATED NATURAL ENEMIES

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ABSTRACT

The application of nanomaterials in agriculture aims in particular to reduce insecticides in plant protection, minimize nutrient losses in fertilization, and increase yields through optimized nutrient management. So, it could be look for alternative method to control *Spodoptera littoralis* Boisd. This experiment was conducted out at El-Riad region, Kafr El-Sheikh Governorate, during two successive seasons 2014 and 2015 to compare the efficacy of silica nanoparticles (SiNPs) at three rates (20, 40 and 60 g/fed) with two pathogens dipel DF at 200 g/fed and biofly 300 ml/fed in controlling *S. littoralis* in early sugar beet plantation. Also, this study aimed to show the negative side effects on some associated natural enemies; true spider, *Chrysoperla carnea* (Stephens) and *Coccinella* spp. Results showed the highest rate of SiNPs (60 g/fed) was the highest effectiveness in reducing the numbers of *S. littoralis*; 59.75 and 61.77% reduction in larvae during two season, respectively. While the two tested insect pathogens came in the second category in controlling the insect. On the other hand biofly showed the highest side negative effect on associated predators followed the dipel DF, while the lowest effect recorded from SiNPs at low rate (20 g/fed).

Keywords: silica nanoparticles, cotton leafworm, sugar beet, natural enemies

INTRODUCTION

Sugar beet, *Beta vulgaris* L. is one of two principal sugar crops and provides about 40 % of the world sugar production and represents the second source, after sugar-cane. This crop is annually planted in Egypt and 55% of the cultivated area is concentrated in Kafr El-Sheikh Governorate (Abou El-Kassem, 2010).

Sugar beet plants attract numerous insect species during growing season. These insects varied in their feeding processes, needs of living and some of them can cause economic damage when they feed on the plants during their early growth stages (Shalaby, 2001).

However, in some cases, some common insect pests like the cotton leafworm, *Spodoptera littoralis* Biosd. could be more dangerous than specific ones. Because the climate change that keeps the temperature relatively high throughout September, *S. littoralis* can severely attack the seedlings of sugar beet causing large bare batches in the field and results in high economic losses (Abou El-Kassem, 2010 and El-Mahalawy, 2011).

A knowledge of the sugar beet ecosystem is essential to develop an insect control strategies which from a backbone of integrated pest management (IPM) program. control of sugar beet insects can be achieved through optimizing the cultural practices such as planting dates, susceptibility of sugar beet varieties, fertilization and addition to insect pathogens and the beneficial insect inhabiting sugar beet crop (Amin *et al.*, 2008 and Tohamy *et al.*, 2008).

Nanotechnology draws its name from the prefix "nano". A nanometer is one-billionth of a meter—a distance equal to two to twenty atoms (depending on what type of atom) laid down next to each other. Nanotechnology refers to manipulating the structure of matter on a length scale of some small number of nanometers, interpreted by different people at different times as meaning anything from 0.1 nm (controlling the arrangement of individual atoms) to 100 nm or more (anything smaller than microtechnology). Richard Feynman was the first scientist to suggest that devices and materials could someday be fabricated to atomic specifications. "The principles of physics, as far as I can see, do not speak against the possibility of maneuvering things atom by atom." This concept was expanded and popularized in a 1986 book Engines of Creation by K Eric Drexler, who applied the term nanotechnology to Feynman's vision (Drexler *et al.*, 1992).

In research experiments nano silica has been reported to provide insecticide activity on its own, through desiccation of insects' cuticles. It has also been successfully applied as a thin film to boost cereal germination and decrease fungal growth (Qhobosheane *et al.*, 2001). However, nano silica is not a preferred auxiliary in crop protection products due to the adverse effect upon inhalation.

The efficiency of the fungus *Beauveria bassiana* Vuill. As biological control agent against sugar beet insect pests were tested in the laboratory and in the field on *Scrobipalpa ocellatella* (Boyd) (El-Sufty, 1987 and Mansour, 1999) or mixing the fungus, *B. bassiana* with the conventional insecticides (El-Sufty and Abbasy 1987)

The efficacy of *B. bassiana* were recorded using the fungus (Biofly) at a rate of 3×10^7 conidia/ml which gave 43.63 and 47.91% for *S. ocellatella* twenty days after treatment (Metwally *et al.*, 2004). Also, the insect population of *S. ocellatella* reduced by 36.32 and 42.13% in the two seasons of study in using *Bacillus thuringiensis*.

Therefore the aim of this study to evaluate the efficiency of silica nanoparticles compared with two insect pathogens in controlling the cotton leafworm, *S. littoralis* in early plantation of sugar beet and the side effect on some associated predators.

MATERIALS AND METHODS

This experiment was carried out at El-Riad region, Kafr El-Sheikh Governorate, during two successive seasons 2014 and 2015. The experimental area was prepared, and sown with Pleno sugar beet cultivar on mid of August every season. This date of sowing was selected to mimic the infestation of cotton leafworm, *S. littoralis* occurs in sugar beet fields, while the temperature is high. All recommended cultural practices were applied along the growing seasons without insecticide applications. Efficacy of the examined materials against target insect started when the egg masses reach to 10 per 100 plant, coincide almost one month after sowing.

To evaluate the reduction of *S. littoralis* larvae dipel DF at 200 g/fed (6.4% WP) a bio preparation of *Bacillus thuringiensis* var. *kurstaki* and Biofly at 300 ml/fed (3×10^7 conidia/ml) having *Beauveria bassiana*. The silica nanoparticles (SiNPs) was obtained from Nanotech Egypt Company Limited, Cairo, Egypt. It's size was approximately 18 nm with a purity of 95 %. The Transmission Electronic Microscope (TEM) image of the silica nanoparticles is shown in Fig. 1. (rates of SiNPs 20, 40 and 60 g/fed.). The experimental area was divided into 24 plots [(5 treatments + control) × 4 replications] in Randomized Complete Block Design (RCBD). The first treatment was the control which sprayed with water. The others were treated with the different concentrations of SiNPs and two pathogens (Dipel DF and Biofly) using CP3 sprayer at 200 liter water per feddan. The normal cultural practices of growing were applied as usual without using any insecticides.

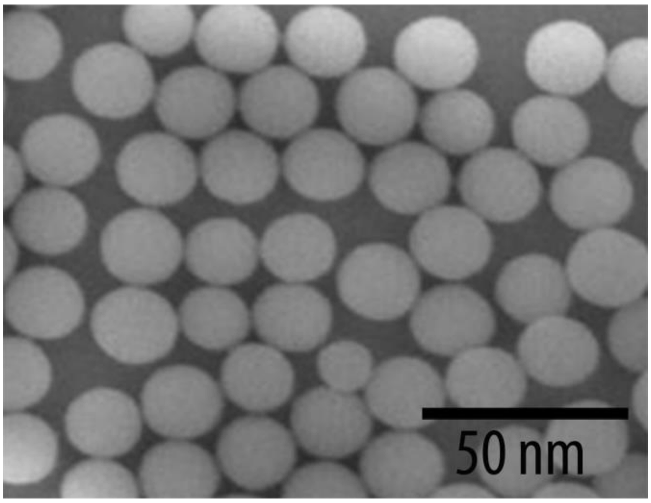

Fig. (1): Transmission electron micrograph (TEM) of silica nanoparticle

The sugar beet plants were examined before and after 1, 3, 7 and 10 days after treatments for each examination, 10 plants/plot were inspected to count the life larvae. Population reductions due to treatments were calculated and compared with the insect numbers in untreated plots (control).

Percentage of infestation reduction was estimated according to the formula of Henderson and Tilton (1955) as follows:

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

To study the effect of these treatments on the associated predators, numbers of true spiders, *Coccinella* sp. (adults and larvae) and *C. carnea* (larvae) were counted per 10 sugar beet plants just before treatments, and then 1, 3, 7 and 10 days after treatments. Also, the reductions in natural enemies were calculated with the same equation.

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

RESULTS AND DISCUSSION

Application of two pathogens, *Bacillus thuringiensis* (Dipel DF) and *Beauveria bassiana* (Biofly) compared with silica nanoparticles (SiNPs) in controlling *S. littoralis* larvae in early sugar beet plantation during the two successive seasons, 2014 and 2015.

a. Reduction in *Spodoptera littoralis* Boisd. larvae:

Data illustrated in Table (1) showed the reduction percentage of *S. littoralis* resulted from using SiNPs (three concentrations), dipel DF and biofly during the first season 2014.

After one day of treatments the high concentration of SiNPs was highly effective which recorded 35.54% reduction of larvae numbers followed by medium rate of SiNPs (40 g/fed) reduced 22.35%. After three, seven and ten days SiNPs (60 g/fed) were recorded 68.44, 65.72 and 69.31% reduction in larvae numbers, respectively. While the lowest reductions were recorded by using SiNPs with low concentrations 20 and 40 g/fed. The two insect pathogen showed moderately reduction in *S. littoralis* larvae followed by the high rate of SiNPs.

The population reduction as overall average of *S. littoralis* larvae in early sugar beet plantation was shown in Fig. 2. The statistical analysis showed significant differences between all treatments. The highest reduction was obtained in using the high concentration of SiNPs (59.75%) followed by dipel DF and biofly with 34.30 and 30.11%, respectively. There are not significant differences among SiNPs 20 and 40 g/fed which recorded 24.43 and 27.41%, respectively.

Table (1): Reduction percentage of *S. littoralis* in early sugar beet plantation at El-Riad region, Kafr El-Sheikh Governorate during the first season 2014.

Treatment	Rate/fed.	Days after treatment			
		1	3	7	10
Silica nanoparticles	20 g	18.13	20.62	25.32	33.63
	40 g	22.35	24.65	37.44	25.21
	60 g	35.54	68.44	65.72	69.31
Dipel DF	300 g	12.16	15.56	54.35	55.12
Biofly	300 ml	15.23	17.12	39.43	48.65

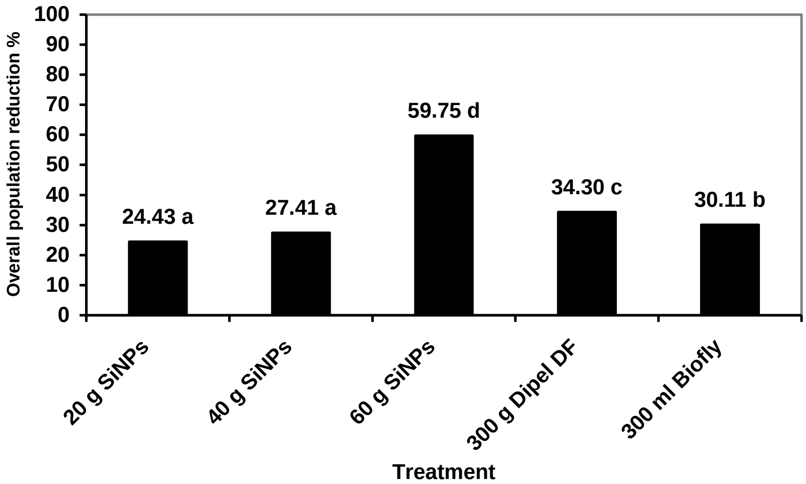

Fig. (2): Overall population reduction percentage of the cotton leafworm, *S. littoralis* in early sugar beet plantation during the first season 2014.

Means followed by a common letter are not significantly different at the 5% level by DMRT

In the second season 2015, data in Table (2) showed after one day of treatments the SiNPs; 60, 40 and 20 g/fed. were recorded 40.14, 20.15 and 16.21% reduction in *S. littoralis* larvae, respectively followed by dipel and biofly at 13.44 and 10.26%, respectively. After one week the high concentration of SiNPs (60 g/fed) was recorded 66.57% followed by dipel DF which recorded 55.23%, while biofly recorded 33.56%.

The overall averages of population reduction percentage of the cotton bollworm, *S. littoralis* numbers after treatments were shown in Fig. 3. The statistical analysis showed significant differences between treatments. The highest effectiveness was recoded by high rate of SiNPs (60 g/fed.) 61.77% reduction followed by dipel DF and SiNPs (40 g/fed.) with 35.48 and 29.74% reduction, respectively. The biofly and lowest SiNPs (20 g/fed.) were recorded 24.09 and 23.94% reduction, respectively without significantly.

The silica nanoparticles enhanced the plant tolerance against cotton leafworm, *S. littoralis* which increase the hardness plants (Borei *et al.*, 2014 and El-Samahy, 2015). So, the hardness on sugar beet leaves reduce the ability of larvae eat.

Table (2): Reduction percentage of *S. littoralis* in early sugar beet plantation at El-Riad region, Kafr El-Sheikh Governorate during the second season 2015.

Treatment	Rate/fed.	Days after treatment			
		1	3	7	10
Silica nanoparticles	20 g	16.21	19.88	23.95	35.71
	40 g	20.15	25.37	35.81	37.63
	60 g	40.14	69.52	66.57	70.84
Dipel DF	300 g	13.44	16.15	55.23	57.11
Biofly	300 ml	10.26	13.31	33.56	39.23

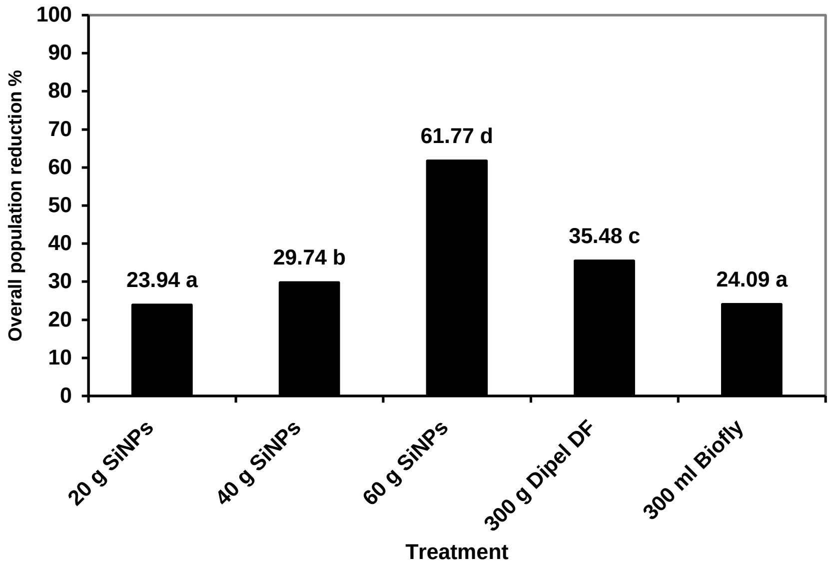

Fig. (3): Overall population reduction percentage of the cotton leafworm, *Spodoptera littoralis* in early sugar beet plantation during the second season 2015.

Means followed by a common letter are not significantly different at the 5% level by DMRT

b. Reduction in true spiders, *Chrysoperla carnea* (Stephens) and *Coccinella* spp.

The reduction percentage in some natural enemies associated with cotton leafworm, *S. littoralis* in early sugar beet plantation during two seasons; 2014 and 2015 were shown in Table (3).

The highest negative side effect of tested materials on true spiders, *C. carnea* and *Coccinella* spp. at mean 37.06, 51.65 and 40.00% reduction, respectively were obtained in using biofly during two seasons. The dipel DF come in the second order in negative side effect. The lowest rate of SiNPs (20 g/fed.) showed the lowest negative effect on three associated natural enemies.

Table (3): Reduction in some natural enemies associated with cotton leafworm, *S. littoralis* in early sugar beet plantation at El-Riad region, Kafr El-Sheikh Governorate during two seasons 2014 and 2015.

Treatment	Rate/fed	True spiders		Mean	*Chrysoperla carnea*		Mean	*Coccinella* spp.		Mean
		2014	2015		2014	2015		2014	2015	
Silica nanoparticles	20 g	18.02	17.31	17.67a	24.15	23.22	23.69	18.44	15.67	17.06a
	40 g	22.36	20.58	21.47b	29.34	35.11	32.23	25.27	23.58	24.43b
	60 g	20.07	29.52	24.80c	35.44	36.54	35.99	26.48	25.17	25.83b
Dipel DF	200 g	25.63	22.66	24.15c	37.23	35.17	36.20	40.22	39.74	39.98c
Biofly	300 ml	38.22	35.89	37.06d	50.67	52.63	51.65	41.45	38.54	40.00c

Means followed by a common letter are not significantly different at the 5% level by DMRT

Data showed SiNPs have moderately negative effects on associated natural enemies; true spiders, *C. carnea* and *Coccinella* spp. and can be control the cotton leafworm, *S. littoralis* in early sugar beet plantation. The obtained results agreement with the results obtained from El-Samahy *et al.*, 2015 who found that SiNPs in 20 nm with purity 99.99% in high concentration reduced the number of *S. littoralis* and associated predators, while the low concentration give satisfied control and low-risk in associated predators.

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مقارنة السيليكا النانومترية باثنين من مسببات الأمراض الحشرية فى مكافحة دودة ورق القطن فى عروة بنجر السكر المبكرة وتأثيرها على بعض الأعداء الحيوية المصاحبة لها

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من الأهداف الهامة فى استخدام المواد متناهية الصغر (النانومترية) فى المجال الزراعى هو الحد من استخدام المبيدات فى وقاية النباتات، وتقليل خسائر المواد المغذية للنباتات علاوة على رفع كفاءة المواد المخصبة. ولذلك أجريت هذه التجربة للبحث عن طريقة بديلة للمبيدات لمكافحة دودة ورق القطن.

أجريت هذه التجربة بمنطقة الرياض بمحافظة كفر الشيخ لموسمين متتالين ٢٠١٤ و٢٠١٥م. وكان الهدف من هذه الدراسة مقارنة فعالية السيليكا النانومترية (ثلاثة معدلات؛ ٢٠، ٤٠، و٦٠جم/فدان) باثنين من مسببات الأمراض الحشرية: الدايبل دى أف (٢٠٠جم/فدان) والبيوفلاى (٣٠٠ مل/فدان) على دودة ورق القطن فى محصول بنجر السكر (العروة المبكرة فى منتصف أغسطس). علاوة على ذلك دراسة الآثار السلبية للمواد المختبرة على بعض المفترسات المصاحبة؛ العناكب الحقيقة – أنواع أبو العيد – مفترس أسد المن.

ولقد أظهرت النتائج أن المعدل العالى من السيليكا النانومترية (٦٠جم/ف) هى الأكثر فعالية فى خفض تعداد يرقات دودة ورق القطن بنسبة ٥٩,٧٥ و ٦١,٧٧٪ فى العروة المبكرة تلاها المسببين المرضيين للحشرات محل الدراسة؛ الدايبل دى إف والبيوفلاى.

ومن جهة أخرى أظهرت الدراسة أن البيوفلاى كان الأعلى تأثيراً على المفترسات المصاحبة فى خفض تعدادها ثم الدايبل دى إف فى حين أن استخدام السيليكا النانومترية كانت الأقل تأثيرا على هذه المفترسات وبخاصة المعدل المنخفض منها.