The Efficacy of Silica Nano-Particles on the Inhibition of Oviposition of Tomato Borer, *Tuta absoluta*

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Abstract

Hayek, R.A.L., S. Tabbache, A.I.K. Ali and M. Ahmad. 2023. The Efficacy of Silica Nano-Particles on the Inhibition of Oviposition of Tomato Borer, *Tuta absoluta.* Arab Journal of Plant Protection, 41(3): 278-280. https://doi.org/10.22268/AJPP-41.3.278280

A laboratory experiment was conducted to examine the efficacy of silica nano-particles (SNPs) at 500 and 1000 ppm concentrations on oviposition of *Tuta absoluta*. One month old tomato plants in pots were used and randomly placed in wooden cages (4 pots/cage). Five pairs of adult insects (males and females) were released in each cage. The number of eggs laid by females was recorded four days after insects release. Results showed that SNPs had an inhibitory effect on egg laying by *Tuta absoluta*, at all tested concentrations. SNPs treatment caused a decrease in eggs number by 71.17, 59.45 and 51.35%, respectively, at 1000, 750 and 500 ppm concentrations, compared with the control. It can be concluded that nano-silica has a potential use as an insecticide to control *Tuta absoluta.*

Keywords: Tomato borer, Egg-laying inhibition, Scanning electron microscope, Silica nano particles.

Introduction

The tomato borer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) is one of the most important pests associated with tomato crops in many countries (EPPO, 2005). This pest is considered as a limiting factor for tomato production all over the world (Desneux *et al*., 2010). The larva is the harmful stage where it can feed on all aerial parts of the plant, producing large galleries in leaves, and consume the apical buds, flowers and young fruits (Vargas, 1970). This can lead to drying of leaves and early defoliation. This pest is capable of causing a yield loss around 80-100% if no control measures are applied (NAPPO, 2012)

Extensive use of chemical insecticides to control insects has led to the development of resistance to these chemicals in addition to the pollution of the environment (Ditta, 2012; Yadav, 2010).

Therefore, recent investigations aimed to reduce dependency on chemical pesticides and to use safe alternatives in pest control programs. Currently, there is a growing trend in using environmentally friendly nanoparticles in the field of plant protection (Biswal *et al*., 2012).

Nano-silica and other nanoparticles can play an important role in the development of pest management techniques in tomatoes and other crops (Barik *et al*., 2008). Nanosilica molecules have already proven to be successful in controlling many pests which belong to different insect orders such as Coleoptera, Lepidoptera and Diptera, the most important of which are the pests of stored products as well as insects that attack several important economic crops such as tomatoes, rice and cotton (El-Bendary & El-Helaly, 2013; Ziaee & Ganji, 2016).

Materials and Methods

Preparation and characterization of silica nano-particles
The method of Patel & Patel (2014) was used with slight modification: Silica nano particles was prepared by drop-wise addition (~ 2 drops/s) of 2.5% HCl in diluted sodium meta silicate (30 gm in 500 ml water) solution with constant stirring for 250 rpm at 60°C until a cloudy, viscous gel was formed. 10 gm of silica gel in 100 ml water was stirred continuously for 250 rpm at 60°C with drop-wise addition (~ 2 drops/s) of 2% hydrogen fluoride, until a clear solution obtained. The solution was filtered using Wattman filter paper no 1. The filtrate was then evaporated to dryness resulted in white powder which was thoroughly washed with distilled water and dried in oven at 80°C. The process was then repeated 4 to 5 times. The final product was dried in an oven at 100°C for more than 24 hours, and in the air at 750°C for 3 hours. The size and shape of prepared nanoparticles was observed by a scanning electron microscope (SEM) (model VEGALL xmu TESCAN).

Rearing insects
Larvae were collected from an infested greenhouse planted with tomato, and then reared in 9 cm petri dishes in an incubator at a temperature of 25±2°C and a relative humidity (RH) of 70%. After adult insects' emergence, they mated in the petri plates. Males and females were then collected separately in small batches for 24 hours until further use.

Egg laying inhibition
The potential egg laying inhibition of the SPNs different concentrations (500, 750 and 1000 ppm) was evaluated in an experiment, where three treated tomato plants (one per treatment) and one plant for untreated control, were placed randomly together inside a wooden cage (45×45×50 cm).

https://doi.org/10.22268/AJPP-41.3.278280

The experiment was carried out in the laboratory using one-month old tomato plants grown in pots. The plants were sprayed with the pesticide liquid using a 1-liter hand sprayer (15 ml of the spraying liquid/plant). The plants were then left in the laboratory air for an hour to dry. Five pairs of *T. absoluta* adults (five females and five males) were released in each cage. The plants were examined 4 days later, and the number of eggs laid by *T. absoluta* females was recorded (Zappala *et al*., 2012). The inhibition efficacy was evaluated by Abbott formula (Abbott, 1925) as follows:

$$\text{Efficacy (\%)} = \frac{\text{Ca-Ta}}{\text{Ca}} \times 100$$

where: Ca is the average number of eggs laid in the control and Ta is the mean number of eggs laid in the treatment.

Results and Discussion

The results obtained showed that the prepared silica nanoparticles were roughly spherical and they were around 22-60 nm in diameter.

SPNs inhibition of *T. absoluta* egg laying

There was a significant reduction in the number of eggs laid by *T. absoluta* females in all tested concentrations of Nano silica (Table 1).

Data obtained showed a significant difference between the untreated control and the rest of the treatments. SNP concentration of 1000 ppm was the most effective treatment and reduced the number of eggs laid by 71.17%, compared to the control. There was no significant difference in the number of deposited eggs between SNP concentrations 750 ppm and 500 ppm, 4 days after the release of adults of *Tuta absoluta*, with egg laying inhibition rate of 59.45 and 51.35%, respectively.

These results are in agreement with earlier findings which indicated that using nanosilica particles at 500 ppm concentration caused a reduction in the number of larvae by 66.67%, 7 days after treatment (Derbalah *et al*., 2012).

Table 1. Effect of SNPs concentration on number of eggs laid by the tomato leaf borer, *Tuta absoluta.*

SNPs concentration (ppm)	Number of eggs laid	Inhibition rate of egg laying (%)
1000	8.00 a	71.17
750	11.25 ab	59.45
500	13.50 b	51.35
Control	27.75 c	-
$LSD_{0.01}$	6.313	-

*Means followed by the same letters in the same column are not significantly different at P=0.01.

It was thought that SNPs mode of action could favor their use because the insect is unlikely to become genetically resistant to such a mode of action. However, the insect may develop a behavioral response to these particles by avoiding contact, similar to their behavior towards mineral oils and sulfur dustable powder (Ebeling, 1971).

Earlier studies suggested that sulfur dustable powder plays a role in preventing egg laying and reduced the pest population by blocking volatile substances from plant surfaces that help the pest locate the host (Zappala *et al*., 2012). Results reported in this study are close to those obtained by Hourieh & Alhayek (2016) who studied the efficacy of mineral oil and sulfur dustable powder on fecundity of *Tuta absoluta*.

It can be concluded from this study that silica nano particles with an average diameter of around 38 nm and spherical morphology can be economically and easily synthesized by acid leaching technique, using the sodium meta silicate as a source and the product can reduce the fecundity of *T. absoluta* females, and thus reduce the insect population density, and consequently crop yield losses. It can be concluded from this study that nano-silica is effective against tomato leaf miner and therefore could be a useful component of an integrated pest management strategy.

الملخص

الحايك، ريتا، سمير طباش، أحمد إبراهيم قرة علي ومحمد أحمد. 2023. دراسة تأثير جسيمات النانوسيليكا في تثبيط وضع بيض حافرة أوراق البندورة/الطماطم (*Tuta absoluta*). مجلة وقاية النبات العربية، 41(3): 278−280. https://doi.org/10.22268/AJPP-41.3.278280

تمّ تنفيذ تجربة مختبرية لاختبار تأثير جسيمات النانوسيليكا، بالتراكيز 500، 750 و 1000 جزء بالمليون، على وضع بيض حافرة أوراق البندورة/الطماطم (*Tuta absoluta*). أُستخدمت نباتات بندورة/طماطم بعمر شهر مزروعة في أصص ووزّعت عشوائياً ضمن أقفاص خشبية بواقع أربعة أصص في كل قفص. أُطلق في كلّ قفص خمسة أزواج (ذكر + أنثى) من بالغات الحشرة. تمّ عدّ البيض الموضوع من قبل الإناث بعد 4 أيام من إطلاق الحشرات. أظهرت النتائج أن لجسيمات النانوسيليكا تأثيراً مثبطاً لوضع بيض حافرة أوراق البندورة/الطماطم عند جميع التراكيز المستخدمة. وقد أثبتت النتائج أن جسيمات النانوسيليكا خفّضت عدد البيض الذي وضعته الإناث بنسبة 71.17، 59.4 و 51.35% عند التراكيز 1000، 750 و 500 جزء بالمليون، على التوالي، مقارنة مع الشاهد. إن النتائج المُتحصّل عليها تشجع على استخدام جسيمات النانوسيليكا كأحد العناصر في برامج المكافحة المتكاملة لحافرة أوراق البندورة/الطماطم.

كلمات مفتاحية: حافرة أوراق البندورة/الطماطم، التأثير المانع لوضع البيض، المجهر الالكتروني الماسح، جسيمات النانوسيليكا.

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Received: May 8, 2022; Accepted: January 3, 2023

تاريخ الاستلام: 2022/5/8؛ تاريخ الموافقة على النشر: 2023/1/3