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RESEARCH ARTICLE
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Role of Some Nanoformulations in Suppression of Silver Whitefly, *Bemisia tabaci* Population in Compared with Their Conventional Formulations in Tomato Fields

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ABSTRACT

Background: Scientific research will continue to search for the best methods to control the insect pests and at the same time reduce insecticide concentrations used. Using of nanoinsecticide formulations may be resolving this problem.

Methods: In this work two types of formulations were used; nanoformulations and their conventional formulations. Three common insecticides were used against the silver whitefly, *Bemisia tabaci*; indoxacarb, spirotetramat and thiacloprid in tomato fields. The nanoparticle sizes were ranged between 210 and 290 nm. The loading capacities were 70.6, 71.2 and 69.1% for indoxacarb, spirotetramat and thiacloprid, respectively. The recommended field concentration for each insecticide was used. The concentrations of nanoformulations were one-fifth of conventional one.

Result: The obtained results showed that indoxacarb was the most effective insecticide against the *B. tabaci* in tomato field with the both formulations (nano and conventional) followed by thiacloprid and spirotetramat. By using of nanoformulations, the per cent of reduction after the third application were 97.7, 38.2 and 44.8%, for indoxacarb, spirotetramat and thiacloprid, respectively. While, the corresponding results with the conventional formulation were 97, 39.8 and 49.2%, respectively. The obtained results also, showed that there were no difference between the nano and conventional formulations. The per cent of *B. tabaci* reduction after the third application were 97.7 and 97.0; and 38.2 and 39.8; and 44.8 and 49.2% for nano and conventional indoxacarb, spirotetramat and thiacloprid, respectively. These results may be throw some light in the advantages of using nanoformulations compared with the conventional formulations.

Key words: Conventional formulations, Insecticides, Nanoformulations, Nanotechnology, Silver whitefly.

INTRODUCTION

Until now the chemical control is considered the most effective method to suppress the pests. Every year the world used approximately 3.5 million tons of pesticide formulations against the pests (Sharma *et al*., 2019). So, the world needs some approaches to reduce the quantity of pesticides used in agriculture system. Using of nanopesticides can be doing it. By using this strategy the volume of pesticide formulations used can be decreased to one-fifth (Sabry *et al*., 2021). Recently, some studies developed nanopesticides formulation and used it against different pests. Sabry and Ali (2022) used nanoformulation to chlorfenapyr, imidacloprid and indoxacarb against the adults of the conical snails, *Cochlicella acuta* and the chocolate banded snail, *Massylaea vermiculata*. The aim of this approach is reducing the insecticides concentrations and also the cost of application (Sabry *et al*., 2021). The silver whitefly, *Bemisia tabaci* was known for its great damage to field crops and fruits by sucking the plant juice and converted the color leaves to yellow, shrivel and drop prematurely (Horowitz *et al*., 2020). This pest is belonging to the Aleyrodidae family. Worldwide, there are over 1550 species of whitefly (Martin and Mound, 2007). It is causing severe economic damage in over 60 crop plants. So, the *B. tabaci* is considered the second most widespread and economically important arthropod pest in the world (Padilha *et al*., 2021). Tomato, *Solanum lycopersicum* is an important economic vegetable crop in Egypt. In 2019, the production volume of tomatoes in Egypt was approximately 6.8 million metric tons. Recently, the yield of tomato was affected by many insect pests such as whitefly, tomato leafminers and grasshoppers. Still now the chemical control is the most effective agent against whitefly (Perring *et al*., 2018). Due to the extensive use of conventional pesticide formulations, this pest has acquired resistance to many conventional formulations. To overcome to this problem, new pesticides formulations must be developed. Nanopesticide formulations are one of these solutions.

Indoxacarb is a new insecticides used against wide range of insect pests. This insecticide is effective against

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whitefly (Bajya *et al*., 2015). This insecticide acts by blocking of the sodium channel in nervous system which leads to paralysis and death to insect pests. Nanoformulation of indoxacarb was used against the cotton leafworm (Sabry *et al*., 2021). Indoxacarb formulation was developed to nanoformulation to improve the pesticide's utilization rate, target control characteristics and ecological security (Wang *et al*., 2020). Spirotetramat also used against wide range of insect pests such as sucking insects in their juvenile, immature stages, including aphids, scale insects and whitefly (Salazar-López *et al*., 2016). Spirotetramat act on insect pest by acting as an Acetyl-CoA Carboxylase inhibitor. This mechanism leads to interrupt lipid biosynthesis in the insect pests. Spirotetramat was used against silver whitefly and has excellent results in reducing of *B. tabaci* population in cotton (Bojan *et al*., 2009). Thiacloprid is an effective neonicotinoids against many insect pests such as aphids, whiteflies and some jassids and also against weevils, leafminers and various species of beetles and it shows good plant compatibility in all relevant crops (Tomlin, 2009).

Thiacloprid acts on insect pests by binding with the nicotinic acetyl choline receptors in nervous system and cause disruption. This work aims to find scientific solution to reduce the quantities of pesticide formulations used against insect pests to get safe and cheap food.

MATERIALS AND METHODS

Tested insecticides

Indoxacarb (Avaunt 15% EC) produced by Du Pont De Nemours. Indoxacarb belong to a new class of insecticides called oxadiazine and it works as a sodium channel blocker. The recommended field rate is 200 ml/feddan (4200 m^2). The recommended field rate was used with the conventional formulation (200 ml/feddan) 75 ppm.

Spirotetramat (Movento 10% SC) produced by Bayer Crop Science Germany. This insecticide belongs to lipid synthesis inhibitors group. The recommended field rate is 160 ml/feddan (40 ppm).

Thiacloprid (Blench 48% SC) produced by Jiangsu Flagchemicals Industry Co. China. This insecticide belongs to neonicotinoids pesticide group. The recommended field rate is 120 ml/feddan (144 ppm).

Tested insect

The silver whitefly, *Bemisia tabaci* was selected to evaluate the efficacy of nanopesticides formulations compared with their conventional formulations under semi-field conditions. This work was achieved during September 2021 to January 2022 on tomato plants (Newcastle Varity).

Agricultural practices

Tomatoes seeds, Newcastle Varity were sown in seedling trays consisting of 120 small holes, filled with compost. After three weeks, the seedlings were transferred into field. Plants were fertilized and all agriculture practices carried out.

Preparation of nanoformulations

All conventional formulations of tested pesticides were developed to nanoformulations according to Vaezifar *et al*. (2013). Chitosan with a high molecular weight was used as a carrier or a polymer for all tested pesticides. First, chitosan was dissolved in acetic acid (2% v/v) followed by continuous stirring with the help of magnetic stirrer for 25-30 min. After that tripolyphosphate 0.8% (w/v) solution containing the tested pesticide (indoxacarb, spirotetramat or thiacloprid) was added to the chitosan solution. The obtained solution put on magnetic stirring for 10-20 min. The suspension was centrifuged at10000 RPM for 30 min. The pellet was collected and lyophilized to obtain nanoparticles formulation. The same work was carried out to all tested insecticides. The obtained nanoparticles were photographed under scan electronic microscope (SEM) (Fig 1). The obtained solution of all pesticide nanoparticles was more transparent than the conventional formulation solutions (Fig 2). This may be due to the nanosizes structure which not interacted well with the light. One-fifth of the recommended concentration in all tested insecticides was used.

To make sure the insecticide formulation was loaded on the carrier (chitosan) loading capacity test was carried out.

Loading capacity test

After preparing of nanoformulations to all test pesticides; loading capacity was determined according to He *et al*. (2017). Tis loading capacity was determined by about 30 mg of the samples (nanoparticle formulations) were weighed and dissolved in 50 ml of acetonitrile and the mixture

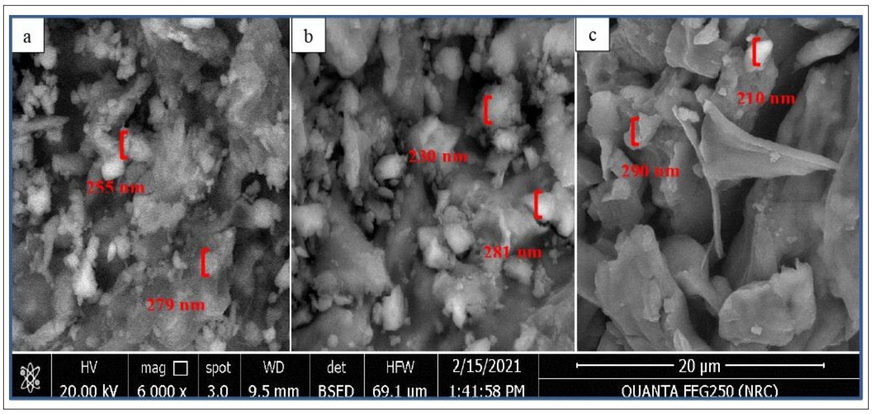

Fig 1: Nanoparticles of indoxacarb (a), spirotetramat (b) and thiacloprid (c) under SEM.

remained in a shaking tank overnight at a constant temperature to completely dissolve the carrier material. Solution was filtered, the mass concentration of tested pesticide in acetonitrile was examined by HPLC (The HPLC system was equipped with an XTerra RP18 column, 5 µm particle size, 4.6 mm internal diameter × 250 mm length (Waters®, USA) under a detection wavelength of 278 nm. The loading capacity was calculated by dividing the mass of loading pesticide on the mass of pesticide nanoparticles × 100.

Loading capacity (LC) =

$$\frac{\text{Mass of loading pesticide}}{\text{Mass of pesticide nanoparticles}} \times 100$$

All tested formulations were kept in refrigerator at - 8°C until used. The concentrations of nanoformulations were one - fifth of the conventional formulations.

Field bioassay

This experiment was carried out under semi-field conditions in Agricultural Research Center, Egypt, during Feb. and Aug. 2022. This experiment was designed as plots area (6 × 7 m). Each tested formulation has three replicates (three plots). Other three replicates were used as a control (treated with water). All plots were treated by tested formulation three time and one week interval. A ten-liter knapsack sprayer was used in insecticides treatment. After each application by 24 hrs, randomly the numbers of silver whitefly adults per 10 leaflets were counted in each plot. The means of adults were also counted. Corrected efficacy of adult whitefly was calculated according to Henderson and Tilton (1955). As follow:

Corrected mortality % =

$$1- \frac{\text{No. of whitefly in control before treatment} \times \text{No. of whitefly in treatment after treatment}}{\text{No. of whitefly in control after treatment} \times \text{No. of whitefly in treatment after treatment}} \times 100$$

The per cent of adult reduction was calculated by (the original number of adults before treatments – the new number after treatment / original number × 100).

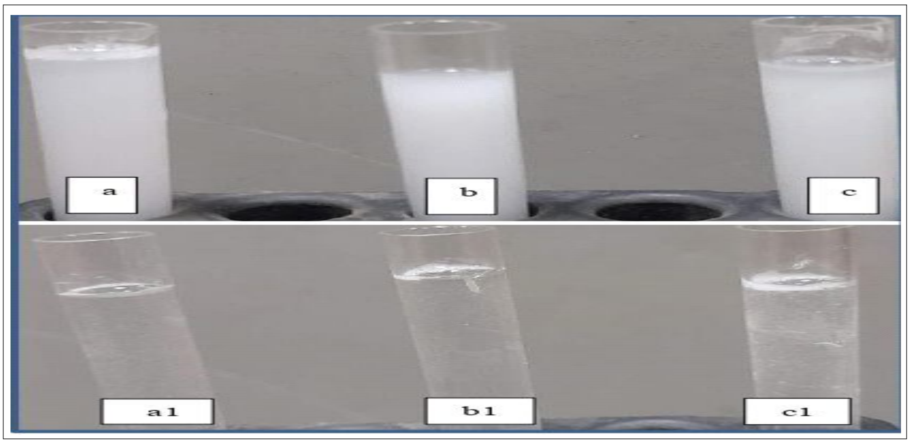

Fig 2: Nanoformulation of indoxacarb (a1), indoxacarb (a), nanospirotetramat (b1), spirotetramat (b), nanothiacloprid (c1) and thiacloprid (c).

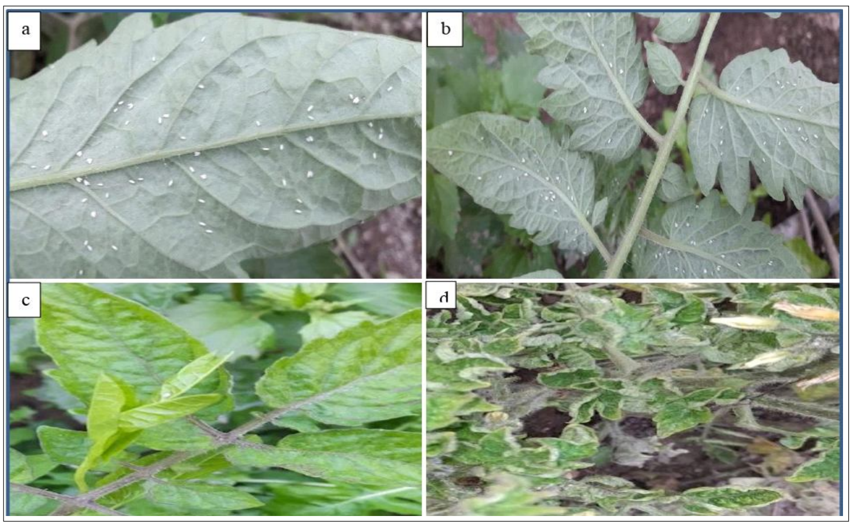

Fig 3: The population of silver whitefly adults before indoxacarb application (a and b), after the third application (c) and in control (d).

Statistical analysis

Data were subjected to the analysis of variance test (ANOVA) *via* randomized complete block design (RCBD) (F test) and analysis of variance (one ways classification ANOVA) followed by a least significant difference (LSD) at 5% (Costat, 1990).

RESULTS AND DISCUSSION

All prepared formulations are tested against the silver whitefly, *Bemisia tabaci* adults under field conditions. The efficacy of these insecticides is tested in both conventional and nanoformulations.

Efficacy of indoxacarb against *B. tabaci*

As clear in Table (1) the efficacy of conventional indoxacarb formulation and nanoformulation is determined. Data show that there is no difference between the nano and conventional formulations. The per cent of silver whitefly reduction after the first treatment is 79.2 and 78.2% with the indoxacarb conventional and nanoformulation, respectively. The same result is found after the second and third treatment. The percent of *B. tabaci* reduction after the third treatment was 97.0 and 97.7%, respectively (Fig 3). The statistical analysis shows that there is no difference between the conventional and nanoformulations. The less significant difference (LSD) is 10.7, 5.1 and 4.7 after the first, second and third treatment.

These results show that the nanoformulation concentration which was one-fifth of concentration of conventional formulation has the same effect against *B. tabaci* adults. These results were consistent with Xiang *et al.* (2013). The authors found that the nanoformulation of thiamethoxam with 50% of the recommended dosage for the pure a.i has the same effect of conventional formulation against the whitefly adults. On the other hand, nanoindoxacarb was used against the cotton leafworm larvae (Sabry *et al.*, 2021). The percent 0f larvae mortality was 95% with nanoformulation compared with 76.7% with conventional formulation.

Efficacy of spirotetramat against *B. tabaci*

Spirotetramat is considered one of the tetramic acid derivatives. The obtained data show that this insecticide has a low toxicity against the silver whitefly after the first application. The percent of whitefly adult reduction not exited 19.0 and 12.0% in both spirotetramat conventional and nanoformulations, respectively. This result shows that the conventional formulation is more effective than nanoformulation after the first application. After the second application the spirotetramat nanoformulation is more effective than the conventional one. The percent of reduction are 47.0 and 42.4 %, respectively (Table 2). This means that the toxicity of spirotetramat is increased after the second and third application. Spirotetramat became moderate toxic against the adult whitefly after the second treatment. The statistical analysis shows that there is no difference among the efficacy of conventional, nanoformulation and control after the first application, but there is a significant deference between treated plants and control after the second and third applications. The statistical analysis shows that there is no significant difference between the conventional and nanoformulations after all applications (Table 2). These results were agreed with Zhao *et al.* (2018). The authors used silica

Table 1: Toxicity of the conventional and nano formulations of the indoxacarb against the silver whitefly adults, *B. tabaci* on tomato.

	No. of *B. tabaci* / leaves									
Formulations	Before treatment	After 1st treatment	Corrected efficacy %	% of reduction	After 2nd treatment	Corrected efficacy %	% of reduction	After 3rd treatment	Corrected efficacy %	% of reduction
Conv.*	57.7±7.2	12.0±2.6[b]	78.3	79.2	7.0±2.6[b]	88.4	87.9	1.7±1.5[b]	97.4	97.0
Nano.**	56.3±6.1	12.3±2.5[b]	77.2	78.2	4.3±1.5[b]	92.7	92.4	1.3±1.5[b]	97.9	97.7
Cont.***	60.0±4.6	57.7±8.5[a]			62.7±3.2[a]			67.0±3.5[a]		
F values		72.5***			496.4***			772.3***		
LSD		10.7			5.1			4.7		

*Conventional formulations, **Nanoformulations, ***Control.

****Means under each treatment sharing the same letter in a column are not significantly different at P = 0.05.

Table 2: Toxicity of the conventional and nano formulations of the spirotetramat against the silver whitefly adults, *B. tabaci* on tomato.

	No. of *B. tabaci* / leaves									
Formulations	Before treatment	After 1st treatment	Corrected efficacy %	% of reduction	After 2nd treatment	Corrected efficacy %	% of reduction	After 3rdt reatment	Corrected efficacy %	% of reduction
Conv.*	54.3±6.0	42.3±5.6[a]	19.0	22.1	39.0±2.0[b]	31.3	42.4	32.7±2.1[b]	46.1	39.8
Nano.**	58.7±4.0	49.7±3.1[a]	12.0	15.3	42.3±2.3[b]	31.1	47.0	36.3±1.5[b]	44.6	38.2
Cont.***	60.0±4.6	57.7±8.5[a]			62.7±3.2[a]			67.0±3.5[a]		
F values		4.6[ns]			75.1***			171.4***		
LSD		12.4			5.1			4.9		

*Conventional formulations, **Nanoformulations, ***Control.

****Means under each treatment sharing the same letter in a column are not significantly different at P = 0.05.

Table 3: Toxicity of the conventional and nano formulations of the thiacloprid against the silver whitefly adults, *B. tabaci* on tomato.

Formulations	No. of *B. tabaci* / leaves									
	Before treatment	After 1st treatment	Corrected efficacy %	% of reduction	After 2nd treatment	Corrected efficacy %	% of reduction	After 3rd treatment	Corrected efficacy %	% of reduction
Conv.*	57.7±3.1	40.7±6.7^{b}	26.7	29.5	31.3±0.6^{c}	48.1	45.8	29.3±1.5^{b}	54.5	49.2
Nano.**	58.0±3.6	47.7±2.1^{ab}	14.5	17.8	41.3±1.5^{b}	31.9	28.8	32.0±2.6^{b}	50.6	44.8
Cont.***	60.0±4.6	57.7±8.5^{a}			62.7±3.2^{a}			67.0±3.5^{a}		
F values		5.4*			177.3***			186.4***		
LSD		12.7			4.2			5.3		

*Conventional formulations, **Nanoformulations, ***Control.

****Means under each treatment sharing the same letter in a column are not significantly different at P = 0.05.

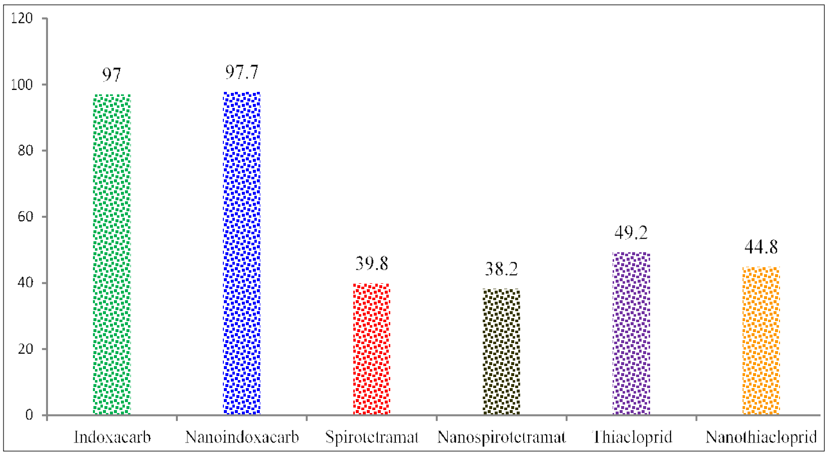

Fig 4: Comparison among all tested formulations against *B. tabaci*

nanoparticles (MSNs) as carriers to spirotetramat to improve the utilization rate of this insecticide and reduce the risk to the environment. On the other hand, spirotetramat was evaluated against the eggs and nymphs of whitefly (Francesena *et al*., 2012). The obtained results showed that spirotetramat not also effective against the whitefly nymphs but also had low toxic against *Eretmocerus mundus* (important parasitoid of *B. tabaci* and is commercialized as a biocontrol agent, mainly in Europe).

Efficacy of thiacloprid against *B. tabaci*

Data in Table (3) shows that thiacloprid is moderate toxic against *B. tabaci* with both conventional and nanoformulations. After the first treatment, the percent of reduction is 29.5 and 17.8% with conventional and nanoformulations of thiacloprid. This means that thiacloprid conventional formulation is more effective against *B. tabaci* than nanoformulation (Table 3). After the second treatment the percent of reduction with conventional formulation (45.8%) is two time than the nanoformulation (28.8%). After the third application the per cent of reduction with conventional formulation (49.2%) is approximately equal the nanoformulation (44.8%). The statistical analysis shows that there is a significant difference between thiacloprid conventional formulation and nanoformulation only after the first treatment (Table 3).

The obtained results showed that indoxacarb in both formulations (conventional and nano) was very effective against *B. tabaci* compared with other insecticides (Fig 4).

Dong *et al*. (2014) found that the efficacy of thiacloprid (conventional formulation) against *B. tabaci* was 90% from one to ten days after treatment. This result may be clears that the increasing of reduction per cent after the third application compared to the first and second treatment. On the other hand, thiacloprid was moderate toxic against *B. tabaci* adults in eggplant field (Kumar *et al*., 2017).

CONCLUSION

The obtained results showed that indoxacarb in both formulations (conventional and nano) was very effective against *B. tabaci* compared with other insecticides (Fig 4). There is no difference between the efficacy of conventional and nanoformulations of all tested insecticides. These results may be a real start for using the nanopesticides formulation instead of the conventional formulation to reduce the risk of insecticides used in environment, to reduce the underground water contamination and reduce the cost of insecticide application.

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Conflict of interest: None.

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