Interaction of ZnO Nanoparticles with the Toxicity of some Insecticides on Cotton Leafworm, *Spodoptera littoralis* (Lepidoptera: Noctuidae)

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ABSTRACT: Laboratory and semi-field studies were carried out to evaluate the toxicity of spinetoram, ß-cyfluthrin and methoxyfenozide as well as the effect of zinc oxide nanoparticles on the toxicity of these insecticides against the cotton leafworm larvae (CLW), *Spodoptera littoralis*. Methoxyfenozide was the most toxic against the 2nd instar CLW larvae with LC_{50} value 0.15 mg L^{-1}. Spinetoram achieved the least toxicity against the 2nd instar CLW larvae with LC_{50} value 7.6 mg L^{-1}. Results of the laboratory studies revealed that, ZnO nano-particles at 10 and 100 mg L^{-1} significantly increased the toxicity of ß-cyfluthrin and methoxyfenozide & decreased the toxicity of spinetoram against 2nd instar larvae of CLW. There are no significant differences between the effects of 10 mg L^{-1} and the 100 mg L^{-1} of ZnO nano-particles on the toxicity of tested insecticides against the 2nd instar larvae of CLW. Results of semi-field studies showed that, ZnO nano-particles at 10 mg L^{-1} increased the residual toxicity of methoxyfenozide and ß-cyfluthrin each alone at 0.5 field rate (FR) or field rate (FR) against the 2nd instar CLW larvae at the two cotton seasons 2015 and 2016. There is no significant difference between residual toxicity of ZnO nano-particles at 10 mg L^{-1} / 0.5 FR methoxyfenozide mixture compared to the methoxyfenozide FR in both seasons. Residual toxicity of ZnO nano-particles at 10 mg L^{-1} / 0.5 FR ß-cufluthrin mixture was also statistically comparable with the results of ß-cufluthrin FR in both seasons. Therefore, results of this study suggest that, ZnO nanoparticles can be used to develop a formulation that reduces the concentration of methoxyfenozide and ß-cufluthrin by 50% in the cotton leafworm control to avoid insecticidal hazards and costs.

Keywords: zinc oxide nanoparticles, spinetoram, ß-cyfluthrin, methoxyfenozide, *Spodoptera littoralis,* residual toxicity.

1.INTRODUCTION

Cotton leafworm (CLW), *Spodoptera littoralis* Boisd., is one of the most important cotton pests which is present during the whole cycle of the crop, requiring several chemical applications to control **(Hatem *et al.*, 2009)**. Therefore, it is relatively more expensive for control of this insect pest, because repeated spraying is necessary. In addition, as a result of the intensive use of insecticides, cotton leafworm has developed resistance against many insecticides groups **(Abo El-Ghar *et al.*, 1986; Abo El-Ghar *et al.*, 2005; Abou-Taleb, 2010)**. For these reasons, development of new formulations and strategies can increase the persistence of insecticides, decreasing the number of required insecticide sprays and combat the resistance development in this insect pest. Persistent insecticides might be preferable to be used against a continuous and heavy infestation of pests like cotton leafworm in cotton fields **(Raha *et al.*, 1993)**.

Using of photo-protective substances or spray adjuvants to increase the residual activity of the insecticides may contribute in reducing the number of the insecticide sprays. Addition of some chemical screen components in the formulation can achieve UV-protection such as acriflavine and methyl green. However, these chemicals have some negative impacts on the natural environment **(Dunkle and Shasha, 1989; Margulies *et al.*, 1988)**. In the recent years, nanoparticles have received much attention as pesticide adjuvants and / or for controlling insects and pathogens attacking agricultural plants. **Jianhui *et al.* (2005)** developed a formulation of dimethomorf using TiO_2/Ag nanomaterials. **Guan *et al.* (2008)** formulated a nano SDS Ag/TiO_2 imidacloprid using chitosan and alginate with properties that could be used for pests control during vegetable production.

In addition, zinc oxide and aluminum oxide nanoparticles were tested against rice weevil **(Keratum *et al.*, 2015)**, silica and silver nanoparticles were highly effective on adults and larvae of cowpea seed beetle **(Rouhani *et al.*, 2013)**, insecticide effect of silver and zinc nanoparticles against *Aphis nerii* was investigated **(Rouhani *et al.*, 2012)**. Therefore, laboratory and semi-field studies were carried out to investigate the effect of zinc oxide nanoparticles on the toxicity of spinetoram, ß-cyfluthrin and methoxyfenozide against the cotton leafworm larvae. These experiments were carried out with the aim to reduce the doses of pesticides and increase their effectiveness.

2.MATERIALS AND METHODS

2.1.Experimental insect: Larvae of cotton leafworm, *S. littoralis,* were obtained from the Plant Protection Research Institute, Cairo. The colony was reared on castor oil leaves under laboratory conditions (27 ±2 °C, RH 65 %) for several years avoiding exposure to any type of pesticides according to the method of **Eldefrawi *et al.* (1964)**. The 2nd instar larvae (2.3 ± 0.1 mg / larva) were used in the bioassay experiments.

2.2.Tested insecticides: Spinetoram (Radiant® %12 SC; field rate is 50 ml/fed.) and methoxyfenozide (Runner 24% SC; field rate is 60 ml / fed (.were obtained from Dow Agrosciences Co. Beta-cyfluthrin (New Blendo® %10 EC; field rate 30 ml / 100 liter water) was obtained from Starchem co. ZnO nano-particles (particle size < 100 nm; 50% WT in water) was obtained from Sigma-Aldrich.

2.3.Laboratory studies: Laboratory studies were carried out to choose the appropriate ZnO nano-particles concentrations to use it in the field experiments. Toxicity of spinetoram, ß-cyfluthrin and methoxyfenozide against the 2nd instar larvae of CLW was studied. The effect of ZnO nano-particles on the toxicity of these insecticides against the 2nd instar larvae of CLW was investigated. Castor oil leaves dipping technique was used according to **Eldefrawi *et al.*, (1964)**. Castor oil leaf discs (5 cm diameter) were cut with a metal punch and dipped in a series of each tested insecticide concentrations solution prepared with distilled water, held vertically to allow excess solution to drop off and then, flattened to dry the test solution. Appropriate numbers of 2nd instar larvae (2.3 ± 0.1 mg / larva) were released on sufficient numbers of discs in an individual plastic cup. Six serial dilutions of each insecticide were used with 4 replications for each concentration. Mortality percentages were corrected according to Abbott equation **(Abbott, 1925)** and subjected to probit analysis **(Finney, 1971)**. LC_{50} and LC_{25} values with their 95% confidence limits were calculated. Effects of ZnO nano-particles at 10 and 100 mg L^{-1} on the toxicity of these insecticides were carried out by mixing the concentration equivalent to each LC_{25} and LC_{50} of each insecticide with each of the two ZnO nano-particles concentrations. There are two groups of control larvae; group one larvae were fed on castor oil leaf discs dipped in distilled water and group two larvae were fed on ZnO nano-particles solutions at 10 and 100 mg L^{-1} with Triton X-100 (0.01 %) as an emulsifier. Larvae were left to feed on the treated leaf discs for 72 hrs at 27 ˚C then, mortality being checked. Mortality percentages caused by the LC_{25} and LC_{50} of each insecticide in presence and without presence of ZnO nano-particles at 10 and 100 mg L^{-1} after 48 and 72 hrs were compared.

2.4.Semi-field Trials: Two field experiments were conducted during 2015 and 2016 summer seasons at AbouElmatameer, El-Behira Governorate. Cotton variety Giza 86 was cultivated at May 4, and May 6, during 2015 and 2016 seasons, respectively. All cultural practices were carried out according to "good agricultural practice". All treatments were assigned to plots in a randomized complete block design. Treatments were each insecticide (ß-cyfluthrin and methoxyfenozide) at the half-field and field recommended rates alone and combined with ZnO nano-particles at 10 mg L^{-1}. Control treatment was sprayed by water only and each treatment was replicated four times. Sprays were carried out once using Knapsack sprayer equipment (CP3) at the rate of 200 liter / fed. at July 27 and 30 during 2015 and 2016, respectively. Cotton leaves from treated and untreated (control) plots were collected from three levels of plants in perforated bags at 0, 1, 3, 6, 9 and 12 days after application and transferred to the laboratory. Two leaves of each sample were placed in a plastic cup containing ten 2nd instar larvae of CLW (enough food for the ten larvae over the 72 hrs). Four replicates were used for each treatment in addition to the control. The experiment was maintained under 27 ˚C and 65 % RH. Mortalities were recorded after 72 hrs of exposure, corrected according to Abbott equation **(Abbott, 1925)**, subjected to analysis of variance (ANOVA) (CoStat Statistical Software, 1990) and difference between treatments were separated by LSD (P = 0.05%).

3.RESULTS

3.1.Toxicity of spinetoram, ß-cyfluthrin and methoxyfenozide against the 2nd instar larvae of CLW:

Laboratory studies were carried out at first to determine the insecticide concentrations which required killing 25 and 50% of treated 2nd CLW larvae (Table 1). Methoxyfenozide was the most toxic against the 2nd instar CLW larvae with LC_{50} value 0.15 mg L^{-1}. Spinetoram achieved the least toxicity against the 2nd instar CLW larvae with LC_{50} value 7.6 mgL^{-1}. The concentrations of methoxyfenozide, ß-cyfluthrin and spinetoram which required killing 25% of the treated 2nd instar CLW larvae are 0.06, 0.44 and 3.7 mg L^{-1}, respectively (Table 1).

Table (1): Toxicity of spinetoram, ß-cyfluthrin and methoxyfenozide against the 2nd instar larvae of *S. littoralis* after 72 hrs of exposure.

Insecticides	LC_{50} (mg L^{-1}) (Confidence limits)	LC_{25} (mg L^{-1}) (Confidence limits)	Slope ± SE*
Spinetoram	7.6 (6.7 - 8.7)	3.7 (3.0 – 4.4)	2.19 ± 0.24
ß-cyfluthrin	0.90 (0.79 -1.02)	0.44 (0.35 – 0.52)	2.16 ± 0.20
Methoxyfenozide	0.15 (0.13 - 0.18)	0.06 (0.05 – 0.07)	1.66 ± 0.13

* SE means standard error

3.2.Effects of ZnO nano-particles on the toxicity of spinetoram, ß-cyfluthrin and methoxyfenozide against 2nd instar larvae of CLW in the laboratory:

Results in Tables (2 and 3) revealed that ZnO nano-particles at 10 and 100 mg L^{-1} significantly increased the toxicity of ß-cyfluthrin and methoxyfenozide & decreased the toxicity of spinetoram against 2nd instar larvae of CLW. The %mortality of CLW 2nd instar larvae increased from 25.3% when methoxyfenozide at concentration equivalent to LC_{25} (0.06 mg L^{-1}) was used alone to 50.3 and 60.3% when it was mixed with 10 and 100 mg L^{-1} of ZnO nano-particles, respectively. While ß-cyfluthrin at LC_{25} alone achieved 25.9% mortality of treated 2nd instar CLW larvae, ß-cyfluthrin at LC_{25} achieved 55.7 and 60.0% mortality of treated larvae when it was mixed with 10 and 100 mg L^{-1} of ZnO nano-particles, respectively (Table 2). The same trend is also recorded with LC_{50} of ß-cyfluthrin and methoxyfenozide (Table 3). Mortality percentages of the CLW 2nd instar larvae caused by the LC_{50} of ß-cyfluthrin alone is increased from 50.4% to 85.8 and 90.4% when the LC_{50} of ß-cyfluthrin was mixed with 10 and 100 mg L^{-1} ZnO nano-particles, respectively. When methoxyfenozide was mixed with ZnO nano-particles at 10 and 100 mg L^{-1} the 2nd instar CLW larvae mortality percentages were 85.0 and 75.1%, respectively, compared to 45.5% mortality in case of methoxyfenozide alone. On the other hand, the mixture of ZnO nano-particles at 10 and 100 mg L^{-1} with both the LC_{25} and LC_{50} resulted in the significant decrease in the toxicity of spintoram against the 2nd instar CLW larvae (Tables 2 and 3).

3.3.Effects of ZnO nano-particles at 10 mg L^{-1} on the toxicity of ß-cyfluthrin and methoxyfenozide against 2nd instar larvae of CLW (Semi-field studies):

Efficacy of ZnO nano-particles on the toxicity of half field rate (0.5FR) and field rate (FR) ß-cyfluthrin and methoxyfenozide against the 2nd instar CLW larvae in a semi-field studies is presented in Tables (4 and 5). Results showed that ZnO nano-particles increased the residual toxicity of both ß-cyfluthrin and methoxyfenozide at the two rates against the 2nd instar larvae of CLW at 2015 and 2016 cotton seasons. Mortality percentages of the CLW 2nd instar larvae which exposed to cotton leaves treated (in the field) by ß-cyfluthrin (FR) only and collected after 0, 1, 3, 6, 9 and 12 days post-treatment were 100.0, 100.0, 92.5, 77.5, 45.0 and 15.0 %, respectively, at 2015, and 100.0, 97.5, 92.5, 75.0, 40.0 and 12.5 %, respectively, at season 2016. When ß-cyfluthrin (FR) / ZnO nano-particles at 10 mg L^{-1} mixture was used these percentages of mortality were 100.0, 100.0, 97.5, 90.0, 75.0 and 52.5%, respectively, at 2015, and 100.0, 100.0, 100.0, 95.0, 80.0 and 62.5%, respectively, at 2016. Zinc oxide nanoparticles also significantly increased and extended the residual toxicity of ß-cyfluthrin at the 0.5FR. Mortality percentages of the CLW 2nd instar larvae which exposed to cotton leaves treated (in the field) by ß-cyfluthrin

Table (2):Effect of ZnO-nanoparticles on the toxicity of spinetoram, ß-cyfluthrin and methoxyfenozide at LC_{25} against the 2nd instar larvae of *S. littoralis* after different exposure times.

Insecticides	Insecticide conc. (mg L^{-1})	ZnO conc. (mg L^{-1})	%Mortality ± SE	
			48 hrs	72 hrs
		-	20.3 ± 2.1 bc	25.6 ± 2.3 c
Spinetoram	3.74	10	5.0 ± 0.4 d	10.0 ± 1.1 d
		100	5.0 ± 0.0 d	5.0 ± 0.2 d
		-	25.6 ± 1.6 b	25.9 ± 2.1 c
ß-Cyfluthrin	0.44	10	50.3 ± 3.1 a	55.7 ± 3.4 ab
		100	55.4 ± 2.6 a	60.0 ± 4.2 a
		-	5.2 ± 0.3 d	25.3 ± 1.3 c
Methoxyfenozide	0.06	10	25.4 ± 2.0 b	50.3 ± 2.6 b
		100	15.5 ± 1.3 c	60.3 ± 3.5 a

Table (3):Effect of ZnO-nanoparticles on the toxicity of spinetoram, ß-cyfluthrin and methoxyfenozide at LC_{50} against the 2nd instar larvae of *S. littoralis* after different exposure times.

Insecticides	Insecticide conc. (mg L^{-1})	ZnO conc. (mg L^{-1})	%Mortality ± SE	
			48 hrs	72 hrs
		-	35.0 ± 2.1 c	45.2 ± 3.2 c
Spinetoram	7.61	10	10.5 ± 1.0 d	20.4 ± 1.5 d
		100	10.5 ± 0.8 d	20.5 ± 1.2 d
		-	50.1 ± 3.7 b	50.4 ± 4.0 c
ß-Cyfluthrin	0.90	10	80.5 ± 5.2 a	85.8 ± 5.3 a
		100	80.2 ± 4.7 a	90.4 ± 4.6 a
		-	15.7 ± 1.3 d	45.5 ± 2.3 c
Methoxyfenozide	0.15	10	35.8 ± 2.0 c	85.0 ± 3.8 a
		100	35.9 ± 3.1 c	75.1 ± 5.1 b

(0.5FR) / 10 mg L^{-1} ZnO nano-particles mixture and collected after 0, 1, 3, 6, 9 and 12 days post-treatment were 100.0, 95.0, 90.0, 75.0, 42.5 and 15.0%, respectively, compared to 100.0, 92.5, 82.5, 55.0, 17.5 and 2.5%, respectively, when ß-cyfluthrin was used alone at 2015. At 2016 cotton season, the %mortality of 2nd instar CLW larvae caused by the ß-cyfluthrin (0.5FR) / 10 mg L^{-1} ZnO nano-particles mixture were 100.0, 95.0, 87.5, 77.5, 50.0 and 27.5%, respectively, compared to 95.0, 85.0, 75.0, 50.0, 12.5 and 2.5%, respectively, when ß-cyfluthrin was used alone after 0, 1, 3, 6, 9 and 12 days post-treatment (Tables 4 and 5).

The residual toxicity of methoxyfenozide at 0.5FR or FR / 10 mg L^{-1} ZnO nano-particles mixture against the 2nd instar CLW larvae is higher than methoxyfenozide alone at the two cotton seasons 2015 and 2016 (Tables 4 and 5). In season 2015, mortality percentages of 2nd Instar CLW larvae results from spraying of methoxyfenozide (FR) alone were 100.0, 95.0, 85.0, 62.5, 35.0 and 5.0%, on days 0, 1, 3, 6, 9 and 12, respectively. These percentages were 100.0, 100.0, 92.5, 85.0, 70.0 and 47.5%, respectively, when methoxyfenozide FR / ZnO nano-particles mixture was used. The mortality percentages of 2nd instar CLW larvae were 100.0, 97.5, 90.0, 72.5, 45.0 and 22.5%, on days 0, 1, 3, 6, 9 and 12 days, respectively, when methoxyfenozide FR was sprayed alone, in 2016 cotton season. Mortality percentages of 2nd instar CLW larvae were 100.0, 100.0, 95.0, 90.0, 75.0 and 55.%, respectively, when methoxyfenozide FR / ZnO nano-particles mixture was used after the same times, respectively in 2016 cotton season. When the methoxyfenozide 0.5 FR / ZnO nano-particles mixture was used, mortality percentages of CLW 2nd instar larvae were 100.0, 95.0, 87.5, 70.0, 47.5 and 30.0% compared to 95.0, 90.0, 77.5, 47.5, 10.0 and 2.5% when methoxyfenozide was sprayed alone, after 0, 1, 3, 6, 9 and 12 days, respectively at 2015. The same trend was recorded in 2016 cotton season, where mortality percentages of CLW 2nd instar larvae were 100.0, 92.5, 85.0, 62.5, 40.0 and 22.5% compared to 90.0, 87.5, 70.0, 35.0, 12.5 and 2.5% when methoxyfenozide was sprayed alone, after 0, 1, 3, 6, 9 and 12 days, respectively. There is no significant difference between results of ZnO nano-particles with the 0.5 FR of methoxyfenozide compared to the methoxyfenozide FR in both seasons. Also, results of ZnO nano-particles with the 0.5 FR alone of ß-cufluthrin mixture were statistically comparable with the results of ß-cufluthrin FR alone.

4.DISCUSSION

Long period of exposure to modern synthetic insecticides has been contributed in variance extents with health problems in humans and other animals. In addition, the enormous application of pesticides leads to pernicious effects on the beneficial organisms. As a result, the chemical control of pests is under increasing pressure

Table (4): Efficacy of ZnO nano-particles at 10 mg L^{-1} on the residual toxicity of ß-cyfluthrin and methoxyfenozide against *S. littoralis* 2nd instar larvae, season 2015.

Insecticides	Rates	%Mortality					
		0-day	1-day	3-days	6-days	9-days	12-days
ß-Cyfluthrin	0.5 FR* alone	100.0 a	92.5 c	82.5 e	55.0 f	17.5 d	2.5 d
	FR alone	100.0 a	100.0 a	92.5 b	77.5 c	45.0 b	15.0 c
	0.5 FR + ZnO	100.0 a	95.0 b	90.0 bc	75.0 cd	42.5 bc	15.0 c
	FR + ZnO	100.0 a	100.0 a	97.5 a	90.0 a	75.0 a	52.5 a
Methoxyfenozide	0.5 FR alone	95.0 b	90.0 d	77.5 f	47.5 g	10.0 d	2.5 d
	FR alone	100.0 a	95.0 b	85.0 de	62.5 e	35.0 d	5.0 d
	0.5 FR + ZnO	100.0 a	95.0 b	87.5 cd	70.0 d	47.5 b	30.0 b
	FR + ZnO	100.0 a	100.0 a	92.5 b	85.0 b	70.0 a	47.5 a

*FR means field rate

Table (5): Efficacy of ZnO nano-particles at 10 mg L^{-1} on the residual toxicity of ß-cyfluthrin and methoxyfenozide against *S. littoralis* 2nd instar larvae, season 2016.

Insecticides	Rates	%Mortality					
		0-day	1-day	3-days	6-days	9-days	12-days
ß-Cyfluthrin	0.5 FR* alone	95.0 b	85.0 d	75.0 e	50.0 d	12.5 d	2.5 d
	FR alone	100.0 a	97.5 ab	92.5 bc	75.0 b	40.0 c	12.5 c
	0.5 FR + ZnO	100.0 a	95.0 bc	87.5 cd	77.5 b	50.0 b	27.5 b
	FR + ZnO	100.0 a	100.0 a	100.0 a	95.0 a	80.0 a	62.5 a
Methoxyfenozide	0.5 FR alone	90.0 c	87.5 d	70.0 e	35.0 e	12.5 d	2.5 d
	FR alone	100.0 a	97.5 ab	90.0 bcd	72.5 b	45.0 bc	22.5 b
	0.5 FR + ZnO	100.0 a	92.5 c	85.0 d	62.5 c	40.0 c	22.5 b
	FR + ZnO	100.0 a	100.0 a	95.0 ab	90.0 a	75.0 a	55.0 a

*FR means field rate

(Kegley and Wise, 1998). The benefits of using pesticide to limit insect's losses cannot be neglected. Therefore, more claims are necessary to develop extra technologies as a promising outlook to reduce the use of pesticides and provides appropriate crop protection for sustainable food, feed and fiber production **(Popp *et al.*, 2013)**. The use of insecticides mixtures is one of the ways to reduce the quantities of insecticides with increasing of its effectiveness **(El-Guindy *et al.*, 1983; Darriet and Corbel, 2006; Abdel Rahman and Abou-Taleb, 2007)**. Recently, the use of nanotechnology in the pesticides formulation can provides one of solutions for the pesticide problems.

In the present study, laboratory and semi-field studies were carried out to investigate the effect of zinc oxide nanoparticles on the toxicity of spinetoram, ß-cyfluthrin and methoxyfenozide against the cotton leafworm larvae. In the laboratory, results revealed that ZnO nano-particles at 10 and 100 mg L^{-1} significantly increased the toxicity of ß-cyfluthrin and methoxyfenozide & decreased the toxicity of spinetoram against 2nd instar larvae of CLW. Approximately, there are no significant differences between the effects of 10 mg L^{-1} and the 100 mg L^{-1} of ZnO nano-particles on the toxicity of tested insecticides against the 2nd instar larvae of CLW. Therefore, spinetoram and the concentration 100 mg L^{-1} of ZnO nano-particles were excluded in the semi-field studies. In the semi-field studies, ZnO nano-particles at 10 mg L^{-1} increased the residual toxicity of methoxyfenozide and ß-cyfluthrin as determined by *S. littoralis* 2nd instar larvae bioassay in 2015 and 2016 seasons. The mixture of ZnO nano-particles with the 0.5 FR of methoxyfenozide or 0.5 FR of ß-cyfluthrin revealed a residual toxicity significantly equal to FR of methoxyfenozide or the FR of ß-cyfluthrin, respectively. Fortunately, **Prasad *et al.*, (2012)** reported the effects of zinc oxide nanoparticles (25 nm) at 1000 ppm concentration promoted the seed germination, seedling vigor and growth of peanut plant.

Numerous studies have used the mineral nanoparticles as insecticides or in the insecticide formulations. **Guan *et al.*, (2008)** improved the biological activities of imidacloprid against *Martianus dermestoides* adults and reduce its residue by using the Ag/TiO_2 nanoparticles. Also, **Rouhani *et al.*, (2012)** recorded that Ag and ZnO nanoparticles can be used as a valuable tool in pest management programs of **A. nerii. Jianhui et al., (2005)** reported the development of such sodium dodecyl sulfate (SDS) modified photocatalytic TiO_2/Ag nanomaterial conjugated with dimethomorph to increase its dispersivity and decomposition in soil while increasing its effectiveness in vegetable seedling. Moreover, **He *et al.*, (2011)** suggest that ZnO nanoparticles could be used as an effective fungicide against *Botrytis cinerea* and *Penicillium expansum* for agricultural and food safety applications.

Finally, the advances in science and technology in several areas made the development of more effective and non-persistent pesticides and new ways of application **(Akelah, 1996)**. In this respect, new types of formulation were developed. One of the most promising is the use of micro and nanotechnology to promote a more efficient assembly of the active compounds in a matrix. The safe and efficient pesticide application methods are essential for controlling the adverse effects of pesticides. On this approach, nanotechnology offers great promises and innovations for more output of safe agrochemicals. Over the last years, several developments were achieved on carrier systems and formulation additives to reduce the concentration of applied pesticides **(Ghormade *et al.*, 2011; Gonzalez *et al.*, 2014)**. Results of our study suggest that, ZnO nanoparticles can be used to develop a formulation that reduces the concentration of methoxyfenozide and ß-cufluthrin by 50% in the cotton leafworm control to avoid insecticidal hazards and costs.

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تداخل حبيبات النانو لأكسيد الزنك مع سمية بعض المبيدات ضد دودة ورق القطن

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قسم بحوث إختبارات المبيدات على آفات القطن ، معهد بحوث وقاية النبات ، مركز البحوث الزراعية ، الصبحية ، الإسكندرية

الملخص العربى

تم إجراء دراسات معملية ونصف حقلية لدراسة تأثير سمية مبيد الاسبينتورام، البيتاسيفلوثرين والميثوكسى فينوزيد وكذلك تأثير حبيبات النانو لأكسيد الزنك على سمية تلك المبيدات ضد يرقات دودة ورق القطن. أوضحت النتائج أن مبيد الميثوكسى فينوزيد أكثر المبيدات من حيث السمية ضد العمر اليرقى الثانى لدودة ورق القطن وكانت قيمة التركيز المطلوب لقتل 50% من اليرقات المعاملة 0.15 مجم/ لتر بينما الاسبينتورام كان الاقل سمية حيث بلغت قيمة التركيز المطلوب لقتل 50% من اليرقات المعاملة 7.6 مجم / لتر. وقد أظهرت نتائج الدراسات المعملية أن حبيبات النانو لأكسيد الزنك عند تركيزات 10 و100 مجم / لتر أدت إلى زيادة معنوية لسمية البيتاسيفلوثرين والميثوكسى فينوزيد وإنخفاض سمية الاسبينتورام ضد العمر اليرقى الثانى لدودة ورق القطن. لا توجد فروق معنوية بين تأثيرات حبيبات النانو لأكسيد الزنك عند تركيزات 10 و100مجم / لتر على سمية المبيدات الحشرية ضد العمر اليرقى الثانى لدودة ورق القطن. أوضحت الدراسات النصف حقلية لحبيبات النانو لأكسيد الزنك عند تركيز 10مجم / لتر زيادة الآثر الباقى لسمية مبيد الميثوكسى فينوزيد والبيتاسيفلوثرين كلا بمفرده عند المعدل النصف حقلى والمعدل الحقلى ضد العمر اليرقى الثانى لدودة ورق القطن خلال الموسمين الزراعيين لمحصول القطن لعام 2015 و2016.

كذلك لا يوجد فروق معنوية لسمية الآثر الباقى لمخلوط حبيبات النانو لأكسيد الزنك عند 10مجم / لتر مع المعدل النصف حقلى لمبيد الميثوكسى فينوزيد أو مبيد البيتاسيفلوثرين بالمقارنة مع المعدل الحقلى لمبيد الميثوكسى فينوزيد أو مبيد البيتاسيفلوثرين منفردا خلال الموسمين الزراعيين. فى ضوء نتائج هذه الدراسة يمكن إقتراح إستخدام حبيبات النانو لأكسيد الزنك فى تطوير صور تجهيزات المبيدات بغرض تقليل تركيزات كلا من مبيد الميثوكسى فينوزيد ومبيد البيتاسيفلوثرين المستخدمة فى عملية مكافحة دودة ورق القطن إلى 50% وذلك لتجنب أضرر المبيدات وتقليل تكلفة المكافحة.