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EFFECT OF NANO-ABAMECTIN IN COMBATING THE TWO-SPOTTED SPIDER MITE TETRANYCHUS URTICAE KOCH (ACARI: TETRANYCHIDAE) UNDER LABORATORY CONDITIONS

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Abstract:

The lethal dose for 50% of the mite community was for abamectin and nanoparticles 100 and 24.5 respectively. As for the concentrations of abamectin used, it was from 20 to 1000 mg/liter, and the death rate was from 11 to 85%. While the concentrations used for nanoparticles was from 10 to 250 mg/L, and the mortality from 13 to 96%. Toxicity index value of nano-abamectin was 25 times compared to the traditional abamectin pesticide. The lethal dose for 50% of the mite community was for abamectin and nanoparticles 812.8 and 228.6 mg/L, respectively. The concentrations of abamectin used was from 40 to 1000 mg/liter, and the death rate from 00.63 to 46.63 %. While the used concentrations for nanoparticles was from 10 to 250 mg/L, and the mortality from 5.00 to 67.7 %. Depending on the toxicity index of the pesticide, the nano-abamectin solution was the most toxic to the egg stage of the mite, where the toxicity index value of nano-abamectin particles was 28 times compared to the traditional abamectin pesticide used.

Keywords: Abamectin, Nano-Abamectin, Spider Mite, Biopesticide, Toxicity Index.

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1. Introduction:

The two spotted spider mite *Tetranychus urticae* Koch (Acari: Tetranychidae), in all agricultural regions in Jordan and most global countries is an important pest on different crops (Al Mommany & Al Antary, 2008; Al Antary & Salem, 2013). Laboratory bioassays were carried out to evaluate the efficacy of pesticides on egg hatchability of the two spotted spider mite selected from different groups (Al Antary & Salem, 2013 ; Al Antary, 1996).

Nanotechnology is one of the applications that has agriculture benefited of these plant protection. The principle of this technology deals with the infinitesimal atoms of any material, and merging them with atoms of other materials, to form a crystal network, known as nanomaterials, which have distinctive properties. It can be applied in the field of precision agriculture and pesticides to increase output (crop yield), reduce inputs (fertilizers, pesticides, etc.) by monitoring climate variables and taking some targeted actions (Huang et al., 2015). To achieve this purpose, Nano sensors and monitors are used, distributed in agricultural fields which monitors the conditions of soil, fertilizers, chemicals, pests, pollutants and water use (Robertson, 2007).

In addition, the state of climatic changes is measured to see if the crops are growing most efficiently, and the nature and location of the local GPS is determined and linked to the problem system and then treated. All this leads to a large agricultural production at low cost, and leads to a reduction in agricultural waste and environmental pollution (AbdEl-Rahman, 2017). Nanotechnology is also included in pesticides, through the production of Nano pesticides, which is one of the most effective way to increase the surface area exposed to the pesticide. Very small granules can cover a large area for controlling some pests and weeds. The residual effect of the pesticide, whether in the soil or plant parts, is transmitted by dependence on humans. Therefore, the use of active substances in very small quantities in the preparation of the pesticide can reduce the remaining quantities (residues) in the environment and food, and thus preserve human health (Danishefskys, 1989). There are many successful experiments for applying nanotechnology in the preparation of pesticides, including abamectin. Avermectins are known as insecticidal compounds and consist of a group of naturally occurring secondary metabolites produced by the soil actinomycete, *Streptomyces avermitilis*. These compounds have proven to be globally important animal health agents and indispensable human medications (Omura et al., 2001). In general, they consist of four closely related major components; A1a, A2a, B1a and B2a and four minor components; A1b, A2b, B1b and B2b, which are lower homologs of the corresponding major components (Danishefskys et al., 1989). However, continuous use of avermectins may lead to the development of resistance in the target species. Thus, this study aims to evaluate the efficiency of nano-emulsion of abamectin 1% EC against *Tetranychus uritcae* Koch mite, in comparison with the conventional used insecticide Vertimec 1.8% EC, to assist in controlling this destructive and common pest in different regions particularly Jordan valley and to avoid pest resistance and to minimize crop commodities from pesticides residues contamination.

Materials and methods

Rearing of two-spotted spider mite

The mites, *T. urticae* used in this study were obtained from our laboratory where they were reared for more than 40 generations on potted bean plant (*Phaseolus vulgaris*) at 25 ± 2 °C and 60 ± 10% RH and 14:10 hours photoperiod (Light:Dark). Fresh plants were supplemented at regular intervals to maintain the culture for experimentation (Abbott, 1925).

Toxicity Test

Nine concentrations ; 20, 50, 100, 150, 200, 400, 600, 800, 1000 ppm were used for conventional insecticide (Vertimec) and nine concentrations; 10, 20, 30, 40, 50, 100, 150, 200 and 250 ppm were used for nano emulsion of abamectin nanoparticles against adult females of T. urticae Koch mite. Five replicates were used for each concentration with ten adults for each. The individuals in treatments were sprayed with insecticide solutions, but control groups were sprayed with distilled water. The individuals of mites were confined on the lower surface of mulberry leaf disks (3 cm in diameter). Mortality was calculated after 24 hour of treatment and corrected according to Abbott's formula (Abbott, 1925).

Ovicide Bioassay (Direct Toxicity to Newly Laid Eggs)

To provide eggs for this test, four adult mite females were transferred to each bean plant (*Phaseolus vulgaris*) leaf disk for 24 hours and then removed. Disks with deposited eggs (24 hours old) were individually immersed in the same concentrations as described above for 30-60 sec. The excess of insecticide solutions was allowed to dry. Three replicates were used for each concentration with100 eggs per each one (replicate). Disks were kept under laboratory conditions as described above. All disks were examined daily for seven days. Egg hatching rate and offspring development were reported daily by counting the numbers of hatched eggs and larvae on the disks.

Statistical Methods

The mortality data recorded was corrected using Abbott's formula (Robertson, 2007), depending upon the mortality in the water sprayed control. The corrected mortalities were then subjected to Probit Analysis (Robertson, 2007) for calculating median lethal concentration values (LC50) for each of the test insecticide. Based on the LC50 values, the relative toxicity of different insecticides were determined.

Results and Discussion

The mortality rates of *T. urticae* Koch adults mites were studied at the various concentrationsas shown in Table 1. Probit analysis indicated that, the LC50 of vertimec, and nano-abamectin was 100 and 24.5mg/L, respectively. For Vertimec in the concentration range (20-1000 mg/L) the induced mortality rates were in the range 11 to 85%, While for nano-abamectin in the concentration range of (10-250 mg/L) the induced mortality rates were ranged from 13 to 96%. Concerning toxicity index at LC50 level, the data confirmed that, solution of nano-abamectin was the most toxic compound to adult female of *T. urticae* mites with index value of 24.5 compared with the conventional insecticide/acaricide Vertimec.

Table 1: Table 1: Mean mortality rates of T.urticae mite after 24 hours to Vertemic and nano-abamectin and their LC50

Treatment	Concentration used mg/L	Mortality rates Mean ± SD	LC_{50} mg/L
Control	Distilled water	01 ± 0.57	
Vertimec 1.8% EC	20	11.0 ± 1.4	100 (95- 195)
	50	33.2 ± 1.3	
	100	47.1 ± 1.1	
	150	53.0 ± 1.3	
	200	67.7± 1.1	
	400	71.0 ± 0.4	
	600	77.0 ± 0.9	
	800	83.0 ± 1.2	
	1000	85.0 ± 1.6	
Nano-abamectin	10	13.0 ± 0.8	24.5 (15.4-27.1)
	20	39.0 ± 1.1	
	30	54.0 ± 1.3	
	40	72.0 ±1.8	
	50	86.0 ± 1.3	
	100	88.0 ± 1.2	
	150	92.0 ± 0.9	
	200	94.0 ± 0.6	
	250	96.0 ± 0.4	

The results of this study revealed that, some concentrations of abamectin in nano-formulation affected mite population greater than vertimec. This finding could be attributed to the nano scale which has the ability to be more stable, penetrate more, and has good sticking ability with the treated surface resulting in more efficiency and residual effects (Gavanji et al., 2013). For example, Abd El-Rahman (2017) found that, nano-particles of abamectin benzoate were the most toxic compound to adult females of *T. urticae* mite with LC50 (0.006 mg/L) compared with methomyl 90% which exhibited LC50 (89.54 mg/L) with toxicity index 0.09. In fact, prepared insecticides in nano-form enhance their stability on treated plants and become more potent. For example avermectin-grafted-N,O-carboxymethyl chitosan was more effective against carmine spider mites than avermectin technical material (Li Qin et al., 2016). The residual rate of the conjugate was 11.22%, while the residual rate of the avermectin technical material was 0.2%. The bounded groups may increase photostability of the compound and work as an antioxidant which captures the hydroxyl radical in the aqueous solution (Guo et al., 2008). Spraying of these concentrations of vertimec and/or nano-abamectin reduced the mite's fecundity compared to the water sprayed control group which exhibited hatching rate of 98.50%. Vertimec treatments reduced the hatching of eggs at percentages ranged from 0.63 to 46.63% with LC50 value of 812.8mg/L (Table 2). On the other hand, nano-abamectin reduced the hatching of eggs at percentages ranged from 5.00 to 67.70% with LC50 value; 228.6mg/L.

Table 2: Egg hatching % after direct spraying of newly laid T.urticae eggs with Vertemic and nano-abamectin.

Several investigations stated that, abamectin's forms or derivatives are more potent to reduced female fecundity of mites. For example, Ismail et al. (2007) found that abamectin significantly reduced female fecundity and killed offspring when applied directly on the egg of *T. urticae* mite.

Treatment	Concentration used mg/L	Hatching %	LC_{50} mg/L
Control	Distilled water	98.5 ± 1.3	
Vertimec 1.8% EC	20	46.6 ± 0.6	812.8 (683-1.043)
	50	40.9 ± 0.6	
	100	35.1± 0.9	
	150	29.4 ± 0.4	
	200	23.6 ± 1.3	
	400	17.9 ± 1.2	
	600	12.1 ± 1.2	
	800	6.4 ± 1.3	
	1000	00.6 ± 0.0	
Nano-abamectin	10	67.7 ± 0.5	228.6 (212.8-251.8)
	20	54.3 ± 0.8	
	30	49.1 ± 0.4	
	40	37.8 ± 0.9	
	50	31.0 ± 1.9	
	100	28.0 ± 0.9	
	150	16.0 ±1.1	
	200	10.0 ± 0.8	
	250	5.0 ± 0.9	

The data of the present study are in accordance with those obtained by Abd El-Rahman (2017), where nano particles of abamectin benzoate were very effective on egg deposition and in reducing mite fecundity by 82.24%. However, common solution of abamectin benzoate was less effective on egg hatchability (35%). Based on present observations, these effects could be caused by residual toxicity of nano-formulation on survival of the mites.

Although low applied concentrations of nano-abamectin induced very toxic effects, further investigations may be demonstrated on predators to provide an adequate indication for selectivity of insecticide/acaricide which is essential for development of pest management programs (Jeppson et al., 1975).

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References

Al Antary T.M. (1996). Pesticides and Toxicity. Al Quds Al Mftuha University Publications, Amman. 443 pp.

Al Antary T.M. & Salem I. (2013). Effects of three acaricides on egg hatchability of three populations of the two spotted spider mite *Tetranychus urticae* Koch (Acari: Tetranchidae). *Jordan J. of Agr. Sci.* ***9*** **(1)**, 343-350.

Abd El-Rahman H.A. (2017). Efficiency comparison of some compounds and their nano-particles against certain mite and its predator in laboratory and field. *Egypt. Acad. J. Biol. Sci. 9*, 47- 59.

Abbott W.W. (1925). A method of computing the effectiveness of an insecticide. *J. Econ. Entomol.* ***1*,** 265-266.

Al Mommany A. & Al Antary T.M. (2008). Pests of Garden and Home. Dar Al Arabiyah for Publication and Distribution. pp 518.

Danishefskys J., Armistead D.M., Wincott F.E., Selnick H.G., & Hungate R. (1989). The total synthesis of avermectin-A1A. *J. Am. Chem. Soc.* ***111***, 2967-2980.

Gavanji S., Larki B. & Mehrasa M. (2013). A review of effects of molecular mechanism of silver nanoparticles on some microorganism and Eukaryotic cells. *Tech. J. Engineer. Appl. Sci.* ***3***, 48-58.

Guo Z.Y., Xing R.E., Liu S., Zhong Z.M. & Li P. (2008). Synthesis and hydroxyl radicals scavenging activity of quaternized carboxymethyl chitosan. *Carbohyd. Poly.* ***73***, 173 -177.

Huang S., Wang L., Liu L., Hou Y. & Li L. (2015) .Nanotechnology in agriculture, livestock, and aquaculture in China. A review. *Agronomy for Sustainable Development* ***35***,369-400.

Ismail M., El Naggar M., Soliman M. & Ghallab M. (2007). Ecological studies on the two spotted spider mite *Tetranychus urticae* Koch and its predators .*Egyption Journal of Natural Toxins* ***4*****(2),** 26-44.

Jeppson L.R., Mcmurtry J.A., Mead D.W., Jesser M.J. & Johnson H.G. (1975).Toxicity of citrus pesticides to some predacious phytoseiid mites. *J. Econ. Entomol.* ***68***, 707-710.

Li Y., Qin,Y., Liu S., Xing R., Yu H., Li K & Li P. (2016). Preparation, characterization an insecticidal activity of avermectin grafted carboxymethyl chitosan. *BioMed Res. Int.* 8 pages. https://doi.org/10.1155/2016/9805675

Omura S., Ikeda H., Ishikawa J., Hanamato A., Takahashi C. & Shinose M. (2001). Sequence of an industrial microorganism Streptomyces avermitilis: Reducing the ability of producing secondary metabolites. *Proc. Natl. Acad. Sci.* USA ***98***, 12215-12220.

Robertson J.I., Russell R.M., Preisler H.K. & Savin N.E. (2007). Bioassays with Arthropods. CRC Press, Boca Raton. pp 250.