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Synthesis and Characterization of the Nanoemulsion Formulations of some Insecticides and their Evaluation against the Green Peach Aphid, *Myzus persicae* (Sulzer) (Homoptera: Aphididae)

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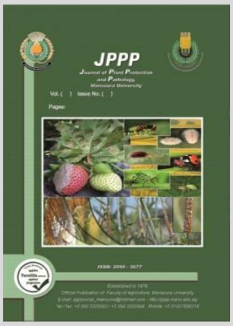

ABSTRACT

This study investigates the synthesis, characterization, and efficacy of nanoemulsions formulated from four insecticides i. e., acetamiprid, alpha-cypermethrin, malathion, and abamectin against the green peach aphid, *Myzus persicae*. The droplet sizes of the nanoemulsions were found to be within the ideal nanometric size range (111.52 nm for acetamiprid, 84.32 nm for alpha-cypermethrin, 94.35 nm for malathion, and 56.43 nm for abamectin), enhancing their surface area and bioavailability. The polydispersity indices (PDI) of the formulations indicated high monodispersity, with values less than 0.3, ensuring uniformity in droplet size distribution. The viscosity measurements confirmed the suitability of the nanoemulsions for agricultural application, with low values facilitating easy spraying and uniform coverage. Stability tests showed no signs of phase separation or degradation under extreme conditions, and zeta potential values indicated the formulations' stability. Toxicity testing in laboratory bioassays revealed a significant enhancement in insecticidal activity when nanoemulsions were compared to conventional formulations. After 24 hours, LC_{50} values for nanoemulsions of acetamiprid, alpha-cypermethrin, malathion, and abamectin were 1.37-, 1.49-, 1.38-, and 1.27-fold lower, respectively, than their normal counterparts. After 48 hours, these values decreased further, with nanoemulsions achieving 1.28- to 1.48-fold increases in toxicity. Field trials also demonstrated the superior performance of nanoemulsions, with acetamiprid showing the highest reduction in *M. persicae* populations, followed by abamectin, malathion, and alpha-cypermethrin. These findings highlight the potential of nanoemulsion formulations to significantly improve the efficacy of insecticides, offering a promising strategy for integrated pest management with minimal environmental impact.

***Keywords*: *Myzus persicae*, acetamiprid, alpha-cypermethrin, abamectin, malathion nanoemulsion.**

INTRODUCTION

The global use of pesticides has escalated significantly, with an estimated 4.6 million tons applied annually. However, a substantial portion (exceeding 90%) of these pesticides fails to reach their intended targets, instead being lost to the environment through processes like volatilization and runoff (Ghormade *et al.*, 2011; Perlatti *et al.*, 2013). This inefficiency has led to severe challenges, including the development of pest resistance, contamination of ecosystems, and potential risks to human health (Dawkar *et al.*, 2013; Kohler *et al.*, 2013; Talebi *et al.*, 2011). Addressing these issues necessitates innovative solutions, among which nanotechnology has emerged as a promising approach. By leveraging the unique properties of nanomaterials, it is possible to develop smart, nano-based pesticides that offer enhanced efficacy and environmental safety (Hamburg *et al.*, 2012; Morris *et al.*, 2011; Scott *et al.*, 2012). The application of nanotechnology in agriculture has gained considerable attention for its potential to overcome limitations associated with conventional pesticide formulations. Advanced nano-based formulations exhibit several advantages: they enhance stability under various spray conditions, improve penetration and targeted delivery, extend the duration of effectiveness, and reduce environmental runoff. Such benefits make these formulations a significant breakthrough in pest management (Ghormade *et al.*, 2011; Smith *et al.*, 2008; Observatory NANO, 2010). Nanopesticides can be created either by converting active ingredients into nanosized particles or by incorporating them into nanocarrier systems for controlled release (Ghormade *et al.*, 2011). Common types of nanoformulations include nanoemulsions, nanocapsules, nanospheres, nanosuspensions, solid lipid nanoparticles, mesoporous materials, and nanoclays (Elsharkawy, 2020). Among these, nanoemulsions have garnered considerable interest due to their versatility and wide range of applications. A nanoemulsion typically consists of an oil phase dispersed in water with the aid of surfactants, forming a stable and efficient delivery system. These systems not only enhance the solubility of hydrophobic pesticides but also facilitate their controlled and targeted release, thereby maximizing their pesticidal activity while minimizing environmental contamination (Salim *et al.*, 2011). One of the critical agricultural pests is the green peach aphid, *Myzus persicae* (Sulzer) (Hemiptera: Aphididae). This highly polyphagous insect poses a significant threat to various crops, including fruit trees, vegetables, and ornamental plants. It has been reported to infest nearly 400 plant species across diverse families, causing extensive economic losses through direct feeding damage and as a vector for plant viruses. Effective management of *M. persicae* remains a challenge due to its rapid reproduction, adaptability, and resistance to many conventional insecticides (Verdugo *et al.*, 2016; and Darwish

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and Attia, 2017). In light of these challenges, this study aims to develop and characterize nanoemulsions of four commonly used insecticides: acetamiprid, alpha-cypermethrin, abamectin, and malathion. The study further seeks to compare the biotoxicity of these insecticides in their conventional formulations versus their nanoemulsion counterparts against *M. persicae* under both laboratory and field conditions. By exploring the efficacy of these advanced formulations, this research contributes to the development of safer and more sustainable pest management strategies.

MATERIALS AND METHODS

The tested insecticides

Acetamiprid (Neonicotinoids), Gentraceta 10% EC, provided by Qingdao KYX Chemicals Co. (25 ml/100 L).

Alpha-cypermethrin (Synthetic pyrethroid), Alpha-zd 10 % EC, provided by Kafr El Zayat Pesticides and Chemicals Co. (250 mL/100 L)

Malathion (Organophosphates), Malason 57% EC, provided by Kafr El Zayat Pesticides and Chemicals Co (400 ml/100 L)

Abamectin (Biopesticide), Abamectin 1.8% EC, provided by Syngenta Co. (40 /100 L.)

Preparation of insecticide nanoemulsions

The nanoemulsions of the four insecticides were prepared by the procedure previously reported by Badawy *et al.*, 2017 as follows:

1. **Preparation of the Oil Phase:** Each insecticide was dissolved in a mixture of toluene and butanol in a 1:1 ratio, which served as a common solvent for the oil phase.
2. **Addition of the Oil Phase to the Aqueous Phase:** The oil phase was gradually added to the aqueous phase (consisting of water and Tween 80) while stirring at 4000 rpm for 30 minutes.
3. **Sonication:** The resulting emulsions were subjected to sonication for 20 minutes at a frequency of 10 kHz and 9 cycles per second using an ultrasonic homogenizer. The temperature was monitored to ensure that the difference between the initial and final emulsion temperatures did not exceed 25°C. (Badawy *et al.*, 2017).

Characterization of insecticide nanoemulsions

Centrifugation Test: The samples were centrifuged at 5000 rpm for 30 minutes to observe any phase separation, creaming, or cracking.

Freeze-thaw cycling: The nanoemulsions were subjected to rapid temperature fluctuations to assess their stability under extreme conditions. The samples were stored at -21°C for 24 hours, then at 21°C until completely thawed for an additional 24 hours, with any layer separation being noted (Kadhim and Abbas, 2015).

Heating cooling test: The nanoemulsions were exposed to two different temperatures (4°C and 40°C) for 48 hours each. Nanoemulsions that demonstrated stability under these conditions were selected for further analysis (Kadhim and Abbas, 2015).

Viscosity Measurement: The dynamic viscosity of the nanoemulsions was measured using a digital viscometer at 200 rpm and 25°C. The results were expressed in millipascal-seconds (mPa.s).

pH Measurement: The pH values of the nanoemulsions were determined using a digital pH meter

Particle Size and Polydispersity Index (PDI): The average droplet size of the nanoemulsions was determined using the dynamic light scattering (DLS) method at room temperature. Samples were diluted to 10% with deionized water before measurement. The droplet size was expressed in nanometers, and PDI values below 0.25 indicated a narrow size distribution and good stability of the nanoemulsions. (Sobhani *et al.*, 2015; Su *et al.*, 2017).

Laboratory application

Toxicity testing was conducted on Alpha-zd 10% EC (alpha-cypermethrin), Gentraceta 10% EC (acetamiprid), Abamactin 1.8% EC (avermectin), Malason 57% EC (malathion), and their respective nanoemulsions against the green peach aphid, *M. persicae*. Prior to the test, colonies of M. persicae were collected from an unsprayed potato farm in the Nubaria district, Beheira Governorate, and were maintained for two generations in plastic jars on potato leaves at 25±2°C and 65±5% RH. Potato leaf discs were cut, immersed in serial dilutions of insecticides for thirty seconds, air-dried for one hour, and then placed adaxial side down on a bed of 2% agar-gel in 10 cm diameter plastic petri dishes, covered with muslin for ventilation. Control leaf discs were dipped in water only for 30 seconds. Another control group was treated only with the nanoemulsion additives. Approximately ten adult aphids were transferred onto the treated leaf discs using a suitable brush. Results were recorded after 24 and 48 hours from application at 25±2°C with a 14:10 h light:dark photoperiod. Any movement from the aphid was considered alive during the counting process. Mortality percentages were corrected according to Abbott (1925). The slope, LC_{25}, LC_{50}, and LC_{90} values (at 95% confidence limits) for each insecticide were calculated according to Finney (1971) using LdP-line, Ehab software (http://www.ehabsoft.com/ldpline/). The toxicity index and relative potency were calculated according to Sun (1950).

Field application

A field experiment was conducted during the summer potato growing seasons of 2022 and 2023 in the Nubaria district, Beheira Governorate, Egypt. The study evaluated the effectiveness of various insecticides and their nanoemulsions (eight treatments) against *Myzus persicae* on potato plants. The experimental area of approximately 2200 m² was divided into 36 plots, each covering around 60 m². Four plots were assigned to each treatment, with an additional four control plots. The treatments were applied in April of both years. For each plot, ten leaves were randomly selected, and the number of live *M. persicae* individuals was counted before treatment and then at intervals of 1, 4, 7, and 14 days post-treatment. The reduction in *M. persicae* populations was calculated using the Henderson and Tilton (1955) equation:

$$\% \text{ Reduction} = 100 \times [1 - (Ta \times Cb / Tb \times Ca)]$$

Where:

Cb = mean No. of *M. persicae* in control plots before application
Ta = mean No. of *M. persicae* in treatment plots after application
Ca = mean No. of *M. persicae* in control plots after application
Tb = mean No. of *M. persicae* in treatment plots before application

Data were analyzed using one-way analysis of variance (ANOVA) within a Randomized Complete Block Design (F-test). The least significant differences (LSD) at a 5% probability level were calculated to compare and differentiate the means between the treated and control plots using SAS statistical software (1999).

RESULTS AND DISCUSSION

Characterization of the prepared nanoemulsions

As illustrated in Table 1 and Figure 1, the droplet sizes of acetamiprid, alpha-cypermethrin, malathion, and abamectin were approximately 111.52, 84.32, 94.35, and 56.43 nm, respectively. These findings confirm that all the synthesized nanoemulsions fall within the ideal nanometric size range, as defined by Sadurní *et al.* (2005). Nanoemulsions within this size range are particularly effective due to their increased surface area, which enhances the bioavailability and penetration of active ingredients. This characteristic is especially relevant for targeting insects like *M. persicae*, which possess a waxy cuticle that can impede the efficacy of conventional formulations.

Table 1. Characterization of nanoemulsions formulations of acetamiprid, alpha-cypermethrin, malathion and abamectin

Pesticides	Acetamiprid	Alpha-cypermethrin	Malathion	Abamectin
Viscosity (mPa.s.) ± SD	3.59	2.21	3.83	3.66
pH ± SD	6.02	6.17	6.43	6.18
Droplet size (nm)	111.52	84.32	94.35	56.43
PDI (nm)	0.23	0.29	0.26	0.22
Zeta potential	-26.2	-30.2	-28.53	-22.19
Centrifugation at 5000 rpm	√	√	√	√
Freeze thaw cycles	√	√	√	√
Heating-cooling cycle	√	√	√	√

√ = the nanoemulsion formulation is stable

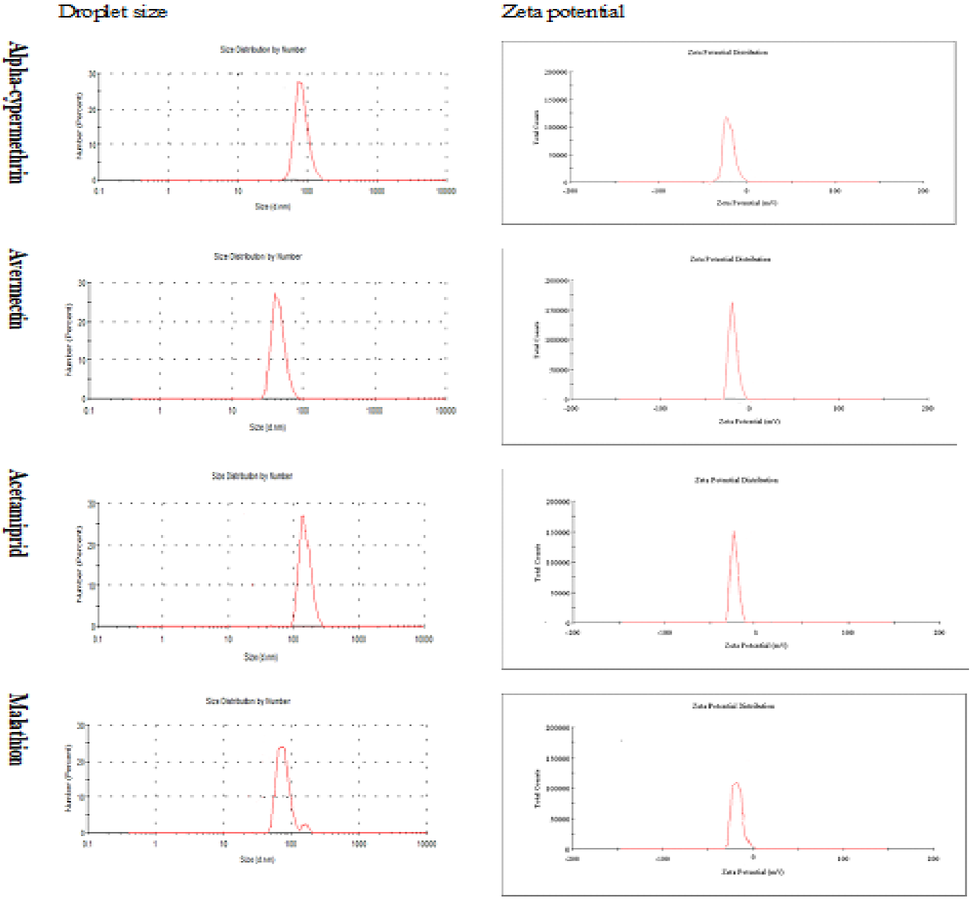

Fig. 1. Droplet size and zeta potential values of alpha-cypermethrin, abamectin, acetamiprid and malathion nanoemulsions

In addition to droplet size, the nanoemulsions demonstrated uniform size distributions, as evidenced by their polydispersity indices (PDI). The PDI values for acetamiprid, alpha-cypermethrin, malathion, and abamectin nanoemulsions were approximately 0.29, 0.22, 0.26, and 0.23, respectively. These values indicate a high degree of monodispersity and homogeneity, with PDI values <0.3 representing a stable system. Baboota *et al.* (2007) emphasized that a PDI below 0.3 is indicative of a uniform droplet size distribution, which is crucial for achieving consistent performance in field applications. Furthermore, formulations with high homogeneity can reduce the risk of uneven deposition during spraying, leading to more effective pest control.

The viscosity of the nanoemulsions was also evaluated to determine their suitability for agricultural use. The recorded viscosities for acetamiprid, alpha-cypermethrin, malathion, and abamectin nanoemulsions were 3.59, 2.21, 3.83, and 3.66 mPa.s, respectively. These low viscosity values are advantageous for practical applications, as they enable easy spraying and ensure uniform coverage of target surfaces.

Additionally, the low viscosity minimizes the risk of clogging in spray equipment, which is a common issue with conventional formulations.

Stability is a critical parameter for nanoemulsion formulations, as it directly impacts their shelf life and field performance. The stability of the synthesized nanoemulsions was assessed through pH measurements and physical observations. The pH values for acetamiprid, alpha-cypermethrin, malathion, and abamectin nanoemulsions were 6.02, 6.17, 6.43, and 6.18, respectively. These values fall within the optimal range for maintaining the stability and efficacy of the active ingredients. Additionally, there were no signs of phase separation, cracking, or creaming after subjecting the nanoemulsions to centrifugation at 5000 rpm, freeze-thaw cycles, and heating-cooling cycles. Such stability under extreme conditions underscores the robustness of the formulations, making them suitable for storage and transportation.

The zeta potential values of the nanoemulsions were -26.2, -30.2, -28.53, and -22.19 mV for acetamiprid, alpha-cypermethrin, malathion, and abamectin, respectively. Zeta potential serves as a key indicator of the stability of colloidal systems. Das *et al*. (2012) highlighted that formulations with zeta potential values exceeding ±20 mV are generally stable due to the strong electrostatic repulsion between particles, which prevents aggregation. The current zeta potential values confirm the high stability of the nanoemulsions, ensuring their effectiveness over extended periods. Prasetiowati *et al*. (2018) further supported that zeta potential values greater than ±20 mV are indicative of stable systems, reinforcing the reliability of these formulations for practical use.

Laboratory evaluation of the tested insecticides against *M. persicae*

The efficacy of the nanoemulsion formulations was evaluated against *M. persicae* through laboratory bioassays as illustrated in Tables 2 and 3 and Figure 2. Results demonstrated a significant enhancement in toxicity when the insecticides were formulated as nanoemulsions. After 24 hours of exposure (Table 2), the LC_{50} values for alpha-cypermethrin, acetamiprid, abamectin, and malathion in their normal formulations were 47.349, 11.858, 25.121, and 51.401 mg/L, respectively. In contrast, the corresponding LC_{50} values for their nanoemulsion formulations were 34.788, 7.511, 12.849, and 31.679 mg/L, indicating a 1.27-, 1.37-, 1.49-, and 1.38-fold increase in toxicity, respectively.

The enhanced toxicity of the nanoemulsions can be attributed to their improved penetration and bioavailability, resulting from their small droplet size and uniform distribution. Nanoemulsions enable more efficient delivery of active ingredients to target sites, overcoming barriers such as the insect cuticle and waxy surfaces of plants.

After 48 hours of exposure (Table 3), the toxicity of the nanoemulsions was further amplified. The LC_{50} values for alpha-cypermethrin, acetamiprid, abamectin, and malathion in their normal formulations were 20.772, 6.127, 7.984, and 22.09 mg/L, respectively. In comparison, the LC_{50} values for the nanoemulsion formulations were 13.231, 4.407, 4.55, and 11.429 mg/L, reflecting a 1.36-, 1.28-, 1.43-, and 1.48-fold increase in toxicity, respectively.

Table 2. Acute contact toxicity of alpha-cypermethrin, acetamiprid, abamectin and malathion against the green peach aphid, *Myzus persicae* (Sulzer) after 24 hr. from exposure time under laboratory conditions

Treatments	Normal formulation							Nanoemulsion formulations						
	LC	Values	Confidence limits Lower	Confidence limits Upper	Slope	X^2	TI	LC	Confidence limits Lower	Confidence limits Upper	Slope	X^2	TI	RP
Alpha-cypermethrin (mg/l a. i.)	LC_{25}	13.271	6.81	20.025				8.43	2.693	13.959				
	$1C_{50}$	47.349	31.724	96.753	1.221 ±0.287	2.589	25.04	34.788	22.689	65.673	1.096 ±0.268	0.982	21.59	0.27
	LC_{90}	530.831	195.185	7236.556				514.174	180.52	8980.66				
Acetamiprid (mg/l a. i.)	LC_{25}	5.321	2.887	7.362				4.096	2.486	5.497				
	LC_{50}	11.858	8.936	15.251	1.938 ±0.367	2.777	100	7.511	5.625	9.243	2.61 ±0.397	1.279	100	0.37
	LC_{90}	54.365	35.022	132.872				23.781	18.521	35.552				
Abamectin (mg/l a. i.)	LC_{25}	5.806	1.403	10.415				3.689	1.001	6.745				
	$1C_{50}$	25.121	15.573	42.285	1.06 ±0.26	0.756	47.2	12.849	7.16	18.886	1.244 ±0.26	0.597	58.46	0.49
	LC_{90}	406.279	150.32	6083.837				137.636	72.941	551.514				
Malathion (mg/l a. i.)	LC_{25}	13.984	6.379	21.215				6.987	1.743	12.26				
	$1C_{50}$	51.401	33.709	116.345	1.193±0.29	2.859	23.07	31.679	20.001	60.452	1.027±0.263	0.698	23.71	0.38
	LC_{90}	609.779	209.38	11236.4				559.96	183.662	14080.2				

Toxicity index (TI) = (LC_{50} of the most efficient pesticide (Acetamiprid)/ LC_{50} of the tested pesticide)×100, (Sun, 1950) X^2 = chi-square, tabulated X^2=6
Relative potency (RP) = (LC_{50} of conventional formulation – LC_{50} of Nanoemulsion formulation)/LC_{50} of conventional formulation

Table 3. Acute contact toxicity of alpha-cypermethrin, acetamiprid, abamectin and malathion against the green peach aphid, *Myzus persicae* (Sulzer) after 48 hr. from exposure time under laboratory conditions

Treatments	Normal formulation							Nanoemulsion formulations						
	LC	Values	Confidence limits Lower	Confidence limits Upper	Slope	X^2	TI	LC values	Confidence limits Lower	Confidence limits Upper	Slope	X^2	TI	RP
Alpha-cypermethrin (mg/l a. i.)	LC_{25}	7.027	3.094	10.871				4.542	1.751	7.48				
	LC_{50}	20.772	14.209	29.241	1.433 ±0.271	2.32	29.5	13.231	8.24	18.534	1.453±0.267	4.765	33.31	0.36
	LC_{90}	162.84	89.501	550.692				100.891	60.69	267.772				
Acetamiprid (mg/l a. i.)	LC_{25}	3.015	1.061	4.558				2.153	0.473	3.617				
	LC_{50}	6.127	3.763	7.795	2.19 ±0.528	0.611	100	4.407	1.98	6.092	2.167±0.571	0.0093	100	0.28
	LC_{90}	12.452	16.189	59.491				17.198	12.307	40.106				
Abamectin (mg/l a. i.)	LC_{25}	2.385	0.536	4.722				1.354	0.19	3.116				
	LC_{50}	7.984	3.716	12.224	1.285 ±0.265	2.047	76.74	4.55	1.487	7.751	1.281±0.28	2.646	96.86	0.43
	LC_{90}	79.303	46.718	234.44				45.521	28.379	113.995				
Malathion (mg/l a. i.)	LC_{25}	7.602	3.486	11.58				4	1.502	6.683				
	LC_{50}	22.099	15.348	31.104	1.455 ±0.274	1.809	27.73	11.429	6.898	16.093	1.479±0.268	4.422	38.56	0.48
	LC_{90}	167.877	92.324	564.903				84.037	52.238	204.315				

Toxicity index (TI) = (LC_{50} of the most efficient pesticide (Acetamiprid)/ LC_{50} of the tested pesticide)×100, (Sun, 1950)X^2 = chi-square, tabulated X^2=6
Relative potency (RP) = (LC_{50} of conventional formulation – LC_{50} of Nanoemulsion formulation)/LC_{50} of conventional formulation

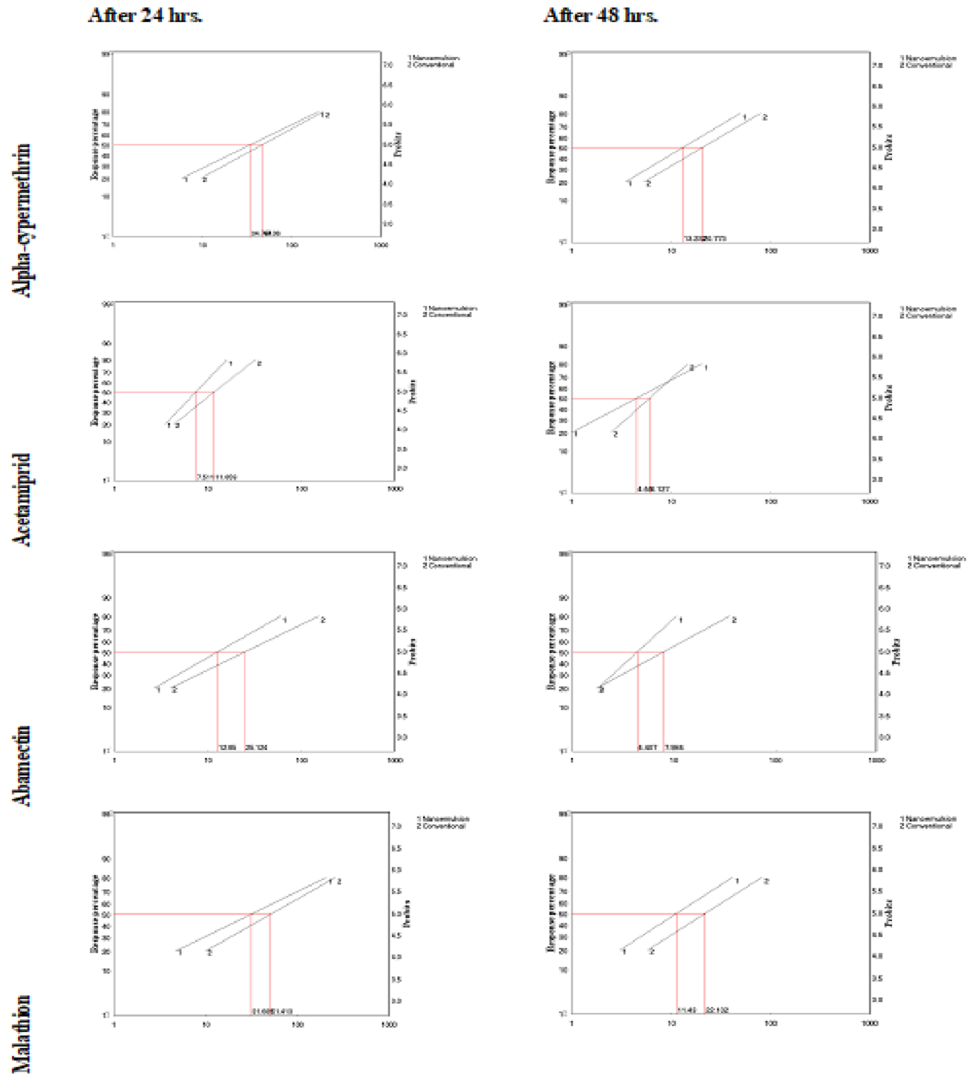

Fig. 2. Toxicity lines and LC_{50} values of abamectin, acetamiprid, alpha-cypermethrin, and malathion in conventional and nanoemulsion formulations against the green peach aphid

The toxicity index, which compares the efficacy of the tested insecticides relative to the most effective one, also highlighted the superior performance of the nanoemulsions. For example, when acetamiprid was used as a reference, the toxicity indices for abamectin and alpha-cypermethrin nanoemulsions were 33.31% and 96.86%, respectively, compared to 29.5% and 76.74% for their normal formulations. These findings underscore the potential of nanoemulsions to enhance the relative effectiveness of insecticides, providing a valuable tool for integrated pest management (IPM) strategies.

The present results align with the findings of Barakat *et al*. (2023), who demonstrated that nanoformulations of acetamiprid and dinotefuran exhibited significantly lower LC_{50} values against *Aphis craccivora* and *Bemisia tabaci* compared to their conventional counterparts. This consistency highlights the broader applicability of nanoemulsion technology for enhancing the efficacy of various insecticides across different pest species.

Field evaluation of the tested insecticides against *M. persicae*

Results presented in Tables (4-5) indicate that the tested insecticides varied in their efficiency against *M. persicae* depending on the type of formulation and the day after application. In the 1st season of 2022, acetamiprid was significantly the most effective insecticide in comparison with the others, causing a 90.12% reduction in the nanoemulsion formulation and an 84.5% reduction in the synthetic formulation. Abamectin followed with a moderate reduction of 82.07% in the nanoemulsion formulation and 77.96% in the synthetic formulation. In the 3rd rank was malathion, achieving about 71.56% and 83.33% reduction as general means for the synthetic and nanoemulsion formulations, respectively. Alpha-cypermethrin proved to be the least effective insecticide, recording a 79.05% reduction in the nanoemulsion formulation and a 70.09% reduction in the synthetic formulation.

In the 2nd season of 2023, the nanoemulsion formulations showed higher effectiveness, with general means of reduction percentages recorded at 92.61%, 85.43%, 74.79%, and 76.61% for acetamiprid, abamectin, alpha-cypermethrin, and malathion, respectively. Meanwhile, the normal formulations recorded 83.58%, 80.39%, 67.92%, and 68.77% for acetamiprid, abamectin, alpha-cypermethrin, and malathion, respectively. These results clearly demonstrate that the preparation of nanoemulsion formulations of the tested insecticides significantly enhanced their effectiveness. Notably, the highest increases in effectiveness were observed with malathion and alpha-cypermethrin.

The current findings align with those reported by Javed *et al*. (2016), who evaluated the efficacy of six insecticides, including acetamiprid, diafenthiuron, imidacloprid, thiacloprid, bifenthrin, and plenum, against green peach aphids under field conditions on peach trees. Their study highlighted that Mospilon® (acetamiprid) was the most effective insecticide in managing *M. persicae*. Similarly, Khan *et al*. (2011) reported that imidacloprid and thiamethoxam achieved significant reductions in *M. persicae* populations under field conditions, recording suppression rates of 74.92% and 67.79%, respectively. Furthermore, the findings are consistent with those of Raqib *et al*. (2007), who demonstrated the successful management of *M. persicae* populations using various insecticides, with acetamiprid outperforming the others in effectiveness.

These observations emphasize the importance of adopting nanoemulsion formulations to enhance the efficacy of insecticides. Nanoemulsion technology offers a promising approach to achieving better control of *M. persicae*, particularly in agricultural systems requiring high efficiency and minimal environmental impact. Acetamiprid, in particular, continues to demonstrate superior performance, making it a valuable tool in integrated pest management programs targeting *M. persicae.*

Table 4. The reduction percentages of the population of green peach aphids, *M. persicae* after 1, 4, 7 and 14 days from the treatment with the nanoemulsion and normal formulations of acetamiprid, abamectin, alpha-cypermethrin and malathion during 2022 season under open field conditions:

Pesticides		*Before spray	After one day		After four days		After 7 days		After two weeks		General means of Reduction percentages %
			*No.	**Reduction percentages %	*No.	**Reduction percentages %	*No.	**Reduction percentages %	*No.	**Reduction percentages%	
Control		25.5	28.75		32.5		46.25		51.25		
Acetamiprid	Normal	28	6	81.07±1.81^{bc}	4.75	86.8±1.91^{ab}	6.5	87.18±2.24^{ab}	9.5	82.96±3.56^{b}	84.5±3.47^{b}
	Nano	28.75	3.5	88.93±3.32^{a}	3.75	89.97±1.06^{a}	4	92.18±2.43^{a}	6	89.42±2.71^{a}	90.12±2.59^{a}
Abamectin	Normal	27.25	5.25	82.69±4.35^{ab}	7.25	79.08±2.96^{c}	11.75	75.72±6.36^{c}	14	74.34±3.45^{cd}	77.96±5.21c
	Nano	27	5	83.35±4.32^{ab}	6	82.21±4.88^{bc}	7.5	84.57±2.96^{b}	11.75	78.13±4.05^{bc}	82.07±4.45^{b}
alpha-cypermethrin	Normal	23.25	8.5	67.35±4.45^{e}	8.25	71.99±3.63^{d}	11.25	73.31±2.7^{c}	15	67.7±4.33^{e}	70.09±4.37^{d}
	Nano	26.75	7.25	75.71±5.8^{cd}	6.25	78.72±2.29^{c}	8	81.8±2.37^{b}	10.75	79.96±2.14^{b}	79.05±3.88^{c}
Malathion	Normal	25.25	8.5	69.95±5.63^{de}	8.5	73.78±4.66^{d}	12.75	71.7±6.59^{c}	14.75	70.8±3.43^{de}	71.56±4.89^{d}
	Nano	27.5	4.5	85.39±4.88^{ab}	6.5	81.5±3.53^{c}	7.25	85.56±.65^{b}	10.5	80.88±3.31^{b}	83.33±3.8^{b}
F value				11.479		13		14.421		16.399	41.354
L. S. D.				6.5443177		4.895447		5.5780989		5.012013	2.90914

*** mean number of *M. persicae* / 10 leaves **The means across each column having the same superscript letters were not significantly different (p>0.05).**

Table 5. The reduction percentages of the population of green peach aphids, *M. persicae* after 1, 4, 7 and 14 days from the treatment with the nanoemulsion and normal formulations of acetamiprid, abamectin, alpha-cypermethrin and malathion during 2023 season under open field conditions:

Pesticides		*Before spray	After one day		After four days		After 7 days		After two weeks		General means of Reduction percentages %
			*No.	**Reduction percentages%	*No.	** percentages %	*No.	**Reduction percentages %	*No.	**Reduction percentages%	
Control		35.75	40.5		45.5		64.25		76.25		
Acetamiprid	Normal	33.75	7.25	81±3.02^{b}	6	86.06±1.89^{bc}	9.5	84.14±3.76^{bc}	12	83.11±4.47^{bc}	83.58±3.59^{bc}
	Nano	37.75	3.5	91.73±2.04^{a}	3.75	92.19±2.28^{a}	4	94.05±1.69^{a}	6	92.48±1.64^{a}	92.61±1.95^{a}
Abamectin	Normal	39.25	8.75	80.42±3.49^{b}	8.75	82.51±2.24^{cd}	13.75	80.52±2.14^{cd}	18.25	78.13±4.3^{cd}	80.39±3.26^{c}
	Nano	33.5	6.75	82.09±3.92^{b}	4.75	88.84±1.28^{ab}	7.5	87.4±0.79^{b}	11.75	83.4±1.4^{b}	85.43±3.48^{b}
alpha-cypermethrin	Normal	35.5	13.25	67.11±4.18^{c}	13.25	70.91±2.57^{e}	19.25	69.45±5.95^{f}	27	64.22±4.6^{f}	67.92±4.79^{e}
	Nano	38	13.25	69.22±4.14^{c}	11.75	77.02±2.79^{d}	15.5	77.23±3.28^{de}	19.75	75.7±1.01^{de}	74.79±4.33^{d}
Malathion	Normal	36.25	13.75	66.38±6.42^{c}	15.25	66.05±4.83^{e}	18.5	70.29±4.59^{f}	20.5	72.36±3.3^{e}	68.77±5.18^{e}
	Nano	37.75	4.25	89.8±4.14^{a}	6.5	68.34±7.91^{e}	6.75	74.35±5.03^{ef}	10.25	73.94±4.87^{de}	76.61±9.68^{d}
F value				23.509		26.994		20.457		23.263	45.319
L. S. D.				5.9696656		5.550938		5.527897		5.156809	3.514616

*** mean number of *M. persicae* / 10 leaves **The means across each column having the same superscript letters were not significantly different (p>0.05).**

CONCLUSION

The nanoemulsion formulations of acetamiprid, alpha-cypermethrin, malathion, and abamectin demonstrated significant improvements in their physicochemical properties, including small droplet sizes, uniform distributions, and high stability, making them highly effective for pest control. Laboratory bioassays revealed a marked increase in toxicity against *M. persicae* for nanoemulsions compared to conventional formulations, underscoring the advantages of enhanced bioavailability and penetration. Furthermore, field evaluations confirmed that nanoemulsions offered superior control, particularly with acetamiprid, which exhibited the highest efficacy. These findings highlight the potential of nanoemulsions as a promising approach for integrated pest management.

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تحضير وتوصيف التجهيزة النانوية لبعض المبيدات الحشرية وتقييم فعاليتها ضد حشرة من الخوخ الأخضر *Myzus persicae* (Sulzer)

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الملخص

هدفت الدراسة الحالية الي تخليق وتشخيص التجهيزة النانوية لمبيدات الاسيتامبريد, الالفاسيبرمثرين، الملاثيون و الابامكتين باستخدام تكنيك الموجات فوق الصوتية ultrasonic emulsification وهدفت الدراسة ايضا الي تقييم المبيدات المذكورة في تجهيزاتها التقليدية والنانوية علي حشرة من الخوخ الأخضر *Myzus persicae* تحت ظروف المعمل والحقل المفتوح. أظهرت مستحضرات المستحلب النانوي مؤشرات تعدد التشتت (PDI) تتراوح من 0.22 (أبامكتين) إلى 0.29 (ألفا سايبرمثرين) وإمكانات زيتا بين -22.19 (أبامكتين) و-30.2 مللي فولت (ألفا سايبرمثرين). كانت أحجام قطرات الأسيتامبريد والملاثيون والألفا سايبرمثرين والمستحلبات النانوية الأبامكتين 111.52 و94.35 و84.32 و56.43 نانومتر على التوالي. اظهرت النتائج انه وتحت ظروف المعمل، أدى تحضير تركيبات المستحلب النانوي إلى زيادة السمية بمقدار 1.27، 1.37، 1.49، و1.38 مرة بعد 24 ساعة من وقت التعرض و1.36، 1.28، 1.43 و1.48 مرة بعد 48 ساعة من وقت التعرض لمركب ألفا- سايبرمثرين، أسيتاميبريد، أبامكتين، والملاثيون، على التوالي. من ناحية أخرى، تحت ظروف الحقل المفتوح (على نباتات البطاطس)، كانت المتوسطات العامة لنسب الخفض في تجمعات *M. persicae* 84.5، 77.96، 70.09، و 71.56٪ (للتركيبات التقليدية) و 90.12، 82.07، 79.05 ، و 83.33٪ (لتركيبات المستحلبات النانوية) للأسيتامبريد والأبامكتين والألفا سايبرمثرين والملاثيون في الموسم الأول من عام 2022. وفي الموسم التالي، 2023، تم تسجيل هذه المتوسطات على أنها 83.58 و80.39 و67.92 و68.77% للتجهيزات التقليدية. التركيبات و92.61، 85.43، 74.79، و76.71% للتجهيزات النانوية، على التوالي.