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Research Article
Toxicity of Some Pesticides and Plant Extracts on *Tetranychus urticae* and its Predator, *Phytoseiulus persimilis*

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Abstract

Background and Objective: Pesticides induced direct and indirect effects on natural enemies so that, this study was aimed to evaluate six pesticides and two plant extracts to choice less toxic one for natural enemy and more toxic for mite. **Materials and Methods:** The toxicity of tested pesticides and plant extracts on *Tetranychus urticae* and predacious mite, *Phytoseiulus persimilis* evaluated using leaf dipping and spraying methods in laboratory and the number of dead adults recorded after 1-7 days of treatment. **Results:** The spraying method was more effective than leaf dipping one. Abamectin 1%+Thiamethoxam 9% were very toxic on *T. urticae* and was less toxic for *P. persimilis*. Moreover, khaya and pomegranate extracts were more toxic for *T. urticae* and were very safer for *P. persimilis* after treated with leaf dipping method. As for spraying method, Fenpyroximate was very toxic to *T. urticate,* where it was safer for *P. persimilis*. **Conclusion:** From this study it was concluded that Abamectin 1%+Thiamethoxam 9%, Fenpyroximate, khaya and pomegranate extracts were toxic to *T. urticae* and safer for *P. persimilis*.

Key words: Pesticides, plant extracts, toxicity, *Tetranychus urticae*, predatory mites, leaf dipping and spraying methods

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Tetranychus urticae Koch (Acari: Tetranychidae) is an important pest worldwide. Phytophagous mites attacking leaves, buds and fruits and induced direct injury to plants[1-3]. The high reproduction potential and short life cycle facilitate rapid resistance development to many acaricides after a few applications[2,3]. Moreover, insecticide treatments reduced the beneficial species such as; natural predators. Many acaricides with different mode of action used to control this pest, including organophosphates, carbamates and pyrethroids[4]. The short life cycle, high fecundity of *T. urticae* enhanced the risks of resistance[4,5].

Pesticides induced direct and indirect affects on natural enemies so that the choice of less toxic pesticides can be preserved for the natural enemies[6,7]. Natural enemies are usually more susceptible to the effects of pesticides than plant feeding hosts or prey because of their smaller size, searching habits and usually less-developed enzymes based detoxification systems. Most of mite species become resistant because they hide underneath leaves where sprays and powders cannot reach[8]. The acaricides, abamectin, spiromesifen, hexythiazox, fenpyraximate and chlorfenapyr are effective and suitable for management of the mite[9]. *T. urticae* developed resistance to many acaricides so that led to develop and introduce compounds with new mode of action, finding alternative strategies such as; bio-active substances and increasing interest to natural pesticides derived from plants or micro-organisms[2,10,11]. There are number of acaricides with novel mode of action are developed in recent years[12].

The haphazard use of conventional pesticides against *T. urticae* resulted in reduction of their natural enemies, pesticides resistance and also contaminated the environment[13]. The lethal doses and the sub-lethal concentrations of chlorfenapyr reduced the population growth rate of *T. urticae*[14]. Abamectin was the most toxic to two-spotted spider mite *Tetranychus urticae* adults followed by fenpyroximate, spiromesifen, chlorfenapyr, propargite, where LC_{50} were 0.39, 5.67, 12.53, 32.24 and 77.05 ppm, respectively[9]. Lambda cyhalothrin and spinosad were the highest toxicity against *T. urticae* followed by chlorpyrifos, deltamethrin and profenofos after using contact toxicity assay[15].

The motivation behind the study was to throw a light on the toxicity of pesticides on spider mite, *T. urticae* and overcome the need to use safe pesticides on the natural enemy *P. persimilis*. So, this study was aimed to evaluate the toxicity of pesticides and plant extracts on *T. urticae* and *P. persimilis*.

MATERIALS AND METHODS

Chemicals: Six pesticides (commercial formulations) and two plant extracts were used in this experiment.

Virmex 1.8% EC (Abamectin), Listomid 24% SC (Spirodiclofen), Shallenger super 24% SC (Chlorfenapyr), Hipoint 10% EC (Abamectin 1%+Thiamethoxam 9%), Trogold 5% SC (Fenpyroximate), Lambda 5% EC (Lambda cyhalothrin) and two plant extracts, khaya (*Khaya senegalensis*) leaves and pomegranate (*Punica granatum*) fruits extracts.

Mite cultures: This study carried out at the laboratory of Pesticides Department at Faculty of Agriculture, Menoufia University from July-December, 2018. The mites collected from the experimental farm of the Faculty of Agriculture, Menoufia University and reared on castor leaves in laboratory maintained at 27±2°C and 60±5% RH with 16:8 (L:D) photoperiod. The predacious mite, *Phytoseiulus persimilis* reared in plastic boxes (26×15×10 cm) a piece of cotton put in the middle of each box, provided with water as a barrier to prevent predatory mite individuals from escaping. Highly infested bean leaves with *Tetranychus urticae* provided as food sources to the predacious mite for feeding.

Preparation of plant extracts: Pomegranate (*Punica granatum* L.) peel and Khaya (*Khaya senegalensis* A. Juss) leaves collected from the experimental farm of Faculty of Agriculture, Menoufia University, Shebin Elkom, Egypt and dried under shade at room temperature (27±2°C) for about 20 days. The dried peel and leaves powdered using an electrical blender. About 100 g of dried Pomegranate peel and Khaya leaves soaked in methanol (1 L) and ethanol (1 L), respectively for 7 days then filtered through Whatman filter paper No. 1. The obtained filtrates concentrated under vacuum on a rotary evaporator at 40°C and stored at 4°C until use[16].

Chromatography-mass spectrometry (GC-MS) analysis: The GC-MS analysis was performed with (Agilent Technologies 7890 A) a mass-selective detector (MSD, Agilent 7000) equipped with an apolar Agilent HP-5ms (5%-phenyl methylpolysiloxane) capillary column (30 m×0.25 mm i.d and film thickness was 0.25 μm) the carrier gas was helium with the linear velocity of mL/min.

Bioassays

Leaf dipping method

***Tetranychus urtica*:** Five concentrations of each pesticide and plant extracts prepared, castor leaf discs (2 cm diameter) cut and dipped in the different concentrations for 30 sec and left to dry. The leaf disks kept fresh by placing it on moisturized filter paper on a piece of wet cotton in Petri dish. Ten adult's stage of *T. urticae* transferred by means of a fine soft brush to each disc. All Petri dishes incubated at 27±2°C and 60±5% RH and four dishes used for each treatment[17].

Phytoseiulus persimilis: Five concentrations of each pesticides and plant extracts prepared, castor leaf disks (2 cm diameter) prepared and dipped in the different concentrations for 30 sec and left to dry. Ten specimens of predacious mite *P. persimilis* and 20 adults of *T. urticae* used for feeding predatory mite transferred by means of a fine soft brush to each disk. All Petri dishes incubated at 27±2°C and 60±5% RH and four dishes used for each treatment[17].

Leaf spraying method

Tetranychus urtica: Green castor leaf disks placed into Petri dishes on moisturized filter paper. Ten adults of spider mite placed in each Petri dish and sprayed with different concentrations of each pesticide and plant extract using a small hand-held sprayer. All Petri dishes incubated at 27±2°C and 60±5% RH and four dishes used for each treatment[18].

Phytoseiulus persimilis: Green castor leaf disks placed into Petri dishes on moisturized filter paper. Ten specimens of predacious mite, *P. persimilis* sprayed with different concentrations of each pesticide and plant extracts using a small hand-held sprayer. Twenty adults of *T. urticae* used for feeding predatory mite transferred after spraying. All Petri dishes incubated at 27±2°C and 60±5% RH and four dishes used for each treatment[18].

Statistical analysis: The results for all previous experiments assayed after 1-7 days of treatment by counting the number of dead adults and corrected according to Abbott's formula[19]. LC_{50}, slope and confidence limits calculated after different periods.

The obtained data subjected to statistical analysis one way analysis of variance (ANOVA) by F-test at 5% probability, where the measurements separated using Duncan's Multiple Range Test (DMRT) through CoStat software program (Version 6.400).

RESULTS

Bioassays

Dipping technique: The obtained data in Table 1 showed that Abamectin 1%+Thiamethoxam 9%, Lambda cyhalothrin, Abamectin and Chlorfenapyr were the most toxic tested pesticides, after 24 h of treatment. About 100% mortality in *T. urticae* adults achieved after 48 h, 4 days of treatment with Abamectin1%+Thiamethoxam 9% and lambda cyhalothrin, after 7 days of treatment with khaya and pomegranate extracts.

As for predacious mite *Phytoseiulus persimilis*, the data in Table 2 indicated that Abamectin1%+Thiamethoxam 9%, Khaya and Pomegranate are safe compounds with the highest LC_{50} values (2881.88-104.14ppm), no mortality-542.78 ppm and (no mortality-661.64 ppm), respectively after 1-7 days of treatment. On the other side, Chlorfenapyr, Lambda cyhalothrin and Abamectin are very toxic compounds with LC_{50} values (34.48 ppm-100% mortality), (91.96-0.94 and 95.73-0.004 ppm), respectively after 1-7 days of treatment.

Spraying technique: The data in Table 3 indicated that Lambda cyhalothrin, Abamectin 1%+Thiamethoxam 9%, Fenpyroximate, Abamectin and Chlorfenapyr showed high toxicity against *T. urticae* adults, where LC_{50} after 24 h of treatment were 0.09, 0.15, 3.48, 23.37 and 32.97 ppm, respectively. Moreover, 100% mortality in *T. urticae* adults achieved after 4 days of treatment with Abamectin, Chlorfenapyr, Abamectin 1%+Thiamethoxam 9%, Fenpyroximate and Spirodichlofen.

In addition, 100% mortality of *T. urticae* adults achieved after 2 days of treatment with Lambda cyhalothrin. On the other side, pomegranate showed low toxicity up to 7 days of treatment, while khaya was less toxic along 3 days of treatment and it increased at the 4th day of treatment.

The toxicity of tested pesticides and plant extracts on *P. persimilis* are presented in Table 4. The data showed that Fenpyroximate, khaya and pomegranate are safe compounds for 7 days of treatment with LC_{50} values (2169.77-105.76 ppm), (no mortality-1833.35) and (6865.93-386.53 ppm), respectively after 1-7days of treatment. On the other side, Lambda cyhalothrin was the most toxic compound with LC_{50} values (35.40-2.18 ppm) after 1-7 days of treatment.

Khaya leaves GC-MS analysis: The obtained data in Table 5 showed that most of components found in the ethanolic

Table 1: LC_{50} ±SE, slope and confidence limits of tested pesticides two plant extracts on two spotted spider mite, *Tetranychus urticae* along 7 days of treatment using leaf disc method

	Tested periods (days)						
Pesticides	1	2	3	4	5	6	7
Abamectin							
LC_{50}	4.21±0.58	2.56±0.58	10.0±0.03	0.01±0.0001	0.009±0.0006	0.007±0.001	0.007±0.001
Slope	0.85±0.30	0.79±0.30	0.60±0.16	0.885±0.15	1.309±0.284	1.049±0.50	1.0149±0.50
C L	-	-	1.134E-6-1.24	0.004-0.002	0.0034-0.02	0.003-0.011	0.003-0.01
Chlorfenapyr							
LC_{50}	30.26±1.15	5.04±0.58	1.12±0.07	0.69±0.096	0.04±0.01	1.03±0.02	1.03±0.02
Slope	1.45±0.18	1.13±0.22	0.91±0.28	1.20±0.54	0.76±0.51	1.88±1.79	1.99±1.79
C L	19.25-42.70	1.20-10.47	0.6 -4.47	9.91E-1 - 3.7	-	-	-
Abamectin 1%+thiamethoxam 9%							
LC_{50}	2.37±0.17	100% dead	100% dead	100% dead	100% dead	100% dead	100% dead
Slope	1.63±0.56	-	-	-	-	-	-
C L	0.04-5.81	-	-	-	-	-	-
Fenpyroximate							
LC_{50}	8848.5 ±27.7	1348.09±27.71	568.36±11.55	181.52±5.77	117.78±9.81	57.27±1.15	28.53±1.73
Slope	0.86±0.17	1.23±0.15	1.38±0.15	1.58±0.26	1.40±0.17	1.80±0.28	1.62±0.33
C L	4070.9-42152.4	970.43-2032.18	428.42-761.17	91.85-30489	79.37-160.75	35.36-78.67	10.24-46.81
Spirodiclofen							
LC_{50}	2389.16 ±17.32	600.08 ±16.24	374.46±11.55	167.57±11.55	20.62±1.15	21.88±0.58	14.63±1.15
Slope	0.82±0.12	1.20±0.13	1.22±0.12	1.23±0.12	1.86±0.33	1.35±0.17	1.56±0.22
C L	1214.79-5239.7	440.56-837.43	275.35-510.22	120.16-227.3	11.94-31.94	12.77-32.40	8.23-21.73
Lambda cyhalothrin							
LC_{50}	2.986 ±0.58	0.58±0.02	0.01±0.001	100% dead	100% dead	100% dead	100% dead
Slope	0.965±0.22	0.99±0.18	0.61±0.25	-	-	-	-
C L	0.140-9.06	0.13-1.29	8.47e-14-0.16	-	-	-	-
Khaya extract							
LC_{50}	17647.2±373.6	15686.4 ±373.6	3583.6±115.5	214.68±8.08	34.68±2.31	2.07±0.04	100% dead
Slope	1.66±0.62	0.62±0.14	0.47±0.10	0.61±0.15	0.67±0.18	0.756±0.15	-
C L	819.16-1.94E+6	6159.3-1.17E+5	1528.9-14960.6	10.25-945.76	0.04-14.50	0.162-7.18	-
Pomegranate							
LC_{50}	11857.2±173.2	5068.10 ±39.26	518.56±10.39	43.24±1.73	1.69±0.05	0.013±0.001	100% dead
Slope	0.924±0.19	0.617±0.12	0.558±0.16	0.803±0.16	0.608±0.12	0.493±0.21	-
C L	5971.88-48573.7	2478.5-16533.9	25.88-4645.43	2.268-168.01	0.077-7.39	1.531E-20-0.8	-

Each value is the mean of three samples±SE, all values of LC_{50} in ppm±SE, C L: Confidence limits

Table 2: LC_{50}±SE, slope and confidence limits of tested pesticides and two plant extracts on predator mite *Phytoseiulus persimilis* along 7 days of treatment using leaf disc method

	Tested periods (days)						
Pesticides	1	2	3	4	5	6	7
Abamectin							
LC_{50}	95.73 ±4	15.31±3	4.28 ±1	1.19±0.1	0.72 ±0.1	0.04±0.01	0.004±.0001
Slope	1.72±0.30	1.62±0.28	1.71±0.29	1.59±0.35	1.62±0.45	0.84±0.42	0.62±0.42
C L	64.26 -157.95	9.17-23.13	2.24-6.88	0.41-2.22	0.14-1.44	1.36E-33-0.44	-
Chlorfenapyr							
LC_{50}	34.48 ±3	0.27±0.02	100% dead	100% dead	100% dead	100% dead	100% dead
Slope	1.32±0.23	0.62±0.27	-	-	-	-	-
C L	16.69-58.24	3.92E-16 - 4.1	-	-	-	-	-
Abamectin 1%+thiamethoxam 9%							
LC_{50}	2881.88 ±20	2006.20±20	1571.14±20	756.99±20	501.51±30	284.17±20	104.14±10
Slope	1.24±0.27	1.15±0.22	1.027±1.187	0.79±0.13	0.71±0.12	0.748±0.118	0.21±0.77
C L	1683.33-7433.48	1178.26-4498.16	895.69-3501.88	392.89-1729.30	245.8 -1167.8	143.10-591.99	9.63-558.85
Fenpyroximate							
LC_{50}	4964.53 ±120	205.97±15	133.56±20	58.08 ±5	12.75±2	0.03±0.01	100% dead
Slope	1.51±0.27	1.86±0.27	1.91±0.28	1.82±0.23	1.69-0.40	0.57±0.37	100% dead
C L	2464.23-1186.23	136.96-302.81	88.47-196.64	36.34-87.59	4.72-21.63	-	100% dead
Spirodiclofen							
LC_{50}	5793.15±20	1073.10±73	165.51±20	43.78±3	20.62±3	6.09±1	2.90±1
Slope	0.57±0.19	0.57±0.19	1.51±0.25	1.50±0.24	1.86±0.33	1.79±0.31	1.664±0.14
C L	1068.86-4.01E+6	411.43-8989.09	103.51-269.24	25.56-69.98	11.94-31.94	3.28-10.14	1.41-5.11
Lambda cyhalothrin							
LC_{50}	91.96±3	41.31±3	22.63±4	6.02±2	0.90±0.2	0.94±0.2	0.94±0.1
Slope	1.47±0.19	1.85±0.23	1.98±-0.26	1.44±0.35	1.44±0.24	1.79±0.33	1.79±0.33
C L	67.20-133.17	31.789-53.99	17.17-28.99	0.63-16.45	0.38-1.53	0.48-1.47	0.48-1.47
Khaya extract							
LC_{50}	0% dead	0% dead	1150.17±50	3065.40 ±65	1236.76±100	911.76±11	542.78±20
Slope	-	-	0.94±0.21	0.66±0.11	0.68±0.17	0.72±0.17	0.76±0.10
C L	-	-	5864.9-53308.8	1644.02-7462.3	250.7-10694.2	174.71-5056.7	301.30-723.54
Pomegranate extract							
LC_{50}	0% dead	0% dead	6567.84±100	3433.99±100	2715.50 ±100	1827.13±100	661.64±20
Slope	-	-	1.27±0.28	1.02±0.17	1.01±0.16	0.81±0.12	0.80±0.11
C L	-	-	4232.39-1609.11	2234.94-6219.29	1780.09-4620.63	1107.55-3278.43	1879.39-553.14

Each value is the mean of three samples±SE, all values of LC_{50} in ppm±SE, C L: Confidence limits

Table 3: LC_{50}±SE, slope and confidence limits of tested pesticides two plant extracts on two spotted spider mite, *Tetranychus urticae* along 7 days of treatment using spraying method

	Tested periods (days)						
Pesticides	1	2	3	4	5	6	7
Abamectin							
LC_{50}	23.37±1	4.55±0.58	0.47±0.06	0.03±0.006	0.001±0	100% dead	100% dead
Slope	1.13±0.27	0.95±0.17	0.80±0.10	0.77±0.16	0.75±0.35	-	-
C L	3.58-98.07	0.84-15.76	0.20-0.91	0.04-0.01	1.3E-24 - 0.02	-	-
Chlorfenapyr							
LC_{50}	32.97±1.15	9.14±0.58	0.27±0.06	100% dead	100% dead	100% dead	100% dead
Slope	1.914±0.398	1.51±0.48	1.01±0.52	-	-	-	-
C L	9.85-64.17	0.001-26.65	-	-	-	-	-
Abamectin 1%+thiamethoxam 9%							
LC_{50}	0.15±0.01	0.002±0	0.001±0	100% dead	100% dead	100% dead	100% dead
Slope	1.58±0.30	0.68±0.27	0.72±0.36	-	-	-	-
C L	0.08-0.23	3.96E-11 -0.02	1.00E-38-0.02	-	-	-	-
Fenpyroximate							
LC_{50}	3.48±0.58	0.22 ±0.01	0.01±0	100% dead	100% dead	100% dead	100% dead
Slope	075±0.18	0.78±0.18	0.61±0.37	-	-	-	-
C L	0.01-4.03	0.02-073	-	-	-	-	-
Spirodiclofen							
LC_{50}	260.38±5.77	29.92±1.15	0.01±0	100% dead	100% dead	100% dead	100% dead
Slope	0.77±0.24	0.88±0.28	0.59±0.19	-	-	-	-
C L	7.72-21390.61	0.01-450.11	2.46E-7 *0.18	-	-	-	-
Lambda cyhalothrin							
LC_{50}	0.09±0.01	100% dead	100% dead	100% dead	100% dead	100% dead	100% dead
Slope	0.75±0.19	-	-	-	-	-	-
C L	0.001-0.44	-	-	-	-	-	-
Khaya extract							
LC_{50}	25465.83±230.9	2760.58 ±34.6	417.03±9.8	122.21±11.54	13.63±0.58	3.99±0.58	0.81±0.12
Slope	0.41±0.11	0.31±0.09	0.28±0.9	0.43±0.14	0.52±0.15	0.64±0.11	0.73±0.18
C L	6438.59-9.53E+5	834.72-31971.8	63.25-1822.06	5.94E-6 -1005.4	0.001-105.38	0.42-13.30	0.01-4.03
Pomegranate extract							
LC_{50}	32020.49±288.7	17376.82 ±57.7	16191.83±173.2	7058.65±33.49	3341.77±57.7	456.87±11.5	216.78±9.2
Slope	0.95±0.30	1.06±0.296	0.62±0.21	0.51±0.23	0.43±0.20	0.57±0.25	0.75±0.29
C L	1070.08-2.48 E+6	7855.70-2.06E+5	6255.98-1.27E+5	-	-	-	-

Each value is the mean of three samples±SE, all values of LC_{50} in ppm±SE, C L: Confidence limits

Table 4: LC_{50}±SE, slope and confidence limits of tested pesticides two plant extracts on predator mite *Phytoseiulus persimilis* along 7 days of treatment using spraying method.

	Tested periods (days)						
Pesticides	1	2	3	4	5	6	7
Abamectin							
LC_{50}	132.64±5.8	83.48±11.5	58.97±5.8	39.65±2.3	25.05±1.7	9.40±0.58	1.27±0.06
Slope	0.67±0.14	0.71±0.14	0.60±0.13	0.66±0.12	0.58±0.11	0.50±0.10	0.23±0.11
C L	556-53.2	265.03-35.83	-	114.6-16.17	76.10-9.14	30.32-2.57	3.82-0.23
Chlorfenapyr							
LC_{50}	318.68±11.5	92.58±5.8	60.88±2.9	56.99±2.3	50.79±2.9	41.76±1.7	18.09±2.3
Slope	0.64±0.15	0.92±0.18	1.07±0.19	1.067±0.19	1.01±0.12	0.95±0.18	0.84±0.19
C L	130.37-933.12	41.53176.75	28.71-108.09	26.41-101.66	21.73-93.54	15.78-80.36	3.65-41.56
Abamectin 1%+thiamethoxam 9%							
LC_{50}	241.71±57.7	58.11±5.8	30.16±2.9	26.44±2.3	26.85±1.15	20.27±1.15	6.02±0.58
Slope	0.61±0.14	0.68±0.16	0.69±0.14	0.69±0.17	0.77±0.16	0.73±0.16	0.66±0.17
C L	124.65-489.08	15.50-132.29	6.24-72.37	4.28-65.84	6.37-60.49	3.50-50.00	0.2-21.50
Fenpyroximate							
LC_{50}	2169.77±46.8	364.86±28.9	259.54±17.3	226.00±5.8	200.04±2.9	164.83±11.54	105.76±2.9
Slope	0.53±0.13	0.62±0.13	0.75±0.13	0.74±0.13	0.76±0.14	0.69±0.13	0.66±0.13
C L	791.14-16171.9	150.71-895.35	119.04-529.63	100.47-462.16	89.22-400.44	64.59-349.84	33.11-237.44
Spirodiclofen							
LC_{50}	3081.11±0.58	167.62±11.5	108.12±4.6	66.32±3.5	66.32±2.3	45.35±2.9	23.39±1.8
Slope	0.51±0.17	0.10±0.13	0.97±0.20	0.90±0.20	0.90±0.20	0.78±0.20	0.66±0.20
C L	-	-	36.81-208.18	14.93-143.10	14.93-143.10	4.95-116.62	0.37-81.50
Lambda cyhalothrin							
LC_{50}	35.40±0.58	13.99±0.58	7.77±1.45	7.12±0.58	5.95±0.58	4.45±0.58	2.18±0.58
Slope	1.169±0.20	0.96±0.16	0.84±0.15	0.83±0.15	0.90±0.15	0.85±0.15	0.77±0.15
C L	20.02-60.57	6.55-25.21	2.83-15.48	2.46-14.44	-	-	0.39-5.46
Khaya extract							
LC_{50}	0% dead	0% dead	55084.92±404.2	38707.9±115.5	7051.59±29.4	4466.6±230.9	1833.35±19.05
Slope	-	-	0.57±0.19	0.43±0.16	0.59±0.16	0.65±0.16	0.64±0.15
C L	-	-	-	-	2436.7-88423.6	1795.2-26573.1	775.49-6625.73
Pomegranate extract							
LC_{50}	6865.93 ±288.7	3212.58 ±57.7	2199.25 ±57.7	928.60±16.2	658.47±11.5	561.04 ±11.5	386.55±11.5
Slope	0.63±0.16	0.54±0.15	0.52±0.15	0.65±0.15	0.72±0.15	0.74±0.15	0.77±0.16
C L	2522.5-64034.8	1146.6-27535.8	776.12-15146.8	379.2-2547.24	281.43-1506.65	237.47-1236.80	157.25-805.86

Each value is the mean of three samples±SE, all values of LC_{50} in ppm±SE, C L: Confidence limits

Table 5: Phyto compounds identified in the ethanolic extract of *K. sengalensis* by GC-MS

Compounds	Area (%)	Molecular weight (g mol^{-1})	Molecular formula
Epinephrine	2.90	183.207	$C_9H_{13}NO_3$
5-Hydroxytryptophan	3.72	220.228	$C_{11}H_{12}N_2O_3$
Octadecanal	2.03	268.485	$C_{18}H_{36}O$
Methyl Palmitate	24.21	270.457	$C_{17}H_{34}O_2$
Ethyl Palmitate	10.10	284.484	$C_{18}H_{36}O_2$
Methyl Linoleate	15.92	294.479	$C_{19}H_{34}O_2$
Phytol	12.58	296.539	$C_{20}H_{40}O$
Ethyl Linoleate	2.03	308.506	$C_{20}H_{36}O_2$
Octadecamethylcyclononasiloxane	1.10	667.386	$C_{18}H_{54}O_9Si_9$
Dibutyl Phthalate	3.20	278.348	$C_{16}H_{22}O_4$
Laudanine	2.91	436.572	$C_{20}H_{25}NO_4$
Eicosamethylcyclodecasiloxane	1.61	741.54	$C_{20}H_{60}O_{10}Si_{10}$

Table 6: Phyto compounds identified in the methanolic extract of pomegranate peel by GC-MS

Compounds	Area (%)	Molecular weight (g mol^{-1})	Molecular formula
Amino-6-tert-butyl-4-methylphenol	0.21	193.29	$C_{12}H_{19}NO$
α-Ylangene	2.41	204.357	$C_{15}H_{24}$
β -Copaene	4.4	204.357	$C_{15}H_{24}$
Cubenol	1.96	222.3663	$C_{15}H_{26}O$
Patchoulene	0.51	204.357	$C_{15}H_{24}$
γ-selinene	0.92	204.357	$C_{15}H_{24}$
B-Humulene	13.41	204.351	$C_{15}H_{24}$
Clovene	5.6	204.357	$C_{15}H_{24}$
Ledene	5.21	204.357	$C_{15}H_{24}$
gamma-Muurolene	5.26	204.357	$C_{15}H_{24}$
Allo-Aromadendrene	13.58	204.357	$C_{15}H_{24}$
Longifolene	24.1	204.357	$C_{15}H_{24}$
Alpha-Elemene	1.50	204.357	$C_{15}H_{24}$
trans-Calamenene	3.21	202.341	$C_{15}H_{22}$
Cedr-8-ene	1.6	204.357	$C_{15}H_{24}$
δ-Selinene	2.65	204.3511	$C_{15}H_{24}$
Zearalenone	3.58	318.369	$C_{18}H_{22}O_5$
alpha-Tocopherol	1.40	430.717	$C_{29}H_{50}O_2$
Cis-Jasmone	1.91	164.248	$C_{11}H_{16}O$
Globulol	4.31	222.372	$C_{15}H_{26}O$
Retinol Acetate	1.40	328.496	$C_{22}H_{32}O_2$
cis-13,16-Docasadienoic acid	0.52	336.5518	$C_{22}H_{40}O_2$
Retinoic acid	0.31	300.44	$C_{20}H_{28}O_2$

extract of *K. sengalensis* leaves were Methyl Palmitate followed by Methyl Linoleate, Phytol and Ethyl Palmitate. The pesticidal activity may be related to one or more compounds of ethanolic leaves extract of *K. sengalensis.*

Pomegranates peel GC-MS analysis: The data presented in Table 6 showed that there were 23 compounds in the methanolic extract of Pomegranate peel. Longifolene, alloaromadendrene and β-humulene compounds recorded the highest one.

DISCUSSION

The obtained results indicated that Abamectin 1%+Thiamethoxam 9%, Fenpyroximate, khaya and pomegranate extracts were toxic to *T. urticae* and safer for predacious mite (*Phytoseiulus*) this were in agreement with authors who found that Spirodiclofen was high toxic to *T. urticae*[20]. Also, the lethal and sublethal doses of chlorfenapyr profoundly reduced the population growth rate of *T. urticae*, where the LC_{50} value of chlorfenapyr for females of *T. urticae* was 47.66 ppm[14]. Chlorfenapyr recorded high activity against *T. urticae* adult females[21]. Abamectin caused 100% mortality of *T. urticae* adults[22] within 24-48 h. Abamectin was the most toxic to the adults of *Tetranychus urticae* (LC_{50} = 0.39 ppm) followed by fenpyroximate (5.67 ppm), spiromesifen (12.53 ppm), chlorfenapyr (32.24 ppm), propargite (77.05 ppm) and dicofol (146.65 ppm)[9]. Lambda-cyhalothrin and fenpyroximate resulted high toxicity to the predatory mites: *Amblyseius swirskii*, *A. andersoni* and *Phytoseiulus persimilis*[23]. Cyhalothrin and fenpyroximate recorded the highest toxicity to adults and egg stages of *Tetranychus urticae*, while wormseed extract

was the least toxic compound[24]. Bifenthrin was the highest toxic agent on two-spotted spider mite adults compared to dimethoate and hexythiazox. In addition, the predatory mite, *P. persimilis* was more sensitive than *T. urticae* against bifenthrin and dimethoate[18]. Abamectin was very toxic to *Amblyseius fallacies* (Garman) and Phytoseiulus *persimilis* Athias-Henriot[25]. Lambda cyhalothrin and spinosad recorded the highest toxicity against *T. urticae* followed by chlorpyrifos, deltamethrin and profenofos[15]. Estimated LC_{50} values for cypermethrin, malathion, deltamethrin and sulphur were 2.9956, 15.8663, 0.5386 and 20.7045 mL cm^{-2} on *T. urticae*, respectively[26].

Abamectin had high efficacy against *T. urticae* when applied as foliar application for at least 2 weeks[27]. Abamectin has a special position in mite chemical control because its high toxic effect and high toxicity index comparing to different mite control agents[28]. The acaricides, challenger and vertimec can be used successfully in controlling the spider mite, *T. urticae*[29]. In addition, Vertimec was more effective than Actellic and Biofly against *T. urticae*[30].

CONCLUSION

The obtained data indicated that Abamectin 1% +Thiamethoxam 9%, Fenpyroximate, khaya and pomegranate extracts were more toxic for *T. urtica* and safer for predacious mite, *Phytoseiulus persimilis*. It can be recommended to use Abamectin 1%+Thiamethoxam 9%, Fenpyroximate, khaya and pomegranate safely in *T. urticae* management programs.

SIGNIFICANCE STATEMENT

This study discovered that Abamectin 1%+Thiamethoxam 9%, Fenpyroximate, khaya and pomegranate are toxic for *T. urticae* and safe for predacious mite, *P. persimilis* that can be beneficial for management programs of the spider mite. Moreover, this study will help the researchers to uncover the critical areas of choice pesticides and plant extracts less toxic for the natural enemy and more toxic for *Tetranychus urticae*.

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