Possible acaricidal activity of *Jatropha curcas* and *Ricinus communis* seed oils on *Tetranychus urticae*

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ABSTRACT

Field evaluation for the acaricidal activity of jatropha (*Jatropha curcas* L.) and castor bean oils (*Ricinus communis* L.) against the nymphs and adults of the two-spotted spider mite, *Tetranychus urticae* on *Alcea rosea* L. conducted out in May 2016 on *A. rosea* in the experimental farm of the Faculty of Agriculture, Suez Canal University, Ismailia, Egypt. The fatty acids constituents of the two essential oils (from seeds) were identified by gas chromatography (GLC) analysis. The acaricidal activity of castor bean oil was higher than that of jatropha oil where the total population reduction rate of jatropha oil was 74.12% for adults and 75.19 % for nymphs. Total population reduction rate of castor bean oil was 77.32% for adults; while it was 82.91% for nymphs on *A. rosea* leaves. Regarding flowers, the total population reduction rate of jatropha oil was 68.74 % for adults; while it was 73.94 % for nymphs but population reduction rate of castor bean oil was72.33% for adults while it was 76.02% for nymphs. The major constituents of fatty acids identified by using GLC analysis in jatropha and castor bean oils were erucic (44.34%) and ricinoleic acid (41.75%), respectively. This study revealed that the essential oil of *J. curcas* and *R. communis* exhibited potent acaricidal activity against *T. urticae* which may be attributed to the presence of different bioactive compounds which may affect alone or in synergism.

Key words: *Tetranychus urticae*, jatropha oil, castor bean oil, GLC analysis, fatty acids, *Alcea rosea*.

INTRODUCTION

Tetranychus urticae (Acari: Tetranychidae) is a serious pest attacks broad range of ornamental plants specially, *Alcea rosea* L. (Ho, 2000 and Paramjit *et al*., 2006). Hollyhock, *A. rosea* L. (Malvales: Malvaceae) is a common ornamental plant cultivated at homeprivate gardens in Egypt (Johri, 2013). It is grown as a decorative plant and also known for its great medicinal uses (Ali Shah *et al*., 2011).

Mite control is still based primarily on the use of synthetic pesticides which lead to many problems. Thus, plants essential oils are ideal nomineesand can be potential alternative for mite control as some of them are selective, biodegradable, as well ecofriendly and economically viable (Tehri and Gulati, 2014).

Jatropha and castor bean are perennial, deciduous shrubs and well adapted to marginal soils. The oil, extracts of *Jatropha curcas* seeds has been used to control various pests in face of seeds are poisonous (Orwa *et al*., 2009).

As well, the castor bean oil extracted from the seeds of *Ricinus communis* has a considerable economic importance. It owns many medicinal properties (Scarpa and Guerci, 1982). Jatropha and castor bean oils proved to be have insecticidal activity against many pests (Kumar and Sharma, 2008 and Abd-Alla *et al*., 2015). Since different plant essential oils like sandalwood, cumine, clove, spearmint and *Lippiasidoides* essential oils have been found to be active against *T. urticae* worldwide (Cavalcanti *et al*., 2010 and Kheradmand *et al*., 2015), few studies dealt with the acaricidal effects of jatropha and castor bean oils (Abd-Alla *et al*., 2015 and Roy *et al*., 2016).

Therefore, the present study to characterize the fatty acids of the essential oils of *J. curcas* and *R. communis* for their chemical profiles and their possible acaricidal activities against *T. urticae* owing to its outbreak observed recently on *A. rosea*, in Egypt.

MATERIALS AND METHODS

1. Collection of *J. curcas* and *R. communis* seeds and oil extraction

Mature *J. curcas* and *R. communis* seeds were obtained from three years old shrubs. The seeds were heated by 70°C for *R. communis* only, wrapped in special bags and pressed using a compressor (KT23-100EL) to extract the crude oil.

2. Extraction of fatty acids:

2.1. Lipid extraction and separation of fatty acids:

Lipid extraction from samples by using chloroform/methanol (2:1 v/v) was handled by method of A.O.A.C. (2000).The lipid samples were saponified with ethanolic KOH (20%) at room temperature over-night. Acidification with hydrochloric acid (5N) were used to free the fatty acid from its potassium salts then extracted with petroleum ether at 40-60°C. The extract was then washed three times by distilled water after; that dried over anhydrous sodium sulfate then filtered off. Finally, diazomethane was primed from methylamine hydrochloride as reported by Vogel (1975).

2.2. Methylation of fatty acids with diazomethane:

Fatty acids extracted from lipid samples and standard fatty acids were dissolved in a little anhydrous methanol then added a small portion of the ethereal solution of diazomethane till gas evolution ceased. The excess diazomethane was added when the mixture gained the pale yellow color, then the reaction mixture was left for 10 min then under nitrogen stream, ether was evaporated at room temperature. After that, the fatty acids methyl esters was dissolved by two drops of redistilled chloroform solution, then this solution was injected into the gas chromatography (Vogel, 1975**).**

2.3. Identification and determination of the fatty acids by gas liquid chromatography (GLC) analysis:

Fatty acids were determined by GLC analysis according to Farag *et al*. (1986).Themethyl esters of fatty acids extracted from oil samples and the standard materials were analyzed by a Pye Unicam Series 304 gas chromatograph supplied with dual flame ionization detector and dual channel recorder. The fatty acid methyl esters separation was handled using a coiled glass column (1.5 mx4 mm) filled with Diatomite (100-120 mesh) and coated with 10% polyethylene glycol adipate (PEGA). The column oven temperature was set at 8˚C/min from 70˚C to 190˚C, after that isothermally at 190˚C for 25 min with nitrogen at 30 ml/min. Identification of peak was accomplished by comparing the retention time (RT) of each compound with those of standard materials.

2.4. Chemical and physical properties of jatropha and castor bean oil:

Acid value, iodine value, peroxide value and saponification value of the oils were determined according to the methods described by A.O.C.S. (1993) and refractive index was measured using an Abberre fractometer (C10, Vee Gee, USA).

3. Bioassays:

Evaluation of acaricidal activity:

The field trial was conducted out conducted in a randomized complete block design with 4 replications in May 2016 on *A. rosea* in the experimental Farm of the Faculty of Agriculture, Suez Canal University, Ismailia (Egypt). The treatments started at the presence of 5 mobile mites at least (adults and nymphs) on a plant. Three treatments {T_1: Triton X 100; T_2: Jatropha oil 15%; T_3: Castor bean oil 15%} with four replications were used on *A. rosea*. Distilled water having 0.05% Triton X100 only served as a control. Concentrations applied were selected after some initial tests. Treatments were applied by a hand-sprayer, as normally performed in open field; oils were sprayed at 7 a.m. uniformly on the two leaf blades (both from the top downwards and from below upwards) up to dripping (Piccinini *et al*., 2015).

Four leaves from each plant were sampled (4 leaves/plant × 8 plants/treatment × 3 treatments×4 replications). Samplings were conducted at 3, 5, 7, 14 and 21 days after treatment. The lower surface of the leaf and the flower were carefully examined, where live and dead individuals were recorded. Percentage reduction rates of adult and nymphal stages after treatments were estimated according to the equation of Henderson and Tilton (1955).

RESULTS AND DISCUSSION

The complete fatty acids profile and its peaks identified in jatropha oil by using GLC analysis were shown in Table (1). Erucic acid (44.34%) represents the major constituent fatty acid in the oil followed by oleic acid (25.84%), α-linolenic acid (14.66%), palmitic acid (9.09%), stearic acid (3.88%) and gondoic acid (2.19%). This finding was in line with reports by Adebowale and Adedire (2006), Kumar and Sharma (2008), Akbar *et al*. (2009) and Cantrell *et al*. (2011). On the contrary, Lateef *et al*. (2014) found that the fatty acids contents of jatropha oil were 5-octodecenoic acid, 6-octadecenoic acid, myristic acid, 4-octadecenoic acid, pentadecanoic acid, 9, 12-hexadecadienoic acid, palmitoleic acid, palmitic acid, arachidic acid, cyclopentanetridecanoic acid, oleic acid, margaric acid, linoleic acid, 15-octadecenoic acid,13-octadecenoic acid and stearic acid.

The complete fatty acids profile and its peaks identified in castor bean oil by using GLC analysis were shown in Table (2). Ricinoleic acid (41.75%) represents the major constituent in the oil followed by linoleic acid (35.71%), oleic acid (11.15%), α-linolenic acid (7.85%), palmitic acid (2.32%), linolenic acid (0.72%), and gondoic acid (0.51%). Similarly to our findings, Wafa *et al*. (2014)and Yusuf *et al*. (2015) showed that the ricinoleic acid (74.10%) is the major constituent fatty acid followed by linoleic (10.32%), oleic (7.55%), stearic (2.81%), palmitic (2.59%), erucic (1.70%) and eicosadienoic acids (0.93%). Our results are in agreement with those reported by Akpan *et al*. (2006).

The fatty acids chemical compositions are a key factor in the acaricidal and/or insecticidal effects of any essential oils (Pascual-Villalobus and Ballesta-Acosta, 2003).The acid value, saponification value, iodine value and peroxide value are relatively high in jatropha oil (3.53, 115.74, 88.80 and 47, respectively) as compared with castor bean oil (1.26, 100.98, 76.14 and 6.5, respectively) as shown in Table (3). The gondoic acid (C20:1) was identified in jatropha and

Table (1): The fatty acids identified in jatropha oil by using GLC analysis.

Peak	Retention Time(min)	Fatty acids		Chemical Formula	Lipid Number	Density (g/cm³)	Area Sum %
		Chemical Name	Common Name				
1	2.434	13- Docosenoic acid	Erucic acid	$C_{22}H_{42}O_2$	C22:1	0.86	44.34
2	22.245	Hexadecanoic acid	Palmitic acid	$C_{16}H_{32}O_2$	C16:0	0.852	9.09
3	29.525	Cis-11-Eicosenoic acid	Gondoic acid	$C_{20}H_{38}O_2$	C20:1	0.883	2.19
4	25.821	Methyl stearate	Stearic acid, ethyl ester	$C_{19}H_{38}O_2$	C18:0	0.849	3.88
5	26.288	9- Octadecenoic acid	Oleic acid	$C_{18}H_{34}O_2$	C18:1	0.895	25.84
6	27.262	12,15- Octadecadienic acid	α- Linolenic acid	$C_{18}H_{30}O_2$	C18:3	0.916	14.66

Table (2): The fatty acids identified in castor bean oil by using GLC analysis.

Peak	Retention Time(min)	Fatty acid		Chemical Formula	Lipid Number	Density (g/cm³)	Area Sum %
		Chemical Name	Common Name				
1	22.293	Hexadecanoic acid	Palmitic acid	$C_{16}H_{32}O_2$	C16:0	0.852	2.32
2	26.546	9- Octadecenoic acid	Oleic acid	$C_{18}H_{34}O_2$	C18:1	0.895	11.15
3	29.26	9, 12- Octadecadienoic acid	Linoleic acid	$C_{18}H_{32}O_2$	C18:2	0.9	35.71
4	28.639	9,12,15- Octadecatrienoic acid	Linolenic acid	$C_{18}H_{30}O_2$	C18:3	0.916	0.72
5	29.622	12,15- Octadecadienoic acid	α- Linolenic acid	$C_{18}H_{30}O_2$	C18:3	0.916	7.85
6	30.29	11- Eicosenoic acid	Gondoic acid	$C_{20}H_{38}O_2$	C20:1	0.883	0.51
7	38.891	Ricinoleic acid	Ricinoleic acid	$C_{18}H_{34}O_3$	C18:1	0.945	41.75

Table (3): Chemical and physical properties of jatropha and castor bean seed oils

Parameter	Value	
	Jatropha oil	Castor bean oil
Acid Value [mg KOH/g]	3.53±1.11	1.26±0.11
Saponification Value [mg KOH/g]	115.74±1.09	100.98±1.05
Iodine Value [g Iodine/100g]	88.80±1.10	76.14±1.11
Peroxide Value [meq/kg]	47±2.0	6.5±1.1
Refractive Index at 25 or 28°C	1.467±0.11	1.473±0.11
Colour	Golden Yellow	Amber Yellow

castor bean oils (2.19 and 0.51%, respectively) with high molecular weight as shown in Tables (1 & 2). Also, erucic acid (C22:1) (44.34 %) with high percentage and high molecular weight was identified in jatropha oil which may play a role in oil toxicity. According to Nabil and Yasser (2012), the insecticidal activity of *J. curcas* oil on *Sitophilus granarius* (Coleoptera) was related to the presence of high molecular weight fatty acids. Similar findings were also reported by Celestino *et al*. (2016) who stated that it might be a key factor in the insecticidal activity of the castor oil. This was in accordance with Khan *et al*. (1983) who found that the insect repellent activity of fixed oil of *Annonas quamosa* and *Polyalthes longifolia* were mainly due to the presence of high molecular weight fatty acids. This, confirming the present findings that the toxicity of jatropha and castor bean oils may be ascribed to the presence of high molecular weight fatty acids among other active agents.

Moreover, the major constituents of any essential oil are not the only components responsible for the toxic action and it is likely that these compounds act in synergy with the other secondary plant metabolites known also for their insecticidal properties (Lopez *et al*., 2008; Moraes *et al*., 2012 and Ribeiro *et al*., 2016). Essential oil constituents are predominantly lipophilic compounds that act as toxins, feeding and oviposition deterrents to different insect pests.

Although insecticidal activity of plant essential oils has been well described, very few works have been conducted in relation to the toxicity of jatropha and castor bean oils against *T. urticae*. Several reports have dealt with the use of essential oils from *J. curcas* to control insect pests. These comprise mosquitoes larvae (Cantrell *et al*., 2011), termites (Singh and Sushilkumar, 2008; Acda, 2009), diamondback moth (Kumrungsee *et al*., 2014), plants bugs (Ratnadass *et al*., 2009), *S. granaries* (Nabil and Yasser, 2012), adults of Coleoptera, *Callosobruchus maculates* (Boateng and Kusi, 2008). Nevertheless, it was used to control some ectoparasite mites (Dimri and Sharma, 2004). Castor bean oil was more recently used as a biocide for ticks *Rhipicephalus sanguineus* by preventing the development of oocytes (Sampieri*et al.*, 2012), bacteria *Leuconostocmes enteroides* (Messetti *et al*., 2010), and also for ectoparasites (Leonardo *et al*., 2001).

The acaricidal activities of the two essential oils studied have been assessed and found toxic to *T. urticae*. Our results clearly confirm that both seed oils of *J. curcas* and *R. communis* significantly affected adult and nymphal stages of *T. urticae*. Population

reduction rate and mean number (±SE) *T. urticae* adults and nymphs after treatments with jatropha (15%) and castor bean oils (15%) on *A. rosea* leaves were summarized in Table (4). Jatropha oil achieved 66.6, 72.7, 78.3, 76.9 and 76.1%reduction of adult stage and 75.4, 78.4, 75.7, 72.6 and 73.9% reduction of nymph stage populations after 3, 5, 7, 14 and 21 days post treatments, respectively. Castor bean oil achieved 70.8, 95.9, 85.0, 72.1, 62.8%reduction of adult stage and 63.9, 97.8, 90.5, 87.4 and 75.0% reduction of nymph stage populations after 3, 5, 7, 14 and 21 days post treatments, respectively. The total population reduction rate of jatropha oil on adult stage was 74.12%; while it was 77.32% for castor bean oil, respectively. But for nymphs, the total population, reduction rate of jatropha oil was 75.19% as compared to 82.91% for castor bean oil, respectively.

Population reduction rate and mean number (±SE) of *T. urticae* adult and nymph stages after treatments with jatropha (15%) and castor bean oil (15%) on *A. rosea* flowers were summarized in Table (5). Jatropha oil achieved 55.6, 71.4, 81.7, 66.0 and 69.0% reduction of adult stage and 65.5, 90.5, 78.6, 62.4 and 72.8% of nymph stage populations after 3, 5, 7, 14 and 21 days post treatments, respectively. On the other hand, castor bean oil achieved total population reduction rate 65.9, 82.6, 76.2, 70.9 and 66.2% for adult stage and 66.4, 87.2, 81.9, 73.8 and 70.8% reduction of nymph stage populations after 3, 5, 7, 14 and 21 days post treatments, respectively. The total population reduction rate of jatropha oil on adult stages was 68.74%; while it was 73.94% for castor bean oil, respectively. But for nymphs, the total population reduction rate of jatropha oil was 72.33% as compared to 76.02% for castor bean oil, respectively.

Generally, the insecticidal effect of jatropha oil has been ascribed mainly to its phorbol ester fraction; it was up to 1-2% (Makkar *et al*., 1998; Makkar and Becker, 2009). It is a tetracyclic deterpenoid that imitates the action of diacyl glycerol, activator of protein kinase C which adjusts many Cellular metabolic activities (Goel *et al*., 2007 and Katoune *et al*., 2011). Roy *et al*. (2016) found that jatropha oil has very strong insecticides and anti-mite properties against thrips and bugs of cowpea at 7.5% and tea red spider mite *(Oligonychus coffeae*), respectively. Similar findings were also reported in other studies showing the toxic effects of jatropha oil against insects where Habou *et al*. (2011) showed the insecticidal effect of *J. curcas* oil against aphids that attack *Vicia fabae*, and cowpea insect pests in fields. On cowpeas, 5% and 7.5% of *J. curcas* oil may reduce the level of attack by 10 and 50%, respectively. Also, Lateef *et al*. (2014) showed that *J. curcas* phorbol esters possess a high level of insecticidal effect on the nymph and adult cockroaches and termites.

Table (4): Population reduction of *T. urticae* adult and nymph stages after treatments with jatropha (15%) and castor bean oil (15%) on *Alcea rosea* leaves.

	Before Treatment	After Treatments										
		3 Days		5 Days		7 Days		14 Days		21 Days		Total % Red.
Treatments	Mean No.	Mean No.	Red. (%)	Mean No.	Red. (%)	Mean No.	Red. (%)	Mean No.	Red. (%)	Mean No.	Red. (%)	
Adults												
Jatropha oil 15%	34.88±3.34	17.50±6.81	66.6	13.38±2.43	72.7	9.38±0.63	78.3	7.88±1.79	76.9	8.5±2.42	76.1	74.12
Castorbeanoil15%	41.00±7.62	18.00±2.90	70.8	2.38±0.26	95.9	6.50±1.69	85.0	9.50±1.75	72.1	13.25±1.75	62.8	77.32
Control	48.88±2.65	73.38±8.80	-	68.63±7.04	-	60.63±11.19	-	47.75±4.90	-	50.14±5.70	-	-
Nymphs												
Jatropha oil 15%	85.75±9.07	34.88±14.02	75.4	29.00±6.87	78.4	33.63±4.78	75.7	32.88±11.98	72.6	19.50±8.15	73.9	75.19
Castorbeanoil 15%	188.13±35.61	112.38±19.78	63.9	6.38±0.73	97.8	28.88±1.33	90.5	33.13±6.64	87.4	41.00±7.88	75.0	82.91
Control	102.63±9.98	169.63±24.01	-	160.50±27.69	-	165.88±29.18	-	143.38±16.64	-	89.57±18.08	-	-

Table (5): Population reduction % of *T. urticae* adults and nymphs after treatments with jatropha (15%) and castor bean oil(15%) on *Alcea rosea* flowers.

	Before Treatment	After Treatments										
		3 Days		5 Days		7 Days		14 Days		21 Days		
Treatments	Mean No.	Mean No.	Red. (%)	Mean No.	Red. (%)	Mean No.	Red. (%)	Mean No.	Red. (%)	Mean No.	Red. (%)	
Adults												
Jatropha oil 15%	10.00±1.15	4.00±0.46	55.6	1.63±0.38	71.4	1.25±0.45	81.7	2.63±0.49	66.0	2.75±0.92	69.0	68.74
Castorbeanoil15%	11.38±1.43	3.50±0.46	65.9	1.13±0.35	82.6	1.63±0.56	76.2	2.25±0.65	70.9	3.00±0.70	66.2	72.33
Control	16.50±1.61	14.88±1.41	-	9.38±0.65	-	11.25±1.01	-	12.75±1.44	-	14.57±3.47	-	-
Nymphs												
Jatropha oil 15%	15.38±2.04	6.00±0.87	65.5	1.50±0.33	90.5	3.25±0.65	78.6	4.63±0.73	62.4	3.00±0.93	72.8	73.94
Castorbeanoil 15%	16.13±2.07	6.13±1.11	66.4	2.13±0.51	87.2	2.88±0.72	81.9	3.38±0.89	73.8	3.38±0.88	70.8	76.02
Control	36.13±3.89	40.88±3.23	-	37.13±1.83	-	35.63±5.03	-	28.88±5.36	-	25.86±5.35	-	-

Our data demonstrated that the castor bean oil recorded higher acaricidal activity than that of jatropha oil with the same concentration for nymph and adult stages on both leaves and flowers of *A. rosea*. This was in agreement with Abd-Alla *et al*. (2015) who studied the acaricidal activities of two local cultivars of *R. communis* against *T. urticae* in Egypt. In contrast, Alonso and Santos (2013) evaluated and analyzed the toxic action and deterrent properties of castor bean and jatropha oil against workers of the leaf-cutting ant (*Atta sexdens*) in laboratory and found that jatropha oil exerted more toxic effects than castor bean oil. The previous studies showed that toxicity of castor oils against different insects was related to ricinoleic acid (87-90%) (Akpan *et al*., 2006 and Conceicao *et al*., 2007).This observation was in line with our study and with earlier reports by Morehouse *et al*. (1986) who stated that ricinoleic acid is the active component of castor bean oil.

The mode of action of essential oil compounds is also not fully understood, but they elicit characteristic neurotoxic symptoms including agitation, hyperactivity, paralysis and knockdown (Koul *et al*., 2008). In this aspect, the acaricidal activity of the essential oils used in our study could be due tophorbol ester, ricinoleic acid or other high molecular weight fatty acids like gondoic or erucic acids or other bioactive compounds which may affect alone or in synergism for jatropha and castor bean oils, respectively.

In conclusion, the use of natural products may be considered as important alternative acaricide to control this pest, since it constitute a rich source of bioactive compounds that are biodegradable, non-toxic, and their effects might be either the result of a synergism of all molecules or could reflect only those of the main molecules. However, the cost of the essential oil may also be an important factor for its implementation, which depends on the availability of the plant and its yield. In accordance with the present conclusions, castor bean essential oil may be used as an ecologically safe alternative pesticide against *T. urticae* followed by jatropha oil. Also, we need to separate the active ingredients of the oils tested, and then evaluate its acaricidal activities on the different life stages of the *T. urticae*.

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