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Toxicity of potato extract on *Tetranychus urticae* (Acari: Tetranychidae) and its effect on biology and life table parameters

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Abstract:

The present study aimed to evaluate the unless and harmful part of the potato plant, which is the green part of tubers contains solanine, as a botanical pesticide. The red spider mite *Tetranychus urticae* Koch (Acari: Tetranychidae) is one of the most dangerous pests all over the world. It has been reported to attack about 1200 species of plants. It causes damage to vegetables, sweet corn, beans, peas, hops, grapes, deciduous fruit trees, strawberries and many other fruit, flowers and ornamental plants. Due to the problems of chemical acaricides to all organisms and environment, natural control replaced pesticides. The green potato extract contains solanine which is toxic and effective material in control. Different little concentrations of green potato extract were applied in control of red spider mite and caused high mortality proportion. In this study, the used concentrations were 1000, 3000, 5000 and 10000 ppm and the mortality increased when the concentrations increased. LC_{50} of the extract was 3503.69 ppm and LC_{90} was 62667.81. Then, LC_{50} was applied on adult female for recording its effect on biology and life table.

Introduction

Potato, *Solanum tuberosum*, is the fourth major crop around the world. In Egypt, it has an important position among all vegetable crops, where about 20% of total area devoted for vegetable production is cultivated with potato. In addition, any disturbance in its production affects severely its local and more importantly export variable. Potato plants are subjected to numerous pathogens and insect pests which cause considerable loss in Egyptian quantitative and qualitative potato yield.

Solanine is a natural toxic chemical compound that is a glycoalkaloid produced in some species of the nightshades family (Solanaceae) such as potato, tomato and eggplant (Tajner-Czopek, 2008). It is produced in potatoes when exposed to light, turning to green and increase glycoalkaloid production.

Several pests attack potato plants, one of these pests is the red spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae). This spider mite is extremely polyphagous, it has a broad host-plant range (Tsagkarakou *et al.*, 2002 and

Tehri, 2014). This mite is a generalist species that can feed on hundreds of hosts plants and causes considerable damage to field, greenhouse and horticultural crops, as well as ornamental and fruit-bearing trees including Rosa (Sedaratian *et al.*, 2010 and Jafari *et al.*, 2012). Feeding activity of spider mite leads to the appearance of typical yellow chlorotic spots on leaves with profuse webbing on the underside of leaves. In severe infestations, leaves may fall, and the flowering may be considerably reduced (Khodayari *et al*., 2008). The short life span and high reproductive potential causes a fast-growing population that allows the mite to achieve economic injury level in appropriate conditions, resulting in a rapid decline of host plant yield and quality (Jalalvandi *et al.*, 2015).

Pesticides produced from natural products, recently, have been attracting the attention of many scientists to avoid many problems caused by synthetic compounds. They are deeply interested in their chemical constituents and biological properties (Abou-Yousef *et al.*, 2010). The aim of this study is to determine the toxicity of extract of green parts of potato, contains solanine, on the red spider mite *T. urticae* and the effect of the extract on biology and life table of the mite.

Materials and methods

1. Rearing mites:

T. urticae were collected from unsprayed potato leaves of unsprayed fields and reared, in laboratory, at 25± 2° C and 60± 5%RH.

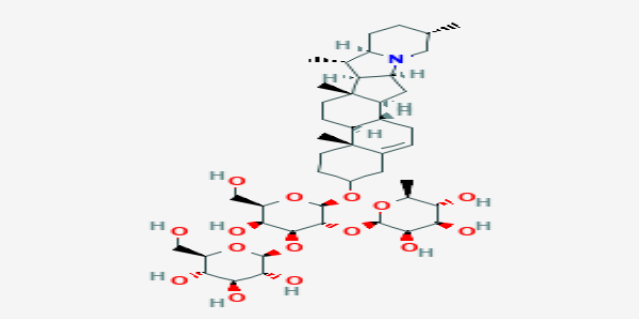
2. Preparation of plant sample and extraction:

Green parts of potato tubers were collected and left to dry at room temperature then grinded into fine powder. Powder was soaked in a mixture of hexane, acetone and ethanol solvents of equal proportions (1:1:1) in a flask for about one week. Finally, the flask was shaked in a shaker and its contents were filtered. The solvents were evaporated under reduced pressure, the crude extract was weighted and kept in deep freezer until use.

3. Preparing the stock solution of the tested plant extract:

Convenient stock, concentrations of green potato extract, was prepared on basis of the tested powder weight and the volume of the distilled water (w/v) in the presence of tween 80 (0.1%) as emulsifier. The stock concentrations were kept in glass stoppered bottles and stored under refrigeration. Such stock solutions were prepared periodically. Four diluted concentrations for the plant extract were used to draw the LC-P Lines. Four replicates were used for each concentration.

- Green parts of potato tubers contain solanine (C45H73NO15) (The Merck Index , 1976).



Desfosses, 1820

4. Application method:

4.1. Toxicity experiment:

For conducting this experiment, potato tubers were planting in pots until the green leaves were appeared to use these leaves as discs for application. Thirty newly emerged adult females were transferred to the lower surface of potato leave discs (2 cm diameter) placed separately on moist cotton wool in Petri dishes. Each petri dish contains three replicates, ten individuals in each replicate. The extract had four concentrations which were sprayed on the individuals. The concentrations used were 250, 500, 750 and 1000 ppm. The percentage of mortality was recorded after one, three, five and seven days and the data were corrected relatively to

control mortality (Abbott, 1925). LC_{50} values were determined using probit analysis statistical method of Finney, (1971).

4.2. Biology and life table:

After calculating LC_{50} of the extract, 3506 ppm, three discs of treated potato leaves with LC_{50} of the extract were prepared comparing with three discs of untreated potato leaves (as control). Three females, for each group, of *T. urticae* were put over the three discs, for each group, one female on each disc. The daily laid eggs were evaluated and counted carefully for life table calculation. Life cycle and life span of *T. urticae* were, also, calculated, for the two groups.

Results were analyzed by life table program (Abou-Setta *et al.,* 1986) and L.S.D. values were calculated by costat program (Costat software, 1990).

Results and discussion

1. Efficiency of potato extract on female of *Tetranychus urticae*:

The data in Table (1) demonstrated that, although the extract concentrations were low, the mortality rate of female of *T. urticae* was high and when the concentrations increased, the total mortality increased. These results agreed with Zbigniew *et al.* (2014) which proved the effectiveness of potato leaf extract against *Galleria mellonella* (L.) (Lepidoptera, Pyralidae).

However, Table (2) and Figure (1) demonstrated that, LC_{50} was 3503.69 ppm and LC_{90} was 62667.81 The probability was 0.092. Zbigniew *et al.* (2014) indicated that potato leaf extract, especially solanine, caused mortality to the larvae of G. *mellonella*.

Table (1): Corrected mortality % of the female of *Tetranychus urticae* treated with potato extract under laboratory conditions 27±2 ◦C and 65±5% RH.

Treatment	Conc. (ppm)	Mortality after treatments %				Total Mortality %
		One day	Three days	Five days	Seven days	
Potato extract	1000	10	6.67	10	6.67	33.34
	3000	20	3.33	10	6.67	40
	5000	23.33	13.33	10	6.67	53.33
	10000	40	16.67	10	3.33	73.33

Table (2): Efficiency of potato tubers extract against *Tetranychus urticae.*

Treatment	Conc. (ppm)	Corrected mortality%	LC_{50}	LC_{90}	Slope± S.D.	LC_{90}/LC_{50}	R	P
Potato extract	1000	33.34	3503.69	62667.81	1.023± 0.180	17.89	0.956	0.092
	3000	40						
	5000	53.33						
	10000	73.33						

R: Regression **P: Probability**

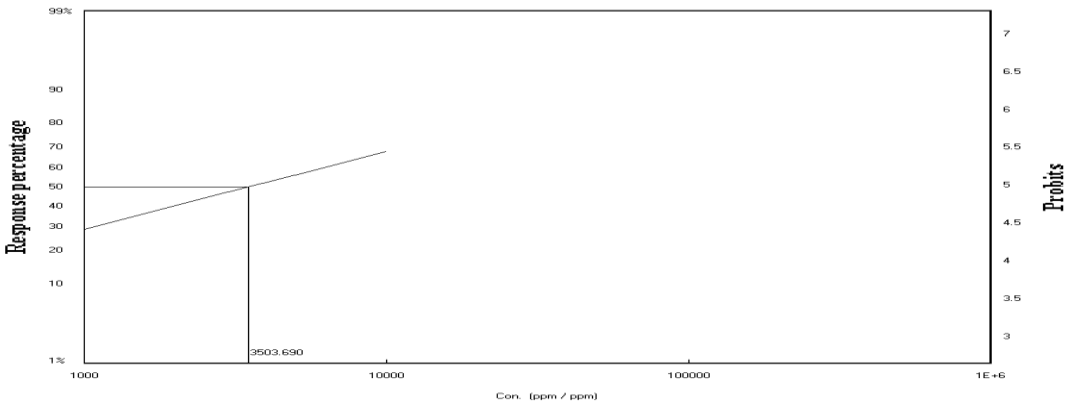


Figure (1): LC-P line for potato extract of *Tetranychus urticae*

2. Effect of LC_{50} of potato tuber extract on biology of *Tetranychus urticae*:

Results in Table (3) indicated that, each of incubation period, larval duration, protonymph and dutonymph of *T. urticae* fed on untreated leaves had smaller periods than *T. urticae* fed on treated leaves. As the result of this, the total life cycle decreased in case of untreated leaves than the treated ones which was 14.2 and 16.2 days, respectively. Also, Table (3) described that longevity and generation periods decreased in case of untreated leaves than the treated ones. However, the life span of *T. urticae* decreased in case of untreated leaves than the treated ones, which was 34.8 and 38.4 days, respectively. These results explained that, green potato extract (contains solanine) increasing all biological durations and as the result of this, generation periods significantly increased so the number of generations per year decreased. Nenaah (2011) indicated that, potato gas reduced the growth rate, food consumption rate, and food utilization by adult *Trogoderma granarium* Everts (Coleoptera: Dermestidae), probably due to their toxic and antifeedant activity. Zbigniew *et al.* (2014) proved the inhibitory effects of potato leaves extract and α-solanine on survival, fecundity and fertility of *G. mellonella*.

Table (3): Effect of green potato extract on life cycle and life span of *Tetranychus urticae*:

Stages	*Tetranychus urticae* Fed on leaves untreated	*Tetranychus urticae* Fed on leaves treated
Incubation period	**3.1 ± 0.57**	**3.8 ± 0.63**
Larvae duration	**3.6 ±0.52**	**4.1 ± 0.57**
Protonymph	**4.2 ± 0.42**	**4.4 ± 0.52**
Deutonymph	**3.3 ± 0.48**	**3.9 ± 0.57**
Life cycle	**14.2 ± 0.92**	**16.2 ± 0.79**
longevity	**20.6 ± 2.97**	**22.2 ± 1.64**
Generation period	**15.8 ± 0.55**	**18.6 ± 0.55**
Life span	**34.8 ± 2.97**	**38.4 ± 1.64**

In Table (4), longevity and fecundity of female of *T. urticae* on both treated and untreated leaves of potato were examined. In the obtained results, longevity of *T. urticae* female fed on untreated potato leaves decreased significantly than the treated ones

and recorded 20.6 and 22.2 days, respectively. While, fecundity of female increased highly significant in case of *T. urticae* female fed on untreated potato leaves than the treated ones and recorded 98.4 and 79.2 eggs/ female, respectively. So, daily rate of eggs/ female was 9.9 and 6.08 eggs/ female, respectively. These results were good guideline that the extract of green potato (contains solanine) had great effect on fecundity of female and reducing the next generations of *T. urticae*. Similarly, α-chaconine (in potato leaves extract) decreased reproduction rates of the potato aphid *Macrosiphum euphorbiae* (Thomas) (Hemiptera: Aphididae) (G¨untner *et al*., 1997). α-solanine and α-chaconine added to an artificial diet, in concentrations lower or like those observed in potato leaves, reduced fecundity, feeding, and increased mortality in adults peach potato aphids *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) (Fragoyiannis *et al.*, 1998).

Table (4): Effect of green potato extract on longevity and fecundity of *Tetranychus urticae* female.

		***Tetranychus urticae* Fed on leaves untreated**	***Tetranychus urticae* Fed on leaves treated**
Average duration (days)	**Pre oviposition Period**	**1.6 ± 0.55**	**2.4 ± 0.55**
	Oviposition period	**10.2 ± 2.17**	**13.0 ± 2.00**
	Post oviposition Period	**8.8 ± 1.30**	**6.8 ± 0.84**
Longevity (Days)		**20.6 ± 2.97**	**22.2 ± 1.64**
Fecundity	**Egg / Female**	**98.4 ± 13.50**	**79.2 ± 15.45**
	Daily Rate	**9.9 ± 1.73**	**6.08 ± 0.79**

In Table (5), data represented that, the net reproduction rate (R_0) was very high in *T. urticae* fed on untreated leaves (4446), while it was (3573) in *T. urticae* fed on treated leaves. However, the mean generation time (T) was little in *T. urticae* fed on untreated leaves (19.14) comparing with *T. urticae* fed on treated leaves (22.57).

Intrinsic rate of increase (r_m) and finite rate of increase ($\exp_{rm}$) were little higher in *T. urticae* fed on untreated leaves (0.44 and 1.55), respectively than *T. urticae* fed on treated leaves (0.36 and 1.44), respectively. As the result of this, the generation doubling time was 3.21 and 3.93 days for *T. urticae* fed on untreated leaves and *T. urticae* fed on treated leaves, respectively. Nenaah (2011) proved that, potato gas also reduced the growth rate for adult *T. granarium*. Similarly, G¨untner *et al.* (1997) indicated that, α-chaconine of potato leaves extract decreased reproduction rates of the potato aphid *Macrosiphum euphorbiae* (Thomas) (Hemiptera: Aphididae).

Table (5): Effect of green potato extract on life table parameters of *Tetranychus urticae* female.

Parameters	*Tetranychus urticae* Fed on leaves untreated	*Tetranychus urticae* Fed on leaves treated
Net reproduction rate (Ro)	**4446**	**3573**
Mean generation time (T)	**19.14**	**22.57**
Intrinsic rate of increase (rm)	**0.44**	**0.36**
Finite rate of increase (exp $_{rm}$)	**1.55**	**1.44**
Generation doubling time (days)*	**3.21**	**3.93**

Generation doubling time (days) = ln_2 / r_m

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