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Repulsive effect of potassium tartrate against *Eobania vermiculata* and *Monacha obstructa* (Gastropoda: Helicidae: Hygromiidae) land snails under laboratory and field conditions

Soha, A. Mobarak; Fatma, M. El-Gohary and Abu El-Kheer, R. K.

Plant Protection Research Institute, ARC., Giza, Egypt.

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Abstract

The effect of potassium tartrat (PT) was studied against Eobania vermiculata (Müller) and *Monacha obstructa* (Pfeiffer) (Gastropoda: Helicidae: Hygromiidae) land snails under laboratory and field conditions. Four concentrations of PT (2, 4, 6 and 8%) were used as dust discs of lettuce leaves using non and free choice feeding methods. The laboratory results revealed that the PT hasn't any toxic effect against both land snail species at non choice feeding test. While, it caused repellent effect against the two land snail species. The 8 % concentration was the most effective concentration which gave 93 % repellency for *E. vermculata* and 85 % for *M. obstrucata* at free choice feeding test. Under Field condition 8% of PT as dust application on plant leaves against *E. vermiculata* and *M. obstructa* land snails was evaluated. The PT achieved 53% reduction for *E. vermiculata* after 7 days of treatment, while it gave 6 % reduction for *M. obstructa*. It was observed the snails avoided feeding and climbing the plants. So, it can conclude that the PT can be using as a product to protect the foliage of plants from snails attack and prevent them to climb the plants. Also, it prevents the pollution with snail's mucus which reduces the economic value of plants. So, it can be using this substance in the organic fields for controlling the snails.

Introduction

Land snails and slugs are herbivorous pests. They are pests of cultivated plant species in many regions of the world (Feldkamp, 2002). The damage of land mollusca caused by different ways, direct way by feeding on several plants such as field crops, orchards and vegetables. While, indirect way as infection by bacteria, fungi and virus due to the feeding of snails by scratching the plants (Lindqvist *et al.*, 2006). The land snails *E. vermiculata* and *M. obstructa* are the most distributed land snails in Egypt. These snails caused severe damage to all parts of orchards trees, vegetables and field crops (El-Okda, 1979). Chemical control is useful, but it can be harmful to other organisms. The commonly used chemical control is in the form of snail's pellets containing the active ingredient metaldehyde (Plomi *et al*, 2009). Also,

methomyl is one of the pesticides use as a molluscicides in Egypt, is known to affect on non target organisms and ground water. Repellent effect is another method to reduce slug and snails herbivores on crops may be to divert the slugs from target plants by offering palatable alternative food plants (Frank and Barone, 1999). However, such an a approach seems to be unsuitable for lettuce as this crop may be suffer sever yield losses from plant competition. Lettuce appears to be an attractive food source to slugs due to its thin, soft leaves and low levels of secondary compounds (Hegnauer, 1964). Snails and slugs pests are usually controlled with bait pellets containing either methocarb or metaldehyde (Garthwaile and Thomas,1996 and Speiser, 2001). In organic farming, there is a need to use friendly bio-compound to control the pests. Potassium tartrate (PT) is a salt of tartaric very used in food additive. Potassium tartrate, as a bird repellent, was tested for protecting non-target bird species from the poisoning hazards of acute and anticoagulant rodenticides (Soliman *et al.* ,2009). PT, proved to be a good repellent for quails, but not toxic for honey bee colonies as well as to be environmentally safe and used as pest integrated control (El-Gohary and Eissa ,2015).

This study is a part of larger research program in which the effect of potassium tartrate as a repellent compound against (land snail as the current study). The repellent effect of potassium tartrate (PT) was studied using dust application method against two land snail species, *E. vermiculata* and *M. obstructa* under laboratory and field conditions.

Materials and methods

1. Chemical compounds:

1.1. Potassium tartrate (PT) :

The material has the following formula: $K_2C_4H_4O_6$ with a molecular weight of 262. The pure PT is in the form of white pure crystal.

1.2. Talc powder:

Clay mineral (used as carrier material) hydratedmagnesium silicate $Mg_3Si_4O_{10}(OH)_{12}$. Talcin powdered form, often in combination with corn starch is widely used as baby powder.

2.Tested animals:

Two land snail species were used in the experiments. Choclate band snail, *E. vermiculata* and clover snail, *M. obstructa*. *E. vermiculata* was collected from orchards of Abu- Roash district, Giza Governorate, and *M. obstructa* was collected from clover field of Kom- Hamada, Behira Governorate. Healthy adult individuals were kept in laboratory in separate glass terraria (70 × 40 × 35) cm containing mixture of clay, sand and peat (1: 1: 1) of about (10 cm) deep was wetted with water and covered by white muslin with rubber band. Snails were performed under controlled temperature and light conditions. Snails were fed on carrot, lettuce and acclimated under laboratory conditions for four weeks. Five replicates (each of 10 animals of each species) were used for each test

3. Laboratory experiments:

3.1.Non choice feeding method:

This method was described according to **Shefte *et al*. (1982).** Serious concentrations of Potassium Tartrate (PT) were used as dust application on foliage lettuce against two land snail species, *Eobania vermiculata* and *Monacha obstructa*i.e. 2, 4, 6 and 8% of PT. Animals were exposed to 25cm^2green lettuce foliage discs for four successive days before the treatment. The consumed area was daily estimated. This procedure was repeated daily for four days with lettuce foliage discs previously dusted by the tested concentrations of PT and other ten snails were exposed to 25 cm^2green foliage dusted by talc powder (as carrier). The repellency

potential was calculated using the following equation according to **Bullard and Shumake (1983).**

$$\text{Repellency\%} = 100 - \frac{\text{Average consumed treated food}}{\text{Average consumed (treated+ untreated food)}} \times 100$$

Value ≥ 60% considered repellent.

3.2. Free choice feeding method:

Free choice feeding method was used according to Russell *et al*. (1989). Animals were exposed to two green lettuce foliage discs treated with the concentrations of potassium tartrate i.e (2, 4, 6 and 8%) and others were untreated. Also, ten animals exposed individually to two green foliage of lettuce 25cm^2 area for each animal. The first leave treated with talc powder and others were untreated. The position of the two exposure leaves was altered daily to avoid any bias to certain location. The area of the treated and untreated leaves was daily estimated. The repellency potential was calculated according to the previous equation.

4.Field experiment:

4.1. Effect of potassium tartrate against *Eobania vermiculata*:

The infested citrus seedling with *E. vermiculata* which planted in Nursery of the Agricultural Ministry, EL-Dokki district Giza Governorat, into three group each (4mx 4m) and the number of snails were counted (5 replicates) pre-treatment in each group. group (1)) dusting by 8% Potasuim tartrate (gave highly repellent effect in Lab) Group (2) dusted by Talc powder (stander carrier), Group (3) untreated as a control The snails were counted after treatment in each group/ replicates after 1 day,3.7 15 and 21 days (post-treatment), according the protocol of agriculture ministry. Reduction percent of snails number on plant were calculated according to Henderson and Tilton (1955) as a following formula.

$$\text{Reduction \%} = 1 - \frac{C_1 \times T_2}{C_2 \times T_1} \times 100$$

C_1=population of snails in control before application.

C_2=population of snails in control after application.

T_1=population of snails in treatment before application.

T_2=population of snail in treatment after application.

4.2. Effect of potassium tartrate against *Monacha obstructa*:

Three kirat of infested clover field with *M. obstructa* which planted in Kom Hamada district, EL-Behira Governorat, Egypt May 2018. Three groups (each 5 replicates) were one kirat. The same method was done as mentioned above.

5. Stattiscal analysis:

The results were statistically analyzed using the standard statistical methods LSD- test was applied in the analyses by SAS (2006).

Results and discussion

1. Repellency tests under labortary conditions:

1.1.Non choice feeding method:

Results in Table (1) revealed that the snails consumed the treated slices of lettuce on first and fourth day of treatment at 2 and 4% of potassium tartrate (PT) while they avoided eating the treated slices of lettuce on second and third day. The consumption of treated lettuce was less than lettuce with standard treatment or control. Regarding of 6 and 8% of PT snails avoided to eat on all days of treatment. PT achieved 100% repellent effect against *Eobania vermiculata* at 8% and it hasn't toxic effect for snail. The effect of PT against *Monacha obstructa* using non choice test was shown in Table (2). Data recorded that the snails avoided tofeed on treated lettuce with 2% PT on the first and third day of treatment while they fed on the second and fourth day. At 4% PT snails fed on 1st and 2nd day while they avoided to eat on the 3rd and 4thday. At 6% and 8% concentrations of PT snails avoided

to eat on the first, third and fourth days. While, they ate on the third day. On the other hand, it was observed that eating of treated plant was little than the carrier material and control. Potassium tartrate achieved 88.3, 54.2, 85.03 and 95.0 repellency% at 2, 4, 6 and 8% concentrations, respectively comparing with 79.87repellencypercentage in case the carrier. On the other side, it was observed that PT has non toxic effect on *M. obstructa*. From the previous results, it means that PT was safety compound and it caused repellent effect against land snails *E. vermiculata* and *M. obstructa*. This effect may be the resulting from the non acceptable taste for snails. Also, data investigated that the higher concentrations of PT were more repellent. Frank *et al* (2002) studied that in non choice test of 0.25 0.75 ml/ L caravane extract reduced the slug feeding comparing with the un- treated. Also, Capinera and Dickens (2016) found that the high concentrations of copper were more effective against snails and slugs as feeding deterrents by four terrestrial mollusks, two slugs and two snails were more effective feeding deterrents. Lindavist *et al.* (2010) registered that Birch tar oil, mixed with vaselline serves as an excellent long-term repellent against *Ariantana arbistorum* land snail and *Arion luwitanicus* land slug.

Table (1): Repellent effect of potassium tartrate (PT) against *Eobania vermiculata* using non choice feeding test.

Concentrations	**Average daily consumption of Lettuce cm^2/ snail.**					**Repellency %**
	1 st day	**2nd day**	**3rd day**	**4th day**	**Average**	
2	4.76±6.5 BAC	0±0.0 D	0±0.0 D	0.1±0.22 D	1.22±1.68 B	85
4	5.9±8.5 BAC	0±0.0 D	0±0.0 D	0.1±.22 D	1.5±2.10 B	82.74
6	0±0.0 D	0±0.0 D	0±0.0 D	0±0.0 D	0±0.0 B	100
8	0±0.0 D	0±0.0 D	0±0.0 D	0±0.0 D	0±0.0 B	100
Standard treatment (carrier material)	7.36±8.5 BA	3.5±4.35 BDC	1.66±2.41 DC	8.1±6.18 A	5.16±1.43 A	58.22
Control	6.64±2.9 BA	5.57±2.84 BAC	8.1±1.90 A	8.47±6.71 A	7.193±2.29 A	

The vertical columns marked with the same letters are not significantly different by SAS (2006).

Table(2) : Repellent effect of potassium tartrate (PT) against *Monaca obstructa* using non choice feeding test.

Concentrations %	Average daily consumption of Lettuce cm^2/ snail.					Repellency %
	1 st day	2nd day	3rd day	4th day	Average	
2	0.0 ± 0.0^{BA}	0.83 ± 1.44^{BA}	0.0 ± 0.0^{B}	0.5 ± 0.87^{B}	0.33 ± 0.58^{B}	88,34
4	5.83 ± 5.06^{A}	0.50 ± 0.87^{A}	0.0 ± 0.0^{B}	0.0 ± 0.0^{B}	2.11 ± 1.84^{BA}	54.23
6	0.58 ± 1.01^{BA}	1.17 ± 2.02^{B}	0.0 ± 0.0^{B}	0.0 ± 0.0^{B}	0.44 ± 0.76^{B}	85.03
8	0.0 ± 0.0^{BA}	0.5 ± 0.87^{B}	0.0 ± 0.0^{B}	0.0 ± 0.0^{B}	0.13 ± 0.22^{B}	95,06
Standard treatment (carrier material)	0.17 ± 0.29^{B}	2.00 ± 3.46^{BA}	0.0 ± 0.0^{B}	0.33 ± 0.58^{BA}	$0.63+0.76^{B}$	79.87
Control	$1.28+0.48^{BZ}$	2.22 ± 0.41^{BA}	4.11 ± 2.21^{A}	2.39 ± 0.63^{BA}	2.50 ± 0.46^{A}	

The vertical columns marked with the same letters are not significantly different by SAS (2006).

1.2. Free choice feeding method.

Data in Table (3) response of *E. vermiculata* land snail to potassium tartrate as dust application using free choice feeding method. Results revealed that *E. vermiculata* snails consumed the un-treated lettuce discs in all concentrations on all days of treatment. While they ate the treated lettuce discs with 2, 4, 6 and 8% concentrations after one day of treatment. The consumed amount was 2.95, 0.0, 0.7 and 0.65 cm^2, respectively comparing with 14.2 cm^2/snails for control. The same trend occurred on the following days of treatment, whereas the consumed amount was little than control. While, the snails avoided to consume the treated lettuce discs after the second and third day of treatment at 6% and 8% concentrations. Results indicate that the repellency percent were 71.57, 91.75, 82.88 and 93.80% at the concentration of 2, 4, 6, and 8% of PT respectively. Concentration 8% of PT was the most effective as a repellent for *E. vermiculata* land snails. The repellent effect of different concentrations of PT as dusting application against *M. obstructa* land snails was shown in Table (4). The same trend was observed in case of *M. obstructa* whereas the consumed amount of treated lettuce discs was less than control. Snails avoided eating the treated lettuce after the second and third day of treatment. Animals began to eat again on the fourth day of treatment, but the consumption of treated lettuce discs was less than the consumption of untreated lettuce. Also, 8% concentration of the PT caused highly repellency percent for *M. obstructa* whereas it gave 85.45% repellency. The other concentrations of PT 2, 4% and 6% caused 75.45, 67.68, and 77.77% repellency, respectively.

Table (3): Repellent effect of potassium tartrate (PT) against *Eobania vermiculata* using free choice feeding test.

Concentrations%	Average daily consumption of Lettuce cm^2/ snail.										Repellency %
	1st Day		2nd Day		3rd Day		4th Day		Average		
	Un	T	Un	T	Un	T	Un	T	Un	T	
2	5.2±7.8^{CEBD}	2.95±4.9^{CEBD}	0.3±0.6^{E}	0.0±0.0^{E}	4.0±5.58^{CEBD}	0.45±1.01^{E}	6.65±6.8^{CBD}	3.0±3.02^{CEBD}	038±5.22^{B}	1.6±2.2^{CBD}	71.57
4	7.5±11,0^{B}	0.0.0±0.0^{E}	0.5±0.6^{E}	0.75±1.68^{E}	4.2±9.39^{CEBD}	0.35±0.78^{E}	0.1±0.2^{E}	0.0±0.0^{E}	3.08±5.3^{CBD}	0.28±0.6^{CD}	91.75
6	4.65±8.7^{CEBD}	0.7±1.5^{E}	2.0±3.6^{CEBD}	0.0±0.0^{E}	0.0±0.0^{E}	0.0±0.0^{E}	2.05±4.5^{CEBD}	1.10±1.4^{E}	2.18±4.2^{CBD}	0.45±6.7^{D}	82.88
8	17.34±9.^{A}	0.65±1.4^{E}	6.73±4.^{CBD}	0.0±0.0^{E}	2.3±3.22^{CEBD}	0.0±0.0^{E}	6.7±4.8^{CEBD}	1.4±3.1^{E}	8.27±5.0^{A}	5.13±1.1^{D}	93.80
St	4.25±5.1^{CEBD}	3.65±5.5^{CEBD}	1.4±3.1^{CEBD}	0.84±1.39^{CED}	1.2±2.17^{ED}	4.94±5.87^{A}	0.85±1.1^{E}	0.85±11.9^{E}	1.92±2.9^{CBD}	2.57±3.6^{CB}	42.55
Cont	14.2±8.3		18.4±6.68		16.7±10.59		13.12±1.0		15.61±6.65		

The vertical columns marked with the same letters are not significantly different by SAS (2006). St= Standard treatment (carrier material) . Cont= control .

Table (4): Repellent effect of potassium tartrate (PT) against *Monacha obstructa* using free choice feeding test.

Concentrations%	Average daily consumption of Lettuce cm^2/ snail.										Repellency %
	1st Day		2nd Day		3rd Day		4th Day		Average		
	Un	T	Un	T	Un	T	Un	T	Un	T	
2	1.3±1.79^{FECD}	0.4±0.89^{F}	5.15±1.79^{F}	0.2±0.45^{F}	0.0±0.0^{F}	0.7±1.57^{FE}	2.45±0.66^{FECD}	1.5±2.56^{FECD}	2.148±0.89^{BA}	0.7±0.87	75..45
4	0.7±0..97^{FE}	0.4±0.89^{FECD}	5.15±5.41^{BA}	2.25±3.18	0.35±0.78^{F}	0.4±0.89^{F}	2.3±2.36^{FECD}	1.01±1.14^{F}	2.125±2.00^{BA}	1.02±1.13^{B}	67.68
6	0.82±1.19^{FECD}	1.05±2.35^{FECD}	4.07±4.8^{FECD}	0.0±0.0^{F}	0.0±0.0^{F}	0.4±0.09^{F}	1.68±1.65^{FECD}	0.48±0.78^{F}	1.68±1.65^{BA}	0.48±0.77^{B}	77.77
8	0.6±0.8^{FE}	0.95±1.37^{FECD}	8.25±10.08^{A}	0.0±0.0^{F}	0.0±0.0^{F}	0.60±1.34^{FE}	2.92±3.58^{FEC}	0.52±0.74^{F}	2.94±3.60^{A}	0.52±0.74^{B}	85.45
St	4.5±10.06^{BC}	2.0±2.94^{FECD}	4.40±1.82^{FECD}	1.0±1.17^{F}	1.00±1.38^{FECD}	0.0±0.0^{F}	3.30±3.03^{FECD}	0.98±1.05^{FECD}	3.30±3.03^{A}	0.10±1.06^{B}	37.95
Con	3.7±2.34		1.23±0.78		1.60±0…91		1.44±0.98		2.01±1.14		

The vertical columns marked with the same letters are not significantly different by SAS (2006). St= Standard treatment (Carrier material). Cont= Control.

From the previous results of Tables (3 and 4) the results revealed that the two land snail species avoided eating the treated lettuce discs after the second and third day of treatment. Also, they fed again on the fourth day of treatment,

The results agreed with Ahmed (2005) who assayed 3% of Opoponax extract and 5% ocimen on *Helix aspersa*. Results showed to deter the snails from feeding on treated lettuce leaf discs. Also, the same results were found by Capinera and Dickens (2016) tested copper hydroxide on two land snails *Ileidyula floridanc* and *Deracera leave* using choice feeding method. Results revealed that the two species consumed the un-treated foliage more than the treated foliage. Capinera (2018) studied the repellent effect of Copper hydroxid on brown snails, *Zachrysia provisoria*. The result indicated that Copper hydroxiede reduced the number of snails crawling ever the treated area.

2. Field experiment.

Data in Table (5) showed the field performance of potassium tartrate (8%) using as dusting application for *E. vermiculata*. Results revealed that the number of snail individuals decreased to 90 and 91 snails/shrub after 1, 15 day of treatment comparing with 132 pretreatment while in the control number increased from 106 snail / shrub to 136, 183, 165 and 145 snails/ shrub after the same period. So, the reduction percentage of population density of snails was 46, 46.9, 53.09, and 50.39% at 1, 3, 7 and 15 days after treatment.

Table (6) showed the field performance of potassium tartrate (8%) using as dusting application for *M. obstructa*. Results cleared PT caused reduction percentages for *M. obstructa* whereas it was 28.4, 10, 6 and 5% after 1, 3, 7 and 15 days of treatment. And it was observed that snails can't climb the plant.

Table (5); Field performance of potassium tartrate against *Eobania vermiclata.*

Period / day	No. of snails in control	No. of snails in Standard	No. of snails after Treatment	Reduction% of snails.
Zero	106	105	132	-
1st day	136	83	90	46.9
3rd day	183	116	121	46.9
7th day	165	132	97	53,09
15th day	145	66	91	50.39

Table (6): Field performance of potassium tartrate against *Monacha obstructa.*

Period / day	No. of snails in control	No. of snails in Standard	No. of snails after Treatment	Reduction% of snails.
Zero	63	72	58	-
1st day	66	57	78	28.4
3rd day	74	59	62	10
7th day	61	57	53	6
15th day	56	56	49	5

From the previous results in Tables (5 and 6) the snails avoided to feed on the treated foliage of plants. So, the potassium tartrate (8%) caused feeding deterrent for two land snail species because it prevents snails from climbing the plants. It was indicated that the reduction of number of *E. vermiculata*

individuals were more than *M. obstructa* this is may be due to the repellent effect of PT differed according to snail species which attributed to differences in feeding patterns or feeding behavior among the snail species. So, the PT was more repellent effect for *E. vermiculata* than *M. obstructa*. Capinera and Dickens (2016) demonstrated that the Copper hydroxide functioned as a repellent and feeding deterrent for Mollusca species. Capinera (2018) found that effect of copper hydroxide prevents snails *Zachrysia provisoria* from climbing the side of pots to access plants in screen houses.

Finally, it concluded that potassium tartrate can be using in organic farmer or land escape for protect the plant from land snails attack.

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