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# Molluscicidal effects of Repcar fertilizer and certain chemical compounds on terrestrial snail *Monacha obstructa* under laboratory and field conditions

Abo-Elwfa M. M.*, Omar M. M. A., El-Shamy E. A., Ibrahim H. A. M.

*Department of Agricultural Zoology and Nematology, Faculty of Agriculture, Al-Azhar University, Assiut 71524, Egypt*

## Abstract

Land snails, particularly *Monacha obstructa,* are destructive pests that infest a wide range of field and vegetable crops. This study aimed to evaluate the effectiveness of certain chemical compounds against the terrestrial snail, *M. obstructa* under laboratory and field conditions. Three bioassay methods were used in the laboratory: baiting, leaf-dipping, and residual film techniques. The tested chemical compounds included several clethodim, bentazone and bifenazate compared with a fertilizer (Repcar 4% S). The laboratory results indicated that Repcar was the most toxic compound across all techniques, followed by Clethodim while Bifenazate showed the least toxicity. Among the tested bioassay methods, the residual film technique proved to be the most effective, yielding the lowest $LC_{50}$ value and highest bioactivity. Furthermore, under field conditions, Repcar and Clethodim achieved the highest reduction percentages in snail populations. These findings suggest that integrating chemical compounds with fertilizers may enhance pest control strategies. Further research is recommended to assess the environmental impact and long-term effectiveness of these compounds.

*Keywords*: *Monacha obstructa*, pest management, fertilizer, clover snail, herbicide, control.

*Corresponding author: Abo-Elwfa M. M.,
*E-mail address:* mohammed.mahmoud91@azhar.edu.eg

# 1. Introduction

Molluscs are found across the globe, with terrestrial species such as snails and slugs, belonging to the class Gastropoda, gaining significant importance in many regions. They have become harmful pests in various parts of the world. In Egypt, terrestrial snails and slugs infest a wide range of agronomic, horticultural, and ornamental plants, leading to severe economic losses by reducing crop yields, quality, and market value, The damage is typically manifested by nibbling on plant leaves and, in some cases, boring into other parts such as roots, tubers, and fruits. In addition to direct feeding, snails can contaminate crops with their bodies, feces, and mucus secretions. Furthermore, they may act as carriers of plant pathogens, including fungi and bacteria (Borkakati *et al*., 2009; Iglesias *et al*., 2003). The terrestrial snail *Monacha obstructa* (family: Hygromiidae) is the most common snail species infesting cultivated crops in Egypt. It has been reported in high population densities on Egyptian clover, cabbage, green beans, maize and cucumber (Shoieb, 2008). The common land snail, *M. obstructa* is an important crop pest and causes considerable damage in agriculture and horticulture, especially in areas where it finds the conditions necessary for rapid multiplication. Chemical control remains the most effective method in the event of land snail outbreaks. Numerous attempts have been made to limit their spread using synthetic pesticides (El-Shahaat *et al*., 2009; Ismail *et al.,* 2005; Sallam *et al*., 2016). Control using chemical substances is still a useful method taking into account the preservation of the environment from pollution. Many investigators evaluated many insecticides against certain land snails under laboratory and filed conditions to find out the suitable molluscicide for control these pests (Farage, 2012; Hegab, 2003; Ismail *et al*., 2010; Mahrous *et al*., 2002; Shetaia, 2005). Moreover, copper-based fertilizers and herbicides have also been explored as control agents (Amusan *et al.,* 2002; Moran *et al.,*2004, Phaceli *et al*., 2021; Thompson *et al*., 2005). Therefore, the present study investigates the molluscicidal activity of the fertilizer Repcar 4% S and selected chemical compounds on the glassy clover snail, *M. obstructa*, under both laboratory and field conditions.

# 2. Materials and methods

## *2.1 Laboratory evaluation*

Laboratory experiments were conducted to study the toxicity of some chemical compounds against adults of the terrestrial snail *Monacha obstructa* using baiting, leaf-dipping and residual film techniques.

### *2.1.1 Tested snails*

Adults of the terrestrial snail *M. obstructa* (12 mm ±1), were collected from different infested nurseries at Sohag governorate, Egypt. The snails were then transferred to plastic bags and taken to the laboratory of the Department of Agriculture Zoology and Nematology, Faculty of Agriculture, Al-Azhar University, Assiut, Egypt. The plastic containers were filled with moist sterilized sandy loam soil in a 1:1 ratio and the snails were fed fresh lettuce leaves (*Lactuca sativa* L.) for 14 days acclimatized to the laboratory conditions.

*2.1.2 Chemical compounds used*

The trade names, compound types and origin of chemical compounds used are listed in Table (1).

*2.1.3 Application methods*

*2.1.3.1 Residual film*

The treated surface exposure method of bioassay was used to evaluate the toxicity of chemical compounds (clethodim, bentazone and bifenazate) compared to Repcar 4% S fertilizer. Serial concentrations of each chemical compound's active ingredient in aqueous solution were prepared as follows: clethodim and bentazone at 0.1, 0.15, 0.2, 0.25 and 0.3%, and bifenazate at 0.1, 0.2, 0.3, 0.4 and 0.5%, while Repcar 4% S at 0.05, 0.1, 0.15, 0.2 and 0.25%. Two milliliters of each concentration were deposited and distributed on the bottom of a Petri dish by gently moving the dish in circles. The water evaporated under room conditions (23°C ± 2) in a few minutes leaving a thin layer of film of the different concentrations for each compound. Ten snails were placed in each dish. Three replicates were carried out per each concentration, in addition to an untreated check group.

Table (1): List of tested chemical compounds, their common names, trade names and their origin used in the study.

| Active ingredient | Trade name | Compound type | Origin |
|---|---|---|---|
| Copper | Repcar 4% S | Fertilizer | Spain, and the importing was by Shoura Chemicals Company (Cairo, Egypt) |
| Clethodim | Select Super 12.5% E C | Herbicide | France, and the importing was by Shoura Chemicals Company (Cairo, Egypt) |
| Bentazone | Basagran 48% AS | Herbicide | Germany, and the importing was by BASF-Egypt Company (New Cairo, Egypt) |
| Bifenazate | Solo 24% S C | Acaricide | China, and the importing was by Shoura Chemicals Company (Cairo, Egypt) |

*2.1.3.2 Leaf dipping technique*

The four chemical compounds mentioned above were applied using the leaf dipping method. The tested concentrations of each chemical compound's active ingredient in aqueous solution were prepared as follows: clethodim and bentazone at 0.1, 0.15, 0.2, 0.25 and 0.3% and bifenazate at 0.1, 0.2, 0.3, 0.4 and 0.5%, while Repcar 4% S at 0.05, 0.1, 0.15, 0.2 and 0.25%. Three plastic boxes were used for each concentration, with each box containing 1/2 kg of sterilized clay soil. The soil moisture content maintained at 75% of water field capacity. Ten adult snail individuals with approximately similar size were introduced in box. Similar pieces of green lettuce leaves were dipped in glass jars containing 100ml of each chemical compound at different concentrations for 5 seconds, then air-dried before being introduced to the land snails. In addition, a parallel control test was conducted using plain water. Also, a parallel control test was conducted using plain water.

### *2.1.3.3 Poison bait technique*

Clethodim, bentazone, bifenazate and Repcar 4% S were tested as poisonous baits. The tested concentrations of the active ingredients were prepared as follows: clethodim, bentazone, bifenazate were tested at 0.25, 0.5, 1, 2 and 3%. The poisonous baits were prepared mixing a known amount of the tested compound with five parts of black sugarcane syrup. This mixture was then combined with wheat bran to make a total of 100 parts, following the method of Abdel-Wahab (2004). The bait was moistened with an appropriate amount of water to form a crumbly mash mixture. Three plastic boxes were used for each concentration. Each box contained 1/2 kg of sterilized clay soil with the soil moisture content was 75% of water field capacity. Approximately 20 grams of each bait were spread into a box. A control treatment was prepared using wheat bran bait without any compounds. Ten adult snails of approximately similar sizes were introduced into each box. The boxes were covered with muslin cloth held by rubber bands. Mortality observations were carried out using a stainless-steel needle, according to the method described by El-Okda (1981).

### *2.2 Field evaluation*

Among the four chemical compounds tested in the laboratory, the two most toxic were selected to be evaluated using two techniques (spray and poison bait) against *M. obstructa* under field conditions.

### *2.2.1 Spray technique*

Two chemical compounds were used at concentrations of 0.25% for Repcar and 0.3% for clethodim. The trial was performed in Arab Sabha village, Dar El-Salam district, Sohag governorate, Egypt during April 2023. The spraying method was used in an experimental area of one feddan (feddan = 4200 m² = 0.420 hectares = 1.037 acres) cultivated with orange and mandarin trees, which was heavily infested with *M. obstructa* snails. The orchard was irrigated four days before treatment. Five trees were chosen for each treatment. Three treatments were conducted, including control (Mostafa, 2020).

### *2.2.2 Poison bait technique*

The two chemical compounds were evaluated at concentrations of 3% for Repcar 4% S and clethodim. The experiment was conducted in an Egyptian clover field heavily infested with *M. obstructa* snails at Naqnaq village, Dar El-Salam district, Sohag governorate, Egypt. An experimental area of one feddan was divided into three plots, including control. Poison baits were prepared as follows: the amount of tested material + appropriate weight from bran + 5% sugar cane syrup (as attractant substance) to give 100 parts of bait, about 200 g of the bait was offered on plastic sheets 50 × 50 cm and distributed in the experimental plots at a known distance (El-sayed Amal, 2010). The number of live snails per 0.25 m² was recorded in both control and treatments before application, and at 1, 7, 14 and 21 days post-treatment. Population reduction percentages were calculated according to the formula given by Henderson and Tillton (1955).

### *2.3 Data analysis*

Probit analysis was done to estimate $LC_{50}$ and $LC_{90}$ values and confidence limits for the four chemical compounds using SPSS statistics 22. Toxicity index of the tested compounds was determined according to Sun equation (Sun, 1950) as follows:

$$\text{Toxicity index } (LC_{50}) = \frac{LC_{50} \text{ of the most effective compound}}{LC_{50} \text{ of the least effective compound}} \times 100$$

## 3. Results

### *3.1 Laboratory evaluation*

#### *3.1.1 Efficacy of certain chemical compounds against Monacha obstructa snail using residual film technique*

The lethal toxicity of Repcar, clethodim, Bentazone and bifenazate against land snails was evaluated using the residual film bioassay technique. As shown in Table (2), the results revealed that Repcar and clethodim were the most toxic chemical compounds compared with the rest of tested chemical compounds against land snails, *M. obstructa.* The $LC_{50}$ values were 0.060, 0.188, 0.211 and 0.360% for Repcar, Clethodim, Bentazone and Bifenazate, respectively. Morever, the toxicity index values of tested compounds against land snails, *M. obstructa* were 100, 31.91, 28.43 and 16.67% for Repcar, clethodim, bentazone and bifenazate, respectively. It was also observed that toxicity increased with increasing concentrations of all tested chemical compounds and with longer exposure times.

#### *3.1.2 Efficacy of certain chemical compounds against Monacha obstructa snail using leaf dipping technique*

Data presented in Table (3) shows the effect of certain chemical compounds on *Monacha obstructa* snails using the leaf dipping technique. Results indicated that Repcar was the most toxic compound with $LC_{50}$ value of 0.094%, while Bifenazate was the least toxic compound with an $LC_{50}$ value of 0.362%. $LC_{50}$ values were 0.094, 0.202, 0.223 and 0.362%. In addition, the toxicity index values were 100, 46.53, 42.15 and 25.9% for Repcar, Clethodim, Bentazone and Bifenazate respectively. The molluscicidal efficiency of the tested chemical compounds can be arranged in descending order as follows: Repcar > Clethodim > Bentazone > Bifenazate.

Table (2): Toxicity of the tested chemical compounds against the glassy clover snail, *Monacha obstructa* using the residual film technique.

| Compounds | $LC_{50}$ (%) | Confidence limits | | $LC_{90}$ (%) | Confidence limits | | Toxicity index (%) |
|---|---|---|---|---|---|---|---|
| | | Upper | Lower | | Upper | Lower | |
| Repcar 4% S. | 0.060 | 0.084 | 0.020 | 0.166 | 0.210 | 0.142 | 100 |
| Clethodim 12.5% E.C. | 0.188 | 0.210 | 0.163 | 0.316 | 0.381 | 0.280 | 31.91 |
| Bentazone 48% A.S. | 0.211 | 0.250 | 0.178 | 0.407 | 0.588 | 0.337 | 28.43 |
| Bifenazate 24% S.C. | 0.360 | 0.424 | 0.311 | 0.653 | 0.860 | 0.553 | 16.67 |

Table (3): Toxicity of the tested chemical compounds against the glassy clover snail, *Monacha obstructa* using the leaf dipping technique.

| Compounds | $LC_{50}$ (%) | Confidence limits | | $LC_{90}$ (%) | Confidence limits | | Toxicity index (%) |
|---|---|---|---|---|---|---|---|
| | | Upper | Lower | | Upper | Lower | |
| Repcar 4% S. | 0.094 | 0.117 | 0.062 | 0.216 | 0.271 | 0.186 | 100 |
| Clethodim 12.5% E.C. | 0.202 | 0.234 | 0.171 | 0.376 | 0.508 | 0.319 | 46.53 |
| Bentazone 48% A.S. | 0.223 | 0.276 | 0.185 | 0.450 | 0.733 | 0.359 | 42.15 |
| Bifenazate 24% S.C. | 0.362 | 0.473 | 0.291 | 0.799 | 1.327 | 0.623 | 25.9 |

### *3.1.3 Efficacy of certain chemical compounds against Monacha obstructa snail under laboratory using baits method technique*

Data in Table (4) shows molluscicidal activity of Repcar, Clethodim, Bentazone and Bifenazate on *M. obstructa* snails when used as toxic baits. It is clear that Repcar exhibited the highest toxic effect, followed by Clethodim, while Bifenazate showed the lowest effect in this respect. Their $LC_{50}$ values were 0.373, 0.562, 1.52 and 2.18%, respectively. Also, the toxicity index values were 100, 50.67, 37.81 and 30.40%, for Repcar, Clethodim, Bentazone and Bifenazate, respectively. Morever, these treatments demonstrated increased toxicity with the increase in exposure time.

Table (4): Toxicity of the tested chemical compounds against the glassy clover snail, *M.obstructa* by using baits method technique.

| Compounds | $LC_{50}$ (%) | Confidence limits | | $LC_{90}$ (%) | Confidence limits | | Toxicity index (%) |
|---|---|---|---|---|---|---|---|
| | | Upper | Lower | | Upper | Lower | |
| Repcar 4% S. | 0.373 | 0.797 | 0.293 | 2.72 | 4.22 | 2.10 | 100 |
| Clethodim 12.5% E.C. | 0.562 | 0.943 | 0.389 | 2.75 | 4.07 | 2.16 | 50.67 |
| Bentazone 48% A.S. | 1.52 | 2.24 | 0.954 | 4.84 | 8.87 | 3.55 | 37.81 |
| Bifenazate 24% S.C. | 2.18 | 4.27 | 1.48 | 6.52 | 17.75 | 4.36 | 30.40 |

### *3.1.4 Comparative toxicity of the tested chemical compounds against Monacha obstructa using three application methods*

The data presented in Figure (1) compares the toxicity of the chemical compounds, Repcar, Clethodim, Bentazone and

Bifenazate using the tested methods. The results indicate that Repcar was the most toxic compound in all techniques, followed by Clethodim. While Bifenazate was the least toxic. Among the tested methods, the residual film technique proved to be the most effective, as it gave the lowest $LC_{50}$ value, and the highest bioactivity compared to the bait and leaf-dipping techniques. Furthermore, this study showed that using Repcar and Clethodim were more effective in controlling the terrestrial snail *M. obstructa* compared to the other tested compounds.

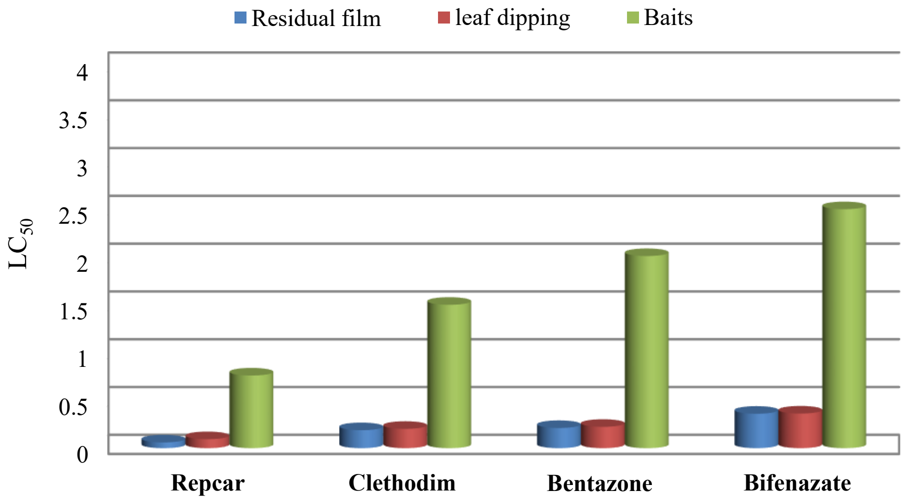


Figure (1): Comparison of three techniques based on $LC_{50}$ values of tested chemical compounds against *Monacha obstructa* under laboratory conditions.

### *3.2 Under field conditions*

Laboratory experiments indicated that Repcar and Clethodim were the most effective compounds against *M. obstructa*. Therefore, they were applied in Egyptian clover fields using the poisonous bait technique, and in orange and mandarin orchards using the spray technique over a period of three weeks in the Dar El-Salam district, Sohag governorate, Egypt. Data in Table (5) showd that the effect of the tested chemical compounds reduced the population densities of *M. obstructa* snail to varying degrees compared to the control. The reduction percentage values of *M. obstructa* snail exposed to Repcar and Clethodim through both poisonous baits and spray techniques were recorded. Data showed that the percentages of snail's reduction after the one day of treatment were 57.77 and

52.15% for Repcar and Clethodim using bait technique, and 10.11 and 11.45% using spray technique, respectively. Regarding the general mean reduction percentages, they were 46.45 and 66.61%, and 39.88 and 47.61% for Repcar and Clethodim under bait and spray techniques, respectively. Generally, it was noticed that under field conditions, the poisonous bait technique resulted in higher reduction percentages compared to the spray technique. The differences in toxicity of the tested chemical compounds against snails may be attributed to their chemical structures.

Table (5): Population reduction percentages of *Monacha obstructa* exposed to the tested chemical compounds treated with different concentrations as baits and spray under field conditions.

| Technique used | Tested compounds | Concentration (%) | Mortality (%) after exposing (days) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 7 | 14 | 21 | Mean |
| Baits | Repcar 4% S. | 3 | 57.77 | 55.74 | 50.32 | 22.00 | 46.45 |
| | Clethodim | 3 | 52.15 | 68.82 | 77.00 | 68.47 | 66.61 |
| Spray | Copper 4% S. | 0.25 | 10.11 | 34.66 | 50.32 | 64.44 | 39.88 |
| | Clethodim | 0.3 | 11.45 | 41.63 | 62.24 | 75.14 | 47.61 |

## 4. Discussion

Land snails have increasingly emerged as a significant concern in agriculture, primarily due to the extensive destruction they inflict on crops. This predicament has spurred a flurry of research endeavours aimed at discovering effective strategies to curb their proliferation. In this study, we took a closer look at the effectiveness of various insecticides, herbicides, acaricides, and fertilizers in managing these agricultural pests. It was observed that weeds provide a moist environment that supports the survival and reproduction of terrestrial mollusca. Therefore, applying herbicides not only suppresses weed growth but also contributes to reducing land snail populations. Furthermore, crops infested with land snails are often simultaneously attacked by various insects and mites. This justifies the use of acaricides, which can simultaneously reduce populations of snails, and mites. This is where miticides come into play, allowing us to shrink the numbers of land snails alongside mites in one fell swoop. Moreover, copper plays an intriguing role in enhancing the nutritional profile of plants, boosting their productivity, particularly in copper-deficient soils. So, not only can copper help to diminish land snail populations, but it can also elevate the overall yield of crops at the same time. It’s a dual-purpose strategy that might just be the key to tackling this agricultural nuisance. Discussing the foregoing results, it is evident from the obtained results that there were variations in toxicity according to the type of compound and method of application. These findings are consistent with those of Gabr *et al.* (2006), who reported that the toxicity of tested compounds differed according to the application method. Similarly, Ghamry *et al.* (1994) found that chlorpyrifos and dimethoate were effective in killing snails within 12 days under laboratory conditions. Rady *et al*., (2018) demonstrated that Neomyl (insecticide) exhibited higher toxicity than Roundup 48% (herbicide) against *Monacha obstructa* when applied using baiting techniques, while the leaf-dipping method showed the opposite trend, with Roundup being more potent. Sallam *et al*. (2016) also confirmed that the toxicity of compounds varied with the application method they reported that baiting was generally the most effective technique, followed by leaf dipping, except in the case of copper hydroxide, where leaf dipping proved more effective than baiting. Moreover, Thompson *et al*. (2005) indicated that copper hydroxide-based products, such as Kocide® 2000 (53.8% copper hydroxide) and Kocide 4.5 LF (37.5% copper hydroxide), were effective in reducing populations of *Deroceras laeve* and *Lehmannia valentiana*. Ismail *et al.* (2015) reported that the poisonous bait technique was more effective than spraying for controlling *Monacha cartusiana* under field conditions.

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