DIFFERENT CONTROL METHODS FOR REDUCING POPULATION DENSITY OF *Eobania vermiculata* (MÜLLER) UNDER FIELD CONDITIONS IN DAKAHLIA GOVERNORATE, EGYPT

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**ABSTRACT:** The use of chemicals to control land snails can lead to environmental pollution, hazards to humans and toxic residues in agricultural products. Therefore, finding safer alternatives for managing these pests has become a priority. Field experiments were conducted to test different methods for controlling *Eobania vermiculata* snails infested navel orange trees in Dakahlia Governorate. These methods included ploughing during the egg-laying period in January, planting cabbage traps in February, applying attractive materials in March, using pesticides in April during the activity period, and hand collection during aestivation period in June. The ploughing process significantly (P≤ 0.05) reduced the populations of *E. vermiculata*. One week after ploughing, the number of snails per sample decreased from 29.22 to 11.76, representing 63.87% reduction. After six weeks, the overall reduction in population was 40.73%. Planting cabbage traps also decreased the snail populations, with a maximum reduction of 68.54% after six weeks. Attractive materials had a significant effect on attracting populations. Sugar-cane syrup and barley powder showed the highest effectiveness, with reductions of 66.05 and 54.12%, respectively. Boiled potatoes had a moderate effect, while vanilla powder was the least effective one, with a reduction of 39.92%. Biocides and plant extracts had a significant effect on the suppression of snail populations. Oikous and clove oil had the highest effect, with 46.05 and 42.56% reduction, respectively. Protecto showed a moderate effect, while eucalyptus oil was the least effective one with 28.21% reduction. The application of pesticides also reduced the snail populations to varying degrees. The molluscicidal efficiency of the tested pesticides could be arranged in descending order after three weeks of application as follows: methomyl < fenamiphos < deltamethrin < oxamyl, with reduction percentages of 60.30, 54.41, 48.81 and 39.03%, respectively. Hand collection during the aestivation period in June also significantly (P≤ 0.05) decreased populations, with a 46.41% reduction as a general mean during the six-week experimental period. Generally, all tested control methods significantly reduced the populations of *E. vermiculata* in navel orange orchard from January to July. Based on the general means of percent reduction, the tested methods can be arranged in descending order as follows: cabbage traps, pesticides, attractive materials, hand collection, ploughing, and using biocides besides plant extracts. The reduction percentages for the snail species were 51.44, 50.64, 48.93, 46.41, 40.73 and 38.81%, respectively.

**Key words:** Land snails, Control, Navel orange, Dakahlia Governorate, *Eobania vermiculata*.

**INTRODUCTION**

Land gastropods are considered a significant threat to sustainable agricultural crops in different parts of the world (Barker, 2002; Speiser and Kistler, 2002; Flint, 2011; Baker, 2012; Schweizer et al., 2019). The importance of these land gastropods containing snails and slugs as animal pests has increased drastically in later decades (Gathwaite and Thomas, 1996;...
Damage caused by these species due to their feeding directly on economic crops, in addition their contamination by bodies, slime or feces leading finally to deterioration of quality and quantity losses of products (Iglesias et al., 2003; Heiba et al., 2018). Its movement causes undesirable smell which could prevent human and farm animals from feeding on these crops (El-Okda, 1984; Sallam et al., 2009; Abo Zaid et al., 2021). Snails have increased and became real pests, causing considerable damage especially for horticultural crops (Heikal, 2015). Several species of these snails were registered in many Governorates of Egypt (Eshra, 2014; Eshra et al., 2015; Abou Senna et al., 2016; Ali and Robinson, 2020).

Control of land snails largely is dependent on the use of pesticides or specific molluscicides, (Radwan et al., 1992; El-Wakil and Attia, 1999; Moran et al., 2004; El-Shahaat et al., 2005; El-Shahaat et al., 2009; Eshra, 2014). In addition, various reports detected molluscicidal effects formulated as poison baits (Miller et al., 1988; Hammond et al., 1996; Geasa et al., 2013). Molluscicides against land snails are only occasionally delivered as sprays or dust, but poison baits techniques are still the most effective (Barker, 2002; Ismail et al., 2014). On the other site, using molluscicides extracted from plant origin as natural products are preferable than synthetic ones (Kumar et al., 2012). Additionally, other classes of compounds, such as biocides, bactericides, and fungicide, have been reported to have phenolic structures (Wicht et al., 2004).

In this study, field experiments had been carried out to gain principal information concerning different control methods, which could be used safely in integrated pest management programs (IPM) for controlling E. vermiculata infesting navel orange fruit trees under field condition at Dakahlia Governorate.

MATERIALS AND METHODS

Experimental Area

The experimental area in Meet Abou El-Hareth village, Aga district, Dakahlia Governorate, was heavily infested with the chocolate-band (brown garden) snail Eobania vermiculata (Muller). This area was planted with 10-year-old navel orange trees, Citrus sinensis and various types of weeds were extensively grown under the trees. The experiments were carried out during the period from January to July 2021. Within this orchard, five parallel strips, each measuring approximately 40 m wide and 50 m in length, were designated as treatment sites. The selected sites were separated from each other by two parallel rows of navel orange trees.

Application of Different Control Measures for Reducing Populations of E. vermiculata

Effect of ploughing as a mechanical control method against E. vermiculata

This trial was undertaken in the first experimental site covering about half feddan to assess the impact of ploughing on diminishing populations of the chocolate-band snail, E. vermiculata. The site was divided into ten plots (rows) each with 8 trees. Five plots were ploughed, while the others were left without ploughing as a check control. Individuals were counted in a quadrate of 50 X 50 cm² under one randomly chosen tree in each plot as well as on the lower portion of the trunk up to one meter height in both ploughed and unploughed plots. Population counts were entailed 24 hrs before and after ploughing and then at weekly intervals over a six-week period starting from the beginning of January 2021. The percent reduction in population density of the snail species was calculated according to the formula given by Henderson and Tilton (1955) as follows: Reduction (%)=[1-(t1 x r2)/(t1 x r2)]x100, where; (t1 & r2) represent number of alive snails before and after treatment in untreated plots, and (t1 & t2) represent number of alive snails before and after treatment in treated plots. Data were statistically analyzed using F test between treatments were calculated at 5% significance level.

Effect of planting cabbage traps as an agricultural control method against E. vermiculata

This trail was conducted at the second experimental site to assess the impact of planting cabbage, Brassica oleraceae as traps on decreasing populations of E. vermiculata infested navel orange trees. The experimental site was divided into ten plots, each containing 8
trees. Five plots were planted with cabbage at a rate of 4 plants between two trees, while the remaining plots were left unplanted as a control treatment. Individuals of the snail species were counted in a quadrate of 50 x 50 cm² under one randomly selected tree in each plot as well as on the lower portion of the trunk up to one meter height in both the cultivated and control plots. Population counts were entailed 24 hrs before and after planting and then at weekly intervals over a six-week period starting from the beginning of February 2021. The reduction percentage in snail population density was calculated according to the formula of Henderson and Tillton (1955). F test between treatments were calculated at 5% significance level.

Effect of attractive materials as an agricultural control method for *E. vermiculata*

This study was conducted, in the third half-feddan experimental site to assess the impact of attractive materials on reducing populations of *E. vermiculata*. The site was divided into ten plots (rows) each containing 8 trees. Five plots were used for the experiment, while the others were served as a control. The tested attractants included boiled potatoes, barley powder, milk powder, sugar-cane syrup, vanilla powder and yeast powder were applied as baits (10 parts water + 5 parts of each attractant + 85 parts wheat bran). Each treatment was replicated 3 times. Baits were placed on plastic trays with 100 gm of 4-baits between two trees. The number of dead and alive snails was counted using 0.25m² quadrate placed next to the bait before and after one day of application and then at 2-day intervals during the experimental time started from the beginning of March 2021. Reduction percentages were calculated using the formula of Henderson and Tillton (1955). Data were statistically analyzed using F test between treatments at 5% significance level.

Efficiency of biocides, plant extracts and pesticides in reducing *E. vermiculata* populations

In this experiment two biocides and two plant extracts as non-chemical compounds along with four commonly used pesticides as chemical compounds, were used to control populations of *E. vermiculata* in orchard trees. The tested compounds were obtained as fresh formulated products directly from market or from the central agricultural pesticides’ laboratory, Dokki, Giza, Egypt. The classes of these compounds, chemical group, common name, trade name, formulation type and chemical or scientific name were as follows:

**Tested compounds Biocides**

1. Oikous, (Azadirachthine, 3.2% E.C), Insecticide biocide.
2. Protecto, (Bacteria, 10% W.P), Insecticide biocide.

Bacteria formulation: *Bacillus thuringiensis*

**Plant extracts**

1. Clove oil (*Syzygium aromaticum*).
2. Eucalyptus oil. (*Eucalyptus obliqua*).

**Insecticides**

1. Deltamethrin. (Kafrothrin,2.5% E.C), Pyrethroid ester insecticide.
2. Methomyl. (Neomyl, 20 % S.L), Carbamate insecticide.

**Nematicides**

D1. Fenamiphos. (Nemaphos, 40% E.C), Nematicide.
D2. Oxamyl. (Vydate, 24 % S.L), Nematicide.

Chemical formula: (C7H13N3O3S)

**Molluscicidal activity**

The fourth experimental site was divided into 10 plots (rows), each with 8 trees. Five plots were treated with toxicants, while the others were left untreated as a control. The toxicants were applied as poisonous baits at concentration of 2 % a.i. (2 parts of toxicant + 5 parts of sugar-cane syrup + 93 parts of wheat bran) for each chemical compound (deltamethrin, methomyl, fenamiphos and oxamyl), and (5 parts of biocide or plant extract + 5 parts of sugar-cane syrup + 90 parts of wheat bran) for each unchemical compound (oikous, protecto, clove oil and eucalyptus oil). Control treatment was designed in the same manner without pesticides. Baits were offered on plastic trays each containing 100 gm at rate of 4 baits between two trees.
Individuals of the snail species were counted in a 50 x 50 cm² quadrate under one randomly chosen tree in each plot and on the lower portion in the trunk of the same tree to about one meter height. Population counts were entailed 24 hrs. before and after application and then, at intervals of two days during the experimental period starting from the beginning of April 2021. Reduction percentages were calculated according to the formula of Henderson and Tillton (1955). Data were statistically analyzed using F test between treatments at 5 % level.

The effectiveness of hand collection as a mechanical control method for *E. vermiculata*

This trial was undertaken during the aestivation period at the fifth experimental site to assess the impact of hand collection in reducing populations of the chocolate-band (brown garden) snail, *E. vermiculata*. The site was divided into ten rows, each containing 8 trees. Five rows were subjected to hand collection by two workers, while the other five rows were left without collection as a control. Individuals of snail species were counted in a quadrate of 0.25 m² under one randomly selected tree in each plot as well as on the lower portion of the trunk up to one meter in height. Population counts were entailed 24 hrs. before and after hand collection and then at weekly intervals during the experimental time started from the beginning of June 2021. The percentage reduction in population density of the snail species was calculated using the formula of Henderson and Tillton (1955). Data were statistically analyzed using F test between treatments at 5% significance level.

RESULTS AND DISCUSSION

A series of field trials were conducted to investigate effective control methods for reducing populations of the chocolate-band (brown garden) snail, *E. vermiculata*, in a navel orange orchard in Dakahlia Governorate from January to July 2021. The trials included ploughing during the egg-laying period in January, planting cabbage (*B. oleraceae*) as traps in February, applying attractive materials in March, and using pesticides as poisonous baits in April during the snails’ activity period. Finally, hand collection was conducted during the aestivation period in June.

Application of Different Control Measures for Reducing *E. vermiculata* Populations

**Effect of ploughing process as a mechanical control method for *E. vermiculata***

The data presented in Table 1 provided valuable insights into this method. The results clearly showed that ploughing significantly (*P* ≤ 0.05) decreased the populations of *E. vermiculata*. One week after ploughing, the number of snails per sample decreased from 29.22 to 11.76, representing a 63.87% reduction. Two weeks after ploughing, there was a 53.68% reduction in populations.

This trend continued, with a slight increase in percentage reduction four and five weeks after ploughing. However, after six weeks, the percentage reduction decreased to 22.30%. Generally, ploughing as a mechanical control method during the egg-laying period resulted in a significant (*P* ≤ 0.05) reduction in populations, with a general mean of 40.73% after six weeks of application.

**Effect of planting cabbage traps as an agricultural control method for *E. vermiculata***

In the search for alternatives to chemical control of land snails in orchard trees, the obtained data presented in Table 2 clearly indicated that planting cabbage traps between navel orange trees decreased the populations of *E. vermiculata*. One week after planting, the number of snails was reduced from 22.13 to 18.92 snails per sample, recording a 26.21% reduction. Three weeks after planting, the percent reduction in populations was 49.37%. This trend continued, with a gradual increase in percent reduction of the snail species. After the sixth week, a maximum percent reduction of 68.54% was recorded. The general mean of percent reduction in populations during the whole experimental period was 51.44%. Therefore, it can be concluded that planting cabbage traps as an agricultural control method showed a significant (*P* ≤ 0.05) reduction in populations of *E. vermiculata*. 
Table 1. Effect of ploughing process as a mechanical control method against *E. vermiculata* infesting navel orange trees in Dakahlia Governorate during January 2021

<table>
<thead>
<tr>
<th>Weeks after application</th>
<th>Mean number of snails per sample (%) Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control area</td>
</tr>
<tr>
<td>1</td>
<td>29.22</td>
</tr>
<tr>
<td>2</td>
<td>30.37</td>
</tr>
<tr>
<td>3</td>
<td>31.51</td>
</tr>
<tr>
<td>4</td>
<td>31.30</td>
</tr>
<tr>
<td>5</td>
<td>32.45</td>
</tr>
<tr>
<td>6</td>
<td>32.55</td>
</tr>
<tr>
<td><strong>General mean</strong></td>
<td>31.23a</td>
</tr>
</tbody>
</table>

Each number represents the mean of five replicates. General means followed by different letter are significantly different at 0.05 level, according to Duncan (1955).

Table 2. Effect of planting cabbage traps as an agricultural control method against *E. vermiculata* infesting navel orange trees in Dakahlia Governorate during, February 2021

<table>
<thead>
<tr>
<th>Weeks after application</th>
<th>Mean number of snails per sample (%) Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control area</td>
</tr>
<tr>
<td>1</td>
<td>22.13</td>
</tr>
<tr>
<td>2</td>
<td>24.20</td>
</tr>
<tr>
<td>3</td>
<td>25.18</td>
</tr>
<tr>
<td>4</td>
<td>26.49</td>
</tr>
<tr>
<td>5</td>
<td>26.38</td>
</tr>
<tr>
<td>6</td>
<td>27.36</td>
</tr>
<tr>
<td><strong>General mean</strong></td>
<td>25.29a</td>
</tr>
</tbody>
</table>

Each number represents the mean of five replicates. General means followed by different letters are significantly different at 0.05 level, according to Duncan (1955).

**Effect of attractive materials as an agricultural control method for *E. vermiculata***

The aim of the present study is to determine the most effective attractive materials for increasing the molluscidial efficiency of pesticides in controlling *E. vermiculata*. Data presented in Table 3 indicated that the tested materials had a significant effect on attracting snail populations. Since, general means of percent reduction after two weeks of application using boiled potatoes, barley powder, milk powder, sugar-cane syrup, vanilla powder and yeast powder as attractants were 46.43, 55.52, 43.12, 67.77, 40.96, and 47.44%, respectively. The same trend was observed after 3 weeks of application with a slight increase in percentage reduction recording parallel values of 43.94, 52.54, 40.81, 64.13, 38.76 and 44.90%, respectively. According to general means of percent reduction during the whole trail sugar-cane syrup and barley powder gave the highest effect recording 66.05 and 54.12%, respectively. Whereas boiled potatoes and yeast powder showed moderate effect in reducing numbers of snails. While milk powder and vanilla powder were the least effective compound with percent reduction of 42.03 and 39.92%, respectively.
Table 3. Effect of attractive materials as an agricultural control method against *E. vermiculata* infesting navel orange trees in Dakahlia Governorate during, March 2021

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Control treatment (%)</th>
<th>Initial effect (%)</th>
<th>Reduction after treatment (in days) 7</th>
<th>14</th>
<th>21</th>
<th>( %) Residual effect</th>
<th>General mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiled potatoes</td>
<td>63.17</td>
<td>50.52</td>
<td>51.03</td>
<td>46.43</td>
<td>34.36</td>
<td>43.94</td>
<td>45.26c</td>
</tr>
<tr>
<td>Barley powder</td>
<td>70.12</td>
<td>60.41</td>
<td>61.01</td>
<td>55.52</td>
<td>41.09</td>
<td>52.54</td>
<td>54.12b</td>
</tr>
<tr>
<td>Milk powder</td>
<td>63.23</td>
<td>46.92</td>
<td>47.39</td>
<td>43.12</td>
<td>31.91</td>
<td>40.81</td>
<td>42.03de</td>
</tr>
<tr>
<td>Sugar-cane syrup</td>
<td>76.86</td>
<td>73.73</td>
<td>74.47</td>
<td>67.77</td>
<td>50.15</td>
<td>64.13</td>
<td>66.05a</td>
</tr>
<tr>
<td>Vanilia powder</td>
<td>62.42</td>
<td>44.56</td>
<td>45.01</td>
<td>40.96</td>
<td>30.31</td>
<td>38.76</td>
<td>39.92e</td>
</tr>
<tr>
<td>Yeast powder</td>
<td>63.61</td>
<td>51.62</td>
<td>52.14</td>
<td>47.44</td>
<td>35.11</td>
<td>44.90</td>
<td>46.24cd</td>
</tr>
</tbody>
</table>

Initial control effect = Mean (%) reduction during the first three days.
Residual control effect = Mean (%) reduction during the rest periods.
General means followed by the same letter (s) are not significantly different at 0.05 level, according to Duncan (1955).

Efficiency of certain biocides and plant extracts as non-chemical control methods in reducing populations of *E. vermiculata*

*E. vermiculata*. Data presented in Table 4 indicated that the tested compounds had a significant effect on the attraction of snail populations. General means of percentage reduction after two weeks of application using Oikous, Protecto, Clove oil, and Eucalyptus oil, as molluscicides were 44.26, 36.87, 40.91 and 27.11%, respectively. The same trend was observed after three weeks of application with a slight increase in percentage reduction recording parallel values of 44.68, 37.22, 41.30 and 27.37%, respectively. According to general means of percent reduction during the whole period Oikous and Clove oil gave the highest effect recording 46.05 and 42.56% reduction, respectively. Whereas Protecto showed a moderate effect in reducing numbers of snails, while Eucalyptus oil was the least effective compound with a percent reduction of 28.21%.

Efficiency of pesticides as chemical control methods in reducing populations of *E. vermiculata*

Data presented in Table 5 clearly showed that the tested pesticides reduced populations of *E. vermiculata* snail to varying degrees, since percent reduction differed significantly from one pesticide to another. According to general means of percent reduction during two weeks after treatment; methomyl and fenamiphos gave the highest effect recording 65.14 and 58.78%, respectively. Whereas deltamethrin showed moderate effect in reducing numbers by 52.72% while, oxamyl was the least effective compound with percent reduction of 42.17%. The same trend was observed after 3 weeks of application with a slight increase in percentage reduction recording parallel values of 59.93, 54.08, 48.51 and 38.80% with methomyl; fenamiphos and deltamethrin and oxamyl, respectively. Generally, the molluscicidal efficiency of the tested pesticides according to general means of percent reduction against the snail species could be arranged in descending order as follows: methomyl < fenamiphos < deltamethrin < oxamyl recording reduction percentage of 60.30, 54.41, 48.81 and 39.03%, respectively.

**Efficacy of hand collection as a mechanical control method of *E. vermiculata***

The efficiency of hand collection method in controlling *E. vermiculata* was studied in a chosen navel orange orchard highly infested with snail species during the aestivation period in June 2021. The obtained data in Table 6 clearly indicated that hand collection obviously decreased populations. One week post collection, the number of snails was reduced from 38.80 to 22.66 snails per sample recording 54.49% reduction while the corresponding numbers after three weeks reduced from 36.86 to 23.69 snails.
Table 4. Efficiency of certain biocides and plant extracts as non-chemicals control methods against *E. vermiculata* infesting navel orange trees in Dakahlia Governorate during, April 2021

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Control treatment (%)</th>
<th>Initial effect (%)</th>
<th>Reduction after treatment (in days)</th>
<th>Residual effect (%)</th>
<th>General mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>14</td>
<td>21</td>
</tr>
<tr>
<td>Oikous, biocide</td>
<td>66.61</td>
<td>51.52</td>
<td>62.34</td>
<td>44.26</td>
<td>27.44</td>
</tr>
<tr>
<td>Protecto, biocide</td>
<td>59.17</td>
<td>42.92</td>
<td>51.93</td>
<td>36.87</td>
<td>22.86</td>
</tr>
<tr>
<td>Clove oil, extract</td>
<td>62.23</td>
<td>47.62</td>
<td>57.62</td>
<td>40.91</td>
<td>25.36</td>
</tr>
<tr>
<td>Eucalyptus oil, extract</td>
<td>53.42</td>
<td>31.56</td>
<td>38.19</td>
<td>27.11</td>
<td>16.81</td>
</tr>
</tbody>
</table>

Initial control effect = Mean (%) reduction during the first three days.
Residual control effect = Mean (%) reduction during the rest periods.
General means followed by the same letter (s) are not significantly different at 0.05 level, according to Duncan (1955).

Table 5. Efficiency of certain pesticides as chemical control methods against *E. vermiculata* infesting navel orange trees in Dakahlia Governorate during, April 2021

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Control treatment (%)</th>
<th>Initial effect (%)</th>
<th>Reduction after treatment (in days)</th>
<th>Residual effect (%)</th>
<th>General mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>14</td>
<td>21</td>
</tr>
<tr>
<td>Deltamethrin, 2.5% EC</td>
<td>39.64</td>
<td>49.99</td>
<td>51.69</td>
<td>52.72</td>
<td>41.12</td>
</tr>
<tr>
<td>Methomyl, 20% SL</td>
<td>50.43</td>
<td>61.76</td>
<td>63.86</td>
<td>65.14</td>
<td>50.81</td>
</tr>
<tr>
<td>Fenamiphos, 40% EC</td>
<td>46.32</td>
<td>55.73</td>
<td>57.62</td>
<td>58.78</td>
<td>45.85</td>
</tr>
<tr>
<td>Oxamyl, 24% SL</td>
<td>38.97</td>
<td>39.98</td>
<td>41.34</td>
<td>42.17</td>
<td>32.89</td>
</tr>
</tbody>
</table>

Initial control effect = Mean (%) reduction during the first three days.
Residual control effect = Mean (%) reduction during the rest periods.
General means followed by the same letter (s) are not significantly different at 0.05 level, according to Duncan (1955).

Table 6. Efficacy of hand collection as a mechanical control method against *E. vermiculata* infesting navel orange trees in Dakahlia Governorate during, June 2021

<table>
<thead>
<tr>
<th>Weeks after application</th>
<th>Mean number of snails per sample (%)</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control area</td>
<td>Collected area</td>
</tr>
<tr>
<td>1</td>
<td>38.80</td>
<td>22.66</td>
</tr>
<tr>
<td>2</td>
<td>32.01</td>
<td>20.60</td>
</tr>
<tr>
<td>3</td>
<td>36.86</td>
<td>23.69</td>
</tr>
<tr>
<td>4</td>
<td>25.22</td>
<td>18.54</td>
</tr>
<tr>
<td>5</td>
<td>22.31</td>
<td>17.51</td>
</tr>
<tr>
<td>6</td>
<td>19.40</td>
<td>16.48</td>
</tr>
<tr>
<td>General mean</td>
<td>29.10a</td>
<td>19.91b</td>
</tr>
</tbody>
</table>

* Each number represents the mean of five replicates.
General means followed by different letters are significantly different at 0.05 level, according to Duncan (1955).
per sample recording 50.45% reduction. The same trend was observed after four and five weeks of collection with a gradual decrease in percentage reduction. However, after the sixth week the percentage reduction in numbers sharply declined to 38.34%. Finally, the hand collection method showed significant effect on percent reduction for the snail species recording 46.41% reduction as a general mean during the total experimental period.

**Effect sequence different control methods on an integrated pest management (IPM) program against E. vermiculata infesting navel orange trees under field conditions.**

To reduce the chemical treatment in controlling land snails and search for more effective processes for successful IPM programs, the following methods were tested for controlling E. vermiculata: ploughing process as a mechanical control method, planting cabbage traps and using attractive materials as agricultural control methods, applied biocides and plant extracts as non-chemical control methods, using pesticides as chemical control method, and hand collection as a mechanical control method. The efficiency of tested methods against E. vermiculata under field conditions in navel orange orchard, according to their general means of percent reduction could be arranged in descending order as follows: planting cabbage traps < using pesticides < using attractive materials > hand collection < ploughing process < using biocides and plant extracts. The general reduction percentages at the end of applications for the snail species were recorded as: 51.44, 50.64, 48.93, 46.41, 40.73 and 38.81%, respectively (Fig.1).

Where, PP= Plowing process as a mechanical control method, CT = Cabbage traps as an agricultural control method, AM = Attractive materials as an agricultural control method, BP = Biocides and plant extracts as non-chemical control method, US = Using pesticides as chemical control method., HC = Hand collection as a mechanical control method.

Before discussing the foregoing results, it is important to note here that, problems caused by snails and slugs on agricultural crops have been reported by many authors in most countries of the world (Baker, 1989; Newman et al., 1994; Castielleio et al., 1996). In Egypt, land snails have been reported in different Governorates attacking many economic crops. Moreover, incidence of land gastropod species has been mentioned by many authors in different Governorates (Ismail et al., 2011; Rady et al., 2014; Kadry et al., 2018; Abd El-Haleim et al., 2022).

Our obtained results agree with the finding of Wouters (1970), who showed that rough ploughing of the soil before sowing winter wheat protected seeds from damage caused by land snails. Moreover, El-Deeb et al. (2003) reported that the efficacy of tillage process depends on land snail species and period after tillage, and it was effective against M. cartusiana compared to E. vermiculata two months after tillage. When discussing the results related to planting cabbage as traps, many authors (Staikou and Lazaridou- Dimitriadou, 1989; Ghamry et al., 1994; Sean et al., 2015, Ibrahim, et al., 2017) discussed the host preference for land snails. They reported that snails fed on lettuce showed higher assimilation efficiency than those fed on Urtica dioica. Leaves of pea and lettuce were the most preferable food for M. cartusiana, while leaves of lettuce and cabbage were the most favorable hosts for E. vermiculata and M. cartusiana compared with other tested food leaves.

In their study on attractive materials for reducing population of land snails, El-Sebae et al. (1982) found, bran baits containing radish and ragee elkone gave higher percentage of snail mortality compared to nokhalah and germah. Godan (1983) mentioned that molasses and wheat bran were the most effective in mixtures with molluscicides, along with boiled potatoes, dry milk powder, rice bran which were added as attractants in poisonous bait techniques. Asran (1994) indicated, bran was the most preferable bait for H. aspersa followed by crushed wheat and crushed maize, with sugar-cane syrup being the most attractive additive substance followed by molasses, while vanilla was the least attractive material. In studying the efficiency of certain biocides and plant extracts (Prakash and Rao, 1997; Batish et al., 2008; Keith, et al., 2009; Howlett, 2012) tested plant products known to possess molluscicidal activity against land snails as well as, plant parts and formulations with...
Fig. 1. Effect of sequential processes against *E. vermiculata* infesting navel orange orchard in Dakahlia Governorate during the period from January to July 2021 for IPM program

Biological activity against land snails. Azadirachtin, and other active components from neem, was also reported to show mulluscicidal activity against *Lymnea luteda* (Ramesh, 1983). Also, Kady et al. (1986) attributed the mulluscicidal action of the wild herb, *Peganum harmala* to its alkaloidal constituents which affect the respiration and/or the nervous system of snails. Kishor and Sati (1990) reported that spirostanol glycoside from the plant, *Yacca aloifolia* was 100% toxic at 10 ppm when tested against *Biumphalaria glabrata* snails.

The results obtained from the use of pesticides agree with those reported by many authors. Godan (1983) showed that using herbicides not only kill weeds but also mollusks either through the animal skin or by ingestion through the intestine. Radwan et al. (1992) found that brane toxic baits of five oxime carbamate pesticides including oxamyl gave highly toxic effect against *Theba pisana*, and organophosphorous compounds gave highest efficiency in controlling *M. cartusiana*. Moreover, Abdallah et al. (1999), Abd El-Monem (2016) and Gaber et al. (2022) tested twenty-four compounds belonging to carbamates, organophosphates, chlorinated hydrocarbons against *E. vermiculata* and *T. pisana*. They illustrated that aldicarb, methomyl, monocrotophos and paraquate were the most toxic compounds against both tested snail species, similar results had been recommended by several authors i.e., Aioub et al. (2000) and Elsayed et al. (2022). Population density of terrestrial snails is obviously increased during spring months as compared to low or moderate values during winter and autumn months (Ghamry et al., 1993; Nakhla et al., 2002; Abo Bakr, 2011). Therefore, application of molluscicides is effectively applied during the month of April.

When discussing the results of hand collection, it is worthy to mention that hand collection methods have been recommended by several authors (Wouters, 1970; Godan, 1983; Shah, 1992; Tillier et al., 1995). Accordingly, ploughing or tillage can be successfully applied when snails aestivate during summer months starting from June. During this time, the animals
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retract into their shell and seal the shell aperture with one or more epiphragms (El-Masry, 1997; Mahrous et al., 2006). Also, Carman (1965) illustrated that hand collection with subsequent squashing of snails was the oldest mechanical method and reported that spraying chemicals during the summer proved to be ineffective in controlling land snails. Shah (1992) indicated that collecting the snail Achatina fulica especially during aestivation period, gave good control and reduction in population density. Moreover, Tillier et al. (1995) reported that physical control of land snails by creating barriers of bare around the crop was the most effective method. In conclusion, integrated pest management (IPM) has become an economic necessity and is vital for modern agriculture. This includes all methods using control procedures to suppress gastropod populations to non-damaging levels.

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طرق مكافحة مخالفة نحقهيم أعذاد Eobania vermiculata (Müller) في محافظة الدقهلية، مصر

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تسبب المواد الكيميائية المستخدمة في مكافحة الفيروسات الأرضية تثبيتاً وazăوت للإنسان، بالإضافة إلى المتغيرات السائمة في المنتجات الزراعية، مما أصبح البحث عن طرق مبتكرة لمقاومة هذه الألفات أمرًا ضروريًا، لذلك تم إجراء تجربة حقلية باستخدام طرق مكافحة مختلفة في أحد بدائي البرتقال بفترة بمحافظة الدقهلية وحُص الأمراض، حيث استُمرت هذه الطرق على الحوثر أثناء فترة وضع البيض في شهر نيسان، ورزمة المواد الداخلية من الكنز في شهر مارس، واستخدام المبيدات خلال فترة النشاط في شهر أبريل، والجمع الدوري خلال فترة الرياح الصيفي في شهر يونيو، حيث أدت بصورة معنوية بعد أربع وأربعة من التطبيق من 29.22 إلى 11.76 في النسبة المئوية، وذلك أن تأثير المبيدات النباتية في علاج E. vermiculata تقص في معدل عدد الألفات بمتوسط مقداره 40.73 بعد ستة أسابيع من عملية الحوثر، وتارد زراعتي مصداقات بنية من نباتات الكنز إلى انخفاض معدل عدد الألفات بعد الألفات الخاص في 68.54%، بينما كان تأثير المواد الجاذبة المعتدلة معروفاً في جذب الألفات إلى الطوع كان أعلى استخدام عمر صب السمك ومصروف الشوهر أعلى تأثير بلغ 66.12% على التوالي، بينما أظهر استخدام الطقس المستوطنة تأثيراً متساماً في حين أظهر استخدام الفينالي أقل فعالية بنسبة خفض في معدل عدد الألفات 39.69%، وكان للبيطيات الحيوية والمستخلصات النباتية تأثير معنوي على قمع معدل الألفات، حيث أعطي زيت ليفوكوس وزيت الزيتون أعلى نسبة تأثير و معدل انخفاض بنسبة 46.05% على التوالي، في حين أظهر زيت الزيتون (كديكية الباليس) تأثيراً متساماً في تقليل الألفات، بينما كان زيت الكافور هو الأقل فعالية بنسبة 28.12%، وأدى استخدام المبيدات التي خفض معدل الألفات أيضاً بدرجات متفاوتة، وأمكن ترتيب كفاءة المبيدات المحتركة ضد الفيروسات من ثلاثة أسابيع حتى ابتعد التوالي: فيناميسون > ندامثيوين > اوكسمايل. حيث بلغت نسبة انخفاض في معدل الألفات 60.30%، 54.41%، 48.81%، 48.03% و39.03% على التوالي، وأظهرت الفيروسات المجتمعية في فضاء معدل الألفات في فترة النشاط في 46.47% في معدل عدد الألفات. كما أعطيت مثبطات علاج الفيروسات الفعالة في فضاء معدل عدد الألفات بدأ مع احتساب معدلات الفيروسات النباتية، حيث أعطيت مثبطات علاج الفيروسات الفعالة في فضاء معدل عدد الألفات بدأ مع احتساب معدلات الفيروسات النباتية، حيث أعطيت مثبطات علاج الفيروسات الفعالة في فضاء معدل عدد الألفات بدأ مع احتساب معدلات الفيروسات النباتية. E. vermiculata

الكلمات الإسترشادية: الفيروسات الأرضية، المكافحة، البرتقال، بسمة، محافظة الدقهلية،

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