Las Babosas, la Agricultura y los Purines

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Proyecto Financiado por
La Unión Europea
FAIR5-PL97
SLUGS DAMAGE ON HORTICULTURAL CROPS

Slugs attack plants inextensive crops (corn, wheat, barley, colza.....) fruit-trees (apple tree, peach tree....) and horticultural crops (strawberry, tomatoes, lettuce, peaper....). It has also been observed that sometimes it can attack to oak and chestnut.
Tonnes of molluscicides applied over all Spanish crops in the last years (after AEPLA, 1999).
Spanish crops and molluscicides

Since 1990 the amount of molluscicides applied to Spanish crops has stabilized at about 2500 tonnes/year, costing 1000 millions of pesetas - £5 millions - per year. All this money being spent by farmers on molluscicides according to AEPLA - Spanish Association for Plant Protection-. Among Spanish Autonomic Communities Valencia and Madrid lead the ranking with 500 tonnes/year. In the other end are La Rioja and Extremadura with only 10 tonnes/year. Metaldehide and Mesurol (Methiocarb are the molluscicides.

Tonnes of molluscicides applied over all Spanish crops in the last nine years (after AEPLA, 1999).

Cost in kEUROS of molluscicides applied over all Spanish crops during last nine years. (after AEPLE, 1999).
EL SUELO

• Factores abióticos
  • Estructura
  • Composición
  • Clima
• Factores bióticos
  • Plantas
  • Animales
• Interrelación entre factores
The soil and their dwellers

The Slugs Ecosystem
One unity interrelated
- Soil
- Vegetables
- Dwellers
- Weather

Balance
Equilibrium

Disturbing
- Plughing
- Chemical Compounds

TEMPERATURE (°C)
RAINFALL (mm)
MOISTURE (%)
POROSITY (%)
AIR CONTENT (%)
FRACTION > 2 mm (g)
GROSS SAND (%)
THIN SAND (%)
SLIME (%)
CLAY (%)
pH
pK
pV
C/N Relation
C (meq/100 g)
N (meq/100 g)
Na (meq/100 g)
K (meq/100 g)
Ca (meq/100 g)
Mg (meq/100 g)
Al (meq/100 g)
The Slugs’ Biological Cycle:

- Temperature
- Humidity
- Light
- Wind
- Shelter

**BENEFITS**

- Modelling
- Prediction
- Molluscicides
- Save Money

**Climate Data**

1. **Climatology of the Mediterranean Galicia**
   - Temperature (°C)
   - Rainfall (mm)

2. **Climatology in the Atlantic Galicia**
   - Temperature (°C)
   - Rainfall (mm)
Controlling Slugs

Search for warm-adapted strain of slug-parasitic nematodes

Field experiments to investigate the efficacy of the nematode biocontrol agent (Nemaslug®)
  - Lettuce
  - Brussels sprout
  - Cabbage

Laboratory and field experiments with low-chemical against slugs
  - Control H
  - Metaldehyde

Mechanical methods
  - Ploughing plot margins
  - Cleaning shelter and weeds
Controlling Slug Eggs

Laboratory test with Microwaves.
- **Powers:** 80, 150, 450, 750, 900 w
- **Times:** 15”, 30”, 45”, 60”

Laboratory and field test with Chemical compound with horticultural application
- Certol H; Tordon 101; Lugsmag-N; Talent; Lotril; Dimilin; Metaldehyde; Luqzinon 60; Linurex; Ata-diuron; Starane 20; Garlon Gs; Esantrene; Chas 48; Sanol-50; Dipsol-80; Arañol; Amigo.

Laboratory and field test with Suidae and Bovidae Manure:
- Different concentrations and origins

Laboratory test with Plant Extracts
- Digitalis purpurea L., Eucalyptus globulus Labill., Euphorbia helioscopia L., Foeniculum vulgare Miller., Laurus nobilis L., Rosmarinus officinalis L., Rubia peregrina L. and Ruta graveolens L.
In February 1998, the Terrestrial Malacology Group from The University of Santiago de Compostela (U.S.C.) found in the Portuguese Algarve (Monchique) and in the north and in the south of Spain some slugs of the genus *Arion*, *Deroceras* and *Milax*, with the zooparasite nematode symptoms described by Wilson.
It is almost impossible to destroy any significant number of terrestrial gastropods by use of bait; probably no more than 10% of a population can be destroyed in this way (Frömming & Plate, 1952). For a control of pest Gastropods it is essential to have precise knowledge, not only of population density, but also of the causal factors affecting it. It is also necessary to know the mortality rate, the development periods of eggs and juveniles, and the longevity of adults and senile, to establish the life span an number of generations per year for any articular species.

Healthy and parasited slugs were captured to get the nematodes. Samples of the soil were taken. The slugs were kept in captivity normal conditions of moisture, temperature and feeding. In one or two weeks the healthy slugs showed the mentioned signs of parasitism. Some days later the surface of the dead body of the slug was completely covered with nematodes. The parasited slug corpses were placed on nutritive agar and sent to Long Ashton.
Searching for Nematode Strains

FOURTH TRIP:
Dates: April and May of 1999.
Places: Northwest part of Spain, Zamora, Salamanca, Cáceres.

Problems with “Diagnostic Test Kits”
For detect Phasmarhabditis in soil
The Spanish *Phasmarhadities sp.* live

Mating and females lying eggs. Live pictures.
The Spanish *Phasmarhadities* Dauer larva

Surveys of the edaphic infauna are necessary to understand the possible competitiveness between soil dwellings.

**FIGURE CAPTIONS**

A and C.- Body of Dauer larva
B and D.- Oesophagus and first part of the intestine with a possible bacteria bag.
E.- Dauer Larva’s head.
C.- Dauer Larva’s tail.
The Protozoans as Slugs Biological controller
Protozoans around an embryo of *D. reticulatum*
Protozoans around
*D. reticulatum*
embryo
Protozoans around *D. Reticulatum* embryo
Protozoans round

*D. Reticulatum*

embryo

Blastómeres

Protozoan
Protozoans around an embryo of *D. reticulatum*
Eggs of *D. reticulatum* laid inside a rearing box.
Egg of *Deroceras reticulatum*. 
Stage IV embryo of *D. reticulatum*
Paper contact toxicity tests
Artificial Soil composition. The initial 3% humidity is an intrinsic factor to this soil. We have used two different moistures: 35% and 40%. For reach this humidity was necessary to add extra water on the soil: 49.5 g and 64 g, respectively.
Eggs of *D. reticulatum* exposed to different metal salts.

- **Normal egg**
- **Cupric sulphate**
- **Aluminium sulphate**
- **Ferric chloride**
Change of aspect of an embryo exposed to 1000 ppm of cupric-sulphate
Change of aspect of an embryo exposed to 1000 ppm of aluminium-sulphate
Change of aspect of embryos exposed to 100 ppm of cupric-sulphate
Slug reaction to contact with irritant or toxic substance
Plant Extracts as Molluscicides

PLANTS

PLANT EXTRACTS

ACTIVE PRODUCT

AGAINST EGGS

AGAINST ADULTS

HOW and WHEN to apply it?

COMERCIALIZATION

SYNTHETIC PRODUCT

PATENT

Plant Extracts as Molluscicides
Agrochemical Compound tests

Filter Paper

Turbe
Quartz Sand
kaolin
Calcium Carbonate
Standart soil
Experiments with Organic Manure

- Organic Manure from:
  - Cow
  - Pig

Objetives

Observe the effect of this manure in the embryo of *Deroceras reticulatum* in filter paper and in Standard soil.
The manure

- Used in agriculture like fertilizer.
- Mixture with or without vegetal material.
Efectos de los Purines sobre la Fauna del Suelo

- Aplicado en gran cantidad afecta a:
  - Aireación del suelo
  - Composición de la atmósfera del suelo
  - Toxico contra lombrices (100% mortalidad)
  - Mortalidad en pájaros al ingerir lombrices (gaviotas, cuervos, tordos,...)
  - Reduce drásticamente las poblaciones de Colembolos detritívoros, pero no a los fitófagos
  - El Amoniaco de los purines reduce las poblaciones de Ácaros
  - A los nematodos omnívoros, fitófagos, pero no los microbianos

- Aplicado en moderados niveles es beneficioso para el suelo y la fauna del suelo
  - Aumento de la biomasa de lombrices en un 60%
Tabla 1.1.- Valores medios, desviaciones estándar y coeficientes de variación de las propiedades del purín de explotaciones gallegas.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Valor medio ( \bar{x} )</th>
<th>Desviación estándar ( S_x )</th>
<th>Coeficiente variación ( \frac{100S_x}{\bar{x}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Densidad</td>
<td>1,034</td>
<td>0,029</td>
<td>2,76</td>
</tr>
<tr>
<td>Materia seca</td>
<td>6,08</td>
<td>3,79</td>
<td>2,29</td>
</tr>
<tr>
<td>Cenizas</td>
<td>25,0</td>
<td>18,46</td>
<td>33,81</td>
</tr>
<tr>
<td>pH</td>
<td>7,50</td>
<td>0,43</td>
<td>5,78</td>
</tr>
<tr>
<td>N-NH(_3^+)</td>
<td>2,40</td>
<td>1,84</td>
<td>76,66</td>
</tr>
<tr>
<td>N-inorgánico total</td>
<td>2,46</td>
<td>1,87</td>
<td>76,07</td>
</tr>
<tr>
<td>N-org</td>
<td>2,04</td>
<td>0,86</td>
<td>42,32</td>
</tr>
<tr>
<td>N-total</td>
<td>4,49</td>
<td>2,24</td>
<td>49,97</td>
</tr>
<tr>
<td>Carbono</td>
<td>41,51</td>
<td>5,53</td>
<td>13,33</td>
</tr>
<tr>
<td>C/N</td>
<td>11,04</td>
<td>4,73</td>
<td>42,86</td>
</tr>
<tr>
<td>CaO</td>
<td>4,48</td>
<td>3,9</td>
<td>88,77</td>
</tr>
<tr>
<td>MgO</td>
<td>1,22</td>
<td>0,50</td>
<td>40,77</td>
</tr>
<tr>
<td>Na(_2)O</td>
<td>1,26</td>
<td>1,10</td>
<td>87,19</td>
</tr>
<tr>
<td>K(_2)O</td>
<td>6,03</td>
<td>4,21</td>
<td>69,80</td>
</tr>
<tr>
<td>P(_2)O(_5) inorgánico</td>
<td>1,19</td>
<td>0,55</td>
<td>45,87</td>
</tr>
<tr>
<td>P(_2)O(_5) orgánico</td>
<td>0,59</td>
<td>0,47</td>
<td>79,66</td>
</tr>
<tr>
<td>P(_2)O(_5) total</td>
<td>1,71</td>
<td>0,63</td>
<td>36,84</td>
</tr>
</tbody>
</table>
Tabla 1.10.- Valores medios de las características de diversos tipos de purines.

<table>
<thead>
<tr>
<th></th>
<th>Vacuno</th>
<th>Porcino</th>
<th>Ponedoras</th>
<th>Gallinaza</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Materia seca (M.S.)</td>
<td>6</td>
<td>6</td>
<td>15</td>
<td>60</td>
</tr>
<tr>
<td>Cenizas (% M.S.)</td>
<td>25</td>
<td>26</td>
<td>35</td>
<td>19</td>
</tr>
<tr>
<td>N(_t) (% M.S.)</td>
<td>5,0</td>
<td>9,0</td>
<td>4,0</td>
<td>9,0</td>
</tr>
<tr>
<td>N-NH(_4^+) (% N(_t))</td>
<td>&gt;50</td>
<td>60-80</td>
<td>20</td>
<td>65</td>
</tr>
<tr>
<td>P(_2)O(_5) (% M.S.)</td>
<td>1,2</td>
<td>3,6</td>
<td>2,7</td>
<td>2,7</td>
</tr>
<tr>
<td>K(_2)O (% M.S.)</td>
<td>6,0</td>
<td>5,5</td>
<td>4,0</td>
<td>3,0</td>
</tr>
<tr>
<td>CaO (% M.S.)</td>
<td>4,5</td>
<td>2,2</td>
<td>4,0</td>
<td>11,0</td>
</tr>
<tr>
<td>MgO (% M.S.)</td>
<td>1,2</td>
<td>1,0</td>
<td>1,0</td>
<td>1,00</td>
</tr>
<tr>
<td>N:P:K</td>
<td>4:1:5</td>
<td>2,5:1:1,5</td>
<td>1,5:1:1,5</td>
<td>3:1:1</td>
</tr>
</tbody>
</table>
Fig. 2.4.- Evolución de la permeabilidad al aire del suelo, después de su tratamiento con purín de vacuno.

Fig. 2.5.- Influencia de la adición de purín de vacuno, a distintas dosis, sobre la porosidad del suelo. (Línea continua: suelo no abonado, sujeto a ciclos de humectación-secado).
Fig. 2.6.- Variación del número de microorganismos de un cambisol húmico (S), 7 días después de la adición de purín (S+P), en dos épocas: 1. Marzo (dosis equivalente a 33 kg N inorg./ha), y 2. Junio (55 kg N inorg./ha).
Fig. 2.21.- Población microbiana del suelo (S) y del suelo abonado con purín (S+P), después de 45 y 180 días de la primera aplicación de purín (90 días después de la segunda). BA, bacterias aerobias; BAE, bacterias aerobias esporuladas; ACT, actinomicetos; H, hongos; AL, algas.

Fig. 2.22.- Población microbiana del suelo (S) y del suelo abonado con purín (S+P), después de 45 y 180 días de la primera aplicación de purín (90 días después de la segunda). PR, proteolíticos; AM, amonificantes; DN, desnitrificantes; AZ, fijadores aerobios de nitrógeno; CL, fijadores anaerobios de nitrógeno.
Table 5.8 Mean numbers of collembolans (m$^{-2}$) with standard errors caught by suction sampling at Johnstown Castle, Co. Wexford. Slurry was applied in April and June at 80–100 m$^3$ ha$^{-1}$ yr$^{-1}$ (from Curry et al., 1980)

<table>
<thead>
<tr>
<th></th>
<th>No slurry</th>
<th>Pig slurry</th>
<th>Cattle slurry</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 1977</td>
<td>658 ± 208</td>
<td>175 ± 54</td>
<td>207 ± 43</td>
</tr>
<tr>
<td>May 1977</td>
<td>1120 ± 302</td>
<td>371 ± 83</td>
<td>490 ± 73</td>
</tr>
<tr>
<td>June 1977</td>
<td>1600 ± 251</td>
<td>355 ± 87</td>
<td>511 ± 86</td>
</tr>
<tr>
<td>August 1977</td>
<td>987 ± 412</td>
<td>650 ± 239</td>
<td>618 ± 242</td>
</tr>
</tbody>
</table>
Figure 5.9  Relative density of mites and apterygotes in fertilized and unfertilized meadows. (After Zyromska-Rudzka, 1976.)
Figure 5.11 Seasonal changes in the population densities of dipterous larvae in cow pats. Numbers of larvae are geometric means per sample (4 x 2.5 cm cores). (From Laurence, 1954.)
Table 5.6 Earthworm responses to cattle slurry applied to grassland plots at Grange, Co. Meath (after Curry, 1976b)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Intervals since treatment (months)</th>
<th>Mean numbers (m(^{-2}))</th>
<th>Mean biomass (g m(^{-2}) fresh mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Control (average of six sampling dates)</td>
<td>–</td>
<td>311</td>
<td>97</td>
</tr>
<tr>
<td>2. Single application of 55 m(^3) ha(^{-1})</td>
<td>5</td>
<td>352</td>
<td>205*</td>
</tr>
<tr>
<td>3. Six applications of 110 m(^3) ha(^{-1}) within 14 months</td>
<td>1–7</td>
<td>407*</td>
<td>188*</td>
</tr>
<tr>
<td>4. Two annual applications of 550 m(^3) ha(^{-1})</td>
<td>2</td>
<td>0*</td>
<td>0*</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>10</td>
<td>7*</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>453</td>
<td>148</td>
</tr>
</tbody>
</table>

*Differing significantly from control (P < 0.05).
Figure 5.10  Seasonal occurrence of insect larvae, collembolans and oligochaetes in cowpats at Rothamsted, England. (From Laurence, 1954.)
Figure 5.13  Macroinvertebrate biomass under different types of land use in the Peruvian Amazonia. (After Lavelle and Pashanasi, 1989.)
Pig Manure test on Filter Paper

Fig 12  Mortality evolution over exposition time.
Pig Manure test on Standard Soil.

Fig. 13 Mortality evolution over exposition time.
Pig manure effect on slug eggs

Pig manure 25.23 mg/cm$^2$

Pig manure 12.6 mg/cm$^2$

Pig manure 6.3 mg/cm$^2$

Pig manure 3.25 mg/cm$^2$

Normal development
Cow Manure test on Filter Paper

Fig. 14 Mortality evolution over exposition time.
Cow Manure test on Standard Soil

Fig. 15  Mortality evolution over exposition time.
Cow manure effect on slug eggs

Cow manure 26.5mg/cm²

Cow manure 13.25mg/cm²

Cow manure 6.625mg/cm²

Normal development
When apply the slug eggs killer on field?

- After harvest
- Between two ploughing
- Repeat the treatment before sowing
- Other Molluscicide will be necessary to apply as the vegetables are growing

What we manage with that?
- Destroy the slug eggs
- Kill the remaining slugs
- Crops free of land snails