Biological control of sweet potato weevils: Current status and perspectives for the Caribbean

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Exploring control options

- Chemicals
- Nematodes
- Viruses
- Fungi
- Bacteria
- Macro BC agentes
- Plant extracts
- Formulation
- Crop phenology
- Application / Efficacy
- Epizootiology
- Economics $
- Action thresholds
- Instar/Population
- Distribution
- Diversidad funcional
- Secondary metabolites

CABI plantwise
Exploring control options

Nematodes

Crop phenology

Interactions

Application / Efficacy

Economics $

Action thresholds

Instar/Population

Distribution

Diversidad funcional

Formulation

Macro BC agentes

Fungi

Economics $
Quick facts about sweet potato weevils (SPW) and their biocontrol agents

• There are 2 SPWs reported in the Caribbean: *Cylas formicarius* and *Euscepes postfasciatus*

• Only a few biocontrol agents have been reported in the world:
  • Parasitoids
  • Predators
  • Entomopathogenic fungi
  • Entomopathogenic nematodes
## Parasitoids

<table>
<thead>
<tr>
<th>Name</th>
<th>Host</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bracon yasudai</td>
<td>Euscepes postfasciatus</td>
<td>Japan</td>
</tr>
<tr>
<td>Bracon sp.</td>
<td>Cylas formicarius</td>
<td>Philippines</td>
</tr>
<tr>
<td><strong>Braconid:</strong> Rhaconotus spp.</td>
<td>Weevil larvae</td>
<td></td>
</tr>
<tr>
<td><strong>Eulophidae:</strong> Euderus purpureas</td>
<td>Cylas formicarius</td>
<td>Florida</td>
</tr>
</tbody>
</table>

- Not found in all the countries
- Difficult mass production
- Sample for local acurrence in the Caribbean
- If found: keep conditions for natural augmentation
## Predators

<table>
<thead>
<tr>
<th>Predatory ants</th>
<th>Hosts</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Tetramorium guineense</em></td>
<td>Generalistic predators</td>
<td>Cuba</td>
</tr>
<tr>
<td><em>Pheidole megacephala</em></td>
<td>Generalistic predators</td>
<td>Cuba</td>
</tr>
<tr>
<td><em>Iridomyrmex humilis</em></td>
<td>Generalistic predators</td>
<td>Argentina</td>
</tr>
<tr>
<td></td>
<td>Damaging for humans and livestock</td>
<td></td>
</tr>
</tbody>
</table>
Field manipulation of ant nests

Nest of *Tetramorium guineense* in banana rotting stems and leaves. Source: Cisneros F. and Alcazar, J., 2001

- Highly effective / Non specific predators
- Attack mainly adult weevil
- Weed control is needed to reduce prey populations (e.g., Aphids)
- *Pheidole* has shown a negative interaction with mealybugs in pineapple
Field manipulation of ant nests

- Ants colonies can be captured with traps (3 to 12 days until the queen moves into the trap)
- Place the ant nests in the sweetpotato plantation 30 days after sowing (early in the morning)
- Previous irrigation may be necessary (ants need moist soil)
- In Cuba: 100 nests /ha protected under the foliage

Banana pseudostem trap used in Cuba for collecting ant colonies. Source: Cisneros F. and Alcazar, J., 2001
Observed weevil damage on sweet potato treated with chemical control and nests of predatory ants in Cuba.
Using entomopathogenic nematodes for controlling the weevils

- Families: Steinernematidae and Heterorhabditidae
- Carry and introduce symbiotic bacteria (*Xenorhabdus* and *Photorhabdus*).
- Its host range includes both weevil species
- They can be grown on a large scale
- They can kill in 48 hours
- Can be stored and applied with conventional methods
## Entomopathogenic Nematod species reported

<table>
<thead>
<tr>
<th>Species</th>
<th>Effectivity</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Heterorhabditis karii</em></td>
<td>Higher effectivity (Larvae)</td>
<td>Kenya</td>
</tr>
<tr>
<td><em>Heterorhabditis indica</em></td>
<td></td>
<td>Kenya</td>
</tr>
<tr>
<td><em>Heterorhabditis bacteriophora</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Steinernema carpocapsae</em></td>
<td>(Less effective) Larvae</td>
<td>Florida</td>
</tr>
<tr>
<td><em>Heterorhabditis sp. H1-24</em></td>
<td>Not mentioned (Adults)</td>
<td>Cuba</td>
</tr>
</tbody>
</table>
Are nematodes a feasible option in the Caribbean countries?
Industrial production of nematodes (Liquid culture)

Gaugler and Han (2002) reported commercial-scale (c.10,000-l bioreactors) production costs of US$31 for *S. carpocapsae* and US$42 for *H. bacteriophora* per hectare (2.5 × 10^9 nematodes/ha).

costs to end-users remain greater than the alternative pest management tactic in most markets. They concluded that growers seemed unlikely to pay a premium to use nematodes when there were familiar, easy-to-use, low-cost alternatives.
Industrialized production of nematodes

Distribution of costs

The high product cost of EPNs is due to the relatively expensive and lengthy processes involved in their mass production, formulation, storage and transport.
In vivo production method

- *in vivo Galleria* process, yields between 0.5 e5 and 4 e5 IJs/larva
- The *in vivo* process is regarded as lacking economy of scale
- Lack of improved quality while increasing scale, the keep small production?
- *in vivo* nematode production is sensitive to biological variations (Grewal *et al.*, 2005).

*Galleria mellonella* larvae inoculated with nemaatodes
Rearing method for *Galleria mellonella*

1. Moths will lay eggs on a filter paper, on the lid of the container.
2. Every two days, the paper is replaced and dead moths are removed.
3. The areas of the paper containing eggs are cut into small pieces and reserved.
4. To stimulate the eggs to hatch, the pieces of paper can be incubated in a container covered with lightly moistened paper, for 24 hours at 25°C.
5. The paper pieces are evenly distributed on a layer of artificial diet in a larger opaque container and covered with another layer of diet.
6. The next days, the eggs will develop into small caterpillars.
7. When larvae achieve a larger size, the bottom and laterals of the diet should be removed (new diet is added) at least every 3 days, to avoid contamination.
8. New moths can be removed from the container, and a new cycle begins.

Illustration: Pereira, F. and Rossi, C. 2020
White trap technique for yielding nematodes from parasitised larvae

Fig. 13.3. (a) White trap method for harvesting EPNs emerged from insect cadavers; (b) infected juveniles (IJs) inside the bodies of EPN-infected insect larvae.
Size of the host and length of the cycle
Planning a selection process for nematode strains

Fig. 26.1. A schematic illustration to design a selection breeding course for entomopathogenic nematodes. (From Gaugler et al., 1989; Burnett, 2002.)
## Entomopathogenic fungi

<table>
<thead>
<tr>
<th>Species</th>
<th>Hosts</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Beauveria bassiana</em></td>
<td>Cylas and <em>Euscepes</em> (adults)</td>
<td>China</td>
</tr>
<tr>
<td><em>Metarhizium anisopliae</em></td>
<td></td>
<td>up to 43% control of <em>C. puncticollis</em> applying 28 days after planting</td>
</tr>
</tbody>
</table>
Entomopathogenic fungi

- *Beauveria bassiana* and *Metarhizium anisopliae* have shown effective against adult weevils

- *Metarhizium* produces more conidia at field level

- 48 to 72 hours for killing

- Application methods:
  - Plant dipping (5% conc.)
  - Spraying: 15 days after sowing (10^e12 conidia/ha every 7-10 days until establishment)
Observed effect of the application of B. bassiana for the control of SPW in Cuba

Damage dropped 5.7% with Beauveria
Generating local strain collections of entomopathogenic fungi and nematodes

Insect bait technique for entomopathogenic fungi and nematode collection
Life cycle of an entomopathogenic fungus (Deuteromicete)

- Sporulation
- Disemination
- Germination
- Penetration
- Multiplication
- Death
- Toxin production
How to produce entomopathogenic fungi?

1. Isolate from insect or directly from soil using bait insects or media with antibiotics
2. Use monosporic isolates to avoid contaminants and assure genetic homogeneity
3. Inoculate the solid substrate (rice) with a conidial suspension of aprox. $1 \times 10^6$ con/ml, 10ml per 100g of substrate in polypropylene bags.
4. Incubate at 24-26 °C for 10 to 15 days
5. For large production, multiply the inoculum with a 3 day liquid fermentation in nutrient broth
Tentative roadmap for developing a biocontrol programme of SPW in the Caribbean

- Consider the use of the 3 main biocontrol agents identified as effective (predatory ants, entomopathogenic fungi and nematodes)

  - **Predatory ants:**
    - Check the existence of *Pheidole* and *Tetramorium* species in the islands
    - Validate the pseudostem trapping method for collecting ant colonies
Tentative roadmap for developing a biocontrol programme of SPW in the Caribbean

- **Entomopathogenic nematodes:**
  - Generate a strain bank isolated from representative soils/environments of the country
  - Screen against weevil larvae and adults
  - Consider Small scale production at community level
  - Analyse the economics and feasibility for a large-scale production system for the region

Photo by: Chigurupati Sai Prasanth
Tentative roadmap for developing a biocontrol programme of SPW in the Caribbean

Entomopathogenic fungi
- Generate a strain bank isolated from representative soils/environments of the country
- Screen against weevil eggs, larvae, pupae and adults
- Consider Small scale production at community level
- Analyse the economics and feasibility for a large-scale production system for the region
Tentative roadmap for developing a biocontrol programme of SPW in the Caribbean

- **Parasitoids**
  - Run field samplings for parasitoid presence
  - If found:
    - Identify
    - Run studies of efficacy
    - Procure adequate environment for augmentation
CABI is an international intergovernmental organisation, and we gratefully acknowledge
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