Biological control of cowpea insect pests: progress, challenges and opportunities

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www.grainlegumes.cgiar.org

Leveraging legumes to combat poverty, hunger, malnutrition and environmental degradation.

and public and private institutes and organizations, governments, and farmers worldwide
Our strategy for **pest control in grain legumes**

**Preventive interventions**

- Improving plant resistance to pests
  - Marker-assisted breeding
  - Interspecific crosses
  - Transgenics (Bt-cowpea)

- Improving ecosystems services
  - Biological control (inoculative and inundative)
  - Ecological engineering

**Curative interventions**

- Application of pest-control products
  - Safe and rational use of synthetic insecticides
  - Bio-pesticides
  - Semio-chemicals
Biological control: a non-obvious option for managing insect pests in cowpea (*Vigna unguiculata* Walp.)

Without insect control, estimated average production loss of 3.8 million tons, ca. 3 billion USD losses every year.

Pesticides can provide effective control, but….

Need for more sustainable plant protection approach.
Biological control: a non-obvious option for managing insect pests in cowpea (*Vigna unguiculata* Walp.)

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Need for more sustainable plant protection approach.
Pesticides in West Africa: problems at several levels

Policy:
Unregulated market, cheap imports of doubtful quality
Permeability of borders

Sprayer/farmer:
Protective equipment: availability, affordability, tropical weather
Pesticide retailer is the ‘village scientist’
Lack of technical knowledge

Consumer:
Pesticide residues – no reliable local infrastructures
Post-harvest pesticides

Environment:
Ground water contamination
Pesticide resistance, including in disease vectors
Pollinators
Natural enemies
An old enemy: the legume pod borer, *Maruca vitrata*

Attacks flowers and pods of various legumes, up to 80% yield loss
Biodiversity studies

Natural enemies of *Maruca vitrata* in West Africa

Lc: *Lonchocarpus cyanescens*  
Ls: *Lonchocarpus sericeus*  
Ps: *Pterocarpus santalinoides*  
Pp: *Pueraria phaseoloides*  
Tp: *Tephrosia plathycarpa*  
Vu: *Vigna unguiculata* (cowpea)

Non-host specific parasitoids, low and insufficient parasitism rates

Arodokoun *et al*, 2006
What can we do??

1) Need to provide farmers with alternatives to harmful pesticide regimes, in the immediate short term. Bio-pesticides can be produced locally: 3 different business models

2) Need to design, develop and deploy a range of sustainable solutions to cowpea pest problems with a longer term perspective in the context of precision-IPM
Business model #1: Social enterprise

Bio-Phyto, Glazoue, Benin: 130 t of neem seeds collected by a community of 800 women during 1 year

Neem oil extraction, 500 l / week

Bio-fertilizers: useful and income-generating by-products, nematicidal effect, over 110 tons sold, supply cannot cover demand: bio-pesticide value chain
Business model #2
Engaging with the private sector

Elephant Vert

- World largest production unit in Meknès (Morocco):
  For 2015, 50 000 tons of bio-fertilisers and 120 tons de bio-pesticides
- Exclusive MoU between Government of Benn, Elephant Vert and IITA for exploiting a fungal strain of the entomopathogen *Beauveria bassiana* under the Nagoja protocol for Access and Benefit-Sharing (ABS)

http://www.elephantvert.ch/elephant_vert_maroc/
**Maruca vitrata** Multiple Nucleopolyhedrovirus *MaviMNPV* discovered at AVRDC

<table>
<thead>
<tr>
<th>Treatment</th>
<th>1(^{st}) rainy season Cowpea yield kg/ha</th>
<th>2(^{nd}) rainy season Cowpea yield kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsprayed control</td>
<td>522.95 ± 28.20(^{a})</td>
<td>282.00 ± 21.88(^{a})</td>
</tr>
<tr>
<td>Chemical control (Decis)</td>
<td>868.62 ± 68.09(^{b})</td>
<td>652.75 ± 62.94(^{b})</td>
</tr>
<tr>
<td>Neem oil</td>
<td>826.42 ± 52.80(^{b})</td>
<td>691.22 ± 22.18(^{b})</td>
</tr>
<tr>
<td>Jatropha oil</td>
<td>867.90 ± 28.29(^{b})</td>
<td>533.60 ± 45.31(^{b})</td>
</tr>
<tr>
<td>MaviMNPV</td>
<td>875.12 ± 47.83(^{b})</td>
<td>545.07 ± 54.50(^{b})</td>
</tr>
<tr>
<td>Neem oil + MaviMNPV</td>
<td>1082.10 ± 58.78(^{c})</td>
<td>552.47 ± 27.32(^{b})</td>
</tr>
<tr>
<td>Jatropha oil + MaviMNPV</td>
<td>1096.30 ± 26.05(^{c})</td>
<td>614.33 ± 11.34(^{b})</td>
</tr>
</tbody>
</table>

Sokame et al, 2015
Business model #3: Community based organisations

Women groups mass-produce *Maruca vitrata*, infest larvae with the virus and sell the dead larvae to the social enterprise for extraction, purification and conditioning (needs training and compliance with regulatory requirements).
In the meantime: what’s the origin of *M. vitrata* and why do we bother?

Source: CABI Crop Protection Compendium

Evidence of South Asian origin supported by latest population genetic studies (Periasamy et al, 2015)
Larger diversity of *M. vitrata* natural enemies in Asia: novel opportunities for biological control

- Our first case study: the exotic parasitoid *Apanteles taragamae*, an interesting biological control candidate
- Up to 60% parasitism on *M. vitrata* feeding on *Sesbania cannabina* in Taiwan (Huang et al., 2006)
- Poor ecological adaptation in W Africa, but useful for developing and testing the biocontrol pipeline (Dannon et al., 2012)
The biocontrol pipeline

Steps in the pipeline towards delivery:
- Discovery of biocontrol candidates
- Technical assessment
- Pre-release assessment
- Delivery systems towards establishment
- Making releases successful
- Scaling of release of biocontrol agents, ecological and economic impact

Science involved:
- Biodiversity, ecology, biology, population genetics
- Eco-climatic suitability, colony establishment, rearing methods, ex-ante socio-economic assessment
- Host range, host finding behaviour, biosecurity, impact on biodiversity, interactions with other IPM methods
- Suitability of gender-equitable mass production by private enterprises, innovative delivery/nursery systems
- Capacity development, novel ICT methods for technology dissemination, targeting of release sites
- Changes in pest population abundance and dynamics, yield data, savings from pesticide use, environmental, social and human health benefits
How to feed the pipeline: novel biocontrol agents through joint GIZ-project with AVRDC

*Therophilus javanus* is the best ever parasitoid against *M. vitrata*, replacing *A. taragamae* in Taiwan

Diversity of *Therophilus* spp. in Vietnam and Cambodia

Up to 40% field parasitism on yard-long beans

*Phaenrotoma philippinensis* best candidate in Thailand

Picture of *Bassus (Therophilus) javanus* taken in Malaysia in 1995
## Biological potential of parasitoids

<table>
<thead>
<tr>
<th>Species</th>
<th>Intrinsic rate of increase ($r_m$)</th>
<th>Finite rate of increase ($\lambda$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Therophilus javanus</em></td>
<td>0.24</td>
<td>1.27</td>
</tr>
<tr>
<td><em>Phanerotoma syleptae</em></td>
<td>0.14</td>
<td>1.15</td>
</tr>
<tr>
<td><em>Maruca vitrata</em></td>
<td>0.19</td>
<td>1.20</td>
</tr>
</tbody>
</table>

Dannon et al., unpublished data
After 2 years of confined testing: first experimental releases of *Therophilus javanus*

*Therophilus javanus*: the next biocontrol hero?

Jan 15, 2016
Pre-release sensitization campaign
Release sites

- Beterou
- Bassila
- Glazoue
- Dassa-Zoume
- Klouekanme
- Houeyogbe
Alternative host plants flowering along major rivers

Releases using adult stages of parasitoids

For each site

- 2000 *Therophilus javanus*
- 1500 *Phanerotoma syleptae*
What am I going to report at the next conference in 4-5 years?

Expected impact:

• Released parasitoids colonize patches of wild host plants, from where they can follow the migration of *M. vitrata* when it invades the cowpea fields during the cropping season
• Overall *M. vitrata* population reduction of 40-60% depending on agro-ecological region
• Integration of biological control with compatible IPM measures such as Bt-cowpea and bio-pesticides
• Leading to an overall reduction of chemical pesticides by >90%
Collaboration with INERA and icipe to start tackling a neglected yet important problem of pod sucking bugs from an ecological perspective

Population dynamics of the pod bugs *Clavigralla tomentosicollis* and its egg parasitoid *Gryon fulviventre*
Empirically derived evidence of male aggregation pheromone emission, currently being investigated at *icipe*.
Can we engineer a system where the egg parasitoids are attracted earlier in the season by the male aggregation pheromone and attack first generation egg masses?
Next steps: BMGF precision IPM project

Three main pillars:

1) Development of a **prototype Expert System (ES)** for modeling pest attack combined with a **Farmer Interface Application (FIA)** that has the potential for both receiving data and delivering pest control recommendations

2) Experimental releases of **biological control agents** and assessment of their effectiveness

3) Completion of ex ante economic and financial analyses to **estimate the potential impact of biologicals** with complementary financial analysis of community biopesticide production
Thanks to all our collaborators

In Africa
Cowpea farmers, extension agents, NGO personnel
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Nigeria: O. Alabi, UI; F. Pitan, UAbeokuta; N. Oigiangbe, UAkure
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Thanks for your attention!