Project report

project	**Development of an Integrated Pest Management Programme for Beet Armyworm (*Spodoptera exigua*) on Escallion (*Allium fistulosum*) – Biological Control Component**
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1 Acknowledgment

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2 Background

The beet armyworm (*Spodoptera exigua*) is one of the best-known agricultural insect pest. It is also known as the asparagus fern caterpillar, and the adult moth is known in the UK (where it is an immigrant and not known to breed) as the small mottled willow. It is native to Asia, but has been introduced worldwide and is now found almost anywhere its many host crops are grown *(http:en.wikipedia.org/wiki/beetarmyworm)*. The voracious larvae are the most devastating stage. They are greenish-brown cutworms, with dark longitudinal stripes. The adult is a drab brown or grey moth 2 to 3 cm in wingspan.

In Jamaica the beet armyworm was reported as far back as the 1970's on legumes. In the 1990's there was the first reported outbreak of the pest on escallion by P. Chung. The pest has also been reported on callaloo, onion and occasionally cotton as part of a Lepidoptera complex. In May 2009 an outbreak of the beet armyworm was reported by farmers in the parish of St. Elizabeth. Escallion fields in Flagaman, Pedro Plains, Little Park, Congo Hill, Rock Hill, Round Hill, and surrounding districts were heavily infested. More than 37 hectares of escallion were affected with more than 75 tonnes of the crop valued at approximately $5 million being destroyed by pest (RADA Plant Health/Food Safety Bulletin-2009).

Diagnostic field visits during Beet Armyworm Outbreaks in South St. Elizabeth

First outbreak, Flagamans, St. Elizabeth, May 2009

On May 22 and 28, 2009 senior officers from R&D and RADA as well as Extension Officers visited several affected fields in Flagamans and the surrounding areas. Officers from R&D participated in the following activities:

(i) Investigated reports of the beet armyworm outbreak on escallion and onion

(ii) Identified factors contributing to the pest outbreak and

(iii) Provided technical advice and recommendations to RADA staff and the farmers for effective control of the pest.

Second BAW outbreak, Junction, St. Elizabeth, December 17, 2009

A total of six farms were visited by the same team of officers as in the previous outbreak (Figures 1 to 3). The areas visited were Todd Town, Shaddock Hill, Bull Savannah, Top Bull Savannah and Comma Pen districts. Investigations were made to identify the factors contributing to the outbreak and provision of technical advice to the farmers.

Figure 1

Figure 2

Figure 3

Figure 1 and 2: Ministry of Agriculture staff members assessing BAW damage in South St. Elizabeth. Figure 3: an infested field.

From the field visits it appeared that BAW had a preference for hybrids, which have bigger and wider leaves, e.g. ‘Evergreen Hardy’ and ‘Green Banner’ and provide safe hiding for many larvae. No serious damages were observed and /or reported on local varieties of escallion e.g. ‘Red Root’ and ‘White Root’ which showed better tolerance to the pest. Leaves of local varieties are much smaller, can only accommodate few larvae and the size of the leaf restricts movement of pest within the leaf.

Economic injury levels were being exceeded in all cases and older instars were visible. It was noted that farmers increased the frequency of application (up to three times a week) as well as the dosage above recommended rates which also proved to have low efficacy. It was suspected that the repeated use of such insecticides led to the selection of a resistant population of beet armyworm which may have contributed to the current outbreak. Patchy leaf coverage and insecticide run off due to poor spraying techniques may have also contributed to the uneven management of BAW in the fields.

Outbreaks of this pest are not new but usually happen after long periods of drought followed by rain. It is believed that during drought, beneficial insects which attack the pest dies, as few BAW are available for them to feed on. However, after rainfall and plants have regrown, BAW moths lay their eggs on the lush vegetation and in the absence of many beneficial insects, most eggs hatch and larvae survive, hence resurgence.

The Integrated Pest Management (IPM) strategies being practiced for this pest generally include the use of monitoring techniques (application of action thresholds and economic injury levels), sanitation measures, tolerant varieties, cultivation practices (nutrition and irrigation), selective and environmentally friendly treatments, cultural practices and biological control.

3 Objectives

- Develop rearing protocol for beet armyworm
- To identify local natural enemies for biological control programme

4 Methodology

Rearing of beet armyworm cultures in the lab.

Beet armyworm egg sacs, larvae and pupae were collected from the field and placed in separate rearing jars in the lab. Larvae were fed callaloo (*Amaranthus viridis*) foliage until they pupated. Adults were fed honey solution for maximum life span. Wax paper was cut in to strips and placed in a rearing jar with adult BAW which facilitated a substrate on which the eggs were laid (Figure 4 & 5).

Figure 4

Figure 5

Figures 4 and 5. Beet armyworm being reared on callaloo (*Amaranthus viridis*) leaves.

Search for natural enemies

Various plant hosts of armyworms (*Spodoptera* spp.) were sampled from fields in three parishes, St. Elizabeth, St. Catherine and St. Thomas to detect associated natural enemies. Parasitized stages of armyworms were collected and reared out in the laboratory. Pictures were also taken in the field and laboratory of natural enemies collected. Search for natural enemies continues within these areas into this financial year.

Field assessments in St. Elizabeth

Three different methods of field assessment were carried out in south St. Elizabeth to assess the parasitism levels of beet armyworm using the parasitoid wasp (*Euplectrus plathypenae*). A ratio of two wasps to one larva was used to ensure parasitism. Therefore, in each case twenty wasps were exposed to ten larvae. The methods of assessment included the use of (i) sleeves where each sleeve was placed over separate BAW infested roots of escallion plants at different locations in the field (ii) exclusion cages and (iii) rearing cages.

5 Achievements against activities and outputs/milestones

- **Objective 1: To identify local and commercial natural enemies for management of the pest**

no.	activity	outputs/ milestones	completion date	comments
1.1	Conduct field visits to identify local natural enemies of armyworm species (Spodoptera spp.)	Field visits conducted to identify natural enemies of army worm species		Three parishes visited to date
1.2	Identify and establish rearing process for natural enemies collected.	BAW natural enemies identified and rearing process initiated		

6 Key results and discussion

St. Elizabeth is located to the south-west end of Jamaica, between Manchester to the east, Westmoreland to the west, and to the south St. James and Trelawny. St. Elizabeth is home to one of the driest areas in Jamaica – the Pedro Plains which has tested the ingenuity of St. Elizabeth farmers who have devised several ways of adapting to suit the nature and limited fertility of the area. It is also known as the bread basket of Jamaica, where tonnes of: escallion fruits and vegetables are produced.

A

B

C

D

Figure 6 A to D: Four varieties of escallion commonly grown in south St. Elizabeth, A: Unknown, B: Evergreen Hardy, C: Red Root and D: Humble Dread.

Fig. 7: Beet armyworm larvae on hybrid escallion in an affected field

Fig. 8: Beet armyworm larvae within the cavity of hybrid escallion leaf

Fig. 9: Beet armyworm affected hybrid scallion field in St. Elizabeth

<u>Factors responsible for the beet armyworm outbreak in St. Elizabeth</u>

A prolonged drought followed by rain affected climatic conditions in St. Elizabeth which may have triggered the pest outbreak. An extended period of drought resulted in significant decline of natural enemies, which usually keeps the pest population in check. The natural enemies of BAW include viruses, fungi, parasites and predators. Wasps, plant bugs, beetles, spiders, birds and lizards (figure 10 & 11) also prey on the beet armyworm moth larvae.

Fig. 10: Birds in a beet armyworm infested escallion field.

Fig. 11: Lizard in beet armyworm infested escallion field.

Resistance to some insecticides developed due to the abuse of insecticides of the same chemistry. The increased frequency of application (up to three times a week) as well as the increased dosage (i.e. above recommended rates) have shown to have low efficacy. The repeated use of increased insecticides resulted in the selection of a resistant population of BAW and thus led to the current outbreak. Poor spraying techniques resulted in insecticide run off and patchy leaf coverage. This resulted in an uneven management of the BAW in the field.

Scouting for the pest was not practiced by farmers, and insecticide treatments were applied when the older stages i.e. 3rd, 4th and 5th instars were present in the field. These instars of BAW are less susceptible to the treatments. Farmers who practiced rotation of insecticides from different chemical families had been successful in managing of the BAW.

Recommendations for the Control of the Beet Armyworm on Escallion/ Onion in St. Elizabeth

1. Farmers should inspect fields at least twice weekly for the presence of all stages of the beet armyworm (moths, eggs, larvae and pupae). Detection of egg masses on leaves is critical for the correct timing of insecticide applications. Threshold of 5 larvae (caterpillars) per every 25 plants should be used. An insecticide application is recommended at the threshold level.
2. The following insecticides are recommended for the BAW management, and should be used in rotation:
   - Bt. formulations (Agree®, Xentari® and Dipel®) should be included into the spraying programme. They should be applied at the stage when eggs have just hatched and larvae are very small in size.
   - Match® is most effective when applied on eggs and young larvae.
   - Danitol® and Lannate® can be added to the rotation for older larvae
   - However, Lannate® should be recommended **only with an outbreak** of BAW. **Lannate should be used with great caution due to its high toxicity.**
   - **Use of contact insecticides on mature larvae might not result in acceptable level of control and can trigger pest resistance.**
3. Farmers are encouraged to apply best crop production practices such as:
   - proper crop rotation
   - proper selection and rotation of insecticides and importantly, correct timing of applications
   - use of varieties which show better tolerance to BAW
   - recognizing the importance of natural enemies and role of biological control. Natural enemies are important asset and they must be preserved.
4. Integrated crop & pest management strategies by farmers will be critical for the prevention of pest outbreaks in future. This can significantly reduce cost of production, minimize damage to the surrounding ecosystem and ensure food safety for consumers.

5. Farmers that have fields devastated by the pest were instructed to deep plough the field in order to destroy pupae in the soil and any infestation on the plant material currently in the field. Mounds of escallion that were rouged from the field to further reduce infestation levels should also be destroyed.
6. A participatory approach in dealing with a pest outbreak is critical. This involves close collaboration between farmers, extension officers and research in conducting short-term on-farm research and farmer experimentation.

Further research needs to be conducted in the following critical areas:

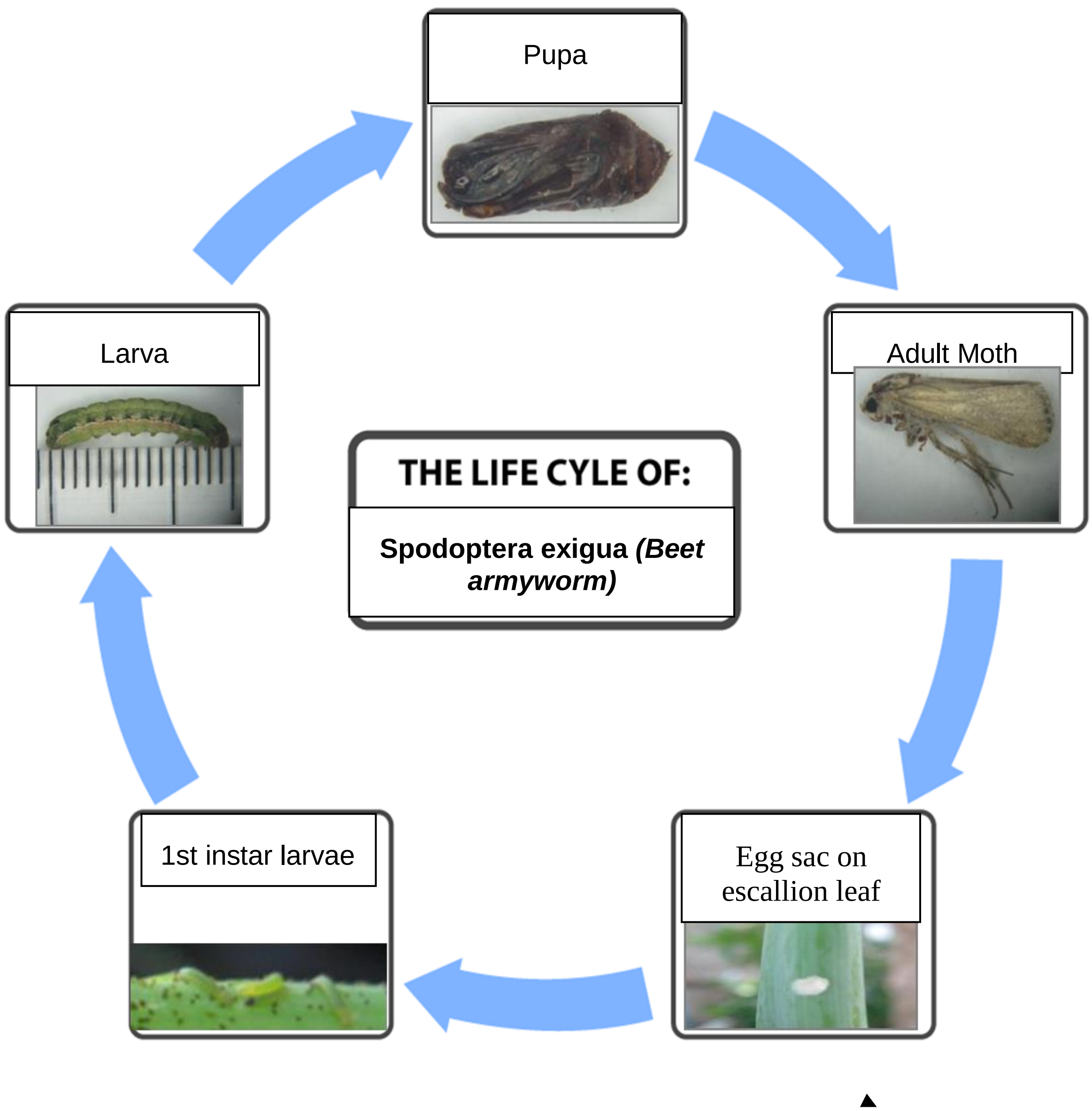
(i) The use of pheromone traps for early detection, monitoring and mating disruption of BAW: efforts are under way to import traps and pheromones. (ii) The testing of insecticides with new chemistries: contacts were made with one of the local distributors of chemicals and the Pesticide Control Authority to import experimental quantities of products and (iii) identification of local and commercially available natural enemies.

Observations from rearing BAW in the lab

Under laboratory conditions, the lifecycle of the beet armyworm was completed within 24 – 25 days. It was observed that should the food source becomes depleted, pupation starts at the 3rd instar resulting in a shorter lifecycle of 15 – 18 days. The pupae were smaller but the adults were viable and capable of ovipositing. The drought conditions may have further enhanced the ability of the pest to shorten its lifecycle. This may explain why an outbreak can occur in a very short space of time.

Life cycle of Beet Armyworm

Fig. 12: Beet armyworm life cycle



Search for natural enemies

St. Elizabeth

A search was made for natural enemies in St. Elizabeth in fields infested with beet armyworm during the two outbreaks. One parasitoid pupa was observed however, after incubating for several days there was no emergence. It was postulated that the parasitoid may have been in contact with insecticides before it was collected.

Clarendon / St. Catherine

A parasitized larva of the fall armyworm (*Spodoptera frugiperda*) found on sweet pepper (*Capsicum annum*) was brought from Thetford St, Catherine to the Entomology lab. Attempts to mass rear the parasitoids failed at the third generation, due to failure to parasitize the new larvae. The parasitoid detected was tentatively identified as *Euplectrus* sp. It is a general parasitoid of noctuid moths. It attacks mostly young larvae. Eggs are usually laid on each host, and hatches in thirteen to fourteen days. The host, which feeds little throughout its life, dies within eight to nine days after parasitism. After the mature parasitoids exit the host larva, the exit holes in the side only act as a superficial sign of the actual damage that occurred to the host. Most of the armyworm organs were consumed by the parasitoid. Attempts were being made to mass rear the new cultures however, the wasps would not parasitize any of the two species of armyworm larvae (*S. frugiperda* and *S. exigua*) to which they were exposed.

On the 27th of July 2010 another parasitized fall armyworm larva was brought to the entomology lab collected on the Bodles property. A rearing procedure was developed for increasing the number of this parasitoid. The parasitoid was identified to be *Euplectrus plathypenae* by senior staff members of the Entomology unit. *Euplectrus plathypenae* is naturally gregarious ectoparasites that develop on noctuid and geometrid larvae. Molting inhibition usually occurs without host paralysis and prevents shedding of the cuticle, which is the site of attachment of the parasite's eggs. Paralysis occurs when the female injects venom into the host before or at the time of oviposition. The host, which feeds little throughout its life, dies before the mature parasitoid emerges. After the parasitoid exits the host larvae, the exit hole in the side of the larva is only a superficial sign of the actual damage that occurred to the host. Practically all organs inside were consumed by the parasitoid. The life cycle takes thirteen to fourteen days. Several lab attempts to rear the parasitoid on beet armyworm was successful. However, attempts are know being made to mass rear the parasitoid in cages in the field. Should this attempt be successful, the next step would be to release the wasps at random at South St. Elizabeth in escallion fields.

Lab assessment

In the lab, observations showed that parasitism level is significantly greater with the fall armyworm (*Spodoptera frugiperda*) than with the beet armyworm (*Spodoptera exigua*). This is as a result of the larger body mass of the fall armyworm. The beet armyworm body mass is much smaller therefore, after development of parasitised larvae desiccation is more likely to occur. The exact parasitism percentage for each is not ascertained.

Fig. 13: Rearing cage, used to rear *Spodoptera* sp. for parasitisation by *Euplectrus plathypenae*

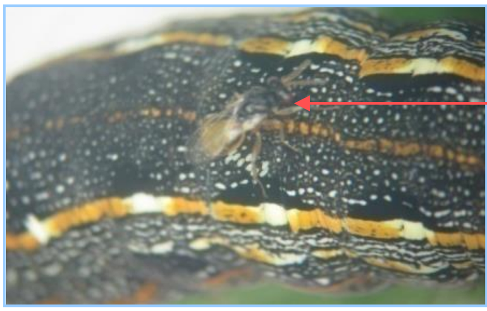


Fig. 14: Parasitoid wasp laying externally on *S. frugiperda* under laboratory conditions

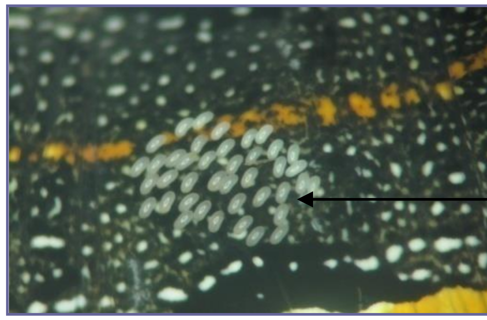


Fig. 15: Parasitoid eggs observed on dorsal side of *S. frugiperda* under a binocular microscope

Fig. 16: *S. frugiperda* on callaloo leaf (*Amaranthus viridis*) which serves as a food source.

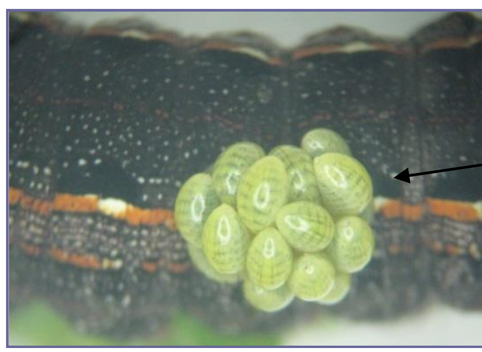


Fig. 17: Development of parasitoid eggs after six days observed under a binocular microscope

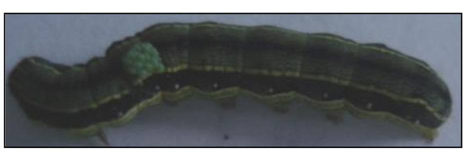


Fig. 18: Development of parasitoid eggs observed on *Spodoptera exigua*

Fig. 19 : Parasitoid larvae on *S. frugiperda*

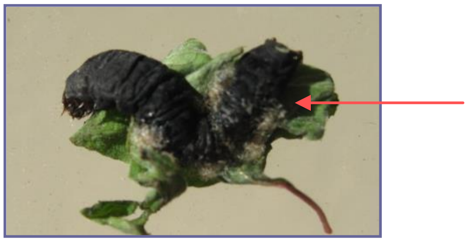


Fig. 20: A mummified *S. frugiperda* larva

Fig. 21: Parasitic wasps which emerged from dead larva

Field assessments in St. Elizabeth

The use of sleeves (Fig 22) to assess the parasitism levels of BAW was unsuccessful because ants invaded the sleeves as soon as they were placed over the beet armyworm infested escallion plants. High levels of beet armyworm in the field attracted high population of ants, however, not sufficient to reduce the BAW population. This invasion could be as a result of easier access to BAW due to confinement by the sleeve.

The second method using the exclusion cages (Fig 23) was also not successful because the mesh covering the cage was too flexible (cloth) therefore, the parasitoids were able to force their way through. The use of the rearing cages (Fig 24) is not fully evaluated as yet, due to seasonal changes and a reduction in infestation levels. Special consideration was also taken to ensure that there was reasonable amount of male to female in each instance. Restricted mileage and unavailability of vehicle also hampered the experiments to some extent.

Fig. 22: S. *exigua* larvae being exposed parasitoid wasps in sleeve.

Fig. 23: Plant Protection Officers erecting exclusion cages in escallion fields in St. Elizabeth to introduce parasitoid wasp to *S. exigua*.

Fig. 24: S. *exigua* larvae being exposed to parasitoid wasps in rearing cage.

7 Impacts

7.1 Scientific impacts – now and in 5 years

The information obtained will help to identify components of an effective management programme for south St. Elizabeth. In addition the monitoring of the population will help to serve as a warning system before an outbreak is experienced so that mitigating steps can be made to help farmers respond before the outbreak occurs and spreads. Data on the local behaviour of the pest will also be obtained.

7.2 Capacity impacts – now and in 5 years

Training of farmers and extension officers to understand the behaviour and life cycle, management of BAW

7.3 Community impacts – now and in 5 years

Farmers were given information on how to identify and manage beet armyworm to reduce the amount of broad spectrum insecticides being used and replace these with more environmentally friendly options, so as to encourage the population of natural enemies in the field.

Economic impacts

The management of BAW will serve to protect the investment and income of farmers and safeguard national food security. Benefiting also is the tourism industry, Agro-processors, fast food chains and vendors that supply the householders. If this pest problem is not managed properly farmers will be unable to supply these markets, forcing importation, resulting in loss of foreign exchange to the country and an increased import bill.

Social impacts

Many training sessions put on by RADA were not attended by farmers in the some areas because at the time they were not yet impacted by the pest. Hence, farmers were unprepared when the infestation levels increased. Many farmers were financially broke and were unable to purchase the chemicals that were ever increasing in cost. Farmers that implemented the recommended strategies for managing BAW did observe improvement in the crop thus maintaining their livelihood and their ability to provide for the basic needs of their family and those that were employed from the community.

Environmental impacts

An extended drought combined with poor water supply for irrigation which caused plant stress increased susceptibility to pest infestations. BAW females prefer to oviposit on drought stressed and more exposed plants. Encouraging the use of environmentally friendly treatments to manage the pest reduces the negative impact on the environment and human health. In addition this practise also helps encourage growth in the population of natural enemies that can help to reduce the population of BAW.

7.4 Communication and dissemination activities

- Two weeks of training were conducted on the 4th and 11th of June 2009 in the Pedro plains and Flagaman area. Weekly trainings were conducted in other affected areas.
- Trainings were conducted by personnel from R&D along with PHFSS from RADA.
- Communication through the printed and electronic media was also carried out
- Preparation of a fact sheet on managing Beet Armyworm
- Communication with the electronic and print media.
- Brief prepared highlighting activities to date
- Regular monthly, quarterly reports prepared