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Edited by
Thomas W. Zimmmerman, Stafford M.A. Crossman,
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CFCS Treasurer
Agricultural Experiment Station
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FAO'S SUPPORT TOWARDS THE SUSTAINABLE MANAGEMENT OF BEET ARMYWORM (*Spodoptera exigua*) IN JAMAICA

Vyjayanthi Lopez[1], Winfred Hammond [2], Michelle Sherwood [3], Marina Young[4], Kathy Dalip[5], Dean Passard[5], Yu Takeuchi[5] and Jerome Thomas[6], [1]Food and Agriculture Organization of the United Nations (FAO) Sub-Regional Office for the Caribbean (SLC), [2]FAO Rome (HQ), [3]Ministry of Agriculture and Fisheries, Jamaica, [4]Rural Agricultural Development Agency (RADA), Jamaica, [5]FAO Consultants and [6]FAO Representation for Jamaica, Bahamas and Belize

Abstract: Jamaica's agricultural sector, largely dominated by small farmer families, plays an important role in contributing to National Food Security. Small farmers in the 'breadbasket' parish of St. Elizabeth, in particular, are important producers of scallion, onion and other crops. Recent advances in onion production are significant elements leading to improvements in their livelihoods. However, these improvements have been threatened by increasingly frequent and serious outbreaks of the Beet Armyworm (BAW) (*Spodoptera exigua* Hübner) infestations. Despite efforts by the farmers and government agencies to control the outbreaks in 2009-2012, the devastation has continued to erode the progress made and the livelihoods of the farmers (J$140 million/US$1.4 million). This is largely due to an inability to provide appropriate production practices and management options to farmers. In response to a request from the Government of Jamaica to the Food and Agriculture Organization (FAO), the project *Strengthening a National Beet Armyworm Management Programme* (TCP-JAM-3401) was formulated and approved in 2012. Activities, which began in January 2013 include consultative and participatory processes among national, international experts and farming communities, towards the development of a strategy to adopt area-wide, integrated and comprehensive approaches to management of the BAW infestations. These are expected to contribute significantly to improved and sustained production. FAO assistance includes the development of a forecasting tool (FT) to assist farmers in making effective management decisions based on climatic conditions, as well as support to undertake an extensive Farmer Field School (FFS) programme, training both national Extension personnel and farmers in Training of Trainers workshops. It is anticipated that this approach would enable more timely and appropriate responses to BAW infestations and an improved/effective management of the BAW, as well as facilitate the institutionalization of FFS for direct empowerment of farmer communities and groups. The paper reports on progress made over the past 18 months, highlighting achievements under each component of the project.

INTRODUCTION

Jamaica's agricultural sector plays an important role in contributing to National Food Security and economic development, employing about 22 % of the labour force (≈ 250,000 persons) and supports 150,000 small farm (≤ 2.02 ha) families. Its contribution, including both fresh produce and agro-processed goods, to GDP in 2000 was 16%. In Jamaica, agriculture is closely linked to rural development and has a multiplier effect on the economy as it impacts on other service

industries such as transportation, marketing, tourism, export and local commerce. It also maintains social stability, thus reducing the problem of rural-urban migration.
Jamaica spent three times more on imports than it earned through exports from January to August 2010. In order to stem this imbalance, the Ministry of Agriculture and Fisheries (MOAF) initiated the Productivity Improvement Programme, aimed at increasing production and productivity of vegetable crops (also onions), not only as a mitigation strategy for the economic down-turns, nutritional deficits and natural disasters (floods, droughts and hurricanes) but also for import substitution in the retail, tourism and agro-processing industries. This required expanding production in major agricultural producing areas such as St. Elizabeth, the "bread basket parish". It is a major agricultural producing area in Jamaica with over 30,000 ha under farming, the main source of employment for many self-employed small farmers. In 2007, St. Elizabeth recorded 22,230 farmers or 14% of all registered farmers island-wide and, therefore, the parish is a major contributor to agricultural production. Onion has a long history of cultivation and tremendous growth potential in St. Elizabeth. The Marketing and Agriculture for Jamaican Improved Competitiveness (MAJIC) project, funded by USAID (United States Agency for International Development), was implemented by the Rural Agricultural Development Authority (RADA) in St. Elizabeth to address production, productivity and marketing. This resulted in 300% increase in onion production (2011-2012), with St. Elizabeth accounting for 75 % of onion and scallion production island-wide.

Since the 1990s, agricultural production in St. Elizabeth has suffered from major outbreaks of beet armyworm (*Spodoptera exigua*) (BAW) which have increased in frequency and severity and thereby threatening the progress achieved by the initiatives for improving productivity. BAW is a pest of agricultural crops worldwide, known for its resilience and its ability to survive harsh environmental conditions as well as to develop resistance to conventional insecticides. Adult moths tend to migrate in large numbers and oviposit on existing host crops. Larvae spend most of their life inside the onion (*Allium cepa*) and scallion (*Allium fistulosum*) leaf, being well-protected from the reach of natural enemies and insecticides, making their management even more challenging. In addition, very few effective pesticide chemistries are currently available to control this pest once it enters the leaf. Farmers, suddenly faced with heavy infestations, tend to increase usage of pesticides which negatively impacts the natural enemy balance and results in escalation of production costs and threats to food safety.

Traditional scallion production in St. Elizabeth involves a continuous crop system (up to 20 years) which creates highly favourable conditions for the feeding and breeding of BAW. Climate change factors such as increase in average temperatures and more prolonged droughts favour rapid growth of the pest population. With the onset of the rainy season triggering active crop growth, the pest population explodes and with poor pest management and the absence of sufficient natural enemies and over-reliance on use of conventional insecticides, the farmers are faced with a dilemma. The need therefore exists for a comprehensive monitoring system for the pest population and the employment of a forecasting system to predict possible outbreaks.

Several interventions, based on internationally recommended best-practices for sustainable management of BAW, have been made by the extension and research agencies. Despite these, outbreaks and/or pest flair ups continue annually due to poor uptake and adaptation of the

technologies by many farmers. Further strengthening of the current management programme is needed to improve mitigation efforts to reduce the impact of future BAW outbreaks.
The Government of Jamaica requested technical assistance from the Food and Agriculture Organization (FAO) to support the demonstration of improved productivity and sustainable management of onion /escallion production, with emphasis on comprehensive and integrated pest management (IPM) and crop management (ICM) approaches, seeking to provide optimal strategy for BAW management, minimal and safe use of pesticides during the life of the crop and prevention of BAW outbreaks. This would further broaden and strengthen the current management programme and improve adaptation by farmers of the various recommended management practices. The project *Strengthening a National Beet Armyworm Management Programme* was formulated in response to this request under FAO's Technical Cooperation Programme (TCP).

PROJECT DETAILS

The two-year project was approved at the end of 2012 and was implemented by the Plant Protection Unit, Bodles Research Station of the MOAF in close collaboration with RADA.

The main project beneficiaries were the farmers of St. Elizabeth. Early in the implementation, the project entered into a partnership with ACDI/VOCA[1], which was in the process of implementing complementary activities in several areas of Jamaica. The project's impact and outcome were '*Jamaica's national food security and economic development strengthened by promoting the sustainable production of onion and scallion in the 'bread basket' parish of St. Elizabeth*' and '*Improved and sustained vegetable crop production through economically effective and sustainable management of beet armyworm populations*', respectively.

Three key outputs anticipated from the project were:

1. On-farm crop/pest management practices strengthened
2. Monitoring and surveillance programme for BAW strengthened and a monitoring tool established and institutionalized in appropriate agencies and supported by farmers
3. National crop/pest management programme broadened and strengthened

PROJECT ACTIVITIES

In the project document, a number of activities were proposed in order to achieve the anticipated outputs. Progress on the implementation of these activities to date is outlined below, together with the next steps.

Output 1: Monitoring and surveillance programme for BAW strengthened and a monitoring tool established and institutionalized

[1] ACDI/VOCA received a 4-year, $14 million award from USAID to implement the Jamaica Rural Economy and Ecosystems Adapting to Climate Change (Ja-REEACH) program (formerly MAJIC program that focused on transforming Jamaica's agriculture sector into a market-driven, competitive industry)
http://www.acdivoca.org/site/ID/jamaica-ja-reeach

A key component of managing pests includes understanding the population dynamics of the target species. An ability to understand when and where an outbreak is likely to occur allows for better focused and increasingly rational management operations. The project aimed to establish the foundation for an integrated and improved management of BAW, specifically to create a forecast system by using geographic information system (GIS) technology to manage BAW populations in Jamaica. Four activities were to be carried out towards this end:

1. Evaluation and improvement of data collection and analysis programme
2. Formulation of a forecasting tool (FT) including an assessment of requirements for a global information system (GIS)
3. Review of institutional arrangements for operating the FT
4. Training of ten personnel from key agencies in Jamaica to maintain the tool

An expert Consultant (Yu Takeuchi) was recruited to develop the FT, which would be based on an analysis of weather patterns in Jamaica, development of a Degree-day Model and pest population dynamics. It was anticipated that the consultant would carry out the activities in three missions, the first of which took place over a two-week period from 22 April to 3 May 2013. The goals for this Mission were (1) to investigate the current situation of BAW in St. Elizabeth, (2) to understand current studies and researches done on BAW in Jamaica, (3) to understand the use of GIS in MOAF, (4) to gather necessary information for a forecast system, and (5) to design a forecast system for BAW.

During several site visits, severe BAW outbreaks were observed in the scallion/onion fields. Farmers tended to rely on insecticides and often over-sprayed the crops. Current efforts were focused on providing alternative management measures and appropriate information to farmers. Life cycle and population fluctuations of BAW had not yet been studied in Jamaica. Basic biological information, such as development time required for each stage, and population at each insect stage, were necessary for the forecast system. Therefore, laboratory and field experiments were proposed to MOAF.

GIS was not commonly used by the MOAF, and its usage was limited to categorizing land cover and soil types in Jamaica. While there were some persons with GIS skills, the limitation was the budget for the purchase of GIS software. The Meteorological Services Division had some weather data, which they were already providing. However, accessing some of the data was not easy, and it was anticipated that getting data could take some time to complete, especially to render paper-based records into digital form. The forecast system for BAW required weather data and duration of BAW development at different temperatures. Phenological models (using heat unit accumulations or degree-days) are commonly used models to predict the timing of the events.

Based on the above, the following were some of the recommendations made by the consultant:

1. The biology of BAW needed to be understood in the Jamaican environment. Population dynamics and insect development experiments were proposed.

2. The Research and Development (R&D) Unit of the MOAF should be responsible for laboratory experiments, while RADA should be responsible for field experiments.
3. MOAF needed to set up pheromone traps in scallion/onion fields to monitor population fluctuations throughout at least one year.
4. ArcGIS should be purchased and maintained by either R&D or RADA. For compatibility with newer software version, ArcGIS 10.1 was recommended.
5. MOAF needed to determine who managed weather data and a forecast system. The database to maintain historical weather data was necessary for BAW and many other species. Also, MOAF needed to identify a person to collect weekly weather data from meteorological services and run a forecast system.

Over the next few weeks, insurmountable challenges were experienced with the purchase and maintenance of ArcGIS software. Therefore, the project team recommended that an evaluation of available alternate options be carried out. Accordingly, the consultant evaluated several free-ware GIS packages, including GRASS, OpenJump, MapWindow and SAGA and compared them with the functions in ESRI ArcMap (as a baseline reference product). GRASS GIS was recommended as a viable, low cost solution that would allow most of the envisioned functionality for the BAW Management system.

Output 2 - On-farm crop/pest management practices strengthened

Two Letters of Agreement (LOAs) were signed with RADA, aimed at building capacity to manage and coordinate Farmer Field Schools (FFSs). Activities to be carried out under the LOA were:

- Conduct (1) a baseline assessment (survey) of current status and (2) post-project impact survey (the survey tool captured farmer profile, practices, knowledge of pest/IPM etc.)
- Conduct intensive one-week residential training course on participatory knowledge transfer to 20 Extension personnel and other key persons
- Establish two demonstration plots to facilitate an eight-week FFS Training of trainers (TOT) for 20 lead farmers
- Train 150 farmers by facilitating 10 FFS (run by the 20 TOT farmers with support of extension staff)
- Produce educational material and best practices Manual

A National FFS Expert (Mr Dean Passard, an ACDI/VOCA Associate) as well as a National Consultant in Entomology (Dr Kathy Dalip) were recruited to support RADA with the activities. It was anticipated that the activities would provide the following results:

- Trained Extension personnel continue utilizing Farmer Participatory (FP) methods in delivery of services
- Farmer groups continue to work together for mutual benefits (sharing knowledge / experiences, marketing)

Activities carried out by RADA to date under the LoA are summarized below:

Activities	Progress to date (June 2014)
Baseline pre-assessment of farmer practices	Both pre- and post-assessments completed. Data

to ID gaps; Post-assessment to gauge learning / knowledge gained through FFS	currently being analyzed
Workshops for Extension personnel (training) and for engagement of farmers and staff	Completed – capacity of Extension personnel enhanced; Farmers and RADA staff fully engaged
Establishment of two demonstration plots for eight-week long FFS-TOT for 20 farmers; Training 150 farmers in FFSs (by 20 TOT farmers, with Extension support)	11 farmers graduated as FFS facilitators. A total of 8 FFSs facilitated and 181 farmers exposed to participatory learning and knowledge sharing as part of the area-wide management of BAW
Production of Instructional video and placement on RADA website	Completed - www.rada.gov.jm Available on YouTube: https://www.youtube.com/watch?v=oTzQpzo4QBo
Manual on Best Practices	Draft compiled
Stakeholder Consultation meeting held	Project status and achievements were presented to farmers and other stakeholders. Feedback obtained
Public Awareness	Project achievements were highlighted during the two major agricultural shows (Denbigh Agricultural and Industrial Shows/ 2013 & 2014; Outdoor broadcast with Northern Caribbean University radio station, with coverage in St. Elizabeth and Manchester

Lessons learnt from the FFS

The following summary on lessons learnt from the FFS is based on observations made during the FFS sessions and testimonials of farmers during training sessions and graduation ceremony (Young, 2013):

- FFS approach is well accepted by farmers and extension officers
- Some farmers, who usually did not attend formal training sessions organized by RADA, were regular attendants at the FFS
- All participants (farmers and facilitators) were very comfortable in sharing information
- Linkages among farmers, extension staff, research officers and other stakeholders were strengthened (farmers actually provided suggestions on what is to be researched further!).
- Farmers indicated that they learnt new information and/or better appreciated information that was already known, through a better understanding of the pest and the crop:
    - Usefulness and importance of an agro-ecological assessment of the field and the surrounding environment (AESA)
    - Knowledge of the BAW life cycle for timely interventions e.g. identify and target early instars of BAW for control before they enter the leaves as they are easier to manage than older instars.

- Better understanding and appreciation of the BAW complexity and its adaptability and resilience. Role play of 'Olympic race' between the BAW, and thrips pests was performed by a group of farmers to highlight their understanding of ability of pest to damage the crop and its economic importance.
- Proper use of pheromone traps and interpretation of trap catch data for planning pest interventions.
- Proper scientific terminology of pest name, life cycle stages and names of natural enemies. This assisted with ability to understand pesticide labels and better relate to common pest names.
- Proper pest scouting and importance of record keeping
- Real impact of field sanitation measures on reduction of pest population (weed management, removal of infested leaves, proper disposal of infested plant residues etc.). Weeds now seen not only as crop competitor for water and nutrients, but a source of pests and diseases.
- Wider use and reliance on mechanical BAW control methods by farmers: hand picking of egg sacks from scallion leaves, removal (clipping) of leaves infested with the beet armyworm larvae to allow access by natural enemies such as paper wasps, spiders and birds)
- Innovations:
    - ✓ Farmers were introduced to innovation by Mr Buchannan, a farmer from Gillards, who designed a compost drum. Plant residues from scallion field are used to generate organic compost used as fertiliser.
    - ✓ Self-made light traps powered with mobile phone battery was innovated by a young farmer from Manchester
    - ✓ Use of thyme for intercropping of scallion as repellent for the beet armyworm adults was well taken by farmers.
- Use of pesticides did not result in expected reduction of pest in demonstration field unless it was done in combination with field sanitation practices.
- Better understanding of pesticide modes of action, timeliness of applications, proper protection of body from pesticide exposure and proper fitting of protective gears.
- Real benefits of soil analysis. Analysis results had helped to apply needed grade of fertilizer resulting in good response from crop and reduction in overreliance on a high nitrogen formulas.
- Appreciation of role of 'farmer friends' -natural enemies (spiders, paper wasps, ants, birds, etc.). Farmer(s) with heavily reliance of insecticides had seen importance of other methods of management and the role of natural enemies

- It is expected that farmers are better equipped to manage the pest and to reduce use of insecticides in their scallion fields. This might have a positive effect on reduction in cost of crop production and cleaner environment. Impact assessment should be able to capture such information.
- Farmers had expressed more appreciation for work done by extension staff and their role. Relations had improved noticeably.
- Community was well aware about FFS. Great interest was generated and other farmers in the community were willing to participate in the next set of FFSs.
- Farmers were more aware about the impact of markets on the beet armyworm population.

- Two new FFS modules were added to the curriculum: Marketing Linkages and Climate Smart Agriculture.
- All TOT farmers can provide advice and suggestions for the BAW management to other farmers in community.
- Farmers were more comfortable to make oral presentations individually or in the group setting.
- Farmers expressed great pride and sense of achievement in graduation FFS.
- Project achievement were backed with support from the Government of Jamaica (GOJ)/ Jamaica Social Investment Fund funded project, where farmers in St. Elizabeth were trained in areas of Good Agricultural Practices, Food Safety and Safe Use of Pesticides (17 training sessions were delivered to date by RADA, benefiting 446 farmers).

Challenges

- Sessions tended to have a longer duration than scheduled due to a number of concerns and issues brought by farmers to the discussion.
- Group recommendations for needed interventions in the fields (weeding and spraying) were not followed by a farmer / field owner, resulting in pest build up. The large size of the field and lack of financial resources prevented timely arrest of BAW population.
- Non availability of water for irrigation acted as limiting factor for crop and pest management in Comma Pen.
- Some FFS sessions had to be postponed due to farmer active involvement with crop planting after ending of prolonged and severe drought, which affected Jamaica in 2013-2014
- Challenges to identify funding support for continuation of FFSs beyond the project
- FFS is not yet fully institutionalized in RADA

Output 3 - National Crop / pest management programme broadened and strengthened

Two key components that were expected to contribute to the achievement of this output were:

1. Development of a comprehensive, integrated crop management programme to promote multi-agency management and response mechanism
2. Identification of appropriate local or foreign biological control agent(s) and evaluate the feasibility of establishing a rearing and releasing programme

The field component of integrated crop management programme involved the implementation of tried and tested area-wide IPM strategies:

- The use of area-wide monitoring of BAW populations with pheromone traps as a tool for decision-making on the management method(s)
- Adjustment of planting season:
  - No late planting of onion, particularly from February to March
  - Delay planting of new fields to the period April-June
  - Harvest mature scallion, onion during April-June period
  - Practice appropriate crop rotation – e.g. rotate with crops belonging to other crop families and / or those which are not attacked by BAW
- Employment of cultural practices: intercropping, crop rotation and removal of grass hosts as well as postharvest materials from onion / scallion as sources of BAW
- Safe use of effective pesticides (including biological control)

The project had a specific component on biological control – the identification and preparation of protocols for rearing / mass production and release techniques for at least two biocontrol agents. The natural enemies of the beet armyworm include predators, parasitoids, entomopathogenic nematodes, fungi and viruses. Available literature indicates that the efficacy of natural enemies in suppressing BAW populations ranges widely, with field parasitism levels of < 1% to 90% (Sertakaya *et al.* 2004, Ruberson *et al.* 1994). Thus, while previous attempts at finding natural enemies had not been successful (Diedrick *et al*., 2011), it was anticipated that at least a parasitoid or an entomopathogen would have been found, the presence of which could have contributed significantly to the overall management efforts of the BAW. During the FFSs and on several other occasions, field visits were made to scallion and onion farms. The immediate environs of the fields were scouted for BAW larvae. Observations were made on sightings of BAW and any natural enemies observed feeding on the larvae as well as from larvae collected from the field. Generalist predators, namely white egret birds, wasps (*Polistes* spp.), spiders and ants were recorded preying on BAW larvae; none of the field-collected larvae showed outward signs of possible parasitization/infection. *Polistes* sp. were observed cutting open the leaves to remove BAW larvae. It soon became apparent that the heavy reliance on insecticide control of the BAW had decimated most of the natural enemy population.

NEXT STEPS

Forecasting tool

It is necessary evaluate and improve data collection and analysis programme and the monitoring protocol developed by the consultant: implementation strategies were being developed by the Technical working group using 10 Farmer Field school farmer groups in tandem with RADA and R&D. Eight agencies are involved in the implementation of the forecasting tool, and it is necessary to formalize institutional arrangements via a Memorandum of Understanding (MOU). Furthermore, a national policy is needed with regard to the use forecasting tools as a part of the Ministry's way forward to address issues of climate change including pest outbreaks and for funds to be allocated to support the associated activities.
The consultant is currently preparing a Manual to be used to train personnel from the Ministry and partner agencies. This training is to be carried out during the second mission. The third and final mission would take place in 2015, with the objective of testing and fine-tuning of the selected forecasting tool. In terms of the establishment of BAW forecasting tool (FT): it would be necessary to (1) ensure that FT is widely and easily accessible to all users – this would fall under the responsibility of the MOAF and RADA, and (2) incorporate updating of weather and BAW population data into RADA's annual work plan to ensure continuity and sustainability. Collaboration is being sought with established Climate Change group headed by RADA and continued research to improve system through the local Universities. *Development of the pest forecasting system has enriched local capacity for the development of similar systems for important pests on priority crops on the island.*

FFS, including biological control

A comprehensive Manual on BAW Management is being prepared for use by Extension personnel in farmer training.

While the initial evaluation of the FFS was generally very favourable, it is necessary to carry out a comprehensive evaluation of (1) the overall impact of the FFS over a period of time and (2) the use of farmer participatory methods for knowledge transfer and learning among farmers. Based on the evaluation, a Formal Policy can be developed to support the utilization of FP methods for the provision of agricultural extension services to farmers and to the farming communities. Through FAO's support, a linkage has been created with CABI and a Concept Note submitted to CABI to support the development of a biological control programme for BAW.

Sustainability

From the outset, it was recognized that the project was not stand-alone, but was to add value to the on-going national programme on BAW management. The following measures that were put in place to ensure the success and sustainability of the project took this into consideration:

1. The Government-appointed National Project Coordinator (Ms Michelle Sherwood, Senior Research Director, MOAF), was the focal point for the execution of the project. She was guided by the Technical Working Group (TWG), comprising representatives from the agencies involved in its implementation: R&D-MOAF, the Agricultural Land Management Division (ALMD) of MOAF (with GIS capability), Director General and Information and Communication Technology (ICT) Unit of MOAF, RADA, The Meteorology Service Division of Jamaica, ACDI/VOCA and National Caribbean University (NCU). The TWG met regularly to review progress and make plans for the next few weeks. This ensured that the agencies were kept abreast of developments and in turn provided the necessary support at each stage.
2. The project supported the development of the forecasting tool as the basis for an early-warning system, a critical gap in the current management programme. It also supported and fostered the cooperation and collaboration that was necessary with several new agencies. The forecasting tool will remain within the MOAF and RADA: it will support and strengthen the early-warning system for BAW in the first instance and for other pests in the long term.
3. At the start of the project, RADA and R&D personnel were trained as FFS facilitators and in the integrated management of BAW. Furthermore, FAO consultants (FFS Expert and Entomologist) supported the newly-trained FFS facilitators in conducting the Training of Trainers for lead farmers. Thus, a cadre of well-trained FFS facilitators as well as lead farmers now exists in Jamaica. It is anticipated that the FFS facilitators will continue to use the skills acquired during the TOT/FFS in their interactions with farmers.
4. Baseline surveys were conducted and sensitization sessions held with farmers prior to the start of the activities in order to establish a baseline of current status of BAW management and farmer perceptions: the information was used in planning the various interventions that were tested in the FFS. Furthermore, farmers were the main focus and subject of the FFS, which empowered them to make evidence-based decisions in crop management not only for BAW on scallions and onions but also for other crops.

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