Final report

project	**Management of the Citrus Root Weevil, *Exophthalmus vittatus* on papaya (*Carica papaya*) at Advanced Farms, Trelawny, Jamaica**
project number	
date published	
prepared by	Michelle Sherwood and Worrel Diedrick
co-authors/ contributors/ collaborators	Dr. Lisa Myers, Principal Research Director
approved by	
final report number	
ISBN	
published by	

Contents

1) Acknowledgments

The authors acknowledge the managers of Advanced Farms who provided access to the farm and cooperated in implementing the recommendations given to them by the research staff. The technical assistance from Dr. Lisa Myers Morgan in identifying the components of the programme. The team of research assistants who have faithfully assisted on each farm visit Mr. Oral James, Ms. Tavia Gordon and Ms. Netalie Francis.

2) Executive summary

Citrus root weevils (CRW) (Fiddler Beetles) are the main insect pests that affect the citrus plant. In 1996 it was determined that the CRW larvae caused losses of US$4,982 per ha per year. The use of mechanical, cultural and chemical methods to control CRW has only provided short-term results. Long- term results can be realized through a biocontrol programme using natural enemies of the pest. Between 1990-1997 parasitoid wasps, *Fidioba citri* and *Aprostocetus haitiensis* were reared and released in Jamaican citrus orchards and were found to be effective against the eggs of the fiddler beetle. The wasps used in the programme gave between 50-80% parasitism.

Since 2008 Advanced Farms has been severely affected by an infestation of *Exophthalmus vittatus* which potentially can destroy the entire production and result in the loss of jobs to over 20 persons. The implementation of a biocontrol programme would serve to control this pest before the entire crop is destroyed on the farm and contribute to increased production. The programme has the benefit of being environmentally friendly as it minimizes the use of pesticides and is cost effective in the long run. The project was implemented by the Research Staff of the Plant Protection Unit headed by Mrs. M. Sherwood (Senior Plant Protection Officer) who was responsible for providing technical advice and conducting field exploration for parasitoids. The Manager at Advanced Farms was to oversee the implementation of the project on farm.

The rearing programme was initiated in the Lab at R &D Ministry of Agriculture under a pilot rearing programme from parasitized cultures collected in the field in St. Elizabeth and St. Catherine. Parasitoids were released by R&D staff from cultures reared in the lab at Advance Farm. Subsequently an on farm lab was established by Advanced Farms with guidance from Entomologists from R&D and cultures from the lab were used to initiate the on farm cultures. Also, farm workers were trained in the rearing process in November 2009. By the end of March 2010 the R&D lab had released 5018 wasps and the on farm lab 19,500 wasps.
Monitoring was conducted by R&D for the pest population (eggs and adults) and the egg parasitism levels. Results up to March 2010 indicated that the population of the pest was directly related to the rainfall levels. In addition the egg parasitism levels were very high ranging between.77.77 – 91 %.

3) Background

The Citrus Root weevil (CRW)/Fiddler Beetle is one of the main insect pests that affects the citrus plant. In 1996, it was estimated that the CRW larvae cause losses estimated at US$4,982 per acre (Alleyne, 1970). The use of mechanical, cultural and chemical methods to control CRW has only provide short-term results. Long- term results can be realized through a biocontrol programme using natural enemies of the pest. Between 1990-1997 parasitoid wasps were reared and released in Jamaican citrus orchards, and were found to be effective against the eggs of the fiddler beetle. The wasps used in the biocontrol programme were *Fidioba citri* and *Aprostocetus haitiensis* giving between 50-80% parasitism.

Since 2008 three diagnostic field visits were made to Advanced Farms in Trelawny, where there was a severe infestation of citrus root weevils. There was a one acre plot with 100 % infestation level of *Exophthalmus vittatus* which potentially can destroy the entire production and result in the loss of jobs to over 20 persons. An Integrated Pest Management programme was proposed to manage the pest and to also reduce the risk of pesticide residues for fruits destined for the export market. Advanced Farm is in the process of seeking entry into the European export market which has stringent requirements for agricultural market access. It is with this in mind that the IPM components being proposed were environmentally friendly, minimizing the use of pesticides and cost effective in the long run.

4) Objectives

1. To provide technical advice to managers of Advanced Farms to develop an IPM programme for control of the Citrus Root Weevil
2. To monitor the effectiveness of imidacloprid for control of CRW larvae
3. To source and establish cultures of the parasitoid wasps *Fidioba citri* and *Aprostocetus haitiensis* in the lab
4. To establish an on farm rearing lab for the parasitoid wasps for release into infested and surrounding fields
5. To monitor the population of the CRW and the parasitoids to determine the effectiveness of the programme

5) Methodology

Diagnostic Field Visits

Three diagnostic field visits were made to Advanced Farms between 2008 and 2009 in response to a report from the Farm Manager of problems managing Citrus Root Weevil infestations. The field was examined and observations made of the pest, damage and adjacent surroundings. Samples of eggs on papaya and weeds were collected to determine whether or not there was any parasitism taking place in the field.

A proposal detailing an Integrated Pest Management programme was prepared by Mrs. Sherwood and sent to the Farm Manager, Mr. Ebanks who supported the content and suggested that the General Manager be approached in order for the programme to be implemented. The IPM Programme would involve the use of Tedder's traps, biological control and the active ingredient imidacloprid in the insecticide Confidor®. Subsequently on a third visit to the farm a meeting was held with Mr. Fulton, the General Manager to support the recommendations for an IPM programme. Based on the discussions Mr. Fulton agreed to support the chemical and biological control component. The Ministry would conduct exploration for the natural enemies and initiate a pilot rearing programme at R&D which would then be transferred to the farm at a location to be upgraded for rearing purposes. Mr. Ebanks (Farm Manager) was responsible for setting up the lab and sourcing imidacloprid (Confidor®) from Mr. Burgess (local Bayer representative) and its field application.

Integrated Pest Management Programme

Biocontrol Component

Sourcing parasitoids and CRW cultures

Three locations were visited in search of parasitoid wasps in St. Elizabeth (1) and Bog Walk, St. Catherine (2). Orange fields infested with citrus root weevils were identified and the leaves checkedfor weevil eggs deposited between two leaves which are held together by an adhesive substance. Parasitized eggs were identified by the brown to dark discolouration of the eggs. These were placed into plastic tubes and sealed with moistened cotton and carried back to the lab for any emergence. In addition adult CRW were collected and placed into large 3 gallon buckets containing ficus (*Ficus benjamina*) leaves for food. Both wasp and weevil cultures were used to initiate the pilot rearing programme in the lab at R&D (St. Catherine) and then subsequently transferred to an on farm lab at Advanced Farms (Trelawny).

Rearing and releasing parasitoids

Cultures of the adult CRW were maintained in plastic buckets to produce a supply of host eggs. Fresh leaves of citrus or *Ficus benjamina* on which the CRW can feed and lay their eggs were then placed in the containers. Fresh leaves were provided every two days. Egg masses were removed from the culture every 2 – 3 days as in older eggs the grubs of the CRW would start to develop and the eggs may not be parasitized. Egg masses between two leaves containing 90 –120 eggs were exposed to at least five pairs of parasites in 2 x 7

cm vials plugged with cotton. Cotton plugs were moistened with water or diluted honey solution to provide food for parasites and prevent desiccation of egg masses. Ideally a temperature below 25°C should have been maintained but in the absence of AC units the cultures were maintained at room temperature.

In order to maintain proper sanitation of the laboratory and materials, tubes and buckets were washed and dried after each use and cotton plugs changed frequently to reduce fungal development and spread. Detergent and antiseptic were used for washing rearing containers. Adult wasps reared from lab cultures were easily released by opening the mouth of containers and allowing the wasps to enter the field

Monitoring CRW populations and CRW egg parasitism levels

Monitoring by Advanced Farms

Weekly monitoring using a ranking system was conducted on farm by scouts at Advanced Farms. The system ranks the levels of CRW from 0 - 5 which would guide the management programme as outlined below

0	-	None on plant	Monitoring by scouts
1	-	Mostly 1 per plant	Manual removal of bugs
2	-	Mostly 4 per plant	Weekly application of pesticides using Sevin® or Dimethoate®; & manual removal
3	-	Mostly 6 per plant	Two application of pesticides weekly and manual removal
4	-	Mostly 8 per plant	Two application of pesticides weekly and multiple manual removal per week
5	-	Mostly ≥15 per plant	Two application of pesticides weekly and multiple manual removal per week

Scouting data were collected from the farm manager from January 2009 to October 2009 in order to ascertain information on the weevil population prior to monitoring by R&D staff and rainfall data was collected from January 2009 to March 2010.

Monitoring by Entomology Staff

Monthly monitoring was conducted by the Entomology staff by examining 30 randomly selected papaya plants in plot 51 at Advanced Farms. The number of adults and egg masses per tree were collected with the use of elevated harvest tractors (Figure 1) to reach the tree tops which can extend up to 12 feet. Initially all eggs were collected for determining the parasitism levels but were reduced by randomly collecting one egg mass each from ten of the thirty trees being sampled in order to reduce the impact, removing all the eggs would have on the biocontrol programme.

Figure 1: Elevated tractor used for monitoring papaya trees at Advanced Farms, Trelawny

Chemical Component

Imidacloprid was identified as an effective treatment for the control of CRW in Hawaii. In Jamaica imidacloprid is registered under the product label Confidor 70 WG. Based on advice from the local agent for the manufacturing company Bayer the product is approved for use on papayas in the US market which is important for continued export to that country. The product also has a Preharvest Interval (PHI) of 6 days since harvesting is conducted on a 7 day cycle. The rate of use is 10-14 oz of a 42% imidacloprid formulation (Admire Pro) which gives the equivalent of 290-406gm active ingredient per hectare but that is for foliar insects such as whiteflies, hoppers & aphids.
In order to arrive at a rate for the root weevil an extrapolation was done from the Banana weevil treatment in Jamaica which is the effective rate being used in Puerto Rico at 10-14 oz/acre. The rate recommended by the Bayer agent was 500gm/ha of Confidor 70% i.e 350 grams of active ingredient per ha as this is the maximum rate recommended for papaya. In applying it through the drip system it is likely that the efficacy on the weevil would be improved relative to other application methods.

With a PHI of 6 days you could apply to non-bearingor young bearing trees up to six days before harvesting begins. For trees which are being actively harvested most fruits were removed before application and no harvesting could be done until 6 days later.
Confidor was packed in boxes of 50 13gm pouches (0-65kg) and the rate recommended per hectare 500gm (350gm a,i/ha). Imidacloprid was applied for one treatment as a soil drench and subsequently through the drip system to target the larval stage present in the soil in Tilson 51. This was done for a short period of time in October and November 2009.

6) Achievements against activities and outputs/milestones

Objective 1: To provide technical advice to managers of Advanced Farms to develop an IPM programme for control of the Citrus Root Weevil

no.	activity	outputs/ milestones	completion date	comments
1.1	Conduct monthly visits	Gather information on the history & current pest problem on the farm		Advisory was given for an IPM programme including biocontrol, cultural & chemical components

Objective 2: To monitor the effectiveness of imidacloprid for control of CRW larvae

no.	activity	outputs/ milestones	completion date	comments
2.2	Monthly field visits were made to sample the adult population	The change in the mean population of adult		The effectiveness of the treatments would not be determined until one year of application

Objective 3: To source and establish cultures of the parasitoid wasps *Fidioba citri* and *Aprostocetus haitiensis* in the lab

no.	activity	outputs/miles tones	completion date	comments
1.1	Conduct field visits to locations infested with the weevil to collect parasitized eggs	Parasitized CRW eggs sourced		
1.2	Establish lab cultures of weevil and wasps	Lab cultures established		

Objective 4: To establish an on farm rearing lab for the parasitoid wasps for release into infested and surrounding fields

no.	activity	outputs/ milestones	completion date	comments
1.1	To identify and refurbish an on farm location for the rearing lab	On farm rearing lab identified and refurbished		
1.2	To source materials for rearing process	Materials for rearing process sourced		
1.3	Transfer lab wasp cultures to the farm	Wasp cultures transferred to on farm lab		
1.4	Establish weevil cultures in buckets for egg harvesting	Weevil cultures established		
1.5	To train farm staff rearing process	Farm staff trained on rearing process		
1.6	To train on farm staff how to release wasps and recording system	Farm staff trained to release wasps and recoding system		
1.7	Make monthly visits to oversee on farm lab activities			

Objective 5: To monitor the population of the CRW eggs and the parasitism levels

no.	activity	outputs/ milestones	completion date	comments
1.1	To monitor the population of the CRW eggs	Population of CRW eggs monitored		
1.2	To monitor the CRW egg parasitism levels	CRW eggs parasitism levels monitored		

7) Key results and discussion

Diagnostic Field Visits

Based on investigations the field visited at Tilston 51 was 100 % infested with the weevil. The adults were observed feeding on the leaves and the gorbandizers and laying eggs on the leaves of wild callaloo in the field. Affected trees were noticeable as they had smaller top branches due to reduced growth and were yellow in colour. Eventually these trees topple over when the roots have been severely damaged and cannot anchor the tree to the soil (Figures 2 (A - D). The field was also observed to be adjacent to a large sugar cane field which serves as alternative host for the weevil. The farm is also located adjacent to a citrus farm, Good Hope and the rest of the area is forested with other potential host trees. The surrounding area therefore serves as a huge reservoir for re-infestation and haven for the weevil.

A


B

C


D

Figures 2 (A - D): (A) Citrus Root Weevil adults feeding on papaya tree leaves (B) CRW larvae damaging papaya root (C) Research staff investigating field at Advanced Farms (D) Papaya tree toppled over due to CRW damage to root system

The manager reported that the main treatment being used was dimethoate through the drip line for the larvae and Sevin® for the adults. Lannate® was applied when there was an outbreak of the pest. Dimethoate is an ineffective treatment for the larvae and recommendations for its discontinuation was recommended. There were other pest problems on the farm which included mites, whiteflies and scale insects. The chemicals being used for control included the active ingredient abamectin.

Biological Control Programme

Sourcing parasitoid wasps and initiating pilot rearing component

After the emergence of wasps from egg masses collected in the field only *Aprostocetus haitiensis* was obtained. A total of 259 wasps were harvested from the field cultures. Parasitism levels recorded for samples collected from Lacovia and Bog Walk was 84% and 75 % respectively (Table 1). No eggs were found at New Hall, St. Catherine. These samples were used to initiate the lab cultures (Figure 3). Up to the end of January 2010, 11,878 wasps were reared in the lab pilot project, 5,018 of which were released at Advanced Farms, 580 at an infested site in Devon, Manchester and the rest used to maintain the rearing process.

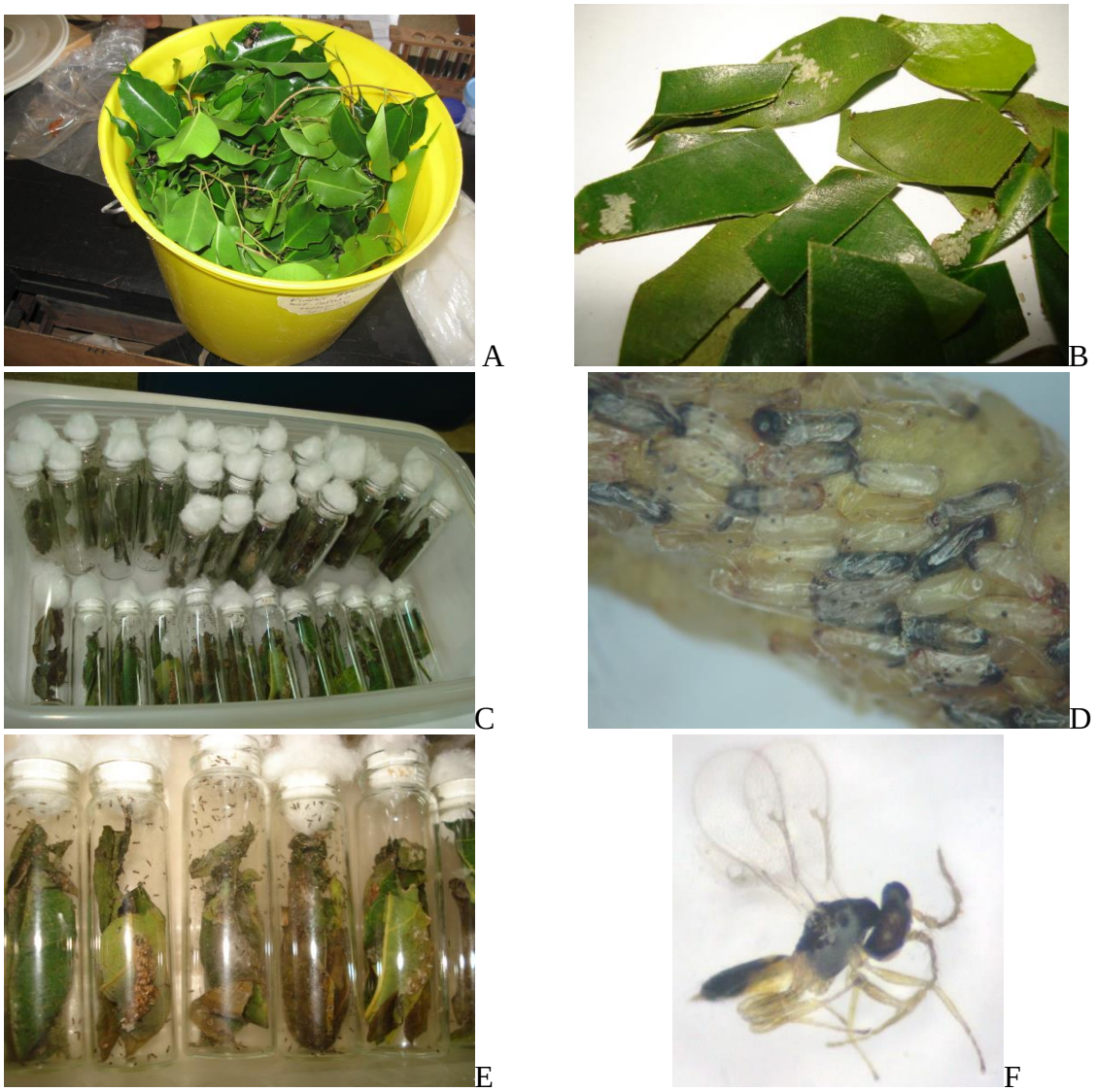

Figure 3 (A-F): Rearing of *A. haitiensis* (A) Buckets containing ficus for CRW egg oviposition (B) Ficus leaves with CRW eggmasses (C) Tubes containing egg masses for parasitism (D) Magnified view of parasitized CRW egg mass (E)Adult parasitoids emerged from CRW eggs in tubes (F) Magnified image of adult *Aprostocetus haitiensis*.

Table 1: Exploration data for egg parasitoids of Exophthalmus vittatus at three locations (September 2009)

LOCATION	NO. OF EGG MASSES	NO. OF WASPS	PARASITISM LEVELS	ADULT POPULATION
Lacovia, St. Elizabeth	130 eggs (4 egg masses)	109	84 %	<1/tree
New Hall, Bog Walk, St. Catherine	0	0	0	<1/tree
Newman, Bog Walk, St. Catherine	200 (6 egg masses)	150	75 %	<1/tree
Total	330	259		<1/tree

Table 2: Production data of parasitoids in Entomology's pilot rearing programme for Citrus Root weevil (October – January 2010)

Month	*No. of wasps*	*Parasitism Levels*	*No. wasps released*	
			ADVANCED FARMS	DEVON, MANCHESTER
October	2,243	45 %	107	-
November	3,754	87 %	1,111	-
December	2,081	98 %	1,000	580
January	3,800	98 %	2,800	-
Total	11,878		5,018	-

On farm lab component

The on farm lab was established at a cost of $50,000. It is located in a room that was once used for storage and is adjacent to a garage/repair shop. The room contains a concrete counter and two shutter windows at each end of the room. There are square holes present on one side of the concrete walls which helps to keep the room cool. Materials required were purchased by Advanced Farms and 35 wasp cultures in tubes (1,750 wasps) were supplied by the Entomology staff to initiate the on farm cultures in November 2009 (Figures 3 (A-B).


A


B

Figure 3 (A - B): (A) Rearing room showing materials used in the rearing process (B) On farm worker responsible for rearing programme

The rearing process was documented in detail to the farm staff in a proposal by the Entomology staff. One farm staff member was assigned responsibility to conduct the

rearing process and see to the daily maintenance of the lab. Since, the cultures were initiated in November, 2009 a total of 19500 wasps has been produced and released in the field (Figure 4).

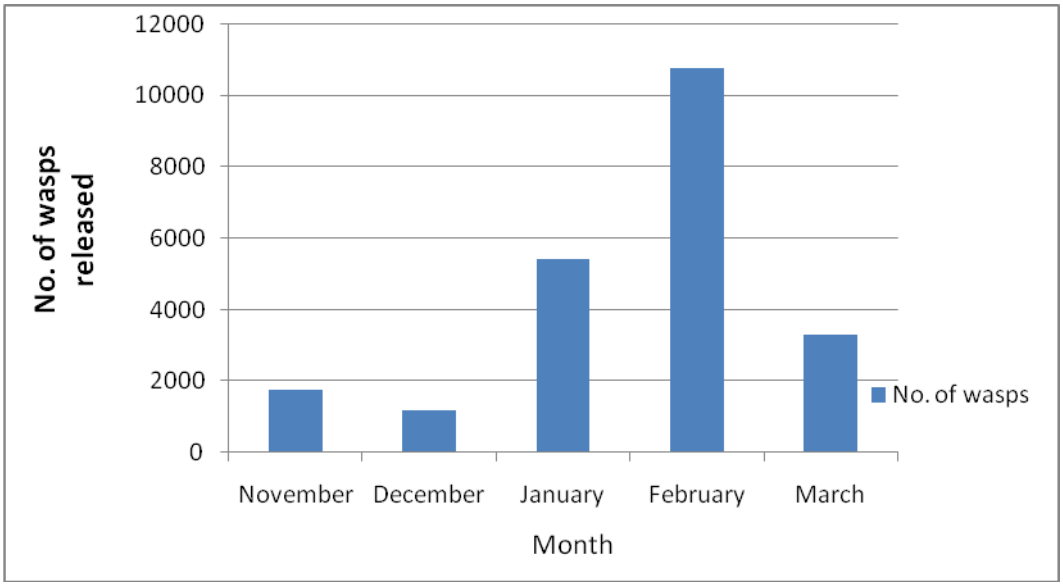

Figure 4: Monthly production and release numbers of *Aprostocetus haitiensis* at Advanced Farms

Monitoring population of CRW and parasitism levels

Monitoring conducted by Advanced Farms in 2009 indicated that the population of the adults was highest in May -June and September which coincides with the two major rainy seasons of the year (Figure 5). The highest mean adult/tree recorded from five months of monitoring by the research staff was in January which also recorded the highest rainfall levels for the October to March period (Figure 5 &6). A higher population of the weevil was observed for the January to March period for 2010 than was experienced in 2009 mainly due to the higher rainfall levels experienced in 2010 than 2009 for that period (Figure 6). One month after releases of *A. haitiensis* began at Advanced Farms (November 2009), the wasp had established in the field recording mean parasitism levels of 89.4 % (Figure 7).

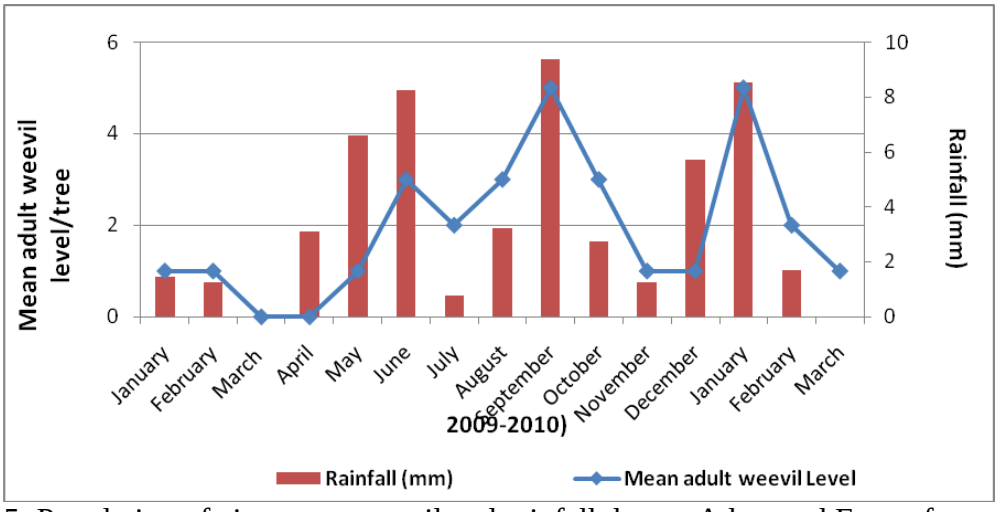

Figure 5: Population of citrus root weevil and rainfall data at Advanced Farms from January 2009 - March 2010

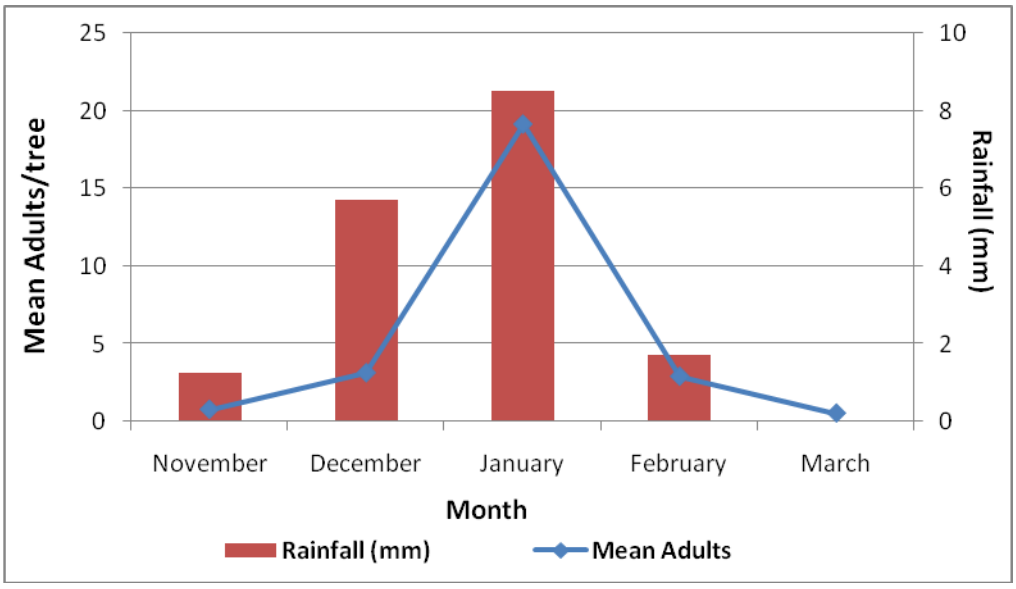

Figure 6: Population of citrus root weevil and rainfall data at Advanced Farms from November 2009 - March 2010

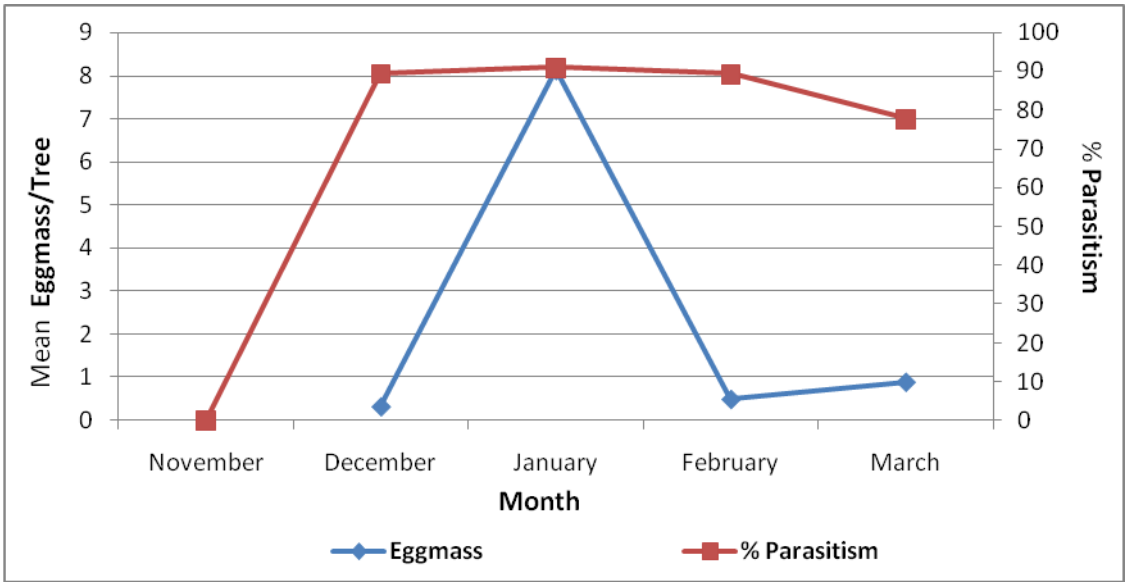

Figure 7: The impact of the parasitoid *A. haitiensis* on citrus root weevil egg mass populations from November 2009 to March 2010 at Advanced Farms, Trelawny

Based on the high population of adult weevils and the pattern of the population changes throughout the year it indicated that the pest had established itself in the area. The implementation of a biocontrol programme which only targets the eggs, would only reduce the further build up of the pest population in the environment. What this indicates is that all the larval and pupal stages that were previously in the soil prior to the programme will complete the lifecycle and emerge as adults. Therefore the effect of the programme will not be realised until 9-12 months when all the larvae present in the soil would have emerged having completed one life cycle.

Chemical Component

The chemical imidacloprid was applied for only two application in Tilston 51 for October and November 2009. Due to the high expense of the treatment Mr. Fulton removed this component of the programme and is focusing on the biocontrol programme only. The effect of this treatment would not have been realised unless it was applied over a one year period when one cycle of the pest would have been completed.
The use of imidacloprid was two fold, to target not only the CRW larvae but also the other sucking insects which were a problem on the farm. In addition this chemical would be compatible with the biocontrol prgramme being implemented.

8) Impacts

a) Scientific impacts – now and in 5 years

The increased knowledge on the effectiveness of this biocontrol agent in managing the pest not only on citrus but papaya. The development of an IPM programme for the pest on papaya which to date no published record has been found for the CRW on papaya.

b) Capacity impacts – now and in 5 years

Training of farmers to manage and maintain a rearing lab for *A. haitiensis* is a step in empowering the farmers to manage pests using an environmentally friendly and cost effective method.

c) Community impacts – now and in 5 years

The biocontrol components of this programme is applicable on any crop affected by this pest hence is transferable.

i) Economic impacts

The management of this pest has served to prevent the loss of an entire business which solely was dependent on harvesting the fruit weekly for export. The severe infestation of over 2 acres of the crop threatened the earning potential of the farm.

ii) Social impacts

The preservation of the income of growers in the industry ensures the protection of the welfare of their families who are dependent on this source to provide for daily health, educational, material, entertainment and other needs. The jobs of persons employed in the industry will also be safeguarded.

iii) Environmental impacts

The use of IPM strategies on the farm serves to reduce the risk to human health protecting the environment and providing healthier food for consumers to eat.

d) Communication and dissemination activities

1. A proposal was prepared and presented to the manager of Advanced Farms
2. Monthly reports prepared on the status of the programme
3. On farm training for the establishment of the rearing lab
4. Article written for publication in R&D's E - News Letter

9) Conclusions and recommendations

Enter text

a) Conclusions

There are indications that the pest population has begun to be reduced using the IPM programme being implemented. The outcome will not be appreciated until at minimum one year after the programme was initiated.

b) Recommendations

- To encourage the re-implementation of the use of imidacloprid would serve to further enhance the effectiveness of the programme
- To source and assess the use of the Tedder's trap as a monitoring and/or control tool
- To identify other parasitoids such as *Fidioba citri* to complement the programme
- To share the programme with other farmers with similiar problems with the pest on papaya and other crops.

.