

PN-ACX-993

First Annual Report

Covering the period 1 February 2003 – 31 January 2004

Submitted to the U.S. Agency for International Development; Bureau for Global Programs, Field Support and Research; Center for Economic Growth

Project Title

Management of *Bemisia tabaci* on virus-resistant cassava plants utilizing natural enemies

Principal Investigator

Dr. D. GERLING, Department of Zoology, Phone 972 3 6408611 FAX 640 7830 or 9403 e-mail dangr@post.tau.ac.il

Grantee Institution: Tel Aviv University, Ramat Aviv 69978, Israel.

Collaborators

Dr. J.P. LEGG, Tel 256 41 223460, FAX 56 41 223459, e-mail jlegg@infocom.co.ug

Institution: International Institute of Tropical Agriculture, Eastern and Southern Africa Regional Centre, PO Box 7878, Kampala, Uganda.

Dr. S. KYAMANYWA, Tel 256 77 220000, e-mail kyamaywa@infocom.co.ug

Institution: Department of Crop Science, Makerere University, PO Box 7062, Kampala, Uganda.

Project number: C22-005

Grant number: TA-MOU-02- C22-005

Grant Project Officer: Lawrence J. Gumbiner

Project Duration: 1 February 2003- 31 January 2006

Table of Contents

Section I	
1. Executive summary	3
2. Research Objectives	4
3. Research Accomplishments	4
4. Scientific impact	7
5. Description of project impact	7
6. Strengthening of developing country institutions	7
7. Future work	8
Section II	8
Managerial Issues	8
Budget	9
Special concerns	9
Collaboration, Travel, Training and Publications	9
Requests for American Embassy Assistance	13

Executive summary

This project was initiated to document the natural enemies of *B. tabaci* on cassava in Uganda, study their biology and the influence of cassava variety on their activity. A screen-house was erected in Uganda and event recorder obtained. The staff was trained to use the event recorder and to conduct behavioral studies. A field survey of three cassava-growing sites was conducted and visited 3 times. In this survey we found three parasitoid species: *Encarsia sophia*, *Eretmocerus* sp. and blackhead *Encarsia* sp. and several predators : spiders, coccinellids, black ants, syrphids and lacewings. Life table and exclusion studies have been carried out for one whitefly generation, and the second generation is being initiated. Rains have proven to constitute a predominant mortality factor.

In Israel, we concentrated on the following: training on Mr. M. Otim; establishing cultures of cassava, sweet potatoes and *Eretmocerus mundus* for the studies; studying the life cycle of the whiteflies on the sweet potatoes and establishing whitefly cultures on the cassava for later studies. All were successfully accomplished except for the latter which is advancing, but very slowly.

Two trips to Uganda of Israeli scientists, Dr. M. Guershon and Prof. Dan Gerling, were conducted. These served as strengthening cooperation and tutoring the Ugandan colleagues on site in the different techniques of whitefly and natural enemy studies.

Section II

Research objectives.

1. Identify the natural enemies of *B. tabaci* (parasitoids and predators) in Uganda and determine their contribution to reducing pest populations in different climatic and agricultural zones of the country.
2. Characterize tritrophic interactions that favor natural enemies of *B. tabaci* through the study of population dynamics of the pest in the field (using life table and exclusion studies).
3. Assess the control potential and shortcomings of the natural enemies present when acting on specific cassava varieties through field observations, with the support of laboratory experiments.

Research accomplishments

a. Natural enemy survey (Uganda)

Three surveys were conducted at Bulisa sub-county (Masindi district), Busukuma (Mpigi district) and Lyantonde (Rakai district), and three parasitoid species (*Encarsia sophia*, *Eretmocerus* sp. and an undescribed black-headed *Encarsia*) were recovered from *B. tabaci* (table 1). Provisionally, *Eretmocerus* sp. outnumbered *En. sophia* at all the locations surveyed, whilst blackhead *Encarsia* was only recovered at Lyantonde and Namulonge. The predators encountered were spiders, coccinellids, lacewings, black ants, and syrphids (Table 2). Spiders, coccinellids and black ants are the most commonly occurring. Spiders and coccinellids were sent for identification to the Plant Protection Research Institute, Republic of South Africa and to the United States Department of Agriculture, respectively. Spiders occurred in the families of Nesticidae, Oxyopidae, Thomisidae, Theridiidae, Araneidae, and Miturgidae. The coccinellids did not agree with species formerly described from Africa, but are probably *Serangium* sp.

Table 1: Numbers of whitefly *B. tabaci* nymphs and parasitoids per 6 leaves per plant on cassava in the different locations during the period November 2003 to February 2004

Location	Total nymphs	<i>Eretmocerus</i> sp	<i>Encarsia sophia</i>	Blackhead <i>Encarsia</i>	% Parasitism
Bulisa	224.8	35.3	8.4	0	29.8
Lyantonde	30.8	4.0	1.8	0.05	26.8
Namulonge	221.4	39.9	15.8	8.4	36.0

Table 2: Predators collected from cassava fields between November 2003 and February 2004

Location	Conwentzia	Coccinellids	Spiders	Syrphids	Black ants	Green lacewings
Bulisa	7 (5)	21 (49)	47	1	38	0
Lyantonde	0	2	25	0	1	0
Namulonge	0	3 (7)	57	11	20	1

Figures in brackets are the numbers of larvae of the different predators

b. Setup of plant and insects cultures

Uganda

Plants: A culture of sweet potato plants has been started for growing whiteflies and their parasitoids.

Insects rearing: Using 50-mesh screen purchased in Israel and carried to Uganda by Mr. Otim, a screen house was erected. It measures 14.4m X 3.23m; has six rooms in total, four rooms measure 3.23 X 2.5 while the remaining two measure 3.23 X 2.2m; and is protected from the rain by a fiberglass roof. The screen house is used for culturing plants and for growing whiteflies. Up to Prof. Gerling's visit, it also served for rearing parasitoids. However, since parasitoids of all kinds are permanently available in the field and can easily be reared out and obtained within days from the time of collection, it was deemed more effective to devote the time and space in the screen house for other purposes that cannot be done outside (see also Gerling's trip report)

Israel:

Plants: Import, culture and establishment of cassava rearing from tissue culture and preliminary tests of infestation.

Plants of the varieties Ebwanateraka and SS4 (the latter being resistant to viral diseases and the former not) were imported as tissue cultures from Uganda in February 2003. They were reared out and planted in a secluded and closed greenhouse in Israel. Thereafter, and after having been tested and found free of diseases by the Plant Protection Service in Israel, the plants were released and are now grown for experimental purposes.

Plants were kept in a greenhouse room and populated with numerous adults of *B. tabaci* from our culture that was reared on cabbage. This was done repeatedly for over a month's time. Initially none of the whiteflies laid eggs on the cassava. They usually lived for a few days and then died. Later, some oviposition was obtained on young cassava foliage. Following this experience, we decided to try two alternative approaches. 1. To concentrate our efforts on working with sweet potatoes; and 2. To try and establish a culture of whiteflies on cassava by using cassava grown whiteflies for reinfestation of the same plants.

Insect studies: The purpose of the studies with sweet potatoes is to determine the suitability of the plants to serve as intercropping hosts for the cassava culture in Africa. The questions that will be asked include: are the plants themselves attractive to the parasitoids? Will parasitoids that have developed on sweet potato-infesting whiteflies readily leave the plants so they could be used for banker plants in the intercropping with cassava? Are there any steps that we should take in order to have the parasitoids move more effectively from one plant species to the next? What levels of sweet potato do we need to obtain in order to make this system work effectively?

In order to study these parameters we first determined the developmental duration of the whiteflies on sweet potato – plants were grown in the greenhouse and kept in a temperature cabinet at $28 \pm 2^\circ\text{C}$. Their development was followed from oviposition to adult emergence from the pharate adult stage (pupae) and was found to range between about 20 to 27 days.

Additional studies: Importing the parasitoids *Eretmocerus mundus*, *Encarsia sophia* and *Encarsia sp.* (nsp?, *nigricephala*?) and predators.

Parasitoids were hand-carried to Israel and placed in quarantine on local cabbage plants infested with *B. tabaci*. In spite of the large numbers of parasitoids released and the repetition introduction of these onto the plants, we were unable to establish a culture of any of the parasitoid species upon the whiteflies. We got a small culture after one generation, but that also died out and no second generation was successfully established.

Therefore, pending further introductions we decided to start working with the local *Eretmocerus mundus*, which is akin to the one in Uganda (if not conspecific).

Predators were not imported so far, since work on the existing insects was too intensive.

c. Life table and exclusion studies (Uganda)

Life table studies:

There are 2 fields, each 15 X 10 meters. One is 6 months old and the other is 3 months old. In each, 100 eggs are marked on top leaves and followed daily until hatch. Then a total of 400, just settling whitefly nymphs are marked individually and numbered. These are followed daily and their fate is registered until they either disappear or hatch etc. After 30 days the leaf is picked and the remaining material on it is examined for any additional information. Altogether some 15 leaves are used, a leaf to a plant, with the plants for examinations being chosen according to a random number system.

It appears that a major disappearance occurs following rains.

Exclusion studies are planned for year 2.

d. Banker plants and intercropping (Uganda)

The study of Mr. Richard Ssemaganda for his M.Sc. degree have shown that there is a reduction of whiteflies in fields that are close to sweetpotato plantings. The possibly utility of this finding will be investigated next two years.

Scientific impact & Description of project impact. Since this was the first year of the project, the impact, both scientific and that of the project could be measured mainly in term of strengthening of developing country institutions.

Strengthening of developing country Institutions

Makerere University acquired an event recorder (The Observer[®], Noldus, 2003) for the collection, analysis and presentation of observational data on natural enemies. In addition, four "hobo" data loggers (Onset Computer, 470 MacArthur Blvd., Bourne, MA USA 02532), for taking weather records have been bought. Michael Otim, the Ph.D. student, spent two-weeks at Prof. Gerling's laboratory at Tel Aviv University (Appendix 1). This increased his capacity in whitefly and parasitoid associated technology including rearing, handling and using "The Observer[®], Noldus, 2003" for studying the behaviour of whitefly and parasitoids.

The staff in Uganda, both the students and technical personnel learned to use the behavioral recording program "The Observer", they also established insect and natural enemy cultures. Fieldwork has advanced well and Mr. Peter Asiimwe and assistants learned how to monitor insect populations in the field and observe how to identify different mortality factors act in the field.

Future work

We expect to follow the original program during the second year.

We shall continue with surveys of *B. tabaci* and its natural enemies in selected districts of Uganda and to study the mortality factors acting on whiteflies in the field. We shall learn how populations on cassava would be affected by intercropping with sweet potatoes and study the behavior of the natural enemies on the leaves of the different plants. Experiments will be conducted to investigate whether the predators observed actually feed on whitefly in the field. The development duration, reproductive capacity, and longevity of the principal parasitoids of *B. tabaci* will be determined. These will be followed by studies to determine the influence of plant characteristics on the development of *B. tabaci*, and the searching and oviposition behaviour of its principal parasitoids. The natural enemy exclusion studies will be completed and analysed and behavioural analysis on cassava varieties will begin.

In Israel we shall concentrate on attraction studies of the plants for the parasitoids and on examination of the characteristics of the plants (cassava and sweet potatoes as hosts for the pest). Finally an analysis trying to determine what activities have to be taken to improve the use of sweet potatoes as banker plants will be undertaken.

Section II

A) Managerial issues

i) Culture of parasites and parasitoid biology studies

Because of the ready availability of parasitoid in the field throughout the year, we decided to maintain only whitefly cultures in the screenhouse. Parasites for biology and behavioral studies will be reared from field-collected hosts. Since the screenhouse conditions are very different from those in the field, parasitoid biology studies will be conducted in the field, with minimal human interference.

ii) **Change in number of sites to survey**

In order to allow Michael Otim to concentrate on the different studies it was decided to limit the field survey sites to 3, Namulonge, Lyantonde, and Bulisa, while Kalangala, Serere have been left out.

B) Budget

There has not been any major change in the budget

C) Special concerns

There are no special concerns or any changes in protocols that address such issues.

D) Collaboration, travel, training and publications

We collaborated with Dr. A.S. Dippenaar-Schoeman of the Agricultural Research Council – Plant Protection Research Institute, South Africa, who identified spiders collected during the surveys. Dr. Steve E. Naranjo from USDA-ARS is helping with the identification of coccinellids.

Travel: Michael Otim spent two weeks at Tel Aviv University. Two Israeli investigators visited Uganda, Dr. Moshe Guershon and Prof. Dan Gerling.

Appendix 1

Travel Reports:

Michael Otim Hilary's visit to Israel

Trip schedule

May 22, 2003 Left Kampala for Tel Aviv

May 23, 2003 Arrived Tel Aviv at 11.50 am

May 24, 2003 Not a working day.

May 25, 2003 Introduced to laboratory and screen house management

May 26, 2003 Introduced to the basic principles of "the observer" software. Carried out preliminary observations with *Eretmocerus mundus* and *Encarsia scapeata*

May 27, 2003 Introduced to sampling of *Encarsia scapeata* that attacks *Trilaeurodes lauri* on Arbutus in the Judean Mountains

Continued with observation in the afternoon

May 28-30, 2003 Continued with behavioral observations

May 31, 2003 Stayed at the hotel because it was not a working day.

June 1 – 5, 2003 Continued with training on the use of the observer, screen house and laboratory maintenance. Search for literature from the online journals.

Introduced to parasitoid dissection.

June 5, 2003 Left Tel Aviv for Kampala

Report of a trip to Uganda – Dr. M. Guershon, 28 Oct. – 4 Nov. 2003

Arrived in Kampala 29 Oct, left 3 Nov.

Discussions were held with Dr. J. Legg, and Prof. Sam Kyamanywa, the students Mr. Michael Otim (Ph.D program), Peter Asiimwe and Richard Ssemaganda (M.Sc. program), and Steve, the technician.

Meetings were held mostly in the Namulonge research station, visits were also made to the Kabanyolo experimental plot, to the field plots in the region of Kampala and to the campus of Makerere University in Kampala.

1. Michael Otim: Will conduct his predator surveys on 10 whole plants in three different regions with 5 fields in each region. On each plant he will assess the predator population on the whole plant, whitefly adults on the top 5 leaves and immatures on leaves 5-11 counting from the top down.

He will also sweep the vegetation near the plants to learn about the whiteflies and predators on these.

Visited the research plot at Kabanyolo. The screen house has been completed, but the culture itself is poor, few small plants only which need to be reinforced with better cultures. Humidity might be too high and shade too heavy. Discussed ways to improve those conditions.

2. Peter Asimwe: He has a young cassava plantation in which he is to sample the populations of the whiteflies and their enemies to create life tables. He is now at the stage of establishing his plots and starting to sample. Conducted a few predator identification exercises.

3. Richard Ssemaganda: His project, studying the whitefly populations on sweet potatoes in order to facilitate the intercropping of this crop with cassava was surveyed and his field plots were examined.

4. Demonstrated and practiced the use of the “Observer” software with the whole team.

5. Surveyed the predators found in the field. Failed to find *Conwenzia* but did locate several coccinellids of interest and identified their gender and different stages. (found mainly coccinellids, lacewing eggs, predatory flies [syrphids and others] and ants.

6. Went over the identification of parasitized whitefly nymphs in their different stages.

7. Collected parasitized material for taking to Israel – in accordance with the permit that we have in possession.

8. Comments and suggestions [all were raised in the summarizing discussion held on Monday the 3 of November].

1. The greenhouse cultures are too weak and must be enlarged and expanded. It was suggested that the culture will be passed on small potted plants set on a table top in a greenhouse. Different regions should be devoted to clean plants, to infested ones and to ones with natural enemies. The culture should be organized around a numerical arrangement that will yield a certain amount of plants and its success and suitability can be followed regularly.

2. The entomological knowledge of Peter must be improved so that he will be able to do independent and reliable field work in his plots. This should be reinforced by obtaining some relevant pictured literature.

3. Pictures should be taken regularly of the insects in the field, of the plant conditions and the plot situations that might be of interest.

Report of a trip to Uganda – Prof. D. Gerling, 28 Jan.- 02 Feb. 2004

Discussions were held with Dr. J. Legg, and Prof. Sam Kyamaniwa, the students Mr. Michael Otim (Ph.D program), Peter Asimwe and Richard Ssemaganda (M.Sc. program), and Steve, the technician.

Meetings were held mostly in the Namulonge research station, visits were also made to the Kabanyolo experimental plot, to the field plots in the region of Kampala and to the campus of Makerere University in Kampala.

1. Michael Otim:

- a. Has completed 3 surveys in which he incorporated the suggestions given by Dr. Guershon.
- b. Practiced parasitoid dissection with him (all 3 species).
- c. Went over the cultures and made suggestion about more effective use of the screen house.
- d. Studied the ovarian anatomy of the blackheaded *Encarsia* and found that it has very small eggs, hence it will be very difficult to follow its oviposition.
- e. Recommended that Michael will use infested plants with known amounts of whiteflies on each. The populations should be followed until whitefly and parasitoid maturity and the rate of whitefly survival should indicate the possible effect of the parasitoids and their capability to reduce the hosts

sufficiently, this will also be an indication of the levels of hosts that we can allow in the field before parasitoids are encouraged through intercropping. This should be done in the screen house.

2. Peter Asiimwe:

- a. Visited his plots, the older one is close to completion and the younger will start getting sampled shortly.
- b. Discussed the features that were discovered during the work and made some recommendations:

To add about 100 whitefly nymphs to the count and these should be protected from rains by means of a plastic cover of some kind. This will give 2 things:

1. A confirmation that really it is the rains that are responsible for the disappearance of the nymphs, and 2. We would find out what would have happened in the absence of rains.
- c. Discussed the set up of future enemy exclusion experiment. It will be conducted in 2 months' time in the same fields. Leaves with about 100 whiteflies altogether will be bagged in organdy bags and isolated by a ring of sticky material. They will be followed twice a week during 30 days and the fate of whiteflies will be registered. As a control, the same number of whiteflies will be kept without exclusion by bags. Since the bags themselves change the atmosphere and therefore will not be equivalent to non bagged materials, experiments should start now in bagging leaves with complete, or partially open bags which will allow entrance of natural enemies; all in order to find the best method for future field applications of the bags.

3. Richard Ssemaganda :

- a. Discussed with him the termination of his sweet potato studies. The results will be summarized in his thesis.
- b. Went over the screen house. It has 6 rooms, is well maintained but needs some fixing- so that the doors will shut more tightly. It has cassava cultures on each of these chambers (some 20 -30 bucket size or small pots, all of the virus resistant, problematic SS4 variety). The material is mostly arranged according to the age of the plants and the whiteflies from the oldest that is at emergence to the youngest that is with 1st instar nymphs. Some of the younger cages have also plants with older material in them. The oldest cage had an introduction of parasitoids (all 3 species) and now they are emerging

and are being introduced into the second cage. Parasitism exists but is very low! Possibly there is no effect of having introduced parasitoids since there are similar levels of parasitism also where none had been introduced.

4. James Legg:

- a. Discussed the project and its continuation, explained the details of the work plans reported above.
- b. Discussed future mutual visit and decided that Peter will be coming to Israel later this spring.

Future trips.

A trip of Mr. Peter Asiiimwe to Israel (May 2004)

A trip of an Israeli Scientist to Uganda.

Publications:

Mr. Otim attended and presented a talk on “**Occurrence of parasitoids of *Bemisia tabaci* on cassava in Africa, A Review**” At the 6th African Crop Science Society Conference in Nairobi, Kenya (12th – 17th October 2003), which centered on the theme “**Harnessing Crop Technologies to Alleviate Hunger in Africa**”.

E. Requests

The staff at the American Embassy has been very helpful so far. No special requests are anticipated.