

FINAL REPORT

Regional Sensitization Seminar and Workshop on the Prevention And Diagnostic of Fusarium Wilt (Panama Disease) of Bananas and Plantains Caused by *Fusarium oxysporum* f. sp. *cubense* – Tropical Race 4

Trinidad and Tobago

27 April - 10 May, 2014

Consultants / Facilitators:

Dr. Luis Perez-Vicente, INISAV, Ministry of Agriculture, Cuba

Dr. Miguel A. Dita, EMBRAPA, Brazil

Mr. Einar Martinez de la Parte, INISAV, Ministry of Agriculture, Cuba



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CARIBBEAN AGRICULTURAL RESEARCH AND DEVELOPMENT INSTITUTE**



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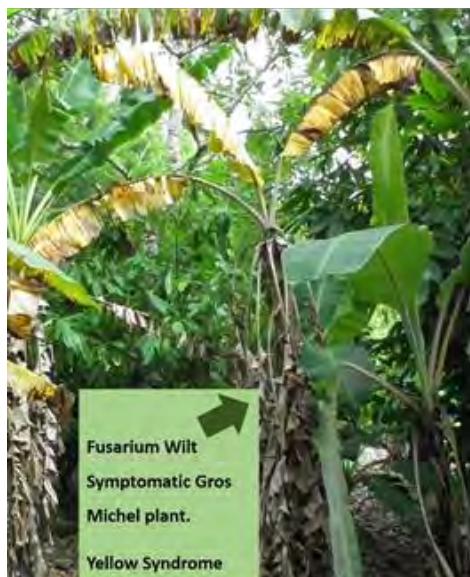
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TABLE OF CONTENTS

| | |
|--|----|
| Executive Summary..... | 4 |
| Introduction..... | 5 |
| Fusarium Wilt TR4 Sensitization Activities in the Caribbean | 6 |
| Detailed Report of Activities..... | 6 |
| Desk activities | 6 |
| Field Mission | 7 |
| Sensitization Seminar | 7 |
| Other pre-workshop activities..... | 8 |
| Workshop Activities..... | 9 |
| Workshop Evaluations | 11 |
| CONCLUSIONS AND RECOMMENDATIONS | 11 |
| Annex 1. Program of the Sensitization Seminar on Fusarium Wilt – Tropical Race 4..... | 14 |
| Annex 2. Participants in the Sensitization Seminar Fusarium Wilt Tropical Race 4 | 15 |
| Annex 3. Regional Workshop Programme..... | 17 |
| Annex 4. List of Participants – Regional Fusarium Wilt Workshop in the Caribbean | 20 |
| Annex 5. Fusarium Wilt Workshop Evaluation by Participants | 21 |

Executive Summary

The banana/plantain industry is the economic backbone (food security, regional/international trade) of many Caribbean countries. Currently, global banana production is seriously threatened by the re-emergence of a Fusarium Wilt caused by the soil-borne fungus *Fusarium oxysporum* f. sp. *cubense* (*Foc*). In the 1950s, Panama disease or *Foc* Tropical Race 1 wiped out the Gros Michel banana industry in Central America and the Caribbean and production shifted to the resistant Cavendish cultivars. Unfortunately, a new strain of *Foc* called Tropical Race 4 (TR4) has overcome *Foc* resistance in the Cavendish clones. TR4 also impacts *Musa* cultivars that are not susceptible to *Foc* Races 1 and 2 mostly grown by small farmers for local consumption and income generation.

In order to raise awareness of its potential threat as a key step to prevent its introduction to the Caribbean, the Food and Agriculture Organization of the United Nations (FAO) provided funds to the Caribbean Agricultural Research and Development Institute (CARDI) via a Letter of Agreement (LOA). Two activities were implemented in collaboration with the Ministry of Food Production (Trinidad and Tobago) and the University of the West Indies (UWI), St. Augustine under the LOA. Dr. Luis Perez-Vicente (Lead) and Mr. Einar Martinez 7of INISAV, Ministry of Agriculture, Cuba and Dr. Miguel Dita of Embrapa, Brazil were recruited as Consultants, with the following Terms of Reference (TORs):

1. prepare a Manual for Fusarium wilt prevention & diagnosis and workshop training materials (field, laboratory)
2. Conduct a Seminar for agricultural stakeholders of TR4 (Dr. Perez-Vicente and Mr. Martinez).
3. Conduct a 5-day training workshop (lectures and laboratory exercises) (all three consultants)

Activities 2 and 3 were carried out during a field mission to Trinidad and Tobago. The main activities during the first week were the Sensitization Seminar (30 April) and laboratory and field preparations for the Training Workshop (5-9 May 2014). The half-day Seminar titled *Impacts, prevention and management of the Fusarium Wilt (Panama Diseases) in the Caribbean Region* was attended by representatives of key agricultural institutions in Trinidad and Tobago. The Seminar and its contents, including remarks by the FAOR, were widely reported in the media throughout the region.

The Workshop titled “Prevention and Diagnostic of Fusarium Wilt (Panama Disease) of Bananas and Plantains caused by *Fusarium oxysporum* f. sp. *cubense* – Tropical Race 4” was held at UWI, St. Augustine from 5-9 May 2014. All planned activities were carried out. Workshop participants were drawn from seven countries and from a range of areas (research, extension, plant protection, pathology, microbiology). The presentations went from simple morphological field diagnostics to more complicated microbiological and molecular tools as the week progressed. The participants remained interested and enthusiastic throughout the week, which ended with the development of a framework for draft Action / Contingency Plans, followed by a formal Closing Ceremony with presentation of Certificates of Participation.

Twenty participants completed the Workshop Evaluation Forms. Knowledge level of the consultants and the course content were rated the highest averaging 4.95 and 4.8 (out of 5), respectively. Overall, technical and logistical areas received high ratings, averaging 4.68 and 4.36, respectively. Positives included: usefulness, timeliness, organization and execution, knowledge and information sharing, networking, and linkage between theory and practical sessions. The two negatives were: time wasted in organizing the laboratory sessions and the lectures being a bit too long.

To face the threat of *Foc* Race 4 in the Caribbean, three major elements need to be considered and integrated:

- 1. Awareness campaigns.** Use available information materials. A major effort needed from governments and National Plant Protection Organizations (NPPOs) re: sensitization and development and implementation of action plans. These initiatives need to be implemented in the national framework, but with regional and global perspectives.
- 2. Preparedness.** Continue training on visual and molecular diagnostic, disease epidemiology and management in each country. A relevant output is that the Molecular Biology Laboratory of the Food Production Department at UWI now has the capacity to carry out diagnosis of *Foc* TR4 and can eventually serve as a Regional Reference.
- 3. Research.** While research *per se* is a long-term issue, on-going efforts should focus on disease management, including the development of resistant varieties. However, even when a fully-resistant (immune) variety becomes available, IPM strategies should not be ignored. In this regard, the establishment of bilateral and/or multilateral cooperation with more advanced institutions worldwide is strongly recommended.

Introduction

The banana/plantain industry is the economic backbone (food security, regional/international trade) of many Caribbean islands. Bananas and plantains are very important commodities in terms of food security. Currently, global banana production is seriously threatened by the re-emergence of the Fusarium Wilt. The disease, caused by the soil-borne fungus *Fusarium oxysporum* f. sp. *cubense* (*Foc*) and also known as "Panama disease", wiped out the Gros Michel banana industry in Central America and the Caribbean, in the mid-1950s. *Foc* Tropical Race 1 (TR1) affected Gros Michel and Silk (apple and Pisang awak) bananas, while *Foc* Tropical Race 2 (TR2) affected Bluggoe. The effects of TR1 were overcome by a shift to the production of resistant Cavendish cultivars, which are currently the source of 99% of global banana exports.

Unfortunately, a new strain of *Foc* called Tropical Race 4 (TR4) has overcome *Foc* resistance in the Cavendish clones. Perhaps even more seriously, other banana cultivars such as plantains, cooking bananas and a diverse range of dessert banana varieties (not susceptible to TR1 and TR2) are also susceptible to TR4. Smallholder farmers for local consumption and income generation mostly grow these local varieties. More than 80% of global banana and plantain production is thought to be based on TR4-susceptible genotypes. Tropical race 4 of *Foc* has caused epidemics in Cavendish plantations in the tropics and is different from those less-severe infections of the Sub-tropical Race 4 (SR4) previously reported in the sub-tropics. This brings back memories of the devastating damage caused by TR1 that led to losses estimated at more than US\$ 1.5 billion dollars during that era.

The devastating impact of TR4 on Cavendish plantations in Asia was first observed in Taiwan in the 1960s, which eventually caused a severe reduction of production to just 10% of former levels and significant increases in production costs rendering its exports much less competitive. In the early 1990s, thousands of hectares of Indonesian and Malaysian Cavendish commercial plantations failed to establish due to severe epidemics of TR4, causing hundreds of millions of dollars in production losses, including from those cultivars grown by smallholder growers.

The occurrence of TR4, causing epidemics in Cavendish farms in China (2004) and the Philippines (2008) and more recently in Mozambique (2013) has renewed serious concerns with regard to its destructive potential in the tropics where most bananas for export and local consumption are produced. It now threatens the 400 million-dollar banana export industry of the Philippines, currently the second largest supplier of the global market after Ecuador. It is also spreading and causing damage to the predominantly Cavendish-based banana production in China, which is presently the third largest banana producer of the world after India and Brazil. Preliminary risk analysis has indicated that the spread of TR4 to Africa and the Americas was only a question of time. The 2013 TR4 outbreaks reported in Oman, Jordan, Pakistan (under evaluation) and Mozambique have proven its threat as a trans-boundary disease of special importance to other major banana producing countries in the world. This trans-boundary phenomenon threatens not only the multi-million dollar banana export industry, but also millions of people in rural communities, who depend on bananas for their food security and livelihoods.

Planting material, water, soil particles, tools, foot wear and farm machineries can efficiently disseminate the pathogen. The fungus can survive in the soil for more than 30 years, has a long latent period (it is detected a long time after introduction) and there are no symptomatic differences among races. Furthermore, cultural practices and socioeconomic factors that contributed to the TR1 epidemic are still present and would contribute to a TR4 epidemic if the pathogen reaches the Americas. The region must use prevention as the main strategy to keep TR4 out of the region. And should an outbreak eventually occur, then early detection of symptoms in the field and rapid laboratory diagnosis are essential steps to either eradication or containment.

It is therefore necessary to raise awareness of the potential threat of TR4 as a key step to prevent its introduction to Latin America and the Caribbean (LAC), a region that is highly dependent on banana and plantains.

Fusarium Wilt TR4 Sensitization Activities in the Caribbean

The Food and Agriculture Organization (FAO) has been concerned about the impact and recent dissemination of TR4 outside Asia and has collaborated with the Agricultural Research and Development allied institutions in the Caribbean to create and strengthen capacities in Fusarium wilt through the development of a '**Regional Sensitization Seminar and Workshop on the Prevention and Diagnostic of Fusarium Wilt (Panama Disease) of Bananas and Plantains caused by *Fusarium oxysporum f. sp. cubense* – Tropical Race 4**'. Through a Letter of Agreement (LOA), the FAO provided funds to the Caribbean Agricultural Research and Development Institute (CARDI) to implement the two activities in close collaboration with the Ministry of Food Production (Trinidad and Tobago) and the University of the West Indies (UWI), St. Augustine.

Under the LOA, Dr. Luis Perez-Vicente (Lead) and Mr. Einar Martinez de la Parte of INISAV, Ministry of Agriculture in Cuba and Dr. Miguel Dita of Embrapa, Brazil were recruited as Consultants, to undertake the activities in a field mission. The activities were to be carried out under the supervision of the Technical Services Manager of CARDI and Plant Production and Protection Officer (PPPO) of the FAO Sub-Regional Office in Barbados (SLC) with the following Terms of Reference (TORs):

- In close collaboration, prepare the first English draft of the Manual for Fusarium wilt prevention and diagnostic and review the final document under the supervision of the PPPO. Prepare training materials for the workshop (field and laboratory)
- Conduct a Seminar (public lecture) for stakeholders from the agricultural sector on the disease potential impact and management practices (Dr. Perez-Vicente and Mr. Martinez).
- Conduct a 5-day training workshop (lectures and laboratory exercises) (all three consultants)

The last two activities were carried out during a 14-day (Dr. Perez-Vicente and Mr. Martinez) and 10-day (Dr. Dita) field mission to Trinidad and Tobago.

Thus, the expected outputs of the activities were:

1. A Manual on the prevention and diagnostic of Fusarium wilt (Panama disease) of banana and plantains caused by *Fusarium oxysporum f. sp. cubense*-Tropical Race 4 (TR4)
2. A Report on Workshop Activities
3. A Sensitization Seminar on the Potential impact of Fusarium Wilt (Panama disease) of banana and plantains caused by *Fusarium oxysporum f. sp. cubense*-Tropical Race 4 (TR4) on the sustainability of the industry on the Caribbean.

Detailed Report of Activities

Desk activities

The three consultants collaborated to prepare a draft Manual on the prevention and diagnostic of Fusarium wilt (Panama disease) of banana and plantains caused by *Fusarium oxysporum f. sp. cubense* -Tropical

Race 4 (TR4), This was submitted to the PPPO at the FAO office in Barbados for feedback and finalized taking the PPPO's comments into consideration.

Field Mission

Dr. Perez-Vicente and Mr. Martinez arrived in Trinidad and Tobago on Sunday 27 April and Dr. Dita on 2 May. All three consultants departed on Saturday 10 May 2014.

The main activities carried out during the first week were a Sensitization Seminar (30 April) and laboratory and field preparations for the Training Workshop, which took place during the second week (5-9 May 2014).

Sensitization Seminar

The half-day Sensitization Seminar titled **Impacts, prevention and management of the Fusarium Wilt (Panama Diseases) in the Caribbean Region** took place on Wednesday 30 April. The Seminar was chaired by Mr. Norman Gibson of CARDI (Annex 1) and was attended by representatives from many key agriculture-related institutions in Trinidad and Tobago (Annex 2), including banana farmers, the Ministry of Food Production, CARDI, UWI, the Inter-American Institute for Cooperation on Agriculture (IICA) and several agri-business agencies. Welcome remarks were provided by Dr. Marcia Blair-Thomas of CARDI and this was followed by Remarks from Mr. Barton Clarke, FAO's Representative for Trinidad and Tobago and Suriname and Professor Neela Badrie, Head of the Department of Food Production. The Seminar and its contents were widely reported in the media throughout the region¹ and thus the key objective of public and stakeholder sensitization was met.



Left: Sensitization Seminar participants;

Right: Dr. Luis Perez-Vicente, Dr. Marcia Blair-Thomas (CARDI), Professor Neela Badrie (UWI), Mr. Norman Gibson (CARDI) and Mr. Einar Martinez de la Parte (from left to right)

¹ <http://www.nbcsvg.com/2014/05/02/tropical-race-four-banana-disease/#.U2bQqYFdXgQ>
http://www.jamaicaobserver.com/news/Banana-disease-warning--_16573213
<http://www.antiguaobserver.com/regional-countries-urged-to-cooperate-in-the-fight-against-tr4-banana-disease/>
<http://www.reporter.bz/world/bananas-under-threat-in-the-caribbean/>
<http://www.news.gov.tt/content/agriculture-experts-we-have-work-all-together-prevent-fusarium-wilt-america#.U2bRBIfdXgQ>
<http://www.bajanreporter.com/2014/04/cardi-and-agricultural-agencies-to-host-sensitization-regional-workshops-on-fusarium-wilt/>
<http://www.bajanreporter.com/2014/05/agriculture-experts-urge-we-have-to-work-all-together-to-prevent-the-entry-of-fusarium-wilt-fungus-into-america/>

Other pre-workshop activities

Preparations for field and laboratory sessions were among the other key activities carried out by Dr. Perez-Vicente and Mr. Einar Martinez during the first week of the field mission. These are reported below.

| Date/time | Activity | Comments |
|--|---|--|
| Monday April 28th. | | |
| 10:00-11:45 AM | Welcome Meeting at CARDI Headquarters. Participants: Dr. Marcia Blair-Thomas (CARDI Country Representative, Trinidad and Tobago); Mr. Barton Clarke (FAO Country Representative, Trinidad and Tobago); Mr. Richard Rampersaud (CARDI); Mr. Norman Gibson Scientific Officer CARDI; Mr. Einar Martinez de la Parte and Dr. Luis Pérez Vicente | Explanation of Global Situation with Fusarium Wilt TR 4 and objectives of Seminar and Workshop |
| 11:00-12:20 AM | Meeting at The University of the West Indies with. Dr. Isaac Bekele (Dean, Faculty of Food and Agriculture); Prof. Neela Badrie (Head of Department, Food Production); Dr. Duraisamy Saravanan Kumar (Lecturer - Pathology, Department of Food Production); Dr. Marcia Blair-Thomas; Mr. Richard Rampersaud (CARDI); Mr. Einar Martinez de la Parte and Dr. Luis Pérez Vicente | <ul style="list-style-type: none"> - Explanation of Global Situation with Fusarium Wilt TR 4 - Seminar and Workshop objectives - Visit Molecular Biology and Microbiology Labs with Dr. Kumar, Mr. Rampersaud |
| 2:00-3:30 PM | Visit to Plant Pathology Unit. Research Division, Ministry of Food Production. Participants in the Meeting: Mr. Anthony St. Hill (Deputy Director of Research, Crops); Mr. Ian Mohammed (Plant Pathologist); Ms. Deanne Ramroop (Plant Pathologist); Ms. Krysta Jennings (Agriculture Officer 1); Mr. Richard Rampersaud (CARDI); Mr. Einar Martinez de la Parte and Dr. Luis Pérez Vicente | <ul style="list-style-type: none"> - Explanation of Global Situation with Fusarium TR 4 - Seminar and Workshop objectives - Check <i>Foc</i> existing isolates obtained from Fusarium wilt diseased plants by laboratory staff. |
| Tuesday April 29th. | | |
| 8:00-12:00 | Collection of banana samples with Fusarium wilt (Plum Mitan and Nariva/Mayaro area in Trinidad) Participants: Ian Mohammed (Plant Pathologist), Richard Rampersaud (CARDI), Einar Martinez de la Parte, Luis Pérez Vicente | Location and samples collection of Fusarium wilt diseased plants |
| Wednesday, April 30th. | | |
| 9:00-11:45 | Sensitization Seminar (Reported above) | |
| 3:00-4:00 | Samples processing in Microbiological Laboratory, Department of Food Production, UWI Campus. Participants: Vidya de Gannes. Chief of laboratory; Technician Shivam Rampersad; Einar Martinez and Luis Pérez Vicente | Processing samples for <i>Foc</i> isolates and preparation of permanent slides for practice. Preparation of microbiological practices at UWI |
| 4:00-7:00 | Preparation of PDF of all presentations | |

| Date/time | Activity | Comments |
|--|--|--|
| Thursday, May 1st– Saturday May 3rd | | |
| | Preparation of microbiological and molecular practices at UWI: Einar Martínez and Luis Pérez Vicente | – Processing samples and preparations. |

Workshop Activities

The Agenda for the Workshop is at Annex 3 and the full list of participants is at Annex 4. The participants were drawn from the main banana producing countries of the Caribbean: Dominica, Grenada, Jamaica, St. Lucia, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago (Guyana was invited but did not attend). The Ministry of Food Production and UWI nominated five participants each. At CIRAD's request, two participants (one each from Guadeloupe and France) were accepted to participate in the Workshop.

The Opening Session was chaired by Dr. Vyjayanthi Lopez, FAO's PPPO and once again addressed by Dr. Marcia Blair-Thomas of CARDI, Mr. Barton Clarke of FAO and Professor Badrie of UWI. All speakers emphasized the importance of the workshop in awareness-raising and in the protection of an important food security crop in the Caribbean. Dr. Lopez assured members of the Heads Table that following the completion of the Workshop, participants were expected to return home and engage the various stakeholders in order to develop / refine their respective Action and Contingency Plans. The focus of the Plans was to keep Fusarium wilt TR4 out of the region and to put measures in place in case it was discovered in future. FAO's media release of the Workshop was widely reported in local and regional media², including Latin America.



Left – Professor Neela Badrie of UWI addressing the participants at Opening Session of Workshop;
Right: Lecture / Presentation by Dr. Luis Perez-Vicente

² <http://www.caribbeannewsnow.com/topstory-Preparing-the-banana-industry-to-prevent-serious-new-threat-20964.html>
<http://www.iwnsvg.com/2014/04/28/agricultural-agencies-to-hold-regional-workshop-on-banana-disease-fusarium-wilt/>
<http://www.guardian.co.tt/business/2014-05-05/banana-industry-braces-new-threat>
<http://www.bernama.com.my/bernama/v7/wn/newsword.php?id=1035773>
<http://www.news.gov.tt/content/fusarium-wilt-presents-%E2%80%98significant-threat-global-food-security%E2%80%99#.U3EguFdU9k>
<http://www.news.gov.tt/content/participants-urged-become-game-changers-fusarium-wilt-regional-workshop-closes#.U3EhcYFdU9k>

Practical Sessions: Field and Laboratory Demonstrations



Left: Banana whole-plant infected with Fusarium wilt – *note dead and bent-over older leaves, yellow and dying leaves at the top, with no fruit production*; Note that the sucker /follower from the mother plant does not show any symptoms

Centre: Opening the stem of an infected banana mother plant; Right: collection of samples for diagnosis.



Left and Centre: Cross and longitudinal sections of infected stem (mother plant); Right: participants practice field collection of samples



Facilitators Dr. Luis Perez-Vicente (right), Mr. Einar Martinez (centre) and Dr. Miguel Dita (left) demonstrate laboratory techniques to Workshop participants

All the workshop activities were carried in accordance with the Agenda. The participants were drawn from a range of areas including research, extension, plant protection, pathology and microbiology. The consultants thus had to adapt the presentations accordingly, starting with simple field / morphological diagnostic tools and moving to the ones that were more complicated (microbiological / molecular) as the week progressed. It was ensured that all participants remained engaged through the theoretical, field and practical sessions. In turn the participants remained interested and enthusiastic throughout the week, ending with the development of draft Action / Contingency Plans and completion of Evaluation Forms for the Workshop. At the Closing Session, the three Heads of Agencies distributed Certificates of Participation and provided brief remarks. In the afternoon, the Consultants completed and submitted the draft Workshop Report to CARDI and FAO.

Thus, in accordance with the ToRs, the following activities were completed by the consultants:

Prior to the start of the Field Mission:

- Prepared the Technical Manual and submitted to the PPPO for review and feedback
- Finalized the Technical Training Manual taking the PPPO's feedback into consideration
- Undertook all the necessary preparatory activities for the training in close consultation with national counterparts in Trinidad and Tobago
- Prepared and submitted all presentations for printing and binding into a folder
- Carried out the half-day Sensitization Seminar (April 30)
- Facilitated the five-day workshop with participants of seven banana-producing countries.

In accordance with an agreement reached with CARDI and FAO, at the end of the Mission:

- Prepared and submitted a draft Mission Report of the activities undertaken (including the Training Manual as a Technical Annex).
- Finalized the Report taking into consideration the PPPOs comments and submitted prior to departure from Trinidad and Tobago.

In addition, all presentations from the consultants as well as photographs from the Workshop and field visits were downloaded into a single folder and provided to participants on CDs.

Workshop Evaluations

Following the Closing Ceremony, twenty participants completed Evaluation Forms and submitted these to CARDI and FAO. Subsequently, the PPPO collated the information and provided a Summary (Annex 5). The knowledge of the facilitators was rated the highest (average 4.95 out of a maximum of 5). Overall, the technical and logistical parameters received high ratings at 4.68 and 4.36, respectively. Positives highlighted were: usefulness and timeliness of the event, organization and execution, knowledge and information sharing, networking, and linkage between theory and practical sessions. The two negatives were the time wasted in organizing the laboratory sessions and the lectures being a bit too long.

CONCLUSIONS AND RECOMMENDATIONS

Banana and plantains play important roles in LAC at the socio-economical level and are key food security crops. Most of export production areas in banana are based on Cavendish, and plantains rely on a limited number of cultivars. This makes the region very vulnerable to the highly destructive disease such as the

Fusarium wilt TR4. Fusarium wilt is currently considered (with some exceptions) a minor disease in LAC. Many persons that dealt with the first epidemic of *Foc* Race 1 in the past are no longer alive or are long retired. Therefore, there is a lack of capacity to deal with this disease at different levels and even with the efforts done in LAC on awareness and capacity building, the perception of many stakeholders on the potential impact of TR4 remains low.

Fusarium wilt has a long latent period and detection of disease symptoms in the field could occur long after the first incursion. The pathogen produces chlamydospores that can persist in the soil for more than 30 years. There are many ways of dispersion, making it difficult to cope with the dissemination and spread of the disease after the pathogen has been introduced and the disease has become established.

The most important *Musa* cultivars in LAC are susceptible to *Foc* TR4 and the entry of TR4 in the region will cause serious impact on field production and grower livelihoods. The important control measure is the use of resistant cultivars, but currently there are no resistant cultivars to replace Cavendish. Other disease management measures are limited and costly, including changes of current practice of banana production, which is based on permanent plantations, to more frequent replanting. The small and medium growers, particularly in the Lesser Antilles, have limited resources and are dependent on governmental support for the production of banana and plantains. They cannot afford to implement such expensive measures.

The Lesser Antilles represent a risk zone on account of the active international tourism as well as movement of persons and goods between islands. The most important measures to adopt at present are to (1) reinforce surveillance and quarantine procedures to reduce risks of *Foc* TR4 introduction (2) develop capacity building among extension officers and farmers and (3) the implementation of a Contingency Plan for eradication, containment and management in the event of an eventual disease outbreak. This plan can be developed based on existing information from Central American countries prepared by OIRSA³. Imports of planting materials from countries that have the disease should be strictly prohibited.

The Seminar and Workshop, carried out in Trinidad and Tobago, were aligned with regional initiatives in LAC. Participants received a substantial amount of information and are now able to identify symptomatic plants and use appropriate procedures for sampling, transport and storage of samples. In addition, the most accurate, sensitive and rapid diagnostic techniques currently known for TR4 detection were discussed, demonstrated and practiced at the Molecular Laboratory of the Department of Food Production at UWI. Participants received relevant theoretical information for a better understanding of current information published in technical and scientific reports. All the information should be transmitted in a multiplication process of awareness in each of the target countries.

There are laboratories in the region that are prepared to carry out diagnostic analysis to detect *Foc* TR4 outbreaks. Certified reference laboratories should be established as soon as possible and Letters of Agreement should be discussed among interested parties in order to ensure the smooth and rapid process that would be required in the event of an incursion.

Historically, the use of infected, asymptomatic planting material has been the main method of dissemination of the disease. It is essential to implement a program that guarantees certified disease-free planting material of high quality to growers at affordable prices.

To face the threat of *Foc* Race 4 in the Caribbean, three major elements need to be considered and integrated:

³ <http://www.oirsa.org/aplicaciones/subidoarchivos/BibliotecaVirtual/PlandecontingenciacontraFocR4TOIRSA.pdf>

1. Awareness campaigns. Awareness initiatives have been carried out at many levels in LAC and different documents have been published / circulated⁴. Conferences on Fusarium wilt TR4 have been mandatory topics in many banana congresses since 2009. However a major effort is needed from governments and National Plant Protection Organizations (NPPOs) in terms of sensitization and development and implementation of action plans. These initiatives need to be implemented in the national framework, but with regional and global perspectives.

2. Preparedness. In parallel with awareness-raising campaigns, NPPOs and relevant stakeholders of many countries have been trained on visual and molecular diagnostic, disease epidemiology and management. These countries are up to date on the impacts caused by TR4 in South Asia and recent incursion in Jordan and Mozambique. Field technicians have been trained on visual diagnostic and how to collect samples and in some countries, laboratory technicians have the capacity to make an accurate diagnosis of TR4 using a molecular diagnostic tool via PCR. There are, however, some countries where PCR capacities are not in place. NPPOs and governments should amplify/multiply these efforts to reach growers and make TR4 a topic of national food security. The contingency plan developed for OIRSA countries constitutes a fundamental background document for formulating and implementing national action plans. A relevant output of the Seminar and Workshop developed in Trinidad and Tobago is that the Molecular Biology Laboratory of the Food Production Department at UWI now has the capacity to carry out diagnosis of *Foc* TR4. This is the first country in the Lesser Antilles with this capacity, and should be considered as a source for capacity building for other countries in the region and eventually as a Regional Reference Laboratory for *Foc* TR4 diagnosis. In each country, key stakeholders should be identified and appropriate, tailored awareness and capacity building should be carried out.

3. Research. In the case of *Foc* TR4, research *per se* is a long-term issue for various reasons. Advances have been made in some areas such as diagnostic tools, but more efforts are needed for disease management, including resistant varieties. Major efforts need to be invested on breeding, which should be treated not as an isolated area, but as a major component of disease management. A resistant variety should be deployed with a tailored production system. Varieties resistant to *Foc* TR4 that meet consumers and export market requirements are not yet available. Considering the complexity, including the time needed to obtain a new resistant, marketable banana variety, parallel efforts are needed to develop integrated tools for a strategic/reasonable coexistence with *Foc* TR4. Even when a fully-resistant (immune) variety becomes available, IPM strategies should not be ignored. In this regard, the establishment of bilateral and/or multilateral cooperation with more advanced institutions worldwide is strongly recommended.

ACKNOWLEDGEMENTS

The consultants wish to acknowledge the FAO, CARDI and the Academic and Technical staff of the Molecular Biology and Microbiology Laboratories, The University of West Indies for all the support that made it possible for all the activities to be successfully carried out. The Ministry of Food Production is gratefully acknowledged for facilitating the field visits. We want to thank especially Dr. Vyjayanthi (Vyju) Lopez, Plant Production and Protection Officer of FAO for the huge effort in making these events happen and for facilitating all the technical sessions during the Workshop. Special thanks also to Dr. Janet Lawrence (formerly CARDI Representative – Trinidad and Tobago) who played a key role in the planning process and to Mr. Richard Rampersaud, Ms. Angela Ferguson and Ms. Bindya Rampersad of CARDI for excellent logistical and administrative arrangements for all the activities related to the Seminar and the Workshop.

⁴ http://banana-networks.org/musalac/files/2013/06/RECOMMENDATIONS-for-travellers_Fusarium_09062011_English.pdf

Annex 1. Program of the Sensitization Seminar on Fusarium Wilt – Tropical Race 4.

30 April 2014, Trinidad and Tobago



PROGRAMME

| Time | ACTIVITY |
|---------------------------|--|
| 8:30 - 9:00am | Registration |
| 9:00 – 9:30am | Opening Ceremony – Chairperson – Mr. Norman Gibson, Scientific Officer, Science and Technology Support, CARDI |
| 9:00-9:15am | Welcome Remarks - Dr. Marcia Blair-Thomas, CARDI Country Representative, Trinidad and Tobago |
| 9:15 - 9:30am | Remarks: <ul style="list-style-type: none">– Mr. Barton Clarke, Representative, Trinidad and Tobago and Suriname, FAO– Prof. Neela Badrie, Head, Department of Food Production, UWI |
| 9:30 – 10:30am | Technical Feature - Dr. Luis Pérez-Vicente, INISAV, Cuba - Impacts, prevention and management of the <i>Fusarium</i> Wilt (Panama Diseases) in the Caribbean Region. |
| 10:30 - 11:00am | Open Discussion - Question and answer. |
| 11:00 -11:05am | Vote of Thanks |
| Light Refreshments | |

Annex 2. Participants in the Sensitization Seminar Fusarium Wilt Tropical Race 4

30 April 2014, Trinidad and Tobago

| Organization | Name | Position |
|---|----------------------------|---|
| Ministry of Food Production, Trinidad and Tobago | Ms. Audine Mootoo | Director of Research |
| | Dr. Anthony St Hill | Deputy Director, Research |
| | Ms. Deokee Bholasingh-Hay | Director of Extension |
| | Ms. Cheryl Roach-Benn | Director RAN |
| | Mr. Govindra Ram | Director RAS |
| | Mr. Aldwin Wellington | Agricultural Officer |
| Caribbean Agricultural Research and Development Institute (CARDI) | Mr Lauckner | Head of Strategic Alliances |
| | Dr. Marcia Blair-Thomas | Country Representative |
| | Mr. Herman Adams | Geneticist/Plant Breeder |
| | Mr. Ansari Hosein | Research Scientist |
| | Dr. Compton Paul | Head of Project Implementation Unit |
| | Mr. Fayaz Shah | Head of Revenue Generation Unit |
| | Mr. Norman Gibson | Scientific Officer |
| | Mrs. Angela Ferguson | Administrative Secretary |
| | Mr. Richard Rampersaud | Programme Associate |
| | Ms. Bindya Rampersad | Assistant, Logistical Support |
| The University of West Indies (UWI) | Dr Isaac Bekele | Dean |
| | Prof. Neela Badrie | Head of Department, Department of Food Production |
| | Dr Wendy Ann Isaac | Lecturer, Department of Food Production |
| | Dr Duriasamy Saravanakumar | Lecturer, Department of Food Production |
| | Dr Selby Nichols | Head of Department, Agriculture Economics and Extension |
| | Prof. Indar Ramnarine | Dean, Faculty of Science and Technology |
| Food and Agriculture Organization (FAO) | Mr. Barton Clarke | Representative, Trinidad and Tobago and Suriname |
| | Ms. Lisa Martinez | Programme Associate |
| | OJT (Trainee) | |
| | OJT (Trainee) | |
| Inter-American Institute for Cooperation on Agriculture (IICA) | Mr. Gregg Rawlins | Country Representative |
| United States Department of Agriculture (USDA) | Mr. Wayne De Chi | Agricultural Scientist |
| Trinidad & Tobago Agribusiness Association (TTABA) | Mr. Robin Persad | Chairman |
| | Mr. Michael Gopie | CEO |

| Organization | Name | Position |
|--|------------------------|---------------------------|
| National Agricultural Marketing and Development Corporation (NAMDEVCO) | Mr. Ganesh Gangapersad | CEO (Ag) |
| Agricultural Society of TT (ASTT) | Mr. Orwin Dillon | Member |
| Caribbean Chemicals | Ms. Diane Ali | Manager of Sales |
| Agricultural Development Bank, Trinidad and Tobago | Ms. Joan Antoine | Technical Support Officer |
| Tracmac | Mr. Brian Boodoo | Manager |
| Banana/Plantain Farmers | Mr. Selwyn Ramsaroop | Farmer |
| | Mr. Dino Balgobin | Farmer |
| | Ms. Deanne Ramroop | Observer |

Annex 3. Regional Workshop Programme

**Prevention and Diagnostic of *Fusarium* Wilt (Panama Disease) of Bananas and Plantains caused by
Fusarium oxysporum f. sp. *cubense* – Tropical Race 4**

Trinidad & Tobago 5-9 May, 2014

| Date/Time | ACTIVITY |
|---|---|
| Sunday May 6th | |
| All day | Participants arrival and accommodation |
| Day 1. May 05th /Monday | |
| 8:30-9:00 | Registration |
| 9:00-10:00 | Seminar Opening – Chaired by Dr. Vyjayanthi Lopez, Plant Production and Protection Officer, FAO-SLC, Barbados 1. Welcome Address CARDI/FAO 2. Introduction of experts, participants and organizers. 3. Introductory remarks on Seminar Objectives and Program. Organizers and experts |
| 10:00 - 10:15 | Coffee break |
| 10:15 - 10:45 | Bananas production and socio economic importance in the Caribbean (FAO/CARDI) |
| 10:45 - 11:20 | Lecture 1: Banana diseases with emphasis in exotic pathogens to the LAC region. Luis Pérez Vicente, INISAV, Cuba |
| 11:20 - 12:00 | Lecture 2: Fusarium wilt or Panama disease: the disease, historic overview, current situation and potential impact of TR4 to the region. Miguel A. Dita, Embrapa, Brazil |
| 12:00 -12:15 | Open Discussion |
| 12:15 – 13:30 | Lunch |
| 13:30 - 13:45 | Logistic organization for field and laboratory practices |
| 13:45 – 14:15 | Lecture 3: Symptoms identification and sampling; manipulation, transport and storage procedures for Panama disease samples; Quarantine procedures on a suspect TR4 outbreak. Luis Pérez-Vicente |
| 14:15 – 14:40 | Lecture 4: Isolation of <i>Fusarium oxysporum</i> f. sp. <i>cubense</i> : Procedures for obtaining single-spore isolates and culture storage. Einar Martinez, INISAV, Cuba |
| 14:40 – 15:00 | Coffee break |
| 15:00 – 16:00 | Reports by countries on the current epidemiological situation of Panama disease race 1 and 2. Report by each country participant |
| 16:00 - 16:30 | Instructions on following day: field practice organization Open discussion on the contents presented over the day. Instructors |

| Date/Time | ACTIVITY |
|--|--|
| Tuesday May 6th | |
| 8:00 – 12:00 (or all day, based on distance to field) | Field practical: Symptom identification, procedures to sampling, manipulation, transport and storage of Panama disease samples. Quarantine procedures on a suspect TR4 outbreak. Luis Pérez-Vicente and Einar Martínez, Miguel A. Dita |
| 12:00-13:30 | Lunch |
| 13:30-16:30 (or the following day depending on distance to field) | Laboratory work in teams. Protocols of: <ul style="list-style-type: none"> - Samples manipulation for storage and shipment - Culture media used and general procedures for isolation - Isolation of <i>Foc</i> from necrotic vessels and rhizome tissues of infected plants Luis Pérez-Vicente and Einar Martínez, Miguel A. Dita Laboratory STAFF |
| Wednesday May 7th | |
| 8:30 - 9:15 | Lecture 5: Evolution of <i>Fusarium</i> taxonomy: morphological, biological and phylogenetic diagnostic concepts. Luis Pérez-Vicente |
| 9:20 – 9:40 | Lecture 6: Population biology of <i>Fusarium oxysporum f. sp. cubense</i> : VCGs concepts and methodology Luis Pérez-Vicente |
| 9:40 – 10 :20 | Lecture 7. Epidemiology of Panama disease: Critical aspects for sustainable management Miguel A. Dita and Luis Pérez-Vicente |
| 10:20 – 11:00 | Coffee break |
| 10:15 – 11:00 | Lecture 8. Integrated management of Fusarium wilt. Strategies used in Asia on TR4. Luis Pérez Vicente |
| 11:00 -11:45 | Current status on research and needs on <i>Fusarium wilt of banana</i> . Miguel A. Dita |
| 11:45- 12:30 | A Contingency Plan for an Outbreak of <i>Foc</i> TR4 Luis Pérez Vicente |
| 12:00-13:30 | Lunch |
| 13:30 – 16:30 | Laboratory work in teams <ul style="list-style-type: none"> - Check isolations carried out from infected pseudostem strands to localize <i>F. oxysporum</i> growth. Microscopic examination to compare with <i>F. pallidoroseum</i> and <i>F. solani</i> isolates commonly associated to banana roots and tissues. - Obtainment of pure cultures of <i>Foc</i>. Morphology of cultures of <i>F. oxysporum</i> and <i>F. pallidoroseum</i> - Preparation of single-spore cultures - Methods of storage in filter paper, carnation leaf and soil. Luis Pérez-Vicente, Miguel Dita and Einar Martínez Laboratory STAFF |
| Thursday May 8th | |
| 8:30 - 12:00 | Lecture 9. Phylogenetic analysis and applied molecular diagnostic methods Miguel A. Dita and Einar Martínez Lecture 10. DNA Extraction Methods. Einar Martínez |

| Date/Time | ACTIVITY |
|--------------------------------------|---|
| | Lecture 11. PCR Diagnostic Protocol of <i>Foc</i> TR4 Miguel A. Dita |
| | Lecture 12. Real time PCR diagnostic protocol of <i>Foc</i> TR4 R1 and R2 Luis Pérez Vicente and Einar Martinez |
| 12:00 – 13:30 | Lunch |
| 13:30 – 16:00 | Laboratory Practice <i>Foc</i> DNA extraction from plant and cultures Lecture PCR diagnostic of <i>Foc</i> TR4 Lecture qPCR diagnostic of TR4 R1 and R2 Miguel A Dita, Einar Martinez and Luis Pérez-Vicente Laboratory STAFF |
| May 9th/ Friday | |
| 9:00 – 12:00 | Laboratory practices 1. Practice on PCR diagnostic of TR4 of <i>Foc</i> . Electrophoresis of PCR products 2. Practice on qPCR diagnostic of R1 and R2. 3. Practice on qPCR diagnostic of TR4 Einar Martínez, Miguel A Dita, Luis Pérez Vicente and Laboratory STAFF |
| 12:00 – 13:30 | Lunch |
| 13:30 - 16:30 | Laboratory Practices continuation |
| 16:30 – 17:00 | Workshop evaluation and closure |
| May 10th/ Saturday | |
| 08:00 | Experts and participants departure. |

Annex 4. List of Participants – Regional Fusarium Wilt Workshop in the Caribbean

| | Name | Surname | Country | Email contact |
|----|--------------|----------------------|---------------------------|--|
| 1 | Einar | Martinez de la Parte | Cuba, Consultant | emdelaparte@gmail.com |
| 2 | Luis | Perez Vicente | Cuba, Consultant | luis.perezvicente@live.com |
| 3 | Miguel Angel | Dita Rodriguez | Brazil, Consultant | miguel.dita@embrapa.br |
| 4 | Vyjayanthi | Lopez | Barbados | Vyjayanthi.lopez@fao.org |
| 5 | Trevorn | Douglas | Dominica | ravev7@hotmail.com |
| 6 | Develon Evon | Alexander | Grenada | evondalexander@hotmail.com |
| 7 | Jaime | Aguayo | Guadeloupe | jaime.aguayo@anses.fr |
| 8 | Yolande | Chilin-Charles | Guadeloupe | yolande.chilin.charles@cirad.fr |
| 9 | Deborah | Henry-Myers | Jamaica | hendeb34@hotmail.com |
| 10 | Lucius | Alexander | St. Lucia | l_alexander69@yahoo.com |
| 12 | Marcus | Richards | St Vincent | ppq@gov.vc mlrids@yahoo.com |
| 13 | Djoeneri | Antoinette | Suriname | adjoeneri@hotmail.com |
| 14 | Casey Marie | Boucher | Tobago | caseyme2@hotmail.com |
| 15 | Augustus | Thomas | UWI | augustusthomas33@gmail.com |
| 16 | Cherrianne | Johny | UWI | cherrijohny@hotmail.com |
| 17 | Duraisamy | Saravanakumar | UWI | agrisara@rediffmail.com |
| 18 | Luanne | Mangenero | UWI | |
| 19 | Oral | Daley | UWI | oraldaley@gmail.com |
| 20 | Samuel | De Costa | UWI | skde03@yahoo.com |
| 21 | Vidya | De Gannes | UWI | vidyadegannes@gmail.com |
| 22 | Petal | Ram | TT Min of Food Production | petalram@gmail.com |
| 23 | Radica | Seerattan Persad | TT Min of Food Production | |
| 24 | Rishi | Mohansingh | TT Min of Food Production | mohansinghrishi@yahoo.com |
| 25 | Ian | Mohammed | TT Min of Food Production | ianb51@gmail.com |
| 26 | Krysta | Jennings | TT Min of Food Production | krystajennings@hotmail.com |
| 27 | Deanne | Ramroop | TT Min of Food Production | |
| 28 | Sharon | Jones | Trinidad and Tobago | planhealth@yahoo.com |
| 29 | Angela | Ferguson | CARDI (support) | |
| 30 | Bindiya | Rampersad | CARDI (support) | |
| 31 | Richard | Rampersaud | CARDI (support) | |

Annex 5. Fusarium Wilt Workshop Evaluation by Participants

| Parameter | Scores from participants on a 1-5 scale (1 = low and 5 = high) | | | | | | | | | | | | | | | | | | | | Average | |
|---------------------------|--|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|---------|---------|------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | | |
| Usefulness | 5 | 5 | 5 | 4 | 5 | 3 | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 3 | 5 | 5 | 5 | 93 | 4.65 |
| Level of knowledge gained | 5 | 5 | 5 | 3 | 5 | 4 | 5 | 5 | 4 | 5 | 5 | 4 | 5 | 5 | 5 | 3 | 5 | 5 | 5 | 5 | 88 | 4.63 |
| Organization of lectures | 5 | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 5 | 5 | 3 | 5 | 4 | 5 | 5 | 93 | 4.65 |
| Practicals | 5 | 5 | 4 | 4 | 3 | 5 | 5 | 5 | 4 | 4 | 5 | 4 | 5 | 4 | 2 | 5 | 4 | 4 | 5 | 5 | 82 | 4.32 |
| Content | 5 | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 96 | 4.80 |
| Presentations | 5 | 5 | 5 | 3 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 4 | 5 | 5 | 4 | 5 | 5 | 5 | 5 | 5 | 93 | 4.65 |
| Knowledge of facilitators | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 99 | 4.95 |
| reference materials | 5 | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 4 | 5 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 94 | 4.70 |
| | | | | | | | | | | | | | | | | | | | | Average | 4.68 | |
| Travel arrangements | 5 | 5 | | | | | 5 | | | | 5 | | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 4 | 50 | 4.55 |
| Accommodation | | 4 | | 4 | | | 5 | | | | 5 | | 3 | 5 | 4 | 4 | 5 | 5 | 5 | 5 | 49 | 4.45 |
| Coffee | 3 | 4 | 5 | 3 | 4 | 3 | 5 | 5 | 5 | 2 | 5 | 5 | 4 | 4 | 5 | 3 | 5 | 5 | 5 | 5 | 85 | 4.25 |
| Lunch | 2 | 4 | 5 | 3 | 4 | 2 | 5 | 5 | 2 | 5 | 4 | 4 | 4 | 5 | 3 | 5 | 5 | 5 | 5 | 5 | 82 | 4.10 |
| Lecture room | 5 | 5 | 4 | 3 | 3 | 4 | 5 | 5 | 4 | 4 | 5 | 4 | 3 | 5 | 4 | 5 | 5 | 5 | 5 | 5 | 88 | 4.40 |
| Laboratories | 5 | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 1 | 4 | 5 | 5 | 4 | 5 | 3 | 5 | 5 | 5 | 4 | 5 | 88 | 4.40 |
| | | | | | | | | | | | | | | | | | | | | Average | 4.36 | |

Comments from 17 participants (three participants did not make any comments)

1. This was very informative and well-organized and well-received.
2. The session was very informative and an 'eye-opener' to reality and to the banana industry.
3. The Workshop was well-organized. The facilitators were excellent in delivery; continual fostering of this network will be important, and I think we should get a nudge now and again from CARDI and FAO as a follow-up to how much activities were executed at the local level to pass on the valuable information received this workshop.
4. Very appreciative of this workshop; Great opportunity to meet key persons from various institutions around the region.
5. Would be better if there were two participants / country; private and public in the future because of the responsibility.
6. This was a very relevant workshop that addressed a very serious potential threat to food security in the region. I do hope that there are follow up to what was done in the workshop.
7. Excellent workshop; well-organized and executed. Field trip was well done. Facilitators were very knowledgeable.
8. Well-organized, easy-paced, yet successfully achieving objectives of the workshop; contact for other participants is needed to initiate the network; appreciate that CARICOM Secretariat and Plant Health Directors will be receiving reports.
9. The laboratories selected for the practicals should be more organized; there was a lot of time wasting with respect to this.
10. Essentially, a well-organized workshop with very experienced and knowledgeable facilitators. A lot of information was transferred in a short time, but effectively done.
11. Well-organized and lectures were very informative.
12. The consultants were highly-trained and imparted a significant amount of knowledge. They were also quite cordial and demonstrated excellent interpersonal skills. The only issue was that the lectures were a bit too long.
13. Wonderful workshop – the knowledge gained was tremendous.
14. Very effective presentations from lecturers.
15. Excellent eye opener. Gave a clear view of how impending this disease is. It also provided us with a base line for preparation in our countries.
16. The workshop is very much useful to the participants and this will definitely help to prevent/ eradicate the dangerous *Foc* Race 4 in LAC.
17. The Workshop was well-organized and executed. Field and laboratory work really enforced the lectures etc. The linkages between theory and practical were very well done.