



Food and Agriculture
Organization of the
United Nations

FAO Conference on Fusarium TR4

World Banana Forum (WBF)

Emergency project on Fusarium TR4 in Latin America and the Caribbean
International Plant Protection Convention (IPPC)

Capacity Building and Awareness Raising in Response to the Threat of Fusarium Wilt of Banana,
Tropical Race 4

Day 2 - "Biosecurity and mobile applications that support surveillance"

Wednesday July 28, 2021

Moderator: Ms Esther Peralta, Specialist in Agricultural Health of the Subregional Office for Mesoamerica of the Food and Agriculture Organization of the United Nations (FAO / SLM)

Opening remarks:

Raixa Llauger, Agriculture Officer (Tropical Fruits), Food and Agriculture Organization of the United Nations

Panelists:

Dr Jorge Palacino, Technical Director of Plant Health of the Colombian Agricultural Institute (ICA) Ing. Fernando Araya, Executive Director of the State Phytosanitary Service (SFE), dependent on the Ministry of Agriculture and Livestock of Costa Rica (MAG)

M.Sc. Mauricio Guzmán, Coordinator of the Phytoprotection Department of the Investigations Directorate of the National Banana Corporation, Costa Rica (CORBANA)

Ing. Jorge Alex Murray, Head of Biosecurity of Bananeros Unidos de Santa Marta SAS, Colombia (BANASAN)

Ing. Antonio J. González of Banana Administrative Services, Colombia (SAB SAS)

M.Sc. Nancy Villegas, Coordinator of the Regional Unit for Risk Analysis of the International Regional Organization for Agricultural Health (OIRSA)

Dr Varma Varun, Senior Associate at Exeter University and Researcher in the Department of Computational and Analytical Sciences, Rothamsted Research Institute, UK

Ing. Jimmy Santiago, Head of Banana Administrative Services Technologies, Colombia (SAB SAS), and developer of the BANASOFT program

Dr Michael Gomez Selvaraj, Senior Researcher in Digital agriculture, Alliance of Bioversity International with the International Center for Tropical Agriculture

The recording of the event is available on the website: <https://www.fao.org/tr4gn/news/news-detail/es/c/1415383/> and the starting times of each session are indicated in blue.

World Banana Forum (WBF)
Emergency project on Fusarium TR4 in Latin America and the Caribbean
International Plant Protection Convention (IPPC)

Summary:

This webinar was oriented to members of the TR4 Global Network, National Plant Protection Organizations of Musaceae producing countries and related public institutions, researchers, professionals and technicians, as well as producers in Latin America and the Caribbean and other geographic areas. The event addressed alternatives for biosecurity in production areas (public strategies, private sector initiatives, risk analysis and mapping technologies), and mobile application tools to support TR4 surveillance.

02:07 Introduction to the second session of the conference:

Ms Raixa Llauger introduced the session by mentioning that FAO has been conducting workshops and virtual conferences with the objective of strengthening the capacities of the countries in Latin America and the Caribbean in the face of the threat of the Banana Fusarium Wilt, Tropical Race 4. She thanked the experts present in the session and emphasized the importance and relevance of the issues addressed in the Conference for the global banana production.


Alternatives on biosecurity in production areas:

05:07 The biosecurity measures of the National Plant Protection Organizations (NPPO)

Dr. Jorge Palacino, accompanied by **Catalina Quintero**, informed the audience about the Specialized Group on Foc that was formed in Colombia since 2019, to address the problem of the disease and monitor the biosecurity actions in the country. The pathogen Foc TR4 is a quarantine pest present in Colombia with restricted distribution (Department of La Guajira, municipalities of Dibulla and Riohacha) and under official control. The National Action Plan contemplates a systemic vision regarding biosecurity.

Among the aspects addressed by the plan, it was highlighted the establishment of a series of regulatory frameworks that cover, among other topics: the regulation of the importation of plant materials; quarantine measures on farms; declaration of national emergency from 08/09/19 to 02/08/21; a biosecurity and surveillance plan in bananas and plantains production areas for export (which includes regulations for the restriction of areas in order to avoid the mobilization of soil, delimitations of exclusive entrances and exits, strategic location and replacement of boots); The plan also includes security measures in relation to movement from affected areas to other areas, including biosecurity measures and control of movement (of plant material, containers, vehicles, machinery and implements).

In addition, the plan provides clarity regarding the surveillance processes using biosecurity protocols during field trips and collection/delivery of samples. The diagnostic processes are carried out through a network of laboratories (national, plant quarantine, Antioquia, Atlántico, Valle del Cauca and in the Magdalena and Urabá banana producing areas), with analytical capacities (of different processes), application of tests (molecular, biochemical) and morphological characterization. The mitigation of the risk of dispersion of plant material and soil is based on control nodes and focused on seaports (logistics and infrastructure) and container yards (washing and disinfection), on the main roads between departments (disinfection of vehicles, mobilization license), on community roads between farms as well



as on the farms themselves (entry and exit control, dirty and clean area for footwear, established checklist by the ICA).

Dr Palacino emphasized the importance of agreements and alliances to provide support to small and medium-sized banana and plantain producers carried out by the ONPF with support of FAO and banana unions such as the Asociación de Bananeros de Colombia (AUGURA) y la Asociación de Bananeros de la Magdalena y la Guajira (ASBAMA) where 88.3 thousand biosecurity kits were delivered for the prevention of FoC TR4. The ICA in collaboration with the Colombian Agricultural Research Corporation (AGROSAVIA), studied the effectiveness of Quaternary Ammonium-based disinfectants (used in Colombia), all of which showed biocidal action on reproductive and survival structures of Foc TR4, in culture media.


Dr Palacino presented the Joint Guide for Importing Plantain and Banana Germplasm and Propagation Materials, which has 14 quarantine protocols (including contingency plan, good practices, wastewater management, agronomic and phytosanitary management, packaging, inspection and monitoring, disinfection and sterilization, weed control, unforeseen events, sampling methods, footwear and foot baths).

The technical director concluded his intervention by mentioning that risk communication, even after controlling the outbreak, has not stopped. He emphasized the training of producers (on biosecurity and good agricultural practices) and the communication materials produced, such as brochures, flyers, billboards, posters and videos, including material harmonized with the countries of the Andean Community, distributed in ports, airports and borders.

Mr Fernando Araya pointed out that Foc TR4 is the pest with the highest risk in the alert system of Costa Rica. The executive director began his intervention by presenting the initiatives of legal nature, including the phytosanitary regulations of operational and preventive exclusion initiated several years ago, in conjunction with the National Banana Corporation (CORBANA), and which has been intensified due to the presence of the disease in the continent.

The activities developed within the country's strategy in the face of the threat, included the development of: a technical factsheet on the pest; the Executive Decree MAG 40.364 / 2017 (with general provisions for prevention); the notification of import requirements for musaceae to the WTO; a guide for the application of phytosanitary measures; an international drill and a resolution with mandatory phytosanitary measures (producers, importers, marketers and the general population).

According to the engineer, since the confirmation of the outbreak in Colombia in July 2019, training sessions were intensified, the Molecular Biology Laboratory of the SFE was strengthened (with the support of CORBANA), the fumigation arches were evaluated (regarding operation and structure, drift and coverage, as well as the use of disinfectants), officials were equipped with kits for suspicious cases and trained on sampling collection. In addition, public funds were reallocated for prevention, canine units were implemented, and a prevention, exclusion and combat fund was established.



The MAG Decree No. 42392/2020 declared State of National Phytosanitary Emergency and Resolution-DSFE-006-2020 established mandatory phytosanitary measures.

He stressed the capacity for early detection of outbreaks as critical for the application of containment measures in the shortest time possible. He underscored the capacity of the staff from SFE and CORBANA as crucial for the execution of an outreach and awareness plan.

Mr Araya highlighted the need of having laboratories with capacity to perform molecular analysis. He also highlighted the importance of developing a containment plan prior to the outbreak with multiple actors and emphasized the importance of adequate information campaigns and the strengthening of alliances between OIRSA, FAO, IICA, universities, multinational companies and technical schools.


According to the engineer, it is necessary to have it available alternative planting materials with high tolerance/resistance to the disease. The Executive Director mentioned the articulated work carried out between the SFE, the National Institute for Innovation and Transfer in Agricultural Technology (INTA) and CORBANA and highlighted the importance of international cooperation for joint research, such as the co-financing mechanism for the development of agricultural technology (FONTAGRO).

48:42 Biosecurity alternatives for small producers and non-certified production areas

Mr Mauricio Guzman defined biosecurity as the set of good practices to minimize the risk of the introduction of harmful organisms, through the strengthening and reinforcement of capacities at all levels for which it requires the development of legal frameworks, as well as guidelines for biosecurity on farms. According to the specialist, there are very good guides concerning different aspects of safe production. In Costa Rica, 15 biosecurity measures were established (main entrance, footbaths, fences and defenses in plantations, disinfection, rubber footwear /boots, tools, information sharing and training) and 42 control points, on which monitoring is carried out.

While large producers (export-oriented) have a high percentage of compliance, small ones have low or no compliance. While the former has a medium biosecurity risk, the latter have high risk. Concerning small producers, the highest risk factors are absent or insecure fences; multiple entry points to the farms; uncontrolled movement of people and animals; non-certified planting materials; and lack of procedures for the disinfection of vehicles, footwear and tools. The main barriers to the adoption of biosecurity measures are the lack of clear and simple information; lack of training; low availability of continuous and timely technical assistance; scarce financial resources; lack of adequate and easily accessible communication channels; and low or no availability of certified plant material. To reduce this gap, it is required: timely and frequent technical assistance; permanent training; practical, simple and inexpensive ideas; clear messages; and improved communication channels.

Colombia had economic support through a special line of credit for biosecurity and disease control, with differentiated rates according with farm size. Given that phytosanitary surveillance is a key factor for defense, the segment of small producers requires urgent support for timely detection, both from the public and private sectors. CORBANA has provided a toll-free telephone line and email to receive reports,



alerts of suspicious plants, and to provide assistance. Each country must diagnose its biosecurity situation and urgently define the necessary actions to improve it at the level of small producers and reduce the gap.

1:15:04 Biosecurity supported by the private sector and certification schemes

Mr Jorge Alex Murray began his intervention by providing an overview of BANASAN. BANASAN manages around 6 000 ha and provide surveillance to 260 production units established by the NPPO (75% present in cooperatives). Since November 2019, the company has implemented protocols, created a biosecurity group (with 5 engineers trained as auditors), and obtained CERES and GLOBALG.AP + Add-on certifications (renewed in 2021). The latter covers compliance controls for Foc TR4, related to understanding the pathogen, training and awareness raising activities, access points control, good agronomic practices and suppression of the pathogen.

Regarding the understanding of the behavior of the pathogen and its epidemiology, the company trained its staff on issues related to the identification of external symptoms, and in the risk analysis concerning soil, plant material and water management.

Regarding capacity building, a biosecurity guide and an ongoing training program were developed. The access points of the farms were jointly evaluated using a risk matrix and a checklist in compliance with ICA and Global Gap regulations. The matrix is composed of four components with their respective scores: (i) infrastructure; (ii) operational; (iii) chemical; and (iv) informative.

Regarding agronomic measures, the company follows the resolutions implemented by the ICA and uses plant materials originating in a certified laboratories or from companies with ICA certification. The company also conducts the washing and disinfection check prior to the movement of machinery. The norms related to the suppression of the pathogen have not been applied in the Department of Magdalena, following resolution of the ICA protocol.

The engineer concluded by mentioning that integration is key for a biosecurity plan to work, highlighting the importance of establishing a permanent connection between industry, government, and the community.

Mr Antonio J. González shared the experience acquired in the quarantined farms of its organization and his contribution to the prevention and establishment of free-disease areas in Colombia. The integration of actors was built through agreements between public (MAG, ICA) and private (ASBAMA, AUGURA) actors that have allowed the channeling of funds in biosecurity, specifically, in the development of training plans at all levels, the provision of quaternary ammonium, risk communication (campaigns), delivery of rubber boots to farms, and delivery of elements to fence farms. This has made it possible to support small producers who do not have sufficient financial resources.

The private sector has developed the following activities: permanent training on farms, communities and productive chains (biosecurity measures); the delimitation of external areas (for vehicles, motorcycles and

bicycles not necessary) and restriction of entry; the establishment of biosecurity areas for changing boots (enter clean, leave clean).

Over time, the costs of biosecurity infrastructure were reduced maintaining safety standards, which increased replicability for small producers. Containers have been adapted as biosecurity areas. At the farm level, progress has been made in the implementation of biosecurity protocols and in La Guajira, given the restriction on the movement of machinery, biosecurity protocols have been implemented from the production site to the entrance of each farm (articulation via communication in Whastapp groups).

The technical personnel, the containers, the machinery and the vehicle of the personnel of La Guajira have been segregated from those of other zones (Magdalena and César). Various technological and handling improvements have been made (ex: pumps for washing and disinfection of vehicles; washing, brushing and rinsing of containers in the yard; bicycles for internal travel; footbath type designs in the field; reduction of movement of soil in footbaths, monitoring of solutions with disinfectant products, among others).

1:44:18 PRA - Determination of risk zones to support biosecurity, surveillance and containment measures


Ms Nancy Villegas provided an overview of OIRSA work, mentioning the support provided to member countries and their NPPOs on the compliance of sanitary provisions in surveillance, diagnosis and Pest Risk Analysis (PRA) developed by the agency.

There are 2,517 regulated quarantine pests that represent a threat to Central America (including insects, fungi, weeds, viruses, bacteria, nematodes, mites, phytoplasmas, viroids and mollusks). Climate change is expanding the range of latitudes suitable for musaceae production, as well as for the distribution of pathogens.

In Latin America and the Caribbean, the main exporting countries are Ecuador, Costa Rica, Guatemala and Colombia, where the banana production systems are diverse. Phytosanitary challenges in the region include historical epidemics (such as Yellow Sigatoka, Black Sigatoka, and Moko), current outbreaks (such as *Dickeya chrysanthemi*, *Radopholus Similis*, and *Cosmopolites sordidus*), threats (such as Xanthomonas wilt of banana and Bunchy top virus) and dangers (such as Foc TR4). It is interesting to know the location of these diseases, their prevalence in the field, their severity/incidence, the factors that condition their appearance, the technological packages available, the ongoing research, as well as the level of awareness of producers and their skills on recognizing and managing the pests.

According to the Coordinator of the Regional Unit for Pest Risk Analysis (PRA), the PRA provides the technical bases and procedures for the implementation of phytosanitary actions that prevent the incursion of the disease.

The PRA procedure considers the following stages: (i) initiation (definition of scope); (i) risk assessment (categorization of pests, estimation of probabilities, estimation of consequences, conclusions and uncertainty); (iii) the risk management (identification of mitigation measures; evaluation of effectiveness



and availability of options; comparing estimated measures with risks; recommendation of measures); decision making and/or re-evaluation. The exclusion measures are focused on the entrances (of regulated goods, non-regulated articles, land, passengers, international mail, etc.), in the external quarantine (by means of intrusive and non-intrusive inspection). It is also important the establishment of disinfection arches, through the treatment of international garbage and the regulation of container sanitation.

Ms Villegas emphasized the importance and relevance of various topics such as: the regulation of diagnostic methods by means of PCR, the development of regulations, the implementation of action plans and active surveillance.

Ms Villegas mentioned that an PRA procedure for Foc TR4 was published in 2018 and updated in 2019 and that until 2022, it is expected to have a publication focusing on emerging and re-emerging quarantine pests in musaceae . In addition, in 2021, a set of biosecurity measures for the introduction and movement of musaceae propagation material was published. Ms Villegas concluded by mentioning that OIRSA also analyzes the ports and terminals enabled for the import and export of bananas in the region in order to identify risk areas for the introduction of the pathogen.

2:08:56 Mapping technologies that complement the territorial PRA

Dr. Varma Varun began the presentation underscoring a series of risks of climatic nature faced by musaceae production. The risks can be observed in long-term (gradual change in the suitability of the land) and short-term (extreme meteorological events of greater frequency and intensity), other risks are variable and derived from the attack of pests and diseases. Risk assessment, management and mitigation of risks requires information on the location of production, and faces the challenge of having high-resolution, accurate, and up-to-date reliable information. In Latin America and the Caribbean (LAC), climate change impacts the productivity of bananas in a variable way (negative or positive), depending on the area of cultivation, the production system and the technology used.

The Banex project developed a global mapping of banana plantation areas, based on high resolution satellite information (10 to 50 m) regularly updated (minimum 6 months). The mapping of production areas in the Americas has been completed, with 50m resolution, and an accuracy of 95-98%. Using the same algorithm, higher resolutions can be reached (up to 10 m/pixel).

Among the applications of these products, it is possible to map the area of plantations affected by hurricanes, identify areas susceptible to floods, among other aspects.

According to the researcher, disease risk assessment and surveillance require trained personnel, incentives and reporting mechanisms, in addition to the use of technological solutions and early warning systems based on satellite information and cartography. Up-to-date high-resolution mapping contributes to the surveillance strategy and infection risk modeling. Dr. Varun concluded by thanking the funding of the Global Food Safety Program and the Science and Technology Facilities Council - Food Network +, and the collaboration of CORBANA, Will Thompson (ETH Zurich) and Banelino.

2:29:31 Collective analysis of existing alternatives

The panelists from Colombia indicated that, through resolutions, the requirements have been established for the entry and movement of machinery and second-hand agricultural vehicles (biosecurity principle: “enter clean, leave clean”), for the eradication of plants (through glyphosate herbicide), and for the mobilization of plant propagation material.

According to the panelists, it is necessary to reinforce traceability and control in border areas and near La Guajira. In La Guajira, the established measures by ICA have been implemented and processes were improved.

At farm level, the biosecurity measures associated costs have been approximately 5-6 cents per box at the beginning of the pathogen's incursion, with the improvements adopted, these costs were reduced to approximately 2 cents per box, according to the characteristics of each farm.

Each checkpoint costed approximately \$ 77,000/year for the NPPO (the post consists of an autonomous trailer, staff, and quaternary ammonium). 17 checkpoints were installed, plus another 15 checkpoints installed by third-parties, with costs reaching approximately 1,9 mi USD/year considering installations in the first year, and 1,3 mi USD/year for maintenance (personnel, biosecurity suits, maintenance of machines sprayers).

Wastewater from washing and disinfection points is directed to separation and infiltration filters. The innovations implemented have reduced the amount of soil reaching these filters. The wastewater should not be directed to rivers or the basin.


In La Guajira, large producers established unified biosecurity areas, in Magdalena, the 550-600 small export-oriented banana producers are grouped in cooperatives, which, in some areas, have established a biosecurity areas for grouped farms.

Representatives of public and private organizations in Costa Rica indicated that not only the infrastructure is important, but the effectiveness of the measures and their relation to the posed risk. In organic farms, the certification schemes have supported farms on reducing limitations on the use of disinfectant products. They have recognized the importance of research for innovation and for the effectiveness of measures throughout the region.

According to specialists, it is necessary to modernize the surveillance on entry points of the countries. In Costa Rica, for example, \$ 250,000 has been invested in the monitoring of land and sea borders (not including airports).

The costs for the implementation of biosecurity measures, considering a productivity of 3,000 boxes/ha, was around 120 dollars/ha, and the maintenance cost around 1 cent/box of banana.

Since disinfectants based on quaternary ammonium salts have limitations, the applicability of the use of glutaraldehyde or mixtures between the two is being studied.



There are procedures and guidelines for the production of healthy plant material that are easy to replicate (based on the use of sprouts and in vitro propagation). The planned strategy in the country considers the regional production of good quality certified seedlings, to minimize the risk of transferring plant materials from different parts. According to the specialists, the Legislation should cover the transport of plant material and the control measures should be disseminated through information chains.

Imports of used machinery requires that the equipment be fully disinfected and free of soil and organic material, upon entering the country.

OIRSA indicated that, since prevention is more cost/effective than control, it is imperative to increase investment in prevention and the application of biosecurity measures in all countries.

Exeter University pointed out that, to improve prevention and early warning, commercial satellite images could be used, however the costs are higher. This could limit the access of countries, affecting uniformity and comparability.

Mobile applications that support pest surveillance:

3:13:23 BANASOFT - an application for outbreak surveillance and monitoring

Ing. Jimmy Santiago provided a description of the BANASOFT web platform, developed by SAB SAS, which digitally carries out relevant processes of banana-producing farms and makes relevant and integrated information available for decision-making, improvement of the processes, increased production and quality, as well in the optimization in the use of resources.

In order to use the platform, the farms are georeferenced and various layers of information are generated (productivity, soils, climate, fertilization, plant health, satellite images). The GIS module displays geospatial information (production, satellite, biosecurity, plant health and laboratories) and gives the option of a “heat map” that can be used to support the eradication of outbreaks. The mobile application is used to insert information regarding field activities, packing house processes and container use.

For the monitoring of outbreaks at the farm level, the person in charge accesses the tool through credentials. Descriptive information and pictures of symptoms (diagnosis of the outbreak and its detailed location) can then be captured. For audits, the field information is organized into the five biosecurity axes based on ICA regulations.

The monitoring of plant health can be done on different dates and periods, by filling in columns of information in spreadsheets, with the option of downloading them in Word, Excel and PDF. With regards to biosecurity, information is recorded at the farm level, lot, coordinates, diagnosis, status, detection date, ICA confirmation, possible eradicated area, etc. Regarding audits, the auditor insert relevant information and compliance statistics and graphs can be generated.

The engineer concluded by mentioning that, for the successful use of the tool, constant monitoring and analysis of the reports are required for decision making.

3:27:38 Tumaini: a mobile application based on artificial intelligence for the diagnosis of specific banana pests and the appropriate control measures

Dr Michael Gomez Selvaraj began its presentation by mentioning that early warning systems need various sensors (unmanned aerial vehicles, satellite images of medium to high resolution and terrestrial sensors) and sources of information (advanced models of artificial intelligence and mobile applications). The Tumaini tool (“hope” in Swahili) is available in English, Spanish, French, Tamil and Swahili.

The application is free and available online on *google play store*. The databases used by the application were collected and tested in India, Africa, Malaysia, and Latin America. According to the researcher, the machine learning process carried out by the application includes the collection of images (validated by phytopathologists), the labeling of data, its dissemination, the development of training, testing and validation databases, the performance evaluation and the disease imaging detection. The second version of the Tumaini application relies on an online and downloadable model, which contains more than 12 thousand images, 30 thousand annotations and 9 classes of pathogens (covering 6 diseases including Fusarium wilt) and 7 detection models.

The software allows the identification of symptoms of whole plants, leaves, pseudostems, clusters, fruit sections, among others (the rachis are still being included). The field image is collected and inserted, specifying the plant tissue. The mobile application then performs the recognition, indicating a percentage of reliability (when greater than 80% is considered adequate). A description of the identified disease, symptoms and control are made available.

Field trainings have been carried out with small farmers for use of the software in the identification of plant pathogens. The challenge identified was related to the classification of new outbreaks and to the differentiation of diseases with similar symptoms (such as Xanthomonas and Fusarium). For this reason, the system encourages users to enter several images of different tissues. The application has limitations considering species level and detection of symptoms at early stages.

The application can merge geographical coordinates, with the disease detection model and images, in order to integrate the information and represent a territorial view. The data collection, analysis, mapping and early warning systems have been improved and can support the development of an integrated tool in the future.

3:44:10 Questions, comments and collective analysis on the topic and the session of the day:

The application developed by SAB SAS is its property (it is not open).

Complex (combined) infections are difficult to identify, for this, multiple images are important (comprising several plant tissues, in particular, the rachis).

It is needed to incorporate more pathogens from Latin America in the application. The application is free.

3:49:02 Closing remarks

To discover the benefits of becoming a member of the World Banana Forum and to take an active role towards a sustainable banana sector, please visit:

www.fao.org/world-banana-forum

World Banana Forum Secretariat
Trade and Markets Division

Food and Agriculture Organization of the United Nations
Viale delle Terme di Caracalla
00153 Rome, Italy

WBF@fao.org | **www.fao.org/wbf** | **@FAOwbf** 

TR4 Global Network

<http://www.fao.org/TR4GN>