



Embrapa Cassava & Fruits embarked in a new Preventive Breeding strategy, following the example of the strategy used against black Sigatoka that proved successful in Brazil, and conscious that TR4 will be the subject of the next battle to be faced in the banana production areas. Technical cooperation projects have already been signed with the Australian Government (Australia-DAAF/University of Queensland-UQ); the Institute of Fruit Tree Research, Guangdong Academy of Agricultural Sciences (IFTR-GDAAS), and the Peoples Republic of China, for evaluation of Brazilian genotypes in Asia and Latin America.

Concomitantly with the pre-breeding work, it was necessary to alert the Brazilian phytosanitary authorities about the danger that would be the introduction of TR 4 in Brazil, so that formal action could be taken in order to avoid an eventual introduction. Embrapa Cassava & Fruits provided relevant information on the disease to the Plant Health Department of the Ministry of Agriculture, Livestock and Food Supply (MAPA), requesting that TR4 be included in the list of quarentenary diseases of Brazil. This would help to establish the basis for concerted actions, including awareness campaigns e proper attention to avoid the entrance of the disease in the national territory.

Embrapa provided MAPA with orientations in a protocol for diagnosis of TR4, containing instructions for the collection of tissue samples affected by the Fusarium wilt; methodology for isolation of *Fusarium oxysporum* f sp. cubense from samples collected from plants of banana and plantain affected by the wilt, and; identification of Foc's Tropical Race 4 using Polimerase Chain Reaction (PCR). The diagnostic protocol of TR4 was developed by Embrapa in Collaboration with PRI/WUR, The Netherlands.

On September 14, 2015, the Ministry of Agriculture published Normative Instruction No 26, including the Race 4 of *Fusarium oxysporum* f. sp. cubense in the list of Absent Quarentenary Diseases in Brazil. This is, undoubtedly, a relevant service provided by Embrapa to the Government of Brazil, the banana industry and producers in the country.

Recognized Dedication

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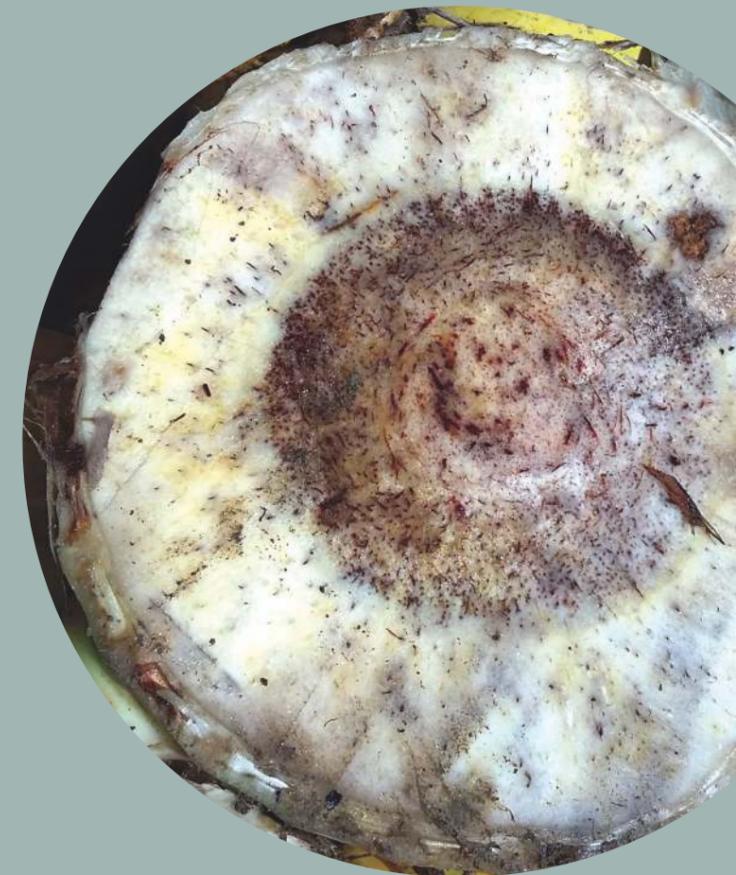
MINISTRY OF
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Research Highlights

Research results
that must be known



INCLUSION OF *FUSARIUM
OXYSPORUM* F.SP. CUBENSE
IN THE LIST OF QUARENTENARY
DISEASES IN BRAZIL



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Research Highlights has been created by Embrapa Cassava & Fruits as a communication channel aimed at disseminating important results of the work performed by researchers dedicated to solve the production constraints faced by the crops which are part of our mandate.

Embrapa Cassava & Fruits was established as a national research center in 1975. It has the national mandate to coordinate research programs involving mainly six tropical fruits (banana, citrus, mango, pineapple, passion fruit, Barbados cherry and papaya), and cassava. The research center has its headquarters in the city of Cruz das Almas, State of Bahia, with advanced posts located in the States of Paraná and Santa Catarina (South); São Paulo, Espírito Santo and Minas Gerais (Southeast); Mato Grosso (CenterWest), Rio Grande do Norte (Semi-Arid Northeast) and two other locations in Bahia. The center has a staff comprising 147 researchers and analysts, 57% of them with a doctoral or post-doctoral degree, and the remaining 37% with a M.Sc. degree. Additional administrative, laboratory and field staff completes the total number of employees, equal to 224 staff members. A considerable number of students are also performing thesis studies and participating in the research activities of the center.

Over the years, Embrapa Cassava & Fruits has obtained research results that certainly

contributed for the improvement of the agricultural sector, as a result of the work done by its scientists and staff members in general. There are dozens of technologies, products and processes that deserve the name of “good research”, but also those that deserve to be named “Research Highlights”, with an outstanding performance, and with a strong impact in the field and/or in the market.

This series reports successful cases of our research history, and has as its main objective to inform our partners and/or potential partners about outstanding results obtained by the Center. It is important to say that we seldom work alone; competent teams of researchers composed by our staff members and representatives of many partner institutions across the country and across the world are those responsible for our *Research Highlights*.

By publishing *Research Highlights*, Embrapa Cassava & Fruits expects that our partners, collaborators and the general public are well informed of our contribution to the splendid growth of the agricultural sector in Brazil in recent decades. We expect that new partners are found and share their experience with us, establishing new partnerships, and that those who generated and disseminated our research results are given the right recognition for the good work!

Fusarium oxysporum f. sp. cubense; efforts against Tropical Race 4 in Brazil

The Fusarium wilt, caused by the soil-borne fungus *Fusarium oxysporum* f. sp. cubense (Foc), have been, historically, one of the most destructive diseases that attach banana plants, being considered as one of the ten most important diseases in the history of Agriculture. Race 1 of the soil-borne fungus was responsible for the epidemic that caused great impact on the America's banana export industry in the 20th century. The epidemic was responsible for the disappearance of the majority of the Gros Michel planted areas, which is highly susceptible to the race 1 of the disease. It also had a great impact on plantings of Maçã, a variety also very susceptible and highly appreciated by Brazilian consumers.

The problem has been partially solved by the banana export industry, with the replacement of Gros Michel plants by clones of the Cavendish sub-group, resistant to the race 1. However, plants of variety Prata Anã, presently the most planted variety in Brazil, are showing high susceptibility levels and high incidence in planted areas.

In 1990 a new variant of Foc, named “tropical race 4” (TR4) was identified in Southern Asia, seriously affecting cultivars of the Cavendish sub-group. This variant is more aggressive than race 1 and it is rapidly disseminating in Asia, provoking great losses in the region, with more than 100,000 ha already destroyed by the disease. Indonesia, the Philippines and China are examples of countries seriously affected by TR4. It is estimated that more than 80% of bananas and plantains produced in the world are susceptible to TR4. In Brazil, where the presence of the disease has not yet been reported, this percentage may go up to 90% of the area planted with bananas.

The reality is that Foc TR4 is now considered as the greatest danger to the world's banana production. In spite of the fact that the race has not yet been reported in the Americas, its appearance in the region is imminent as proved by the recent surges in Jordan (2013) and Pakistan, Lebanon and Australia (2015). See Table 1 for a list of countries where the disease has been officially recognized and is present in their respective territories.

Table 1. Countries where the presence of TR4 has been officially confirmed

Continent	Country	Year
Asia	Taiwan	1986/2000/2004
Asia	Malaysia	1996
Asia	Indonesia	1994/1996/2000/2001/2005/2009
Asia	Philippines	2008
Asia	China	2001/2008
Asia	Pakistan	2015
Middle East	Oman	2012
Middle East	Lebanon	2015
Oceania	Australia	1997/2000/2015
Africa	Mozambique	2013

Taiwan: Su et al., 1986; Ploetz and Pegg, 2000; HsieheKo, 2004.

Malaysia: Peninsular Malaysia and Sarawak: Ong, 1996.

Indonesia: Halmahera, Irian Jaya, Java, Sulawesi, Kalimantan and Sumatra: Nuthardi et al., 1994; Pegglet al., 1996; Ploetz and Pegg, 2000; Lee et al., 2001; Ploetz, 2005b; O'Neill et al., 2009.

Philippines: Molina et al., 2008.

Peoples Republic of China: (in Guangdong, Guangxi, Hunan, Hainan: Qi, 2001; Qi et al., 2008).

Paquistan: Ordoñez et al. 2015.

Oman: Ministerial decision No.194/2012.

Lebanon: Ordoñez et al. 2015.

Australia (northern territories, 1997, and Queensland, 2015; Ploetz and Pegg, 2000; Australian Banana Growers Council, 2015. * [http://abgc.org.au/biosecurity/panama"tr4](http://abgc.org.au/biosecurity/panama)).

Moçambique: IPPC, 2013.